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DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

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DIRECTOR'S OVERVIEW

This is the fifth Research Plan of the Department of Conservation and Land Management.

Over the past year there have been several important developments and achievements in Research Division. Some of these are:

- Some staff attended meetings of the IUCN Congress and its Commissions, which were held in Perth in late 1990. This major international meeting provided an opportunity for staff to see our work in an international context and meet research scientists and policy makers from other countries. Following the meeting I have been appointed a Regional Member of the Species Survival Commission and Chair of the Australasian Marsupials and Monotremes Specialist Group. This reflects the high regard that many people have for research work conducted in the Division and the standing of Divisional scientists.
- The Research Division Policy Group (RDPG) has agreed that one of its aims is to have a minimum professional - technical staff ratio of 1:1 in each research centre and research program. It is recognised that achievement of this aim will take time.
- John Bartle is now no longer involved in the RDPG, being fully occupied with the Vegetation and Tree Planting Advisory Service. The Division thanks John for his past contributions.
- The positions of Research Centre Manager at Woodvale and Collections Manager at the Herbarium were created and filled. I congratulate Ron Sokolowski on his promotion to the Woodvale position, welcome Chang Sha Fang as the new Collections Manager and thank Matt Williams for accepting the position of Centre Manager at Como Research Centre.
- There have been the following changes to Program Leaders: Gordon Friend has replaced Neil Burrows (Fire Research Program) and Janet Farr has replaced Ian Abbott (Economic Entomology). I congratulate Gordon and Janet and thank Neil and Ian for their contribution over past years.
- The Western Swamp Tortoise Captive Breeding Management Committee, which I chaired, was a runner-up in the inaugural IBM Conservation Award. The $1000 prize was spent on DNA fingerprinting some of the captive colony. This Committee has now been replaced by the Western Swamp Tortoise Recovery Team, including CALM, Perth Zoo, University of Western Australia and Curtin Univerity of Technology staff, setting a trend for the management of other threatened species.
- There will be an award for excellence made to Division staff this year. Details are being finalised.
- Divisional staff participated in the preparation of three applications in the first round for Cooperative Research Centres. Unfortunately, none of these were successful. The Division is participating in the preparation of two applications for the second round, closing in July 1991.
- A large number of scientific papers have been published over the past year, maintaining the high standards of science ouput by Divisional staff.
- Several major articles by Divisional staff have been published in *Landscope*.
- A workshop on improving vegetation cover in rural south-western Australia was held by the Division and was well attended by CALM staff.
- The Division has continued to attract significant external funds over the past year.

In common with the rest of CALM and many other Government Departments, the past year has been a difficult one for the Division because of reductions in financial support and staff numbers. The consequences have included:

- A change in the staffing costs - operating finance ratio from 66:34 in 1988/89 to 74:26 in 1990/91. Any reduction below 70:30 is considered to be highly undesirable in most research organizations and is particularly difficult to deal with in one like ours which is required to work over a large geographic area.
- The temporary suspension of the Marine Research Program. The resignation of Dr Jim Stoddart and our inability to fill the consequent vacancy has meant that our infant marine research program has had to be put largely on hold. Research on the early life history of *Drupella* at Ningaloo Marine Park, which is funded by the Australian National Parks and Wildlife Service, has continued.

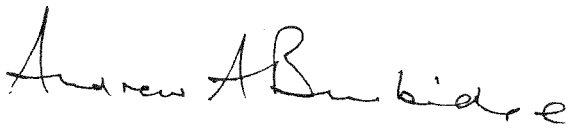
- Several other vacancies in a variety of programs are not being filled. Several Research Projects have had to be cancelled or deferred. This has meant that we have been unable to meet some commitments in last year's plan.
- An inability to provide funds to external organizations to carry out complementary research of importance to conservation and land management.

The Division continued to attract significant funds from external sources. Almost $900 000 was received in research grants and contracts last year; nearly half of this came from the Australian National Parks and Wildlife Service. Without these additional funds the Division would be unable to achieve many of its objectives.

Over the past year the following staff have left us because of transfer, resignation or retirement: Janet Gardner, Angas Hopkins, Gary Inions, Peter Jenkins, Denis McDonald, Don Munro, Colin Sanders, Jeni Scott, Peter Skinner, Peter Solar and Jim Stoddart. We wish them well. We welcome David Brockwell, Chang Sha Fang, Irene McPharlin, Jenny Nicholson and Michael Yung.

I would like to thank all Division staff for the support they have given me over the past year, especially the members of RDPG, the Research Program Leaders and the Research Centre Managers.

I also thank those who have helped prepare this Plan, especially the Program Leaders, Ian Abbott, Christine Farrell, Jill Pryde, Jenny Nicholson and Irene McPharlin.



ANDREW A BURBIDGE
Director of Research

30 June 1991

EXECUTIVE SUMMARY

MAJOR ACHIEVEMENTS

The significant accomplishments of each program are summarized below:

EXECUTIVE AND RESEARCH SUPPORT PROGRAM

The Entomology Research Program was reviewed in February 1991, and the Native Forest Silviculture Research Program was reviewed in April 1991. A major review of research into dieback disease caused by *Phytophthora* species was completed and forwarded to the Executive Director.

BIOGEOGRAPHY PROGRAM

The editorial preparation of the forthcoming book on Kimberley rainforests was completed. The study provides an overview of Kimberley rainforests and their conservation significance, and includes recommendations for improvements in the conservation reserve system and for management of rainforest in Western Australia.

A major review of the conservation estate in the Kimberley was finalized and published.

A major project to identify conservation needs in pastoral lands was completed.

Analysis and writing up of data from the Eastern Goldfields survey continued: the Manuscript for the Kurnalpi/Kalgoorlie cell was completed and edited ready for publication, and a draft Manuscript has been prepared for the Norseman-Balladonia cell. Survey sites in the Goldfields were re-visited and accurately positioned using the satellite-based Global Positioning System, in order to facilitate future monitoring.

A report was prepared reviewing the data available to assess the adequacy of the jarrah forest conservation reserve system in the Dale Botanical Sub-District.

A major paper was published explaining the methodology, outcome and recommendations of the Nullarbor District survey.

A number of specific areas were surveyed and/or reports produced. Areas covered included John Forrest National Park, vacant Crown land east of Kalbarri, a portion of Boolardy Station, Cape Arid National Park, various parts of the Swan Coastal Plain, Greenmount National Park, Ashmore Reef National Nature Reserve, Mitchell Plateau, Fitzgerald River National Park, North-west islands, Lancelin-Dongara islands and Exmouth Gulf islands.

Compilation of a Checklist of the flora of the Pilbara was commenced. It will provide an improved data base for future work in the region. The Census of Australian Vascular Plants, for which the Biogeography Program provided distributional data for the 8 316 Western Australian taxa, was published by the Australian Biological Resources Study.

Bibliographic data-bases of the Pilbara Region and of conservation reserves and proposals across the State were commenced.

ECONOMIC ENTOMOLOGY

Re-monitoring density of Jarrah Leafminer 18 months after an experimental Autumn fire near Collie has shown that this type of fire is ineffective in reducing density for longer than 12 months.

A survey in Collie and Manjimup Districts of adjacent stands of Jarrah forest differing in time since logging showed that recent logging did not favour Leafminer.

An extensive survey of Gumleaf Skeletonizer distribution in the central and southern forest revealed a patchy distribution of the insect.

The existence of two Gumleaf Skeletonizer populations in the South West and South Coast of Western Australia was verified. A univoltine (one generation per year) population is confined to the Jarrah forest, whereas a bivoltine (2 generations per

year) population occurs in the wheatbelt and isolated locations in the Jarrah forest.

A further parasitoid of Gumleaf Skeletonizer has been identified as the Tachinid fly *Winthemia lateralis.*

The psyllid infesting Flat-topped Yate, formerly thought to be *Cardiaspina brunnea*, is now confirmed as a new species endemic to the Lower Great Southern.

Intensive study of tagged leaves at Cranbrook has shown the survival rate of *Cardiaspina* sp. nov. from egg to fifth instar to be 28%. A decrease in the survival rate to 1.1% was observed after an influx of Striated Pardalotes into the area. A parasitic wasp, *Psyllaephagus* sp. (family Encrytidae), has also been found to affect the survival of *Cardiaspina* sp.nov. although its incidence of parasitism is very low.

Flat-topped Yate trees possibly resistant to *Cardiaspina* sp. n. have been located near Fitzgerald NP.

A considerable backlog (1984-1989) of data on insect herbivory and abundance of foliage arthropods has been written up.

A paper on the composition, distribution and economic impact of the termite fauna of metropolitan Perth was published.

A menu driven data base for the Manjimup insect collection was established.

Monitoring of caged billets of radiata pine from the Ferndale and Pinjar plantations has proven that only one species of the three biocontrol agents for *Ips grandicollis* has established. This species is the Torymid wasp *Roptocerus xylophagorum.*

A concise synopsis of biological data for the 19 insect species so far recorded infesting trees in plantations was provided for CALM's insect manual.

FAUNA CONSERVATION

A workshop to determine priorities in fauna conservation research was held on the 10 October 1990. It was attended by a wide cross-section of CALM staff, from Operations Division and other parts of the Department with an interest in fauna and its conservation. The main outcomes were that the program should maintain the present mix of species-oriented and process-oriented research, but that more attention should be focussed on feral cats and introduced herbivores, invertebrates and the fauna of the jarrah forest.

Program members were again very successful in raising external funds. New and ongoing grants were received for research on Western Mouse, Red-tailed Phascogale, Quenda, fox biology and control, small mammals on Barrow I, Greater Stick-nest Rat, Western Swamp Tortoise, marine turtles and *Drupella.*

The Western Swamp Tortoise Wildlife Management Program was published, being launched by H.R.H. Prince Philip in November 1990.

The Chuditch Wildlife Management Program was approved by Corporate Executive and funds have been provided by the Australian National Parks and Wildlife Service for its publication as a Species Recovery Plan.

Funds were also successfully sought from ANPWS to produce Species Recovery Plans for the Tammar, Woylie, Black-flanked Rock-wallaby, Shark Bay Mouse and the endemic frogs *Geocrinia alba* and *G. vitellina.*

A "Manual on Fox Control" was produced as the result of WWFA Project 106 and forwarded to the funding body, to be published soon.

A WWFA-funded research project on the conservation of the Western Mouse has provided important biological information on this threatened species. A previously unknown population was discovered at Rock View NR, and the use of radio-tracking has shown that these rodents nest in burrows, but are partially arboreal.

The Greater Stick-nest Rat, presumed extinct in Western Australia, was re-introduced to the State in 1990 by the release of 40 captive-bred animals on Salutation Island in Shark Bay in association with the South Australian National Parks and Wildlife Service. Monitoring of the colony has shown that

the surviving rodents are in good condition and are breeding despite a dry summer. All indications at this stage are that a viable population has been established.

Previously unknown populations of the Red-tailed Phascogale, a threatened species apparently restricted to the wheatbelt, have been discovered in Highbury State Forest, and at three Nature Reserves in the Great Southern. The species has been found to be still present in Dongolocking, Boyagin, Tutanning and East Yornaning NRs, and in Dryandra State Forest.

An aerial baiting program in part of the Fitzgerald River NP was implemented in order to test further the hypothesis that predation by foxes is regulating populations of native mammals. A census of the Ground Parrot within and outside the baited area was also carried out to allow measurement of the effect of foxes on this threatened species.

Techniques were developed to eradicate the introduced Black Rat from Barrow Island while minimising the effect on native mammals.

FIRE

Prescribed burning of vertebrate and invertebrate sampling areas in the Stirling Range National Park was completed during the year, the burns being carried out in November 1990 (spring) and March/April 1991 (autumn). Regular trapping to monitor the impact of these fires is continuing.

Research on the effects of prescribed burning on vertebrates and invertebrates in wheatbelt nature reserves is also progressing. All of the burns planned for this project have now been completed, the most recent being on East Yorkrakine Nature Reserve in March 1991. Regular post-fire fauna sampling is continuing at Tutanning, Durokoppin and East Yorkrakine Nature Reserves. Post-fire trapping and radio-telemetry studies on the rare dasyurid *Phascogale calura* have also continued at Tutanning in conjunction with the Fauna Program.

The effects of fire on the vegetation in the Stirling Range National Park and at the Tutanning Nature Reserve continued to be monitored.

Autumn and spring samples of invertebrates from Jarrah forest in the Perup Nature Reserve have been collected as part of a long-term study of fire and invertebrates in this forest type. No burns have yet been conducted on these plots.

Fire ecology plots established in jarrah forests throughout the south-west were experimentally burnt again in spring 1990 and autumn 1991. This study aims to determine the long term effects of various fire regimes on the forest understorey. Assessment of the response of vegetation to various fire regimes is continuing.

Stem sections from large, old jarrah trees were analysed in an attempt to obtained data on the forest fire regime prior to European settlement. Preliminary results show that prior to settlement, incidence of fire injury was low, but increased significantly following settlement. This suggests that either fires were very infrequent (40-120 years apart), or were of low intensity and therefore frequent. Given the wide use of fire by Aborigines and the frequency of lightning strikes, the latter is more likely. Fire exclusion during the early part of this century allowed fuels to accumulate with the result that wildfires were very intense and damaging to the trees. The incidence of fire injury has reduced since the 1960s with the introduction of broadscale fuel reduction burning.

The experimental burning program in the Stirling Range National park continued with a further seven plots burnt. This work has confirmed the importance of litter fuel moisture content in determining thresholds for fire spread in mallee-heath fuels. Research staff gathered data during a number of prescribed fires and wildfires in the South Coast Region. Studies of crown fire initiation of *Pinus pinaster* stands were undertaken jointly with Fire Protection Branch and a visiting researcher from Forestry Canada.

Studies on the effect of fire on desert vertebrates are progressing. In Queen Victoria Spring Nature Reserve, study plots were sampled on three occasions and show interesting trends in species succession in agamid lizards and small mammals. The study area in the Gibson Desert Nature Reserve was burnt in October 1990 to leave patches of unburnt vegetation of different sizes. The vertebrate assemblages in these patches are being sampled in an ongoing study.

Old and senescing *Melaleuca viminea* thickets east of Collie were burnt last autumn to regenerate habitat suitable for the Tammar wallaby. Regeneration was poor as the fire was not intensive enough to stimulate seedfall. Another area is planned for regeneration with a higher intensity fire.

FLORA COLLECTIONS

In excess of 30 000 new records were entered into the WA Herbarium specimen database, WAHERB; this database now contains 115 000 specimen records. A grant of $105,000 from the Environmental Resources Information Network was received to database the genus *Eucalyptus*, selected grass genera and Kimberley Acacia species; to date almost 8 000 records, from an estimated 28 000, have been databased. Funds from the Nature Conservation & National Parks Trust Account have enabled the databasing and curating of the State's conservation taxa to continue. Names have been captured for inclusion in the computerized Census of W.A. Plant Names, WACENSUS.

FLORA CONSERVATION

Area-based Wildlife Management Programs for rare and threatened flora in the CALM Merredin District and the CALM Metropolitan Region are near completion following extensive surveys of these areas. In total 164 rare and threatened taxa were surveyed including 42 Declared Rare Flora. Some 140 new populations were documented which also included populations of two presumed extinct species *Sowerbaea multicaulis* and *Calytrix breviseta* ssp. *breviseta.*

Conservation genetic, breeding system and population ecology studies have been completed for three Species of Declared Rare Flora *Acacia anomala, Banksia cuneata,* and *Stylidium coroniforme* and are near completion for *Diuris purdiei.* The preparation of Wildlife Management Programs for these species has been initiated. These studies have been particularly informative in the development of strategies for the conservation of genetic resources and management of these and other rare or threatened plant species. The preparation of ANPWS - funded recovery plans for *Eucalyptus rhodantha, Acacia anomala, Banksia cuneata,* and *Stylidium coroniforme* is also underway.

FLORA INFORMATION

The enormous task of preparing the manuscript of the Flora of the Kimberley Region is now at typesetting stage. The project, which has taken six years to complete, keys out and describes all of the flowering plants recorded in the Kimberley Region.

Treatments of the genera *Kippistia, Minuria* and *Olearia* and *Zieria* for the forthcoming Flora of New South Wales were completed.

Dr Terry Macfarlane completed his tour of duty as Australian Liaison Botanist at the Royal Botanic Gardens, Kew, England. During this year he also spent three months in Paris at the invitation of the Musée d'Histoire Naturel, to examine its collection of WA taxa.

A plant identification course was held for CALM's Northern Forest Region.

A total of 7 671 general enquiries were serviced of which in addition, a further 340 forensic enquiries were handled.

HERBARIUM SERVICES

The State Collection of flora now comprises approximately 450 000 specimens of higher and lower plants. The collections of lower plants are now housed on new shelving in the recently completed specimen storage area, making them more accessible to researchers and curators.

A significant component of the work of services staff is now devoted to ensuring that all incorporated specimens are accurately named. Staff are also responsible for the compilation of the computer-based inventory of names of Western Australian taxa and the development of the herbarium specimen database.

NATIVE FOREST SILVICULTURE

The Program was reviewed in April 1991 and increased emphasis has been placed on forest and woodland conservation, disturbance ecology and silvicultural systems.

Karri (*Eucalyptus diversicolor*) silvicultural and ecological knowledge was summarised for publication as the Karri Bulletin. This will complement the Jarrah Bulletin produced in 1986 by Abbott and Loneragan and the book "The Jarrah Forest" edited by Dell, Havel and Malajczuk. Karri growth and survival trials have been remeasured and new trials are being established to complete coverage of karri's natural range.

Three methods of measuring water use by forest trees (sap flux by automated heat pulse logging, leaf transpiration by meterological and stomatal conductance measurements, soil water extraction by neutron probe) have been compared. Reliable measurement of tree water use will be of assistance in determining likelihood of water stress and efficiency of water use in both native forests and plantations. This is a major collaborative project involving CALM, CSIRO, Water Authority of WA and ALCOA.

The effects of firewood collection and of logging on the number of tree hollows suitable for faunal habitat were studied. Data collected are being analysed.

Survey of bushland remnants nominated for the Remnant Vegetation Protection Scheme was completed. The survey found that a significant percentage of remnants had been incorrectly described by the landowners. However, errors in provision of fencing grants to farmers were considered acceptable considering the aims overall benefits of the scheme.

Silvicultural, dieback and vegetation-type surveys were completed on the Yarragil 9A experimental catchment. The catchment is now ready for thinning.

PLANT DISEASES

Results from trials on the control of *Phytophthora cinnamomi* with phosphorous acid continue to be very encouraging. *Banksia grandis* treated with phosphorous acid has contained infection by *Phytophthora cinnamomi*. In comparison infection by *P. cinnamomi* kills untreated *B. grandis* within 12 months. One injection of phosphorous acid has protected trees for at least 4 years (the longest time the trials have been running). In spray trials in an infected stand of the endangered *B. brownii*, plants have stopped dying in sprayed plots but continue to die in unsprayed plots.

A functional mycology laboratory has been established at the Manjimup Research Centre. Susceptibility of plant species to *P. cinnamomi* has been assessed in the Walpole-Nornalup National Park and in the South Coast Region.

In screening trials, mortality of *P. cinnamomi* resistant jarrah clones continued to be less than 10%. Susceptible clones have mortality levels of at least 40% with 100% mortality of some clones. Growth of resistant clones is significantly greater than surviving susceptible clones.

A project on survival of *P. cinnamomi* zoospore cysts funded by ALCOA has been completed. Predictive formulae for zoospore cyst survival were developed for each soil type and matric potential and cyst survival in field soil conditions was compared with predicted outcomes.

A trial assessing rate of lesion extension of *P. cinnamomi* in artificially inoculated stems of jarrah in variously thinned plots is continuing. The water relations of the trees in each treatment are being investigated to determine the effects of tree water status on lesion extension.

A project funded by ALCOA of Australia and sand mining companies has identified improved methods for the production of oospores by *Phytophthora* species. The improved methods will facilitate *Phytophthora* identification.

From mid April 1990 to mid April 1991, 171 cultures were forwarded by the detection service for identification. Eighty one of these were *Phytophthora* species, all of which were identified to species level and added to the database.

Pathogenicity tests have shown that death of *Banksia coccinea* is associated with infection by a *Diplodina* species. Surveys of *B. coccinea* stands around Albany have revealed extensive cankering from *Diplodina*. A number of canker fungi are causing death of *Banksia* species throughout south-western Australia.

PLANTATION SILVICULTURE

Growth of *Pinus pinaster* on Bassendean and Spearwood sand dunes can be reliably predicted based on extensive silvicultural and tree breeding trials. Using this information and a management regime to optimize water production, growth rates using a variety of seed sources have been determined. The predicted mean annual increment using a routine seed source is $7.7m^3$ /ha 1yr. Seed sources from the Joondalup, Mullaloo and the new Manjimup seed orchards will lift this to 10.5, 11.5 and 13.2 m^3/ha/yr respectively. A recent economic study by Dr G. Malajczuk has shown that it would be profitable to replant *P. pinaster* on Bassendean and Spearwood sites using the genetically-improved seed now available. Internal rates of return in the range of 5-13% (real) or more would result, using a growth rate of 9.5 m^3/ha/yr.

Large scale *Eucalyptus globulus* and *E. botryoides* provenance trials were established.

Forty experiments investigating *E. globulus* establishment were set up in the 1990 planting season. Measurement and data analysis were completed for 43 experiments currently in the ground. Research has resulted in the West Manjimup Plant Propagation Centre adopting the 64 Kwikpot as the new seedling container. Recommendations about the timing of fertilizer application in relation to site, and the benefits of continued weed control have been disseminated to operations staff.

Potassium deficiency was identified as a major growth limitation for *P. radiata* on the deep sandy soils on the south coast. A series of experiments has commenced to examine the extent of nutrient deficiencies in the plantations on the south coast.

The soil survey system developed from the Blackwood Valley drought survey has been tested by research staff and is ready for use by operations staff.

Substantial progress was made in analysing and writing up improvement and thinning data for *Pinus pinaster*. Bulletins on Provenance Studies and Tree Improvement have been submitted to the Scientific Editor and a paper on Gains from Improvement was completed.

RESEARCH TECHNIQUES

In the past year more than 90 research project plans have been assessed and modified where necessary by the biometrician. Some of these plans extend into the next century. Data drawn from the whole range of research activities have been analysed, thus contributing to many scientific publications.

A method to determine numbers of the marine snail *Drupella cornus* was developed for use at the Ningaloo Marine Park. A new, more efficient method of calculating the Soil Dryness Index was developed. A scientific paper on quantifying defoliation was written, and a paper reviewing statistical methods in the Research Division was submitted to RDPG. This review will help to determine priorities for statistical training within the Division.

Significant progress has been made in automating Herbarium procedures. A new system for databasing incoming specimens has streamlined data collection and processing. Work has commenced on a project to enable electronic capture and processing of data on the W.A. flora. A major project to integrate the Green Census and the CAVP index into WACENSUS was completed.

A significant new project has commenced to standardize taxonomic nomenclature and coding within CALM. This will result in greater integrity of data, and more efficient information exchange with non-CALM bodies.

The goal of providing each Research Scientist with access to at least one micro-computer was achieved in 1990/91. The program continued to provide technical and planning support for this computer network. Training courses were conducted regularly at the major research centres. Levels of computer literacy, expertise and usage continued to increase. Laptop computers are now an integral part of field work and are becoming indispensable to efficient research.

Hardware and software continue to be upgraded and there is greater integration within the Division.

Program staffing has again increased and the Research Division is now well supported by qualified professional staff. This paves the way in the

coming financial year for a significant increase in the levels of computer usage, efficiency of research, as well as greater professional involvement by program members in the conduct of research projects.

WETLANDS AND WATERBIRDS

During the past year funding was obtained for a major survey of the invertebrate aquatic fauna and fringing and emergent flora of wetlands of the south coast, from Cape Naturaliste to Albany. This work is to be completed by early 1992. Further funding is likely to be obtained in 1991-92 for surveys of wetland-associated vertebrates (principally fish and frogs) and submerged aquatic flora of the region. Knowledge of the conservation values of the wetlands of the south coast will be greatly improved by this work.

The aquatic fauna of Two Peoples Bay Nature Reserve was documented. Forty-two species of waterbird, eight species of fish and 118 species of aquatic invertebrate have been recorded. This work will be published in a departmental Research Bulletin on Two Peoples Bay in 1992.

Work continued on a long-term multi-disciplinary study of Lake Gregory in the Great Sandy Desert. Collections of aquatic invertebrates and waterbird counts have been made in October 1989, when the lake was saline and about to dry out and in June 1990, after the lake had re-flooded and was fresh. Approximately 80 000 birds were counted on both occasions and the number of aquatic invertebrates was high, especially after the lake re-flooded. Geological work is about to begin. Cores taken from the lake can be used to study past climatic conditions. Small invertebrate fossils in the cores can be used to study how the ecology of the lake and the fauna within it have changed with climate.

Research undertaken by scientists of Murdoch University, with partial funding and supervision from CALM, has identified a more environmentally acceptable alternative to the organophosphate Temephos for midge (chironomid) control. This work has also demonstrated the importance of good catchment management (particularly reductions in nutrient discharge) in long term control of midge populations.

A wetland-waterbird database, incorporating data obtained from the 1981-85 surveys of waterbird usage of Wetland Nature Reserves of the South West and from subsequent surveys, has been established. It is intended that historical and contemporary data will be added as and when funding permits, and that this will be the major State repository for data concerning waterbird usage of Western Australian wetlands.

WOOD UTILIZATION

Research into the VALWOOD® process continued, with assessment of different adhesives and of stability in panels under different environmental conditions. Timber from nine-year-old Tasmanian blue gum was successfully converted into VALWOOD®, and other eucalypt species from the Eastern States are being assessed.

The CALM dryers were shown to have considerable commercial potential, and drying schedules for different species and thickness of timber were developed. Other drying research assessed ultrasonic methods for determining moisture content and treatment of timber before drying to increase the rate of drying. A major study of brown wood in karri included identifying fungi which subsequently decay the wood and adversely affect its utilization.

Research findings are 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. Six WURC Reports and nine Technical Reports were published.

ADMINISTRATIVE CHANGES

In 1990-91 formal reviews of the Entomology Research Program and the Native Forest Silviculture Research Program were undertaken. This has allowed goals to be both redefined and refined.

New positions for Centre Manager at the Herbarium and Woodvale Research Centres were created and filled.

At June 1991 there were 14 vacant staff positions in Research Division, with the Fire and Plantation Silviculture Research Programs being most affected.

ACCOMMODATION

Shortage of laboratory and office space remains a problem, particularly at the Herbarium and Woodvale Research Centres.

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 1990/91 were Australian National Parks and Wildlife Service ($415 000), Alcoa ($146 000), Western Australian Heritage Committee ($55 000), and World Wide Fund for Nature ($43 000). In addition, funding from more than 20 other sources totalled $235 000 for the year.

RESEARCH PROJECT PLANS

All proposed research is vetted for relevance, cost effectiveness and scientific excellence. During 1990/91 74 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 1990/91 64 papers were approved. In addition, over 151 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 receives national and international exposure, thereby maintaining the high scientific profile enjoyed by CALM.

SEMINARS

19 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.

STAFF GUIDELINES

A set of guidelines to assist staff in carrying out their duties efficiently and effectively was provided to each Research Scientist during the year.

PUBLICITY

Many interesting articles on aspects of the research of Divisional staff were published in Perth and country newspapers.

VOLUNTEERS

Several Research Division staff have attracted voluntary research support from the general public. This helped overcome backlogs in processing research data.

The Herbarium Services Program has established an active volunteer program at the WA Herbarium. A number of volunteers assist with mounting backlog specimens and incorporate them into the collections. The taxonomic coverage of the Herbarium's Community Reference Herbarium is being extended by volunteers.

PART 1 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 public lands and waters entrusted to the Department.

To provide the scientific basis for the production and regulation of supply for those resources that the Government decides should be used, on a sustainable yield and ecologically sustainable basis.

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.

Management of Divisional Personnel

To provide members of Research Division with opportunities to reach higher levels of self-development.

PART 2 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 1991.

Some 400 copies of this Plan are printed and circulated widely within CALM and to similar organizations and other Government Departments, both within Western Australia and interstate. About half of the copies are disseminated within Research Division.

Within Research Division the Plan is used by the three SPRS/PRS teams to administer their portfolios. In particular, the information contained in the extensive Table appended to each Research Program is used at the annual appraisal of all professional staff to assess progress. Because the Table summarizes agreed research targets, it provides a definitive indicator by which research performance can be measured. Other major users of the Plan are the Program Leaders, who coordinate the research carried out by scientist members of the Program.

Outside Research Division the Plan is intended to be used mainly for communication purposes, both general and specific. Since it was first published (in 1987), many compliments about the value of the Plan have been received. Users who have suggestions for improving the Plan should contact the Director of Research.

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 Western 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 subsequently developed. In 1991 this Program was merged with the Fauna Conservation Program following the resignation of its Program Leader.

In 1989-90 the Research Programs of "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 3 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 Administrative 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 outstation), Manjimup and Busselton. Responsible for the Plantation Silviculture, Wood Utilization, Native Forests Silviculture and Economic Entomology Programs and for the administrative areas of Wood Utilization Research Centre, Directors of Research Committee (Forestry Council), Research Steering Committee, interaction with Forest Resources Division.

Senior Principal Research Scientist - Steve Hopper

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

Senior Principal Research Scientist - Jim Armstrong

Responsible for the staff at the Herbarium and the Research Centre Managers at Dwellingup and the Herbarium. Responsible for the Flora Collections, Flora Conservation, Flora Information, Herbarium Services 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. Responsible to the Director of Research, through RDPG, for the administration of external grants for the Research Division.

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.

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 responsible 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 at Woodvale and the Herbarium occupy substantive positions. Research Centre managers at small centres are appointed by

RDPG and are part-time positions held by Research Scientists. 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 respectively.

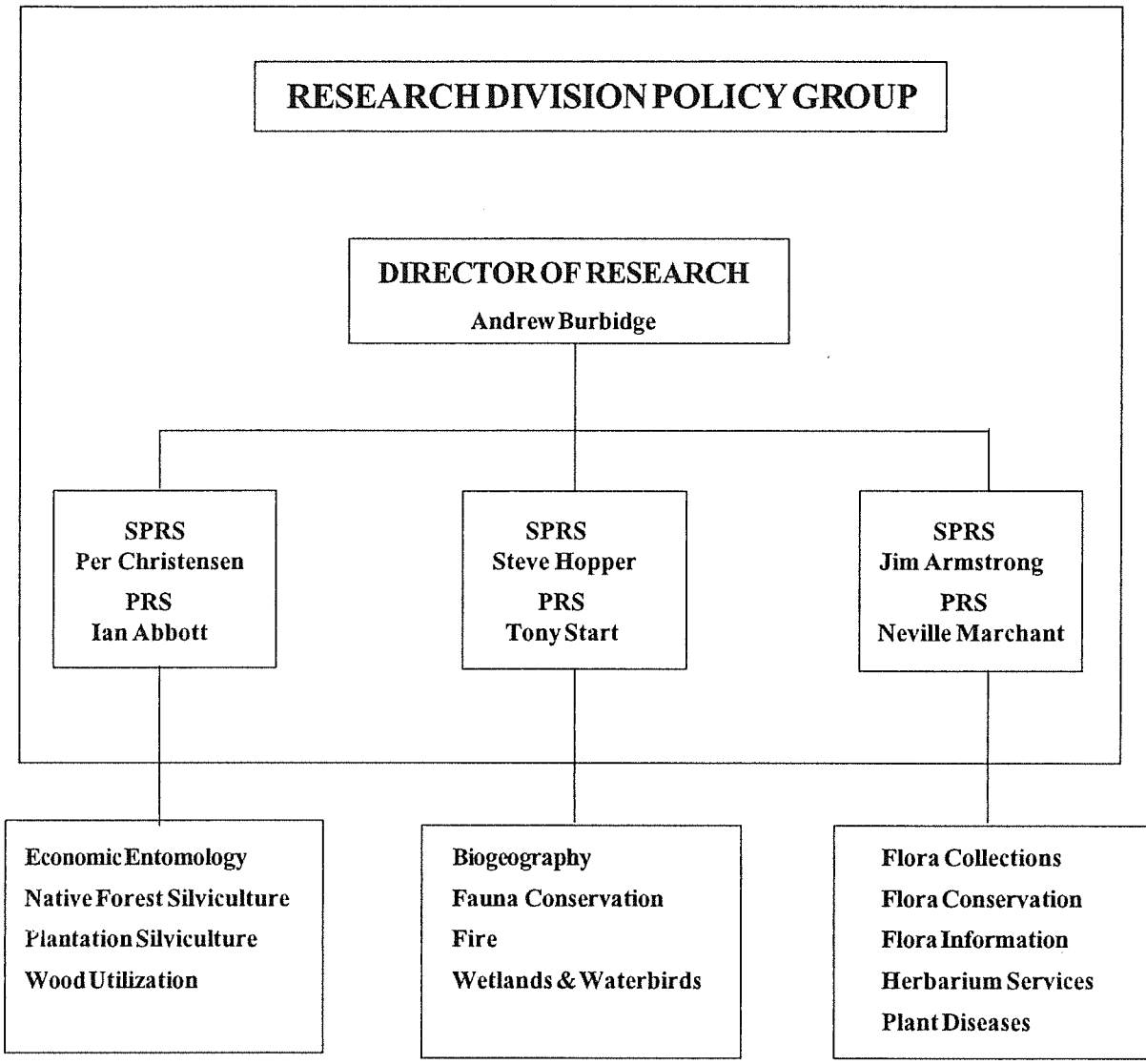


Table 1

Principal Officers of the Research Division

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.E.S. 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.J. Abbott, *BSc(Hons)(Sydney)PhD(Monash)*
Principal Research Scientist	N.G. Marchant, *B.Sc (Hons)(W.Aust)PhD(Cambridge)*

Program Leaders

Executive and Research Support	A.A. Burbidge, *BSc(Hons)PhD(W.Aust)*
Biogeography	G.J. Keighery, *BSc(Hons)(W.Aust)*
Economic Entomology	J.D. Farr, *BAgSc(Hons)PhD(Adelaide)*
Fauna Conservation	J.A. Friend, *BSc(Hons)PhD(Tasmania)*
Fire	G.R. Friend, *BSc(Hons)PhD(Melbourne)*
Flora Collections	B.R. Maslin, *BSc(Hons)MSc(W.Aust)*
Flora Conservation	D.J. Coates, *BSc(Hons)PhD(W.Aust)*
Flora Information	N.S. Lander, *BSc(Sydney)MSc(Sydney)*
Herbarium Services	C.S. Fang, *MSc(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.F. 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	M.R. Williams, *BSc(Hons)(W.Aust)*
Dwellingup	D.S. Crombie, *BSc(Hons)(Qld)PhD(Glasgow)*
Herbarium	C.S. Fang *MSc(W.Aust)*
Manjimup	W.L. McCaw, *BForSc(Hons)(Melbourne)*
Woodvale	R.E.S. Sokolowski, *BSc.(Murdoch Univ)*

PART 4 RESOURCES

In 1991/92 the Division comprised 49.65 Professional and 69.65 Technical and Clerical staff, totalling 119.30 persons (full time equivalent). Some of these persons were casual or part-time.

The total CRF budget in 1991/92 was $6409 506 consisting of $4698 006 for salaries and $1711 500 for operating costs (research, wages, travel and plant).

In 1991/92 Research Division accounts for 8.9% of staff positions and 5.2% of the Department's total budget. The corresponding figures for 1990/91 were 8.5% and 5.2%.

Estimated resources for 1991/92 for each program are 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 1991/92 in Research Division (CRF), as at 1 July 1991

Program	Prof FTE	Tech Cler FTE	No. FTE	% Staff	Salaries $	Operating Budget $	Total $	Finance %
Executive & Research Support								
Executive Support	5.45	5.00	10.45	8.91	466 218	117 205	583 423	9.1
Herbarium Services	-	4.80	4.80	4.06	154 709	158 700	313 409	4.9
*Journal Publications	-	1.00	1.00	.84	38 193	30 570	68 763	1.0
*Research Support	.50	11.05	11.55	8.86	327 155	353 775	680 930	10.6
Biogeography	5.35	4.80	10.15	8.58	416 351	114 700	531 051	8.3
Economic Entomology	1.30	3.00	4.30	3.64	190 835	24 000	214 835	3.3
Fauna Conservation	4.80	6.15	10.95	10.02	611 507	128 200	739 707	11.5
Fire	5.00	8.45	13.45	10.61	406 986	162 700	569 686	8.9
Flora Collections	2.90	-	2.90	2.45	153 032	19 450	172 482	2.7
Flora Conservation	4.50	1.65	6.15	4.57	254 395	50 200	304 595	4.7
Flora Information	3.75	.70	4.20	3.55	202 267	19 700	219 967	3.4
Native Forest Silviculture	3.15	5.50	8.65	7.31	274 773	102 300	377 073	5.9
Plant Diseases	3.40	6.50	9.90	8.37	370 983	118 350	489 333	7.6
Plantation Silviculture	4.50	8.50	13.00	10.99	481 851	170 100	651 951	10.1
Research Techniques	4.70	2.10	6.80	5.07	232 196	125 750	357 956	5.5
Wetlands & Waterbirds	1.90	.80	2.70	2.28	11 655	43 800	160 355	2.5
Research Division Total	49.65	69.65	119.30	100	4698 006	1711 500	6409 506	100

Note: Excludes staff vacancies, study leave etc.
*Combined

Table 3

Summary of External Resources 1990/91 in Research Division (as at June 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 4

Summary of External Resources available and spent in Research Division during 1990/91

Program	External-funded Staff Employed	Total Expenditure	Finance %
Fauna Conservation	3.2	604 250	67.56
Flora Collections	1.5	71 122	7.95
Flora Information	-	2 471	0.28
Native Forest Silviculture	.2	15 211	1.70
Plantation Silviculture	.5	30 508	3.41
Plant Diseases	3.5	130 847	14.63
Wetlands	1.0	40 000	4.47
Total	8.9	894 409	100

Note: The above shows actual expenditure for 1990/91 and it is anticipated that similar funds (excluding WURC and VATPAS) will become available for 1991/92.

PART 5 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 managed lands vs other lands

CALM has responsibilities for conservation and timber production which extend beyond the boundaries of CALM-managed public land. Also activities outside CALM public 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 that 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, often extending beyond the 5 year term of this plan. 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 the 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-managed public 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 6 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.

STAFF MOVEMENTS AND APPOINTMENTS

Three professional officers joined the permanent staff of the Division in 1990/91. Two permanent officers left the Division by way of promotion, four officers resigned and three retired.

New Appointments 1990/91

Professional

M. Yung Research Scientist

Technical and Clerical

D. Brockwell
C.S. Fang
I. McPharlin
J. Nicholson

Departures 1990/91 (transfer, promotions and resignations)

Professional

A. Hopkins
G. Inions
J. Stoddart

Technical and Clerical

J. Gardner
D. McDonald

D. Munro
P. Jenkins
C. Sanders
J. Scott
P. Skinner
P. Solar

Movements between Research Centres

Some minor movement of staff occurred between country and metropolitan Research Centres during 1990/91. 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 1990/91 the following movements of staff between research locations occurred:

N. Burrows (Senior Research Scientist) from Como to Woodvale

D. Coates (Principal Research Scientist)) from Woodvale to Herbarium

Staff Currently on Study Leave

G. Stoneman (Research Scientist)
D. Ward (Senior Research Scientist)

PART 7 GEOGRAPHICAL DISTRIBUTION OF RESEARCH EFFORT

Research effort is spread throughout the State. Table 5 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 5, as it is a service program.

Table 5
Geographical Distribution of Research by Programs 1990/91

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	10	11	-	6	3	2	15	9	10	22	11	-
ENTOMOLOGY	-	-	-	-	-	5	2	2	41	40	10	-
FAUNA CONSERVATION	5	13	11	1	17	35	5	3	1	1	8	-
FIRE	-	11	-	22	2	11	-	2	1	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
HERBARIUM SERVICES	5	3	2	3	18	27	10	5	3	5	16	3
NATIVE FOREST SILVICULTURE	-	-	-	-	-	18	-	48	9	25	-	-
PLANT DISEASES		-	-	-	5	-	18	41	5	6	25	-
PLANTATION SILVICULTURE		-	-	-	-	5	-	25	35	25	10	-
RESEARCH TECHNIQUES	-	-	-	-	-	-	68	11	7	14	-	-
WETLANDS & WATERBIRDS	10	-	-	-	5	10	15	20	20	10	10	-
WOOD UTILIZATION	-	-	-	-	-	-	-	30	37	33	-	-

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

PART 8 STAFFING

OVERVIEW

Most of the staff in the Division work in one of three career areas; professional, technical or clerical/administrative. All professional staff are Public Servants but within both the technical and the administrative/clerical groups there remains a mixture of Public Servants and "CALM Act" Officers. However all the latter have been invited to transfer to the Public Service. Most have done so and the rest are considering the option.

PROFESSIONAL STAFF

All professional staff are Scientific Officers bearing the title "Research Scientist" (L2/4 and L5), "Senior Research Scientist" (L6) "Principal Research Scientist" (L7) or "Senior Principal Research Scientist" (L8). All positions are substantively L2/4 and all vacant positions revert to that Level. Promotion is by Criteria Progression. All Scientific Officers have Criteria Progression prospects to L8.

TECHNICAL STAFF

Almost all technical staff are titled "Technical Officer" (L2 and L3) or "Senior Technical Officer" (L4). All positions are substantively L2 and all vacant positions revert to that Level. Promotion is by Criteria Progression. All Technical Officers have Criteria Progression prospects to L4. The Division no longer appoints L1 Technical Officers and the few remaining anomalies are being addressed through Criteria Progression.

All Technical Officers have access to Criteria Progression to Level 4. The RDPG has further improved career opportunities for Technical Officers by creating two L5 positions: A Research Centre Manager at the Wildlife Research Centre, Woodvale and a Collections Manager at the W.A. Herbarium. Appointments have been made to both positions.

Technical Officers at the Wildlife Research Centre, Woodvale, work overtime in accordance with a Commuted Overtime Agreement. All other Technical Officers work in accordance with standard Public Service provisions. The Commuted Overtime Agreement is due for re-negotiation. In preparation for that action a one year survey of actual hours worked overtime by all Technical Officers is being conducted. At the conclusion of the survey a new, uniform overtime agreement will be negotiated. It will embrace all Technical Officers in the Division. In the meantime there is in place an internal agreement, devised by the Technical Officers, that ensures equity where Technical Officers from both areas are working in the field together.

The RDPG desires a commuted overtime scheme to apply to all Technical Officers undertaking field trips involving one or more nights away from home. It proposes 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 additional week of ARL was awarded to Technical Officers at the Wildlife Research Centre, Woodvale prior to the introduction of the Commuted Overtime Agreement to compensate for disruption to home life resulting from extended periods in the field. It is now seen by many people as an integral part of the Commuted Overtime package.)

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 separate from Research Centre administrative structures because the issues are not confined to particular Centres. At present it comprises, full time, an Administrative Officer L3, and a Clerk Typist Level 2. They are attached to the Director's office. Besides specific tasks allocated by the Director the L3 Officer co-ordinates all routine

staffing issues at the Divisional level and provides secretarial support to the RDPG.

The 1988/89 edition of this plan foreshadowed creation of a L4 position as Divisional Administrative Officer. That has not eventuated but remains as an objective. However during 1990/91 the Administrative Assistant position at Como Research Centre was reclassified to Administrative Officer L4. This Officer co-ordinates financial management at the Divisional level (and for the Wood Utilization Research Centre, VATPAS and Como Research Centre as well).

Large Research Centres (LRC)

RDPG considers that LRC administrative staff should consist of an Administrative Assistant L3, Accounts Officer L2 and Clerk Typists L1. The number of Clerk Typists should be determined by work loads.

Research Centres (RC)

RDPG considers that RC administrative staff should consist of an Administrative Assistant L2 and a Clerk Typists L1.

Research Stations

Research Stations are normally attached to Operations Division offices that provide support such as typing. Administratively (including budget management) 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 in the short term. Nevertheless the Division's long term aim will be to achieve these structures but not at the expense of reducing staff actively involved in research.

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

PART 9 SCIENTIFIC PAPERS APPROVED FOR PUBLICATION

The following scientific papers were approved for publication during 1990/91. Further details on these papers can be obtained direct from the authors.

BIOGEOGRAPHY

Alford, J. A new species of *Tetratheca* Smith from the Coolgardie district of Western Australia.

Andersen, A.N. and Burbidge, A.H. An overview of the ant fauna of Cape Arid National Park, W.A.

Keighery, G.J Floristics of system six reserves I. Pelican Pt, Alfred Cove and Milyu.

Keighery, G.J. A new species of *Guichenotia (Sterculiaceae)* from south Western Australia.

Keighery, G.J. Floristics IV. Vegetation and flora of Hepburn Heights.

Keighery G.J. and Keighery, B.J. Floristics of Brixton St wetlands.

Keighery, G.J., Lucchese, F., Pignattii, E. and Pignattii, S. Vegetational sketch of the Stirling Range.

FAUNA CONSERVATION

Burbidge, A.A. What the Tortoise taught us.

Davis, J.A., Harrington, S.A. and Friend, J.A. Relict stream communities in the arid zone : the macroinvertebrate fauna of the George Gill Range, central Australia.

Fuller, P. and Burbidge, A.A. Pelsaert Island, Houtman Abrolhos, Western Australia.

Fullard, J.H., Koehler, C., Surlykke, A. and McKenzie, N.L. Echolocation ecology and flight morphology of insectivorous bats in south Western Australia.

Kinnear, J.E., Onus, M.O. and Bromilow, R.N. A note on the Depuch island rock-wallaby extinction: role of the fox.

Kinnear, J.E., Onus, M.L., Morris, K., Oliver, G. and Bromilow, R.N. Fox control and Rock Wallaby population dynamics in the Dampier Archipelago: A pristine environment.

Keighery G.J. and Keighery, B.J. Floristics of Brixton St wetlands.

Serena, M., Soderquist, T. and Morris, K. The Chuditch.

Start, A.N. Food for Bats.

Turner, S.J. The egg capsules and early life-history of the corallivorous gastropod *Drupella cornus* (Roding, 1798).

Williams, A.E. New locality records for six *Lycaenid* butterflies in Western Australia.

Williams, M.R., Hay, R.W., Bollam, H.H. and Atkins, A.F. The life history of the western dark azure (*Ogyris otanes* C. & R. Felder) in the Stirling Range, Western Australia (Lepidoptera: Lycaenidae).

Williams, M.R., Williams, A.A.E. and Atkins, A.F. The life history of *Trapezites sciron sciron* Waterhouse and Lyell.

Wong, D.H., Kirkpatrick, W.E., Kinnear, J.E. and King, D.R. Defluorination of sodium monofluoroacetate by microorganisms isolated from Western Australian soils.

Wong, D.H., Kinnear, J.E., Runham, C.F. and DenHollander, L.C. A preliminary report on bacteriological assay for compound 1080 (sodium monofluoroacetate.)

Wong, D.H., Kirkpatrick, W., Kinnear, J.E. and King, D.R. Defluorination of sodium monofluoroacetate ("1080") by microorganisms in baits.

Wong, D.H., Kirkpatrick, W.E., Kinnear, J.E. and King, D.R. Environmental factors and microbial inoculum size and their effect on biodefluorination of sodium monofluoroacetate.

FIRE

Buchanan, A.P. and Wardell-Johnson, G. Managing animal habitat using remote sensing and geographical information systems.

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

Burrows, N.D. A simple and inexpensive method of estimating the moisture content of dead *Pinus pinaster* litter.

Hopper, S. From the ashes grow.

McCaw, W.L., Maher, T. and Gillen, K. Wildfires in the Fitzgerald River National Park.

McCaw, L. Fire spread prediction in mallee-heath shrublands in south Western Australia.

Wardell-Johnson, G. and Nichols, O. Forest wildlife and habitat management in south Western Australia; knowledge, research and direction.

FLORA COLLECTIONS

Maslin, B.R. *Acacia cyperophylla* var. *omearana,* a new variety of "Minni Ritchi" Acacia from the Pilbara region of Western Australia.

Maslin, B.R. *Acacia setulifera*: A new Kimberley record of a rarely collected Northern Australian Wattle.

Stirton, C.H. and Maslin, B.R. Generic and infrageneric classification in *Acacia Leguminosae: Mimosoideae:* A critical list of species on which to build a comparative data set.

Wilson, P. The classification of the Australian species currently included in *Helipterum* and related genera (Asteraceae: Gnaphalieae)*:* Part I.

FLORA CONSERVATION

Keighery, G.J. Environmental weeds of Western Australia.

Kenneally, K. *Stylidium lateriticola* (Stylidiaceae), a new species from the Perth Region, Western Australia.

Perry, G. Nomenclatural stability and the botanical code: A historical review.

Hopper, S. and Wyatt, R. Pollination ecology of *Eucalyptus caesia*: floral attributes, nectar production, and bird foraging behavior.

FLORA INFORMATION

Curry, S. Wicked deceptions.

Lander, N.S. *Kippistia, Minuria, Olearia* - treatments for Flora of New South Wales.

NATIVE FOREST SILVICULTURE

Chester, G.W. and Crombie, D.S. Interception of rain in forests: A review of study methods.

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

PLANT DISEASES

Bennett, I., Cahill, D., McComb, T. and Stukely, M. The use of tissue culture in the breeding of *Phytophthora* resistant Jarrah *(Eucalyptus marginata*).

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

White, H.R. and Wills, R.T. Leaf spot fungus on *Acacia alata.*

Wills, R.T. The ecological impact of *Phytophthora cinnamomi* in the Stirling Range National Park, Western Australia.

PLANTATION SILVICULTURE

Hopkins, E.R. and Butcher, T.B. Improvement of *Pinus pinaster* Ait. in Western Australia.

Hopkins, E.R. and Butcher, T.B. Provenance comparisons of *Pinus pinaster* Ait. in Western Australia.

McGrath, J.F. Site assessment for *Pinus radiata* plantations in the Blackwood.

RESEARCH TECHNIQUES

Gioia, P. Computers, Research and Pretty Pictures.

WETLANDS AND WATERBIRDS

Halse, S. The relationship between catchment management and wetlands, avifaunal utilisation of wetlands and agricultural wetland management.

Halse, S.A., Pearson, G.B. and Patrick, S. Vegetation of depth-gauged wetlands in nature reserves of south Western Australia 1987-88.

Lane, J.A.K. An overview of wetland conservation policies and programs in W.A.

Lane, J.A.K. The wise use of wetlands - managing wildlife habitat.

Sharley, A.J., Best, L.W., Lane, J.A.K. and Whitehead, P. An overview of lead poisoning in Australian waterfowl and implications for management.

WOOD UTILIZATION

Brennan, G.K., Glossop, B.R and Hanks, W.R. Drying regrowth Eucalypts using a low temperature batch kiln.

Brennan, G.K. Basic and air-dried density and log moisture content survey of regrowth Jarrah and Karri.

Brennan, G.K., Glossop, B.R. and Rayner, M.E. Sawmilling regrowth Karri of different ages from different site types and dominance classes.

Davison, E. Impel rods are unsuitable for controlling rot in Karri trees.

Mathews, L.R. Drying of Valwood® in a veneer dryer.

McDonald, T.G. Developing a solar, low cost, timber drying system.

Newby, P. Practical aspects of producing Valwood® blanks.

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

Thomson, A.B. Moisture loss from small jarrah firewood billets.

White, K.J. Growth stress evaluation of regrowth Jarrah.

PART 10 SEMINARS PRESENTED BY RESEARCH AND ASSOCIATED STAFF 1990/91

During 1990/91 nineteen seminars were organized and presented by Research Division 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 Hopkins	Regeneration strategies of vascular plants after disturbance
P Pigott	Degradation and remnant bushland on wheatbelt farms
J Lane	Management of duck hunting in Western Australia
B Maslin	*Acacia*: How many genera?
D Coates	Genetic diversity, population size and extinction
P Hewett	Thinning regrowth karri - preliminary results
S Patrick	The role of CALM's Flora Information Program
G Brennan	Utilisation of regrowth hardwoods
P Christensen	Gibson Desert mammals and fire
R Mazanec	Genetic parameters and potential gain from selection in Karri
D Algar	Fox control: an overview
G Perry	Nomenclature stability and the Botanical Code
N Burrows	Fire history of the Jarrah forest based on dendrochronological analysis
T Macfarlane	Electronic methods of presenting flora information - alternatives to the written word
M Choo	Applying modern technology to research
J Wheeler	Western Australian regional floras - a new format
S Hopper	Early postfire regeneration of granite outcrop mallee communities on Chiddarcooping Nature Reserve
J Farr	*Cardiaspina* sp n. A new insect species outbreaking on Flat-Topped Yate
L McCaw	Fire management in the western United States : some contemporary issues

PART 11 NEW RESEARCH PROJECTS

The following new Research Project Plans were approved during 1990/91. Information on these research projects can be obtained from the principal investigator.

RPP No	Title	Principal Investigator
Biogeography		
8/90	A regional study of the Warren Botanical sub district	N Gibson
9/91	Biological survey of islands in the Dampier Archipelago	K Morris
10/91	Biological survey of the terrestrial and marine environments of the Montebello Islands	K Morris
12/91	Management guidelines for the Montebello Islands	K Morris
22/91	Assessment of conservation values of VCL near Coolcalalaya	AH Burbidge
31/91	Biological survey of the islands of Exmouth	N McKenzie & A Start
57/91	Analysis software for survey data	N McKenzie
58/91	Eastern Goldfields Biological Survey	N McKenzie & G Keighery
59/91	Ecomorphological clues to community structure	N McKenzie
60/91	Kimberley Rainforest	M McKenzie
61/91	Mandora Paledriver/Radi Hills Survey	N McKenzie
62/91	Buccaneer Archipelago Survey	N McKenzie & K Kenneally
63/91	Regional Survey Design	N McKenzie, G Keighery, K Kenneally
66/91	Genetic variation among endemic eucalypts	G Wardell-Johnson
67/91	Vertebrate and flora survey of the Walpole Nornalup National Park	G Wardell-Johnson
68/91	Floristic pattern in the Warren and Menzies botanical subdistricts	G Wardell-Johnson
69/91	Forest fauna and habitat management in south-western Australia - a review of research	G Wardell-Johnson
70/91	Biogeography and ecology of WA granite outcrop plants	S Hopper
71/91	A biological survey of the proposed Mt Windell (eastern access) road alignment into the Hamersley Range National Park	S van Leeuwen
72/91	Flora surveys of the wheatbelt and other selected lands	S Hopper
74/91	Comparing floristic and structural data and satellite thematic mapper OTM imagery in the Walpole Nornalup and Mt Frankland National Parks	G Wardell-Johnson
78/91	Biological survey of John Forrest National Park and the adjacent Red Hill area	AH Burbidge
83/91	Biological survey of Serpentine National Park	AH Burbidge
Economic Entomology		
1/91	Spatial variation in rate of parasitization of Jarrah Leafminer larvae	I Abbott
36/91	Impact of prescribed Spring fire on rate of parasitization of Jarrah Leafminer in heavily infested Jarrah forest	I Abbott

RPP No	Title	Principal Investigator
37/91	Impact of Autumn (dry soil) burning on abundance of Jarrah Leafminer in Collie District	I Abbott
Fauna Conservation		
7/91	Breeding Seabirds Database	AA Burbidge
8/91	Reintroduction of the Greater Stick-nest Rat	K Morris
11/91	Biological survey of islands in the Freycinet Harbour, Shark Bay	K Morris
28/91	The eradication of the introduced Black Rat *Rattus rattus* on Barrow and Middle Islands	K Morris
29/91	Monitoring the total numbers of the Lesser Noddy (*Anous tenuirostris*) in Australia and the numbers of some other seabirds breeding on Pelsaert Island	AA Burbidge
30/91	The ecology and conservation of small mammals on Barrow Island	K Morris
33/91	Conservation of the Chuditch *Dasyurus geoffroii*	K Morris
34/91	Western Swamp Tortoise - population monitoring	AA Burbidge
35/91	Western Swamp Tortoise captive breeding project	AA Burbidge
55/91	Mormopterus taxonomy	N McKenzie
64/91	Database of mammal records from Australian islands	AA Burbidge & I Abbott
65/91	Systematics and zoogeography of Australian Landhoppers	J Friend
77/91	The early life history of *Drupella cornus* at Ningaloo	S Turner
Fire		
21/90	Effects of a prescribed autumn burn on a population of *Phasogale calura* in Tutanning Nature Reserve	G Friend
59/90	Locating and regenerating mainland Tammar (*Macropus euguni*) thickets	P Christensen
60/90	Boodie re-introduction to Gibson Desert	P Christensen
61/90	The response to disturbance of the vascular flora of the Warren Botanical Sub-district	G Wardell-Johnson
21/91	Fire responses of plants from *Banksia* woodlands vegetation associations	N Burrows
26/91	Symptoms on *Pinus radiata* clones infected by *Phythophthora* spp.	E Davison and M Stukely
27/91	Measurement of oxygen concentration in sub-surface flows	E Davison
52/91	Effects of fire on plant species and communities at Tutanning Nature Reserve	A Hopkins
54/91	Fire Mulga study	A Start & S van Leeuwen
Flora Collections		
20/91	Register of type specimens and photographs held at the Perth Herbarium	B Koch
115/91	The clarification of the taxonomy of *Tegicornia* and some sections in the genus *Halosarcia* (Chenopodiaceae)	P Wilson
116/91	The taxonomy of the *Helipterum - Helichrysum* group (Asteraceae) in Australia	P Wilson
117/91	Research curation of the family Rutaceae in the WA Herbarium	J Armstrong
143/91	Botanical survey of Greenough District	K Kenneally
144/91	Flora of Australia : *Acacia*	B Maslin

RPP No	Title	Principal Investigator
145/91	Generic status of *Acacia* : an assessment	B Maslin
146/91	Taxonomy of *Acacia tumida* and its allies	B Maslin
Flora Conservation		
119/91	Taxonomy and Phylogeny of Rutaceae	J Armstrong
120/91	Rare and poorly known WA eucalypt survey	S Hopper
121/91	Book on pollination of Western Australian Orchids	S Hopper
122/91	Systematics of Kangaroo Paws and related plants (Haemodoraceae subfamily Conostylidoideae)	S Hopper
123/91	Wildlife Management Program for *Anigozanthos pulcherrimus* and *Macropidia fuliginosa*	S Hopper
124/91	Orchids in major WA Conservation Reserves	S Hopper
125/91	Systematics and biogeography of Western Australian eucalypts	S Hopper
126/91	Systematics of selected Western Australian orchids (*Caladenia* and allied genera).	S Hopper
127/91	Rare Flora Management Plan for the Moora District	S Patrick
128/91	Population biology and conservation genetics of *Acacia anomala*	D Coates
129/91	Population biology and conservation genetics of *Banksia verticillata*	D Coates
130/91	Population biology and conservation genetics of *Stylidium coroniforme*	D Coates
131/91	Population biology and conservation genetics of *Banksia brownii*	D Coates
132/91	Population biology and conservation genetics of *Banksia cuneata*, Banksia oligantha and *Banksia ilicifolia*	D Coates
133/91	Biosystematics and evolution in *Stylidium*	D Coates
134/91	Field surveys and conservation status of rare and threatened flora	D Coates
135/91	Conservation status of members of the family Rhamnaceae	B Rye
136/91	Taxonomic studies in the Lyperaceae	B Rye
137/91	Taxonomy of the Liliaceae	B Rye
138/91	Taxonomic revision of *Beaufortia* R.Br.	AA Burbidge
139/91	Taxonomy of selected WA grasses	T Macfarlane
140/91	Taxonomy of Pultenaea and other legume genera	T Macfarlane
141/91	Taxonomic research on Liliaceae sens. lat. and related monocots of W.A.	T Macfarlane
142/91	Assessment of the nomenclatural problems associated with names on schedule "Protected Flora Declared as Rare Flora - Item 2 Taxa Presumed to be Extinct"	G Perry
Flora Information		
46/91	Taxonomic studies in the family Rhamnaceae	B Rye
47/91	Preparation of Flora Handbook "Flora of the Kimberley Region"	J Wheeler
48/91	INFORM: An integrated taxonomic multimedia tool for the description of Western Australian flora	A Chapman N Lander T Macfarlane
49/91	Allergenic and irritant plants, Identification Guide	S Patrick
50/91	Taxonomic studies in the genus *Olearia* (Asteraceae)	N S Lander
51/91	Endemic plant species of the Darling Scarp. Identification guide to Threatened and Reserve List Taxa	S Patrick
84/91	Taxonomic and evolutionary studies in Drosera and Byblis	N Marchant
85/91	Taxonomic studies in Western Australian Myrtaceae	N Marchant

RPP No	Title	Principal Investigator
112/91	Flora writing pilot project, the genus *Agonis* (Myrtaceae)	JR Wheeler
113/91	Flora of the Walpole-Nornalup National Park	JR Wheeler
118/91	Preparation of "Flora of Australia" contributions	T Macfarlane
Native Forest Silviculture		
6/90	Preliminary assessment of soil seed banks of remnant Salmon Gum (*Eucalyptus salmonophloia* F. Muell) woodland near Lake Taarblin	P Pigott
56/90	Effect of initial espacement on growth and form of planted *E. diversicolor* seedlings on high quality karri sites	P Hewitt
75/91	*Eucalyptus viminalis* family provenance trials	R Mazanec
76/91	*Eucalyptus callophylla* seed collection and family provence trials	R Mazanec
Plantation Silviculture		
55/90	*Eucalyptus botryoides* family trial	R Mazanec
57/90	Long term effect of fertilizer on survival growth and form of karri (*Eucalyptus diversicolor*) seedlings	P Hewett
64/90	Response of *Pinus radiata* to potassium (K) fertilization	J McGrath
56/91	Inoculation of *Pinus radiata* seedlings with different mycorryhizal fungi	E Davison
79/91	Comparison of the efficiency of four grass specific herbicides to control weeds in the Tuart National park	R Fremlin
89/91	The effect time of application of quizalop-ethyl	R Fremlin
Plant Diseases		
30/90	Symptoms of *Pinus radiata* clones infected by *Phytophthora* spp.	E Davison & M Stukely
33/90	Field inoculation of jarrah clones selected for tolerance to *Phytophthora cinnamomi*	M Stukely
52/90	Infection of *Banksia* spp. by *Phytophthora citricola* and *P. cinnamomi*	E Davison
54/90	Control of *Phytophthora* species in *Banksia* communities north of Perth by phosphorous acid	B Shearer
63/90	Comparison of infection of Jarrah roots by *Cryphonectria culinies*, *Endothia gyrosa* and *Phytophthora cinnamomi*	E Davison
65/90	assessment of the impact of *Armillaria luteobubalina* in woodlands and shrublands of the coastal plain	B Shearer
66/90	Control of *Armillaria luteobubalina* in coastal shrubland by phosphorous acid	B Shearer
67/90	Control of *Phytophthora* species in *Banksia* communities north of Perth by phosphosus acid	B Shearer
68/90	Susceptability of plant species in the Jarrah forest understorey to infection by *Phytophthora cinnamomi*	B Shearer
15/91	Impact of *Phytophthora cinnamomi* and other plant pathogens on the flora of national parks in southern Western Australia	R Wills
16/91	Survival and distribution of inoculum of *Phytophthora cinnamomi* in the roots of both resistant and susceptible plant species	R Wills
17/91	The pathogenicity of canker fungi isolated from native plant species at the King Jarrah Heritage Trail, Manjimup	R Wills

RPP No	Title	Principal Investigator
18/91	The impact of pathogenic fungi on native vegetation at the King Jarrah Heritage Trail, Manjimup	R Wills
19/91	Infection of tolerant and susceptible *Pinus radiata* clones by *Phytophthora* spp.	E Davison & M Stukely
20/91	Register of type specimens and photographs held at the Perth Herbarium	B Koch
23/91	Pattern analysis of climatic data to assess correlates with the activity of pathogenic fungi in the south west of Western Australia	R Wills
26/91	Symptoms on *Pinus radiata* clones infected by *Phytophthora* spp.	E Davison & M Stukely
27/91	Measurement of oxygen concentration in sub-surface flows	E Davison
81/91	Heat tolerance of *Phytophthora citricola, P cinnamomi* and *Armillaria luteobubalina*	E Davison
Research Techniques		
2/91	Standardization of Taxon names and codes in CALM	M Choo
95/91	Consolidating a State-wide Lat/Long Map Base	P Gioia
96/91	TAXAPLOT	P Gioia
97/91	Register of Research Division corporate datasets	P Gioia
98/91	Database of Research Project Plans	M Choo
99/91	TRAK - animal radio tracking utility - feasibility study	P Gioia
100/91	SEDIT - A species editing utility	P Gioia
101/91	Networking PCs in Research Division	P Gioia
102/91	Declared and Endangered Fauna Register	P Gioia
103/91	HERBIE	P Gioia
Wetlands and Waterbirds		
24/91	Annual waterfowl counts in South-Western Australia	S Halse
25/91	Assessment of the value of different types of wetland for waterbirds using the Swan Coastal Plain as a case study	S Halse
32/91	Pelican breeding colonies, movements and survival	J Lane
38/91	Surveys of aquatic invertebrate fauna of south Western Australia	S Halse
39/91	Habitat use, diet and prey occurrence for migratory waders at Roebuck	S Halse
40/91	Waterbirds and limnology of Lake Gregory	S Halse
82/91	Lead shot ingestion by waterfowl	J Lane
Wood Utilization		
58/90	Attempts to fruit fungi from karri brown wood and rots	E Davison

PART 12 REVIEW OF PROGRAMS 1991

BACKGROUND

The Research Division Policy Group reviewed the Entomology and Native Forests Silviculture Programs in 1990/91. The object of each 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 1990/91) 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) Meeting 1 - this was attended by 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) Meeting 2 - this was attended by RDPG members and the relevant Program Leader. At this meeting the Program Leader summarized the 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.

DECISIONS REACHED

Economic Entomology Program

1. Entomology will retain its program status but will be retitled Economic Entomology Program. This is to avoid confusion and obviate the perception held by several CALM staff that conservation entomology research should be a major undertaking of the program.

2. As a consequence of the program title change no amendments to the aim of the Program is necessary.

3. The Program's primary objectives to be amended in keeping with the new Program title.

4. Priority order of 20 year goals: Monitoring insect infestations on tree ecosystems other than in south western forests to be considered a higher priority than potential pest monitoring within the south western forests.

5. Research into Gumleaf skeletonizer and lerp should continue at its present level.

6. Research into insects feeding on *Eucalyptus globulus* to be included at the fifth level in the Program's 5 year goals.

7. A new Program Leader to be assigned as a result of the Program Review.

8. The vacant Level 4 technical position to be filled by a contract Professional Entomologist whose task will be to undertake research into *globulus* insect pests.

Native Forest Silviculture Program

Respondents to the program review questionnaire identified effects of logging on forest ecology, conservation of biodiversity and optimisation of wood production commensurate with conservation of other forest values as being the most important requirements in native forest research. CALM staff (including corporate, regional and district management) in particular called for more precise information on how to integrate forest management to achieve the many goals required of a truly multiple use forest.

1. The effect of silvicultural operations on the ecology of native forests will receive greater emphasis. An immediate target will be to integrate research by silviculture and other programs (eg. Fire, Biogeography, Flora Conservation and Fauna Conservation) to study jointly agreed aspects of forest management, possibly using the same study sites.

2. Conservation of the genetic resource of the native forests will be addressed by a program of planting trials and isozyme studies of variability in jarrah, marri and other selected species.

3. Existing silvicultural techniques may be useful in the protection of remnants of native vegetation in the wheatbelt; the potential for such application is to be investigated.

4. Optimizing thinning and fertilising prescriptions for optimizing production of wood from regrowth karri forests will continue to be a high priority. As resources permit existing karri and jarrah regeneration experiments will be remeasured and needs for regeneration research determined.

5. Efforts to inform Operations staff of research results and obtain their input into research planning and execution must be a high priority.

6. Catchment and forest hydrology research will be reduced in priority because of a perception the water production is not of direct benefit to CALM and that it does not follow from CALM's overall aims.

PART 13 THE PROGRAMS

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

PROGRAM LEADER

CURRENT RESOURCES (1991/92) AND RESOURCES IN THE PREVIOUS YEAR (1990-91)

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 1991/92 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 1996. 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 1991 TO JUNE 1996

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 1990/91

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 1990 and June 1991 is summarized. The column entitled Targets 1991-92 is intended to convey in a telegraphic style the works program for the period July 1991 - June 1992.

EXECUTIVE & RESEARCH SUPPORT PROGRAM

This program provides leadership and administrative support to the Division. It is divided into two sub-programs.

PROGRAM LEADER

AA Burbidge

SUB-PROGRAM A. EXECUTIVE

CURRENT RESOURCES (1991/92)

This program comprises 10.55 persons (6.65 Professional and 3.9 Clerical). Its estimated CRF budget is $583 423 (including $446 218 salaries and $117 205 operating costs). Operating costs include a contingency fund, mainly used to support new or under funded high priority research projects.

BACKGROUND

This sub-program is responsible for the direction and leadership of Research Division.

Leadership is coordinated by 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 20 year goals and 5 year goals of RDPG members are set out below. All members of RDPG are expected to commit a proportion of their time to carrying out research.

ACHIEVEMENTS

The Entomology Research Program was reviewed in February 1991, and the Native Forest Silviculture Research Program was reviewed in April 1991. A major review of research into dieback disease caused by *Phytophthora* species was completed and forwarded to the Executive Director.

AIM

To direct and lead 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 Research Plan and changes in Departmental 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.

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. 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.

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

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

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

6. 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 land 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 Economic 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 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 Economic 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 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 - N. MARCHANT

20 YEAR GOALS

1. Support the SPRS to provide direction and leadership for the plant-based programs.

2. Provide guidance and encouragement to Herbarium curatorial staff so that the collections are adequately housed and flora information can be used effectively for conservation and land management purposes.

3. Guide the expansion of the State Collection so that its specimens more adequately represent taxonomic and morphologic diversity.

4. Develop and foster liaison between the plant-based programs and other programs in the Division and in the Department.

5 YEAR GOALS

1. Develop and administer an effective system which facilitates applications for external grants by Divisional staff.

2. Assist with plant-based information towards the development of a nature conservation strategy for Western Australia.

3. Promote the dissemination of plant-based research findings to the public and the scientific community.

4. Effectively represent the Division and the Department.

PRINCIPAL RESEARCH SCIENTIST - A.N. START

20 YEAR GOALS

1. Ensure that good working conditions and an *esprit de corps* is develope 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.

SUB-PROGRAM B. RESEARCH SUPPORT

CURRENT RESOURCES (1991/92)

This program comprises 10.55 persons (1.0 Professional and 9.55 Technical and Clerical). Its estimated CRF budget is $680 930 (including $327 155 salaries and $353 775 operating costs).

BACKGROUND

This sub-program provides administrative and other support for all activities within the Division. It includes the Research Centre Managers, administrative and clerical staff, and some technical staff time for such duties as safety and fleet (vehicle) management.

AIM

To administer Research Division.

PRIMARY OBJECTIVES

Administration

To administer the Division through Research Centre Managers and administrative and clerical staff.

Scientific Publications

To ensure rapid dissemination of scientific and technical findings that are submitted for internal publication.

JOURNAL PUBLICATIONS

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. All Departmental scientific publications, except workshop proceedings, are reviewed by at least two referees, one of whom is external to CALM.

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 Information Resources Division.

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

One person, Ms Lewis, spends 100% of her time managing scientific publishing, including editing of scientific publications emanating from other Divisions.

The estimated budget for scientific publishing is $31 500 (1991/92 $30 570).

In the past year 12 new manuscripts (1300 pages) were received for publication; 8 papers (505 pages) were published; the personal computer was upgraded; and a new CALM research journal was approved.

20 YEAR GOAL

Ensure that scientific publications produced by CALM are of a high standard and conform to Divisional and Departmental objectives.

5 YEAR GOALS

The first 5 year goal in previous editions of the Plan has been achieved. This was to explain to CALM staff the purpose, scope, leadership and requirements of each research and technical publication produced by the Department.

1. Revise and update Guide to Authors.

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 policy and specifications for CALM research journal.

4. Maintain a publishing plan to minimize editorial delays and provide an efficient publishing service.

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

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

7. Develop and foster good working relationships with authors, and Corporate Relations Division.

8. Upgrade computer skills.

9. Develop and maintain a computerised manuscript tracking system.

10. Develop and maintain a computerised register of referees.

11. Revise and upgrade the mailing list.

BIOGEOGRAPHY PROGRAM

PROGRAM LEADER

GJ Keighery

CURRENT RESOURCES (1991/92)

This program comprises 10.15 persons (5.35 Professional + 4.8 Technical). Its estimated CRF budget is $531 051 (including $416 351 salaries and $114 700 operating costs).

RESOURCES IN PREVIOUS YEAR

This program comprised 10.7 persons (5.8 Professional + 4.9 Technical). Its budget was $510 869 (including $396 169 salaries and $114 700 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 editorial preparation of the forthcoming book on Kimberley rainforests was completed. The study provides an overview of Kimberley rainforests and their conservation significance, and includes recommendations for improvements in the conservation reserve system and for management of rainforest in Western Australia.

A major review of the conservation estate in the Kimberley was finalized and published.

A major project to identify conservation needs in pastoral lands was completed.

Analysis and writing up of data from the Eastern Goldfields survey continued: the MS for the Kurnalpi/Kalgoorlie cell was completed and edited ready for publication, and a draft MS has been prepared for the Norseman-Balladonia cell. Survey sites in the Goldfields were re-visited and accurately positioned using the satellite-based Global

Positioning System, in order to facilitate future monitoring.

A report was prepared reviewing the data available to assess the adequacy of the jarrah forest conservation reserve system in the Dale Botanical District.

A major paper was published explaining the methodology, outcome and recommendations of the Nullarbor District survey.

A number of specific areas were surveyed and/or reports produced. Areas covered included John Forrest National Park, VCL east of Kalbarri, portion of Boolardy Station, Cape Arid National Park, various parts of the Swan Coastal Plain, Greenmount National Park, Ashmore Reef National Nature Reserve, Mitchell Plateau, Fitzgerald River National Park, North-west islands, Lancelin-Dongara islands and Exmouth Gulf islands.

Compilation of a Checklist of the flora of the Pilbara was commenced. It will provide an improved data base for future work in the region. The Census of Australian Vascular Plants, for which the Biogeography Program provided distributional data for the 8 316 Western Australian taxa, was published by ABRS.

Bibliographic data-bases of the Pilbara Region and of conservation reserves and proposals across the State were commenced.

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

a. Community Biogeography

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.

b. 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.

To assess the likely impact on flora and fauna if particular National Parks and Nature Reserves are opened for mineral exploration or mining.

c. Management Planning

To use 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.

d. Broad-scale Monitoring

To measure changes with time 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.

e. Communication

To ensure the aims and results of biogeographic research are widely disseminated, understood and appreciated.

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

1. Extend the data base to include representation of additional Phytogeographic Districts found in Western Australia. The priorities will be influenced by the variety of widespread uses that may be superimposed on the land, as well as government and community priorities (Primary Objectives a & b).***

2. Establish a monitoring system and have it operating.(Primary Objective d)

3. Continue specific purpose surveys as the need arises. (Primary Objectives b & c)

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 re-monitored sites in selected districts.**(Primary Objectives a & d)

5. Undertake major reviews of the biogeography of Western Australia, to maintain a state wide perspective of Biogeographic patterns.* (Primary Objectives a & b)

5 YEAR GOALS

1. 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 other CALM staff, with other organizations and with the community at large.

2. 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.

3. 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.

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

5. Continue to 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 Yanchep National Park, Cape Arid National Park, Shark Bay Islands, Montebellos, Warren Botanical Subdistrict, Granites, Exmouth Gulf Islands, Kimberley coastal vegetation and Warren coastal vegetation.

6. 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.

7. 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).

8. In collaboration with Research Techniques Program 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.

9. Undertake remonitoring of Kalgoorlie Cell and Chrusher Vine Thicket (Mitchell Plateau).

PROJECTS TO BE COMPLETED FROM JULY 1991 TO JUNE 1996 (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 1990/91

*Andersen, N.A. and Burbidge, A.H. (1991). The ants of the vine thicket near Broome : a comparison with the northwest Kimberley J. R. Soc. W.A. 73:79-82.

*Buchanan, A.P. and Wardell-Johnson, G. (1990). Managing animal habitat using remote sensing and geographical informations systems. In Procedures of the Fifth Australasian Remote Sensing Conference pp 1022-1031.

*Burbidge, A.A. and van Leeuwen, S.J. (eds) (1990). The Hill River Project and the proposed Conservation Reserve at Lesueur. Dept. Conservation and Land Management, Occasional Paper 1/90.

*Burbidge, A.A., van Leeuwen, S.J. and Gibson, N. (1990). Conclusions. In: The Hill River Project and the proposed conservation reserve at Lesueur (Eds. A.A. Burbidge and S. van Leeuwen) Dept Conservation and Land Management, Occasional Paper 1/90.

Burbidge, A.H. (1990). Biological survey of vacant Crown land south of Coolcalalaya : preliminary report. (CALM internal report, 24pp).

Burbidge, A.H. and Rolfe, J.K. (1990). Preliminary report on the conservation values of open country paddock, Boolardy Station (CALM internal report, 13pp).

*Gibson, N. (1991). The anatomy and morphology of four Tasmanian cushion species. In Banks M.R. *et al* (eds) Aspects of Tasmanian Botany - a tribute to Winifred Curtis. R. Soc. Tas. Hobart: 231-238.

*Gibson, N., Davies, J. and Brown, M.J. (1991). The ecology of *Lagarostrobos franklinii* (Hook.f.) Quinn (Podocarpaceae) in Tasmania. 1. Distribution, floristics and environmental correlates. Aust. J. Ecol. 16:215-222.

*Gibson, N and Brown, M.J. (1991). The ecology of *Lagarostrobos franklinii* (Hook.F.) Quinn (Podocarpaceae) in Tasmania. 2. Population structure and spatial pattern. Aust. J. of Ecol. 16:223-229.

*Gibson, N. and Hopkins, A.J.M. (1990). Vegetation. In The Hill River Project and the proposed conservation reserve at Lesueur. A.A. Burbidge and S. van Leeuwen (eds). pp 9-20 CALM Occasional Paper 1/90.

Hickey, J., Gibson, N. and Shepherd, S. (1988 released 1990). Conservation status of rainforest in Tasmania. A report to the Working Group for Forest Conservation. Forestry Commission of Tasmania.

Henry-Hall, N.J. with assistance from Hopper, S.D., McKenzie, N.L. and Keighery, G.J. (1990) Nature Conservation Reserves in the Eastern Goldfields, Western Australia. Report to the EPA Red Book Task Force, 264pp.

*Hopper, S.D., van Leeuwen, S., Coates, D.J. and Gibson, N. (1990). Flora In A.A. Burbidge, S. van Leeuwen (eds), The Hill River Project and the proposed conservation reserve at Lesueur: a report to the Environmental Protection Authority from the Department of Conservation and Land Management, pp 21-29. CALM Occasional Paper 1/90.

*Keighery, G.J. (1990). Vegetation and Flora of Shark Bay, Western Australia. In Research in Shark Bay, Eds. P.F. Berry, S.D. Bradshaw and B.R. Wilson. pp 61-88.

*Keighery, G.J. (1991). Floristics of System Six Reserves and Bushland III Blackwell Reach Reserve Flora List. W.A. Wildflower Society Spec. Publ. 23-32.

*Keighery, G.J. (1991). Floristics of Systems Six Reserve and Bushland IV Hepburn Heights. W.A. Wildflower Society Spec. Publ. 33-45.

*Keighery, G.J. and Alford, J.J. (1990). Flora of Benger Swamp, south-western Australia. West. Aust. Naturalist. 18:65-70.

*Keighery, G.J., Harvey, J.A. and Keighery, B.J. (1990). Vegetation and Flora of Bold Park, Perth. West. Aust. Naturalist. 18:100-120.

*Keighery, G.J. and Keighery, B.J. (1991). Floristics of System Six Reserves and Bushland II Brixton Street Wetlands Kenwick. W.A. Wildflower Society Spec. Publ. 1-22.

*Moore, S., Cavana., Chevis, H. Gillen, K., Hart, C., Hopper, S., Orr., K. and Schmidt, W. (1990). Fitzgerald River National Draft Management Plan 1991-2001. Department of Conservation and Land Management, Perth.

*Wardell-Johnson, G. and Roberts, J.O. (1991). The survival status of the *Geocrinia rosea* (Aura:Myobatrachidae) complex in riparian corridors : Biological Implications. In Nature Conservation - the role in corridors. Ed. Saunders, D.A., Hobbs, R.J. Surrey Beatty and Sons, Chipping Norton pp 167-175.

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
Community Biogeography	8	1	Develop micro-computer entry system for survey data Acquire software to process and analyse survey data NL McKenzie 57/91	Developed usage	Continue as opportunities allow
	1,7	2	Census of Australian Plants Descriptive catalogue GJ Keighery 4/90	Published	Completed
	6	3	Heterogeneity of Nullarbor Quadrats NL McKenzie 63/91	No progress	Analyse data
	6	4	Automatic bat assemblage sampling NL McKenzie 59/91	Master tape of bat ultra-sounds for 20 species compiled	Opportunistic
	6	5	Extending the Nullarbor data-base: do the patterns change? NL McKenzie 63/91	Preliminary analysis completed	Interpret and write up if time allows
	6	6	Biogeographic patterns versus soil attributes NL McKenzie 63/91	Field data collected and compiled by consultant	Analyse if time allows
	5,6	7	Ecol. biog. of 4 endemic forest eucalypts G Wardell-Johnson 44/88	Sampling completed	Analyse data
	2,7	8	National Rainforest Conservation Program KF Kenneally	Published	Finished
	5,7	9	Dampier land Peninsula survey KF Kenneally	M/S updated	Finalize Ms
	5,7	10	Biological survey of existing, proposed reserves: AH Burbidge	-	-

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
	5,7	11	Coolcalalaya AH Burbidge 22/91	Area sampled; preliminary report produced	Carry out supplementary surveys, analyse data
			John Forrest N.P. AH Burbidge 78/91	Sampling completed, report submitted	Prepare MS for publication if time allows
			Swan Coastal Plain - remnant vegetation GJ Keighery	Survey commenced	Submit preliminary report, extend survey
	5	12	Camden Harbour Survey KF Kenneally	Survey completed	Process specimens and prepare MS
	5,7	13	Walcott Inlet survey KF Kenneally	Updating of list from rainforest survey & added herbarium records	Prepare MS
	5,7	14	Ashmore Reef survey KF Kenneally	MS accepted	Completed
	5	15	Mitchell Plateau survey KF Kenneally	Specimens identified & added to floristic list	Continue to compile
	5,7	16	Kimberley rivers survey: WA Naturalists Club KF Kenneally	Specimens identified & added to floristic list	Prepare MS
	5,7	17	Buccaneer Archipelago KF Kenneally	Further specimens identified	Compile data
	5	18	Wongan Hills KF Kenneally	Additional records added to checklist. Provided floristic information to A Coates	Continue updating checklist
	5	19	Pilbara Flora Checklist S van Leeuwen	Commenced.	Continue to compile
	5,7	20	Biological bibliography of Pilbara Region S van Leeuwen 41/91	Commenced	Continue to compile

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
Community Biogeography, Reserve System Design and Land-use Advice	5	21	Flora surveys of the wheatbelt and other selected lands SD Hopper 72/91	Post fire survey of Fitzgerald River NP.	Post fire surveys of Kalbarri, Peak Charles, NPs, Dundas NR.
	5,7	22	Walpole-Nornalup National Park survey G Wardell-Johnson 67/91	MS prepared	Submit M/S for publication
	5,7	23	Yanchep NP survey AH Burbidge 32/90	M/S drafted	Complete M/S
	5,7	24	Boonanarring Reserve Survey AH Burbidge 31/90	M/S updated	Submit M/S.
	5,7	25	Biological survey of Dampier Archipelago KD Morris 9/91	Further data collected	Prepare M/S
	5,7	26	Cape Arid Survey AH Burbidge 3/91	Draft report prepared; MS on ants submitted	Continue preparation of MS
	5,7	27	Fitzgerald River NP Survey NL McKenzie (liaison)	Referees comments addressed	Publish
	4,7	28	Eastern Goldfields NL McKenzie 58/91	Cells 12 drafted, 8 submitted.	Submit MS for cells 3, 12. Draft MS for cell 9
	1,2,7	29	Rainforest Survey NL McKenzie 60/91	Submit MS	Launch publication
	5,7	30	Ecological Bigliography of W.A. conservation reserves and proposals NL Gibson 7/90	Added more references	Continue to compile
Reserve system design and Land-Use Advice, Management Planning	5	31	Buccaneer Archipelago Survey NL McKenzie 62/91	No progress	Compile data & maps etc for report
	5	32	Biological survey of Shark Bay islands KD Morris 11/91	Survey completed	Prepare MS

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
	5	33	Mandora Palaeoriver/Radi Hills Survey NL McKenzie 61/91	No progress	Compile data
	5	34	Cooloomia Nature Reserve Survey SD Hopper	No progress	Deferred
	1,5,7	35	Flora Survey of Islands: Lancelin to Dongara GJ Keighery	In press	Completed
	1,5,7	36	Stirling Range & Environs flora GJ Keighery 6/91	Prepared annotated flora list for management plan.	Submit MS
	5	37	Dorre Island and associated Shark Bay Island survey RIT Prince	No progress	Undertake 15 years resample
	5,7	38	Bold Park flora survey GJ Keighery	Published	Completed
	5	39	Millstream-Chichester National Park Survey S. van Leeuwen	Volunteer project completed	Deferred
	5	40	Barlee Range Survey Pilbara Region with S. van Leeuwen	Pilot project undertaken	Sample
	5	41	Biological Survey of Mt Windell Rd, Karijinii NP Pilbara Region with S van Leeuwen 71/91	Reconnaissance completed	Sample
	5	42	Flora Survey Pilbara Hill complexes S van Leeuwen	Commenced	Opportunistic sampling
	5	43	Monte Bello Island Survey KD Morris 10/91	No progress	Deferred
	5	44	Biogeography and ecology of WA granite outcrop plants SD Hopper 70/91	Several rocks surveyed and specimens lodged in Herbarium	Analyse Karroun Hill and Ornduff Rocks data sets and orchid data.

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
	5,7	45	Warren NP coastal survey N Gibson 8/90	Initial sampling completed.	Complete sampling and analyse.
Management Planning	7	46	Management guidelines for Monte Bello Island KD Morris 12/91	In press	Completed
	7	47	Management Plan for North-west Islands KD Morris	Provided advice as requested by Protection Branch.	Advise as requested
	5	48	Buccaneer Archipelago Management Plan RIT Prince	Continued to collect data	Deferred
Community Biogeography	6	49	Bat assemblages: disturbance and determinism NL McKenzie 59/91	In press	Completed
	6	50	Lizard litter patch guilds NL McKenzie 63/91	No progress	Continue if time allows
	5,6	51	Distribution and taxonomy of Geocrinia complex G Wardell-Johnson 69/91	Published 2 papers	Draft 2 papers
	5	52	Kwongan vegetation dynamics N Gibson 9/90	Sampling carried out	Complete sampling and analyse data
Reserve System Design and Land-Use Advice	1,7	53	Landuse advice N Gibson 7/90	Mt Lesueur report, Watheroo, Plumridge Lakes	Contribute to CALM Conservation Strategy; respond to requests
	5	54	Exmouth Gulf Islands AN Start/N McKenzie 31/91	Surveyed Simpson Group	Survey Rivoli Group
	5,7	55	Botanical Survey - Porongurup GJ Keighery 4/91	Completed survey	Submit Ms

ECONOMIC ENTOMOLOGY PROGRAM

PROGRAM LEADER

J Farr

CURRENT RESOURCES (1991/92)

This program comprises 4.3 persons (1.3 Professional + 3.0 Technical). Its estimated budget is $214 835 (including $190 835 salaries and $24 000 operating costs).

RESOURCES IN PREVIOUS YEAR

This program comprised 5.4 persons (1.4 Professional + 4.0 Technical). Its budget was $177 622 (including $153 622 salaries and $24 000 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. The program was formally reviewed in 1991 (see Part 12).

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

Re-monitoring of density of Jarrah Leafminer 18 months after an experimental Autumn fire near Collie has shown that this type of fire is ineffective in reducing density for longer than 12 months.

A survey in Collie and Manjimup Districts of adjacent stands of Jarrah forest differing in time since logging showed that recent logging did not favour Leafminer.

An extensive survey of Gumleaf Skeletonizer distribution in the central and southern forest revealed a patchy distribution of the insect.

The existence of two Gumleaf Skeletonizer populations in the South West and South Coast of Western Australia was verified. A univoltine (one generation per year) population is confined to the Jarrah forest, whereas a bivoltine (2 generations per year) population occurs in the wheatbelt and isolated locations in the Jarrah forest.

A further parasitoid of Gumleaf Skeletonizer has been identified as the Tachinid fly *Winthemia lateralis.*

The psyllid infesting Flat-topped Yate, formerly thought to be *Cardiaspina brunnea*, is now confirmed as a new species endemic to the Lower Great Southern.

Intensive study of tagged leaves at Cranbrook has shown the survival rate of *Cardiaspina* sp. nov. from egg to fifth instar to be 28%. A decrease in the

survival rate to 1.1% was observed after an influx of Striated Pardalotes into the area. A parasitic wasp, *Psyllaephagus* sp. (family Encrytidae), has also been found to affect the survival of *Cardiaspina* sp.n. although its incidence of parasitism is very low.

Flat-topped Yate trees possibly resistant to *Cardiaspina* sp. n. have been located near Fitzgerald NP.

A considerable backlog (1984-1989) of data on insect herbivory and abundance of foliage arthropods has been written up.

A paper on the composition, distribution and economic impact of the termite fauna of metropolitan Perth was published.

A menu driven data base for the Manjimup insect collection was established.

Monitoring of caged billets of radiata pine from the Ferndale and Pinjar plantations has proven that only one species of the three biocontrol agents for *Ips grandicollis* has established. This species is the Torymid wasp *Roptocerus xylophagorum.*

A concise synopsis of biological data for the 19 insect species so far recorded infesting trees in plantations was provided for CALM's insect manual.

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 and other economically important plants.

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.

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. Monitor on a broad-scale insect s in the South infestation of trees in other ecosystems in Western Australia. **

3. Complete a checklist of potential pest insect species in the forests of south-western Australia, together with details of their distribution.**

4. Expand research in conservation entomology in the native hardwood forests. *

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. Compile an inventory of insects feeding on *Eucalyptus globulus* and search for individual trees resistant to insect feeding.

6. Investigate the impact on regrowth Karri and the causes of infestation by the borer *Tryphocaria acanthocera*.

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.

PROJECTS TO BE COMPLETED FROM JULY 1991 TO JUNE 1996 (numbers refer to the Table following)

1,3,4,5,6,7,10,11,12,14,15,16,19,20,23,27,28,33,34, 35,38

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

1. Investigate the biology, ecology and oviposition behaviour of *Tryphocaria acanthocera* in Karri regeneration and old growth forest.

2. Develop a non destructive sampling technique for *Tryphocaria*.

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 e by way of 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 1990/91

* Abbott, I. (1990). Insect outbreaks in Western Australia. In "Population Dynamics of Forest Insects" (ed A.D. Watt, S.R. Leather, M..D. Hunter & N.A.C. Kidd), 95-103 Intercept, Andover.

Abbott, I. (1990). Insects known to be injurious to trees. Section 3 of CALM's Insect Manual (19pp).

*Abbott, I. (1991). Annual activity of a population of *Catasarcus asphaltinus* Thompson (Coleoptera: Curculionidae) in Perth, Western Australia. Aust. ent. Mag. 18:21-24.

*Blyth, J. & Abbott, I. (1991). Spineless wonders: are invertebrates second - class citizens ? Landscope 6(3): 28-33.

*Postle, A. & Abbott, I. (1991). Termites of economic significance in suburban Perth, Western Australia: A preliminary study of their distribution and association with types of wood (Isoptera). J. Aust. ent. Soc 30: 183-186.

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
Ecological Knowledge	Jarrah Leafminer (JLM)	1	Impact on wood growth (I Abbott) 24/86	Plot near Dwellingup remeasured Dec 90	Write up
		2	Annual monitoring of defoliation (I Abbott)		
			44/87	Damage to tagged leaves measured Oct 90 in 20 plots, Collie District. New cohort tagged.	Estimate JLM density on tagged leaves Oct 91 and tag new leaves.
			20/84	New leaves tagged in 20 plots in Manjimup District Nov 90	Estimate JLM density on tagged leaves Nov 91 and tag new leaves
			20/84	Leaves tagged Nov 85 in Manjimup District measured quarterly for damage up to Feb 88 - Draft written	Publish
			2/85	Damage to leaves tagged in NJF in Nov 85 and Nov 87 Draft written	Publish
			-	Aerial survey of forest in Collie District Oct 90	No action
			-	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	Continue
		4	Tree mortality (I Abbott) 20/88	180 trees marked, Proprietary block, Collie District	Continue
		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 91	Do annual sampling of 45 trees Jan 92

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
		7	Distribution of GLS N of outbreak zone (J Farr) 48/87	Surveyed Southern and Central regions Oct-Dec 90	Repeat Oct-Dec 91
		8	Annual monitoring of outbreak (J Farr)	No action	Postpone until 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 91. Population density of GLS caterpillars measured	Repeat crown assessment Jan 92 & 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	No action	Analyse and write up data collected to Dec 90. Complete experiment when population levels higher.
		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	Late instar larvae reared pupal weights & fecundity recorded	Ongoing
	Lerp	15	Life cycle studies (J Farr) 22/90	Monitored tagged leaves over 12 months;	Ongoing. Examine data collected to construct life table.
		16	Taxonomy (J Farr)	Lerp confirmed as new species	Complete
		17	Crown decline & tree mortality (J Farr) 24/90	July and Nov 90 monitoring achieved. March 91 sampling, no action	Ongoing
		18	Population monitoring (J Farr) 23/90	Data collected for 3 generations in 90-91	Ongoing

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
		19	Stadia identification (J Farr) 26/90	Lerps measured over 12 months	Asses data collected to date. Continue experiment to determine seasonal and annual changes in nymph size.
		20	Adult emergence (J Farr) 25/90	First assessment for one generation completed.	Ongoing
	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 and in E. globulus plantations	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	Accepted for publication	-
	Curation, maintenance & protection of pinned & spirit-collection of insects, collection of wood samples showing insect damage, and herbarium of insect-damaged foliage	24	Provide identification service of insects damaging wood or foliage, and maintain records of occurrence of infestations (I Abbott, J Farr)	60 public telephone and 50 written enquiries dealt with.	Incorporate SJF samples into spirit collection. Complete computerized data base for pinned collection
		25	Checklist of insect species recorded in forests of south-western Australia (I Abbott)	Some updating of list	Publish
Stand Management	JLM	26	Stand hazard rating (I Abbott)	Pilot project with CSIRO Remote Sensing Unit	Liaison as required
		27	Frequency of occurrence of resistant trees in NJF (I Abbott) 45/87	No action	Write up
		28	Effects of fire & thinning (I Abbott) 20/88	JLM cut outs collected in cone traps Oct 90	Ongoing
			22/89	No action	Write up
			5/90	JLM cutouts counted in adjacent stands in period since last logging.	Write up
	GLS	29	Stand hazard rating (J Farr)	No action - remote sensing not possible due to decline in abundance	-

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
		30	Effect of fire (J Farr) 19/87	Sampled Jan 91. Burn not achieved in Autumn 90.	Discontinue due to site degradation
			Effect of thinning (J Farr)	No action due to low population levels	Suspend until population increases
	Lerp	31	Resistant trees (J Farr)	Observations made: Apparent resistance found.	Ongoing
Control	JLM	32	Impact of parasitoids (I Abbott) 47/87	Forest between Julimar & Collie surveyed by Northern forest region staff.	Ongoing
		33	Spatial variation in rate of parasitism of larvae (I Abbott) 1/91	Pilot survey completed in Collie and Harvey districts. RPP written	Survey two N-S transects within and outside the outbreak area
		34	Impact of Spring fire on parasitization of larvae (I Abbott) 36/91	RPP written	Gather data Oct 91
		35	Impact of Autumn fire on life cycle (I Abbott) 37/91	RPP written	Gather data Oct 91
	GSL	36	Biocontrol (J Farr)	1990-91 generation sampled Fourth parasitoid species identified	Continue sampling.
	Lerp	37	Biocontrol (J Farr)	Sampling continued. One parasitoid and one predator identified	Conntinue sampling. Prepare RPP when rearing technique established
	Ips	38	Prescription for introduction of parasitoids and predators (I Abbott)	Caged billets form Ferndale and Pinjar used to calculate success of introductions	No further action
	Sirex	39	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 and collate data

FAUNA CONSERVATION PROGRAM

PROGRAM LEADER

JA Friend

CURRENT RESOURCES (1991/92)

This program comprises 10.95 persons (4.80 Professional + 6.15 Contract Professional + 6.15 Technical). Its estimated CRF budget is $739 707 (including $611 507 salaries and $128 200 operating costs). Commitments of an additional $270 507 have been received from external sources for 1991/92. Growth in permanent staff since last year has been due to the incorporation of the Marine Conservation Program into this Program.

RESOURCES IN PREVIOUS YEAR

This program in 1990/91 comprised 8.6 persons (3.85 Professional + 0.50 Contract Professional + 4.15 Technical). Its CRF budget was $494 521 (including $366 321 salaries and $128 200 operating costs). An additional $249 367 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 native mammal species 'not protected'. Conversely, 41 mammals, including 26 marsupials (40%), 12 other land mammals (15%) and 3 marine mammals, 37 birds (8%), 6 land dwelling reptiles (2%) and one marine turtle, and 2 frog species have been declared as threatened fauna. Two fish from inland waters have also been so declared.

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 managed 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. 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 is 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 them and some cetaceans will continue to be dealt with under this program. Studies of the biology of the marine gastropod *Drupella* in connection with its effect on the corals of Ningaloo Reef are being carried out under this program in the absence of a 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. The development of an overview of the status of Western Australian invertebrates, however, is a short-term aim of the program.

ACHIEVEMENTS

A workshop to determine priorities in fauna conservation research was held on the 10 October 1990. It was attended by a wide cross-section of CALM staff, from Operations Division and other parts of the Department with an interest in fauna and its conservation. The main outcomes were that the program should maintain the present mix of species-oriented and process-oriented research, but that more attention should be focussed on feral cats and introduced herbivores, invertebrates and the fauna of the jarrah forest.

Program members were again very successful in raising external funds. New and ongoing grants were received for research on Western Mouse, Red-tailed Phascogale, Quenda, fox biology and control, small mammals on Barrow I, Greater Stick-nest Rat, Western Swamp Tortoise, marine turtles and *Drupella*.

The Western Swamp Tortoise Wildlife Management Program was published, being launched by H.R.H. Prince Philip in November 1990.

The Chuditch Wildlife Management Program was approved by Corporate Executive and funds have been provided by the Australian National Parks and Wildlife Service for its publication as a Species Recovery Plan.

Funds were also successfully sought from ANPWS to produce Species Recovery Plans for the Tammar, Woylie, Black-flanked Rock-wallaby, Shark Bay Mouse and the endemic frogs *Geocrinia alba* and *G. vitellina*.

A "Manual on Fox Control" was produced as the result of WWFA Project 106 and forwarded to the funding body, to be published soon.

A WWFA-funded research project on the conservation of the Western Mouse has provided important biological information on this threatened species. A previously unknown population was discovered at Rock View NR, and the use of radio-tracking has shown that these rodents nest in burrows, but are partially arboreal.

The Greater Stick-nest Rat, presumed extinct in Western Australia, was re-introduced to the State in 1990 by the release of 40 captive-bred animals on Salutation Island in Shark Bay in association with the South Australian National Parks and Wildlife Service. Monitoring of the colony has shown that the surviving rodents are in good condition and are breeding despite a dry summer. All indications at this stage are that a viable population has been established.

Previously unknown populations of the Red-tailed Phascogale, a threatened species apparently restricted to the wheatbelt, have been discovered in Highbury State Forest, and at three Nature Reserves in the Great Southern. The species has been found

to be still present in Dongolocking, Boyagin, Tutanning and East Yornaning NRs, and in Dryandra SF.

An aerial baiting program in part of the Fitzgerald River NP was implemented in order to test further the hypothesis that predation by foxes is regulating populations of native mammals. A census of the Ground Parrot within and outside the baited area was also carried out to allow measurement of the effect of foxes on this threatened species.

Techniques were developed to eradicate the introduced Black Rat from Barrow Island while minimising the effect on native mammals.

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.

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 for other purposes on fauna 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 biology and ecology of species and groups of fauna for which Western Australian populations are of major conservation significance.***

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

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

4. 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.**

5. 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.**

6. 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 1991 TO JUNE 1996

1, 3-14, 16-32, 34.

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

1. A major project on the feral cat in Western Australia with respect to its effects on native fauna and its control. This project should be developed in association with ANPWS and other State governments, following a recent workshop on the species held in May 1991 in Canberra.

2. An overview of invertebrate conservation in Western Australia. This study will review present knowledge of threatened invertebrates, identifying threatened habitats and threatening processes. It will also pinpoint groups and areas where knowledge is insufficient for these judgements to be made, and recommend the direction for further research.

3. Studies of the vertebrate fauna of the northern jarrah forest (concentrating on threatened species) in relation to logging practices.

4. A study of the Quenda *Isoodon obesulus* in the jarrah forest and on the Swan coastal plain, in relation to forest management practices and urban development, respectively.

5. A study of the Brush Wallaby *Macropus irma* to determine its conservation status, to identify factors contributing to any detected decline, and to develop appropriate habitat and population management techniques.

PROPOSED NEW PROJECTS - with existing resources

Nil.

PUBLICATIONS * AND REPORTS 1990/91

*Algar, D. and Kinnear, J.E. (1991). Fox density and dispersal into baited areas. Proceedings of the 9th Vertebrate Pest Control Conference, pp.177-180.

*Burbidge, A.A. (1990). The tail of the mysterious Kimberley Possum. Wildlife Australia 27(2):26-27.

*Burbidge, A.A. (1990). Why save endangered species? Aust. Geog. 21:29.

*Burbidge, A.A. and Friend, J.A. (1990). The disappearing mammals. Landscope 6(1):28-34.

*Burbidge, A.A. and Fuller, P.J. (1990). Fauna. In "Nature conservation, landscape and recreation values of the Lesueur area" (ed. A.A. Burbidge, S.D. Hopper, and S. van Leeuwen), pp 71-82. Bulletin 424, Environmental Protection Authority, Perth, .

*Burbidge, A.A. and Fuller, P.J. (1990). On the vernacular name of *Petrogale burbidgei*. West. Aust. Mus. Rec. 14:645-646.

*Burbidge, A.A. and Fuller, P. (1991). A million seabirds. Landscope 6(1):17-23..

*Burbidge, A.A., Kuchling, G., Fuller, P.J., Graham, G. and Miller, D. (1990). The Western Swamp Tortoise. Western Australian Wildlife Management Program No. 6. Department of Conservation and Land Management, Perth.

*Burbidge, A.H. (1990). Grey Honeyeater. In "Threatened Birds of Australia. An annotated list" (ed. J. Brower and S. Garnett). pp. 28-29. RAOU & ANPWS, Melbourne.

*Burbidge, A.A., McKenzie, N.L. and Halse, S.A. (1990). Fauna. In The Hill River project and the proposed conservation reserve at Lesueur (ed. A.A. Burbidge and S. van Leeuwen), pp. 31-42. Department of Conservation and Land Management Occasional Paper 1/90.

*Burbidge, A.H. (1990). Endangered! The Ground Parrot. Landscope, 5(4):41.

*Burbidge, A.H. (1991). Endangered! The Gouldian Finch. Landscope, 6(3):53.

*Burbidge, A.H. and Fuller, P.J. (1990). Possible effects of fox (and/or cat) predation on ground-nesting birds in Western Australia. CALM Landnote 2/90.

*Burrows, N.D. and Thomson, C. (1990). Re-introduction of rare and endangered animals of the Gibson Desert. Aust. Ranger Bull. 6(1): 21-22.

*Brathwaite, R.W., Friend, G.R. and Wombey, J.C. (1991). Reptiles and amphibians. In : Monsoonal Australia - Landscape, Ecology and Man in the Northern Lowlands Eds. C.R. Haynes, M.G. Ridpath and M.A.J. Williams pp 109-124. A.A. Balkema Press, Netherlands.

Danks, A., Rolfe, J. and Burbidge, A.H. (1991). Radio-tracking the Noisy Scrub-bird: report on a feasibility study, 20 July-2 August 1990. (CALM internal report, 14pp.)

*Friend, G.R. and Cellier, K.M. (1990). Wetland herpetofauna of Kakadu National Park, Australia: seasonal richness trends, habitat preferences and the effects of feral ungulates. J. Trop. Ecol. 6: 131-52.

*Friend G.R. (1990). Breeding and population dynamics of *Isoodon macrourus* (Marsupialia : Peramelidae) studies from the wet-dry tropics of northern Australia In : Bandicoots and Bilbies (eds. J.H. Seebeck, P.R. Brown, R.L. Willis and C.M. Kemper) pp. 357-65. Surrey Beatty and Sons, Sydney.

*Friend G.R., Morris, K.D. and McKenzie, N.L. (1991). The mammal fauna of the Kimberley Rainforests In : Rainforests of the Kimberley, Western Australia : Ecology and Biogeography (eds. N.L. McKenzie, P.J. Kendrick and R.B. Johnson) pp. 393-412 Surrey Beatty and Sons, Sydney.

Friend, G.R. and Hall, G.P. (1990) Report No. 3 to WWF Australia Project P144 "Fire and Invertebrate Conservation in Mallee-Heath Remnants".

Friend, G.R. and Hall, G.P. (1991). Report No 4 to WWF Australia Project P144 "Fire and Invertebrate Conservation in Mallee-Heath Remnants".

*Friend, G.R. (1991). Does corridor width or composition affect movement? In Nature Conservation: the Role of Corridors (eds. D.A. Saunders, and R.J. Hobbs) pp. 404-405. Surrey Beatty and Sons, Sydney.

*Friend, G.R. and Hall, G.P. (1991). Mountains of Mystery. Landscope 6(4) : 9-13.

*Friend, J.A. (1990). The status of bandicoots in Western Australia. In "Bandicoots and Bilbies" (ed. J.H. Seebeck, P.R. Brown, R.L. Wallis and C.M. Kemper), pp. 73-84. Surrey Beatty & Sons, Sydney.

*Friend, J.A. (1990). The Numbat *Myrmecobius fasciatus* (Myrmecobiidae): history of decline and potential for recovery. Proc. Ecol. Soc. Aust. 16:369-377.

*Friend, J.A. and Thomas, N.D. (1990). The Water-rat, *Hydromys chrysogaster* on Dorre Island, W.A. West Aust. Natur. 18(3): 92-93.

*Friend, J.A. (1990). Numbat dawn. Landscope 5(4):15-19.

Friend, J.A. and Friend, G.R. (1990). Report No.1 to ANPWS on ESP Project 22 (Phase 1) Conservation of the Red-tailed Phascogale.

Friend, J.A. and Friend, G.R. (1991). Report No.3 to ANPWS on ESP Project 22 (Phase 1) Conservation of the Red-tailed Phascogale.

Friend, G.R. and Friend, J.A. (1990). Report No.2 to ANPWS on ESP Project 22 (Phase 1) Conservation of the Red-tailed Phascogale.

*Gaynor, W.T., Cousins, D.V. and Friend, J.A. (1990). Mycobacterial infection in numbats. J. Zoo Wildl. Med. 21(4):476-479.

*Hall, G.P. and Friend, G.R. (1990). Distribution, habitat and behavioural patterns of *Nickerlea sloanei* (Lea) (Coleoptera : Cicindelinae) In southwestern Australia. J. R. Soc. W. Aust. 73: 57-59.

Kinnear, J.E. and Algar, D. (1991). A manual on fox control. Report to WWFA on Project 106.

Kinnear, J.E., Algar, D. and Marlow, N. (1990). Report No.1 to ANPWS on ESP Project "Control and Ecology of the Red Fox in W.A.".

Kinnear, J.E., Algar, D. and Marlow, N. (1991). Report No.2 to ANPWS on ESP Project "Control and Ecology of the Red Fox in W.A.".

*Kinnear, J., King, D. and Morris, K. (1990). Vandals in a vulnerable land. Landscope 6(1):44-48.

*Morris, K. (1990). The quoll that came from the west. Wildlife Australia, Spring 1990:310-312.

*Morris, K.D. and Bromilow, R.N. (1991). A record of the Euro *Macropus robustus* in John Forrest National Park. West Aust. Natur. 18(6):166-167.

*Morris, K.D. and Dickman, C.R. (1991). The status and conservation of the Golden Bandicoot *Isoodon auratus* on Barrow Island, W.A. Abstract, Australian Mammal Society meeting, Armidale, February 1991. (published in AMS Newsletter, May 1991).

Morris, K., Whisson, L., Burbidge, A.A. and Wallace, K. (1991). Progress Report No.2 to WWFA on Project 145: Status and conservation of the Western Mouse *Pseudomys occidentalis*.

Pearson, D. (1991). First records of the Mulgara, *Dasycercus cristicauda* from the Gibson Desert and Queen Victoria Springs Nature Reserves. W.A. Nat. 18(6): 159-161.

*Pearson, D.J. and Robinson, A.C. (1991). New records of the Sandhill Dunnart, *Sminthopsis psammophila* (Marsupialia : Dasyuridae) in South and Western Australia. Aust. Mamm. 13(1):57-59.

Prince, R.I.T. (1990). Progress Report: Western Australian Marine Turtle Conservation Project, 1986-1989/90. (ANPWS SCAP Project No. 4458).

Prince, R.I.T. (1990). Marine Turtle Newsletter No.2.

Prince, R.I.T. (1991). Progress Report on Beach Work - Western Australian Marine Turtle Project. 1990-91 season to 21 December 1990. (Report to W.A. Marine Turtle Program volunteers and assistants).

*van Leeuwen, S., Burbidge, A.A. and Hopper, S.D. (1990). Inter-relationships of plants and animals. In "Nature conservation, landscape and recreation values of the Lesueur area" (ed. A.A. Burbidge, S.D. Hopper, and S. van Leeuwen), pp 83-88. Bulletin 424, Environmental Protection Authority, Perth.

*Williams, A.A.E. (1991). New southern records of the Yellow Palmdart *Cephrenes trichopepla* (Lower) (Lepidoptera: Hesperidae) in Western Australia. Aust. ent. Mag. 18(1):43-44.

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-1	Targets 1991-2
Knowledge	Specialized knowledge	1	Mormopterus taxonomy (RS130) NL McKenzie	No progress	Complete work if opportunity arises
	Specialised knowledge	2	Landhopper taxonomy (65/91) JA Friend	SW Tasmanian material identified for National Rainforest Conservation Project. SW WA landhopper distributions plotted	Contribute to paper on SW Tasmanian rainforest fauna. Complete New Caledonian material; contribute to paper. Complete identification of material from E. Gippsland.
	Specialised knowledge; management support	3	Forest fauna habitats RIT Prince	Liaison with other CALM staff.	Develop if circumstances allow.
Knowledge; Population studies	Feral exotic; control programs	4	Fox biology and fox control (RS104, 105-111) D Algar	Preliminary assessment of the effectiveness of different baiting intensities. Established a dispersal study at Namming NR. Established the extent of dispersal into a control area over time (Watheroo NP).	Further assessment of the effectiveness of different baiting intensities. Examine dispersal factors in the northern sandplain area. Conduct calibration trials on CPUE index (density) including measurement of fox home range at a number of different sites.
	Biology, ecology; feral exotic; control programs	5	Fox Ecology JE Kinnear	Baiting of Fitzgerald River NP completed. Fox census using CPUE indices completed in unbaited and baited areas of NP. Macropodid spotlight transects completed. Public relations program completed. Biodegradation studies on 1080: two papers accepted for publication.	Repeat baitings of FRNP. Repeat CPUE indices. Repeat macropodid census. Carry out small mammal census (subject to dieback restrictions). Proceed with development of bioasssay for 1080. Submit two papers for publication.
	Biology, ecology; feral exotic; control programs	6	Fox ecology, contact rates and biological control N Marlow	Established project to determine fox contact rates. Examined fox home ranges in Yanchep NP. Obtained blood samples for virus screening and DNA fingerprinting.	Continue this work, plus initiate experiment to determine the threshold densities of foxes which reduce the populations of prey species to below their carrying capacity.
	Identify relict populations; specialized knowledge; potential impacts of feral exotic; management support; biology and ecology	7	Rock Wallaby conservation (RS103, 104-105) JE Kinnear	Annual monitoring and population surveys completed	Continue annual monitoring. Assess genetic viability of populations. Submit paper.

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-1	Targets 1991-2
	Management support; biology and ecology	8	Rock Wallabies, Dampier Archipelago (RS108) JE Kinnear	Paper in press	Habitat analysis of West Lewis population
	Identify relict populations; management support; biology and ecology	9	Rock Wallabies, East Pilbara (RS108-109) JE Kinnear	Paper in preparation	Project suspended
	Management support, biology and ecology.	10	Numbat study. Habitat and food sources (RS39-41) JA Friend	First draft of management program completed	Complete paper on feeding activity and termites. Progress management program to submission.
	Identify relict populations; management support; biology, ecology	11	Chuditch conservation (33/91) KD Morris	Completed species management program. Continued survey of wheatbelt reserves. Continued obtaining distribution data.	Employ technical officer with external funds to initiate research requirements of management program.
	Management support; biology, ecology	12	Western Barred Bandicoot ecology (RS43-44) JA Friend	Analysis of home range data completed.	Field trip to Dorre I: carry out trapping study to test habitat usage hypothesis.
	Management support; biology, ecology	13	Ground parrot conservation (RS17-18) AH Burbidge	Permanent quadrats set up to determine changes in habitat following Fitzgerald fires; censusing parrots in baited and unbaited areas to determine effects of foxes.	Continue habitat work and censusing; prepare publications
	Management support; biology, ecology	14	Ecology and conservation of small mammals on Barrow I. (30/91) KD Morris	Study commenced November 1990	Complete obtaining ecological data on Isoodon. Commence rodent program.
	Identify relict populations; develop management support programs	15	Nullarbor Quail-thrush conservation AH Burbidge	Funding application prepared & submitted to WWFA	Proceed if funding provided by WWFA
	Management support; techniques	16	Western Swamp-Tortoise breeding (35/91) AA Burbidge	Initial project successfully completed. New project designed and funds sought.	Continue to assist captive breeding project at Perth Zoo via Recovery Team.
	Management support; techniques	17	Western Swamp-Tortoise populations (34/91) AA Burbidge	Seasonal work completed as required	Monitor Western Swamp Tortoise population at Ellen Brook NR.

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-1	Targets 1991-2
	Management support, biology, ecology	18	Numbat study - translocation and re-establishment (RS43-43) JA Friend	Translocations to Karroun Hill and Tutanning NRs carried out (monitoring by radio-tracking continued). Aerial baiting carried out at KHNR after negative chuditch trapping survey. Fox CPUE index obtained before and after baiting. Seven young captured and radio-collared at KHNR. Diggings survey at Boyagin NR carried out.	Monitor survival of young at Karroun Hill. Continue translocation to Tutanning. Continue monitoring diggings at Boyagin. Complete Boyagin report for WWFA.
	Management support, biology, ecology	19	Banded Hare-wallaby, Stage 3 (RS141) RIT Prince	Project suspended due to land tenure problems at Shark Bay & insufficient funds	Reactivate if problems solved with implementation of Shark Bay Region Plan
	Identify relict populations; specialized knowledge; management support; biology and ecology	20	Red-tailed phascogale distribution and ecology (42/91) JA Friend & GR Friend	Surveys completed at Lake Magenta NR, Dongolocking NR, Highbury SF and 6 smaller reserves in the Great Southern. Radio-tracking of 13 animals at Tutanning over 2 weeks in March gave further home range and nesting data	Surveys of other sites including Fitzgerald River NP, Bendering and N. Karlgarin NRs. Radio-tracking males and females during mating/male dieoff period in July 1991
	Identify relict populations; specialized knowledge; management support; biology and ecology	21	Status and conservation of the Western Mouse KD Morris & L Whisson	WWFA project. Surveyed wheatbelt reserves, long-term study sites established.	Continue obtaining biological information. Commence fox baiting trial at Dragon Rocks NR to determine effect on WM population
	Management support; biology and ecology	22	Re-introduction of the Greater Stick-nest Rat to WA (8/91) KD Morris	GSNR successfully translocated to Salutation I.	Continue monitoring wellbeing of population.
	Management support; biology and ecology	23	Quenda translocation methods JA Friend	Funding secured from MRD. Initial survey trapping carried out.	Determine quenda population size at source site. Select destination site from baited wheatbelt reserves. Set up translocation experiment to test efficacy of release enclosures.

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-1	Targets 1991-2
Population Studies; Management Applications	Biology and ecology	24	WA marine turtle conservation (RS144-5, 132-3) RIT Prince	External funding for operational and Aboriginal participation work secured; field program work continued with volunteer support and gas and oil industry assistance. Salvage and reporting network for SW improved. Attended AMTC workshop (Nov 1990) and presented data. Established regional international contacts during IUCN meeting.	Proceed with development of project as specified. Increase cooperative work in NW Shelf area. Submit preliminary results from project for publication.
	Biology and ecology	25	Biogeography of Dugong and seagrasses (RS142) RIT Prince	Liaison with external research workers and Aboriginal communities continued. Salvage specimens secure.	Plan Pilbara coastal surveys. Proceed as opportunities and resources allow.
	Identify populations; biology and ecology	26	Dugong conservation (RS142-4) RIT Prince	Discussion on Pilbara population work continuing	Proceed as funding permits
	Management of Aboriginal exploitation	27	Management of Dugong & marine turtle exploitation (RS142-4) RIT Prince	Contacts maintained. Problem areas for attention identified.	Proceed as funding permits.
	Specialized knowledge; biology and ecology	28	Life history of Drupella at Ningaloo (77/91) S Turner	Preliminary information on early life history stages obtained. Temporal and spatial distribution of juveniles at Ningaloo established.	Rear larvae through to settlement. Determine length of larval life. Determine behavioural responses during planktonic stage. Determine settlement responses.
	Potential impacts of feral exotic; control programs; techniques; contact with Regions	29	Eradication of Rattus on Barrow and Middle Is (28/91) KD Morris	Trial baiting program to determine techniques successfully undertaken.	Complete eradication on Barrow and Middle Is
	Specialized knowledge; specific needs; techniques; contact with Regions	30	Seabird database (7/91) AA Burbidge	Database maintained & updated	Continue; paper(s) integrating knowledge to be prepared
	Specialized knowledge; specific needs; techniques; contact with Regions	31	Island mammal database (64/91) AA Burbidge & IJ Abbott	Database maintained & updated; data being incorporated into draft paper	Continue; submit paper

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-1	Targets 1991-2
	Biology and ecology	32	Monitoring Lesser Noddy and other seabirds in Houtman Abrolhos (29/91) AA Burbidge	Population size of Sooty Tern on Pelsaert I estimated, two papers prepared.	Repeat count of all Lesser Noddy populations.
	Techniques; administrative support	33	Kangaroo management programs RIT Prince	Harvest quota advice provided. Planning for collaborative analysis of harvest and population data with ANPWS, NKMU personnel continuing.	Ongoing
Knowledge; management applications	Management support; techniques; biology and ecology	34	Marine conservation research methods SD Hopper/JA Friend	Supplementary grants made for research projects, reports received.	Decide future of program

FIRE PROGRAM

PROGRAM LEADER

GR Friend

CURRENT RESOURCES (1991/92)

This program comprises 12.55 persons (3.10 Professional + 9.45 Technical + 0.60 Contract Technical). Its estimated CRF budget is $569 686 ($406 986 salaries and $162 700 operating costs).

RESOURCES IN PREVIOUS YEAR

This program comprised 16.55 persons (6.00 Professional + 10.15 Technical to + 0.4 contract technical). Its budget was $758 626 ($595 926 salaries and $162 700 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 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

Prescribed burning of vertebrate and invertebrate sampling areas in the Stirling Range National Park was completed during the year, the burns being carried out in November 1990 (spring) and March/April 1991 (autumn). Regular trapping to monitor the impact of these fires is continuing.

Research on the effects of prescribed burning on vertebrates and invertebrates in wheatbelt nature reserves is also progressing. All of the burns planned for this project have now been completed, the most recent being on East Yorkrakine Nature Reserve in March 1991. Regular post-fire fauna sampling is continuing at Tutanning, Durokoppin and East Yorkrakine Nature Reserves. Post-fire trapping and radio-telemetry studies on the rare dasyurid *Phascogale calura* have also continued at Tutanning in conjunction with the Fauna Program.

The effects of fire on the vegetation in the Stirling Range National Park and at the Tutanning Nature Reserve continued to be monitored.

Autumn and spring samples of invertebrates from Jarrah forest in the Perup Nature Reserve have been collected as part of a long-term study of fire and invertebrates in this forest type. No burns have yet been conducted on these plots.

Fire ecology plots established in jarrah forests throughout the south-west were experimentally burnt again in spring 1990 and autumn 1991. This study aims to determine the long term effects of various fire regimes on the forest understorey. Assessment of the response of vegetation to various fire regimes is continuing.

Stem sections from large, old jarrah trees were analysed in an attempt to obtain data on the forest fire regime prior to European settlement. Preliminary results show that prior to settlement, incidence of fire injury was low, but increased significantly following settlement. This suggests that either fires were very infrequent (40-120 years apart), or were of low intensity and therefore frequent. Given the wide use of fire by Aborigines and the frequency of lightning strikes, the latter is more likely. Fire exclusion during the early part of this century allowed fuels to accumulate with the result that wildfires were very intense and damaging to the trees. The incidence of fire injury has reduced since the 1960s with the introduction of broadscale fuel reduction burning.

The experimental burning program in the Stirling Range National park continued with a further seven plots burnt. This work has confirmed the importance of litter fuel moisture content in determining thresholds for fire spread in mallee-heath fuels. Research staff gathered data during a number of prescribed fires and wildfires in the South Coast Region. Studies of crown fire initiation of *Pinus pinaster* stands were undertaken jointly with Fire Protection Branch and a visiting researcher from Forestry Canada.

Studies on the effect of fire on desert vertebrates are progressing. In Queen Victoria Spring Nature Reserve, study plots were sampled on three occasions and show interesting trends in species succession in agamid lizards and small mammals. The study area in the Gibson Desert Nature Reserve was burnt in October 1990 to leave patches of unburnt vegetation of different sizes. The vertebrate assemblages in these patches are being sampled in an ongoing study.

Old and senescing *Melaleuca viminea* thickets east of Collie were burnt last autumn to regenerate habitat suitable for the Tammar wallaby. Regeneration was poor as the fire was not intensive enough to stimulate seedfall. Another area is planned for regeneration with a higher intensity fire.

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 Karajini 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 1991 TO JUNE 1996 (numbers refer to the Table following)

1,2,3,5,6,11,16,20,21,22.

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.

PUBLICATIONS * & REPORTS 1990/91

*Burrows, N.D. and McCaw, W.L. (1990). Fuel characteristics and bushfire control in banksia low woodlands in Western Australia. J. Envir. Manage. 31:229-236.

*Burrows, N.D., Ward, B. and Robinson, A. (1991). Fire behaviour in spinifex fuels on the Gibson Desert Nature Reserve, Western Australia. J. Arid Envir. 20:189-204.

*Burrows, N.D. and van Didden, G. (1991). Patch burning desert nature reserves in Western Australia using aircraft. Int. J. Wildland Fire 1:49-55.

Friend, G.R. and Hall, G.P. (1990). Report No. 3 to WWF Australia Project P144 Fire and Invertebrate Conservation in Mallee-Heath Remnants.

Friend, G.R. and Hall, G.P. (1991). Report No. 4 to WWF Australia Project P144 Fire and Invertebrate Conservation in Mallee-Heath Remnants.

*Friend, G.R. and Hall, G.P. (1991). Mountains of Mystery. Landscope 6(4) : 9-13.

*Hall, G.P. and Friend, G.R. (1990). Distribution, habitat and behavioural patterns of *Nickerlea sloanei* (Lea) (Coleoptera : Cicindelinae) In southwestern Australia. J. R. Soc. W. Aust. 73: 57-59.

Start, A.N., van Leeuwen, S. Fuller, P.J. and Bromilow, R. (1991). Mulga and Fire. Landscope 6(4):20-23.

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks Completed 1990-91	Targets 1991-92
Fire Behaviour and Suppression	Fuel reduction guides for karri regrowth	1	Karri regrowth fuels 2/84 (L McCaw)	No action	Submit for publication
		2	Prescribed fire behaviour 21/85 (L McCaw)	No action	Prepare for publication.
		3	Fire damage to karri regrowth 15/85 (L McCaw)	Fuel accumulation sampled.	Analyse data and prepare for publication.
	Fire behaviour in heathlands and mallee shrublands	4	Fire behaviour in heathlands and shrublands 61/88 (L McCaw)	7 plots burnt. Data gathered from wildfires. Fitzgerald River N.P. fires written up.	Burn remaining plots.
	Complete analysis and write up of fire behaviour - jarrah forest	5	Fire studies - jarrah 28/78 (N Burrows)	Completed data analyses. Commenced write up.	Complete write up.
		6	Lab studies of fuels (combustion rates) 18/86 (N Burrows)	Completed data analysis.	Complete write up.
		7	Fuel studies in southern wetlands 47/86 (N Burrows)	Fifth annual remeasurement of structure and biomass. Progress reports submitted	Remeasure in June 1992. Submit progress reports
Fire Ecology	Effects of fire on forest understorey plant species and some animals	8	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 1991 & Autumn 1992. Complete seedling counts, biomass, photography at other sites.
		9	History of fire in the jarrah forest based on dendrochronological analysis (N Burrows)	Jarrah stems collected and prepared for analysis.	Complete analysis. Commence write up.
		10	Effects of 3 fire regimes on ground-dwelling invertebrates in Jarrah forest. 20/90 (G Friend)	Autumn and spring seasonal sampling of all treatments.	Continue seasonal trapping of all treatments.
		11	Regeneration of heartleaf thickets 7/84 (G.Wardell-Johnson)	Assessment completed.	Held in abeyance.
		12	Fire effect on Lambertia rariflora 23/87 (N Burrows)	Site burnt March 1991	Assess postfire mortality & recruitment. Prepare progress report.

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks Completed 1990-91	Targets 1991-92
	Fire effects - semi arid land reserves	13	Effects of prescribed burning on invertebrates in Durokoppin and East Yorkrakine Nature Reserve 19/90 (G. Friend)	East Yorkrakine burn completed. Seasonal trapping and data analysis continuing	Continue seasonal trapping, habitat assessment and data analysis
		14	Effects of prescribed burning on small vertebrates in Tutanning Nature Reserve 17/90 (G.Friend)	Seasonal trapping and data analysis continuing	Continue seasonal trapping and habitat assessment. Analyse data.
		15	Effects of prescribed burning on invertebrates in Tutanning Nature Reserve 18/90 (G. Friend)	Seasonal trapping and data analysis continuing	Continue seasonal trapping and habitat assessment. Analyse data.
		16	Effect of prescribed burning on Phascogale calura 21/90 (G. Friend/J.A. Friend)	Seasonal trapping, radio tracking and data analysis continuing.	Continue seasonal trapping and habitat assessment. Analyse data.
		17	Effects of fire on vegetation of Tutanning N.R. 52/91 (S. Hopper, G. Friend and A. Hopkins)	Annual assessment	Post fire sampling, analyse data.
	Fire effects - heathland and shrublands	18	Vegetation response to fire in shrublands, Stirling Range N.P. 53/91 (S. Hopper, G. Friend and A. Hopkins)	Pre-fire sampling.	Commence post fire monitoring.
		19	Fire effects on vegetation - Stirling Range N.P. 62/88 (L McCaw)	Plots burnt.	Post fire assessment.
		20	Fire effects on reptiles, frogs and small mammals. Stirling Range N.P. 31/88 (G Friend)	Seasonal burns completed.	Continue trapping and data analysis.
		21	Fire effects on invertebrates in the Stirling Ranges National Park 16/89 (G. Friend)	Seasonal burns completed.	Continue trapping and data analysis.

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks Completed 1990-91	Targets 1991-92
		22	Effects of various fire control strategies on vegetation 15/87 (L McCaw)	Submitted Ravensthorpe paper for publication.	
	Fire effects - hummock grasslands	23	Effects of mosaic burns on birds 20/88 (AA Burbidge)	First two post-burn censuses completed	Continue post-burn censuses.
		24	Effects of season of burn and fire size on desert vertebrates 32/88 (D Pearson)	Continued monitoring. Expanded trap grid, invertebrate sample grid established.	Continue monitoring, preliminary write up.
		25	Effects of fire on medium-sized desert mammals 38/88 (P.Christensen)	Continued habitat survey; description of habitat sites.	Continue monitoring.
		26	Effects of fire season & intensity on floral succession 33/88 (D Pearson)	Extensive vegetation and soil sampling, mapping, ground truthing.	Complete sampling, establish fire history, write up.
		27	Effects of patch burning on lizards 34/88 (D Pearson)	Study area burnt. Post fire monitoring.	Write up of initial response to fire.
		28	The effects of fire on floristics and structure of major vegetation communities in Plumridge Lakes Nature Reserves 106/91 (N.Burrows)	RPP suspended.	RPP suspended.
		29	Effects of patch-burning and feral predator control on the survival of rare mammals re-introduced to the Gibson Desert Nature Reserve. 60/90 (P Christensen, G. Liddelow)	Release sites located, burning and baiting strategies prepared.	Establish pit traps, assess and describe habitat, bait feral animals.
	Fire effects - mulga woodlands.	30	Effects of fire on invertebrate communities in mulga woodlands (S van Leeuwen and T Start).	Proposal prepared, study sites selected.	Prepare RPP, commence assessment.

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks Completed 1990-91	Targets 1991-92
		31	Effects of fire on vertebrate fauna in mulga woodlands (T Start and S van Leeuwen).	Proposal prepared, study sites selected.	Prepare RPP, commence assessment
		32	Effects of different fire regimes on the vegetation of mulga woodlands (S van Leeuwen and T Start).	Proposal prepared, study sites selected.	Prepare RPP, commence assessment.
Fire Management	Computerized fire management system - Tutanning N.R.	33	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.	34	37/88(D Pearson)	Collation of historical information and Aboriginal interviews.	Comparison of remotely sensed record, historical and oral evidence, preliminary write up.
	Protection of fire vulnerable communities in Karajini National Park	35	Identification of fire vulnerable mulga communities in the Karajini National Park (T. Start and S van Leeuwen). 54/91	RPP submitted, study sites sampled, initial assessment and data analysis commenced.	Complete data analysis, prepare publication.
	Prescriptions for the use of fire to regenerate specific habitat in forests of the south west.	36	Regeneration of suitable habitat for Tammar wallaby using fire. 59/60 (P. Christensen and G. Liddelow)	Monitoring of post fire regeneration. Other potential sites located for regeneration.	Monitor post-fire regeneration. Burn two other sites in Collie District. Arrange workshop on Tammar habitat.

FLORA COLLECTIONS PROGRAM

PROGRAM LEADER

BR Maslin

CURRENT RESOURCES (1991/92)

This program comprises 2.9 persons (2.9 professional FTE and 0.0 Technical FTE). Its estimated CRF budget is $172 482 (including $153 032 salaries and $19 540 operating costs).

RESOURCES IN PREVIOUS YEAR

This program comprised 5 persons (2.85 professional FTE and 2.15 technical FTE). Its budget was $43 739 (including $24 289 salaries and $19 450 operating costs).

ACHIEVEMENTS

In excess of 30 000 new records were entered into the WA Herbarium specimen database, WAHERB; this database now contains 115 000 specimen records. A grant of $105 000 from the Environmental Resources Information Network was received to database the genus *Eucalyptus*, selected grass genera and Kimberley *Acacia* species; to date almost 8000 records, from an estimated 28 000, have been databased. Funds from the Nature Conservation & National Parks Trust Account have enabled the databasing and curating of the State's conservation taxa to continue. Names have been captured for inclusion in the Census of W.A. Plant Names, WACENSUS.

AIM

To discriminate and describe the biological entities representing the diversity of the flora of Western Australia.

PRIMARY OBJECTIVE

Collections

To undertake systematic research on the State's flora and to provide authoritative names and species circumscription to the State Collection and its associated databases.

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)

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.

PUBLICATIONS* AND REPORTS 1990/91

*Lang, P. and Maslin, B.R. (1990). *Acacia praemorsa*. J. Adelaide Bot. Gard. 13: 118-123.

*Cowan, R.S and Maslin, B.R. (1990). A new species of Acacia from Western Australia. W.A. Naturalist 18(3): 79-82.

*Maslin, B.R., Conn, E.E. and Hall, N. (1990). Cyanogenesis in Australian Leguminosae: Herbarium survey of some *Acacia* and Papilionoideae species. Kingia 1(3): 283-294.

*Newbey, B.J. & Maslin, B.R. (1990). Obituary: Kenneth Raymond Newbey. Kingia 1(2): 135-139.

Primary Objective	5 Year Goal		Projects (RPP No.)	Tasks Completed 1990/91	Targets 1991/92
Collection	Maintain 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 1990/91
		2	Automated loans procedure. (A. Chapman)	New project	Design and implement procedures
		3	Automated specimen-folder labelling (A. Chapman)	New project	Design and implement procedure
Databases	Maintain and develop WAHERB specimen database	4	Manage WAHERB specimen database. (B.R. Maslin & A. Chapman)	New SUN Computer acquired.	
		5	Register of type specimens and photographs held at the Perth herbarium (B. Koch) 20/91	New project	Databank all type specimens and publish a preliminary register
		6	Integrate specimen label generation with data entry into WAHERB. (A. Chapman & B.R. Maslin)	New Project	Develop and implement procedures
		7	Specimen entry into WAHERB (K. Veryard, S. Bakker Contractees)	Acacia, Eucalyptus and Proaceae (in part) databanked. Automated loans procedure completed. Gazetted rare flora and Priority flora databanked	Data bank specimens as required, esp. Eucalyptus and Type specimens
	Maintain and develop Census of WA plant names	8	Maintain a current census of the flora of Western Australia. Capture new records and update records as required (P.G. Wilson)	Names information captured, including infraspecific taxa.	Incorporate into WACENSUS.

Primary Objective	5 Year Goal		Projects (RPP No.)	Tasks Completed 1990/91	Targets 1991/92
		9	Develop data base from current Census files (A. Chapman & P. Wilson)	-	-
Systematics	Chenopodiaceae	10	Halosarcia: taxonomy (P.G. Wilson) 115/91	-	Collect material of the known but undescribed species.
	Leguminosae: Mimosoideae	11	Acacia bivenosa group taxonomy and Flora of Australia treatment (B.R. Maslin & A.R. Chapman)	1 paper in press; Flora descriptions edited; illustrations commenced.	Publish paper, complete Flora editing, illustrations and key.
		12	Acacia sect. Plurinerves: taxonomy and Flora of Australia treatment. (B.R. Maslin & R.S. Cowan)	1 paper published; Flora descriptions edited; illustrations commenced.	Finalize MSS for miscellaneous new sp.; complete Flora editing, illustrations and key.
		13	Acacia sect. Juliflorae: taxonomy and Flora of Australia treatment. (B.R. Maslin & A.R. Chapman)	MSS descriptions of new species prepared; Flora descriptions prepared.	Publish new species; edit Flora descriptions.
		14	Acacia sect. Alatae. (B.R. Maslin)	Flora descriptions prepared; MS descriptions of new taxa prepared	Prepare MS for publication
		15	Acacia sect. Pulchellae. (B.R. Maslin)	Flora descriptions edited for c.30 species	Complete illustrations
		16	Acacia: assessment of generic status (B.R. Maslin et al.) 145/91	Immunological study in progress (with P. Brain, Africa). MS prepared (with C. Stirton, England). Application for funds to work abroad (with J. Aronson, France and D. Seigler, USA).	Publish papers.
	Asteraceae: Inuleae	17	Helipterum-Helichrysum generic classification (P.G. Wilson) 116/91	Completed; MSS prepared	Publish papers; prepare Flora of Australia treatment.
	Rutaceae	18	Systematics of the genera Argentipallium and Lawrencella sensu lato (Asteraceae : Gnaphalieae) PG Wilson	-	-

Primary Objective	5 Year Goal		Projects (RPP No.)	Tasks Completed 1990/91	Targests 1991/92
		19	Phebalium sens. lat. (JA Armstrong and P. Waterman, Scotland)	Material from 30 taxa collected and papers prepared	Collect further material for collaboration.
		20	Tribe Boronieae (Rutaceae) (J.A. Armstrong) 117/91	Publication prepared	Submit for publication
		21	Acacia survey of hybridity (B.R. Maslin et al.)	Database of Acacia hybrids prepared	Prepare MS
	Compile catalogue of floristic lists for W.A.	22	Prepare floristic lists (K.F. Kenneally)	New project	Catalogue the published floristic lists
	Provide index to information on taxonomy of WA plants	23	Develop index systems (P.G. Wilson, Librarian)	Index cards prepared for current year	Continue
	General	24	Brown, R.: Aiton's Hortus Kewensis contribution (BR Maslin)	MS in preparation	Complete MS
		25	Dorrien-Smith, A.A.:Plant collection from south-west WA (K.F. Kenneally)	Localities identified	Ongoing as time permits.
		26	Fitzgerald, W.V.:diary. (K.F. Kenneally) 143/91	Further editing & field surveys carried out.	Edit MS and prepare biography.
		27	Gould, J./Gilbert, J.: Plant collecting in the Swan River Colony. (K.F. Kenneally)	Further editing & archival documents examined	Edit MS for publications.

FLORA CONSERVATION PROGRAM

PROGRAM LEADER

DJ Coates

CURRENT RESOURCES (1991/92)

This program comprises 6.65 persons (5.0 Professional + 0.04 Technical). Its estimated CRF budget is $304 595(including $254 395 salaries and $50 200 operating costs).

RESOURCES IN PREVIOUS YEAR

This program comprised 6.15 persons (4.25 Professional + 1.90 Technical). Its budget was $202 489 including $152 289 salaries and $50 200 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. Research will continue on the distribution and impact of environmental weeds. 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

Area based Wildlife management programs for rare and threatened flora in the CALM Merredin District and the CALM Metropolitan Region are near completion following extensive surveys of these areas. In total 164 rare and threatened taxa were surveyed including 42 Declared Rare Flora. Some 140 new populations were documented which also included populations of two presumed extinct species *Sowerbaea multicaulis* and *Calytrix breviseta* subsp. *breviseta.*

Conservation genetic, breeding system and population ecology studies have been completed for three species of Declared Rare Flora *Acacia anomala, Banksia cuneata,* and *Stylidium coroniforme* and are near completion for *Diuris purdiei.* The preparation of Wildlife Management Programs for these species has been initiated. These studies have been particularly informative in the development of strategies for the conservation of genetic resources and management of these and other rare or threatened plant species. The preparation of ANPWS funded recovery plans for *Eucalyptus rhodantha, Acacia anomala, Banksia cuneata* and *Stylidium coroniforme* is also underway.

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 survey major invasive weeds and assess their impact on the native flora particularly rare and endangered species. 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 undertake surveys of major invasive weeds and assess their impact on the native flora.**

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. Carry out surveys of major invasive weeds in the metropolitan region and adjacent areas.

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

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

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

12. 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 1991 TO JUNE 1996
(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; $70,000 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 1990/91

*Clasen-Bockhoff, R., Armstrong, J.A. and Lehne, M. (1991). The inflorescences of the Australian genera *Diplolaena* R. Br. and *Chorilaena* Endl. (Rutaceae). Aust. J. Bot. 39 : 31-42.

*Coates, D.J. (1991). The protection of Western Australia's flora. Proceedings of the International Plant Propagators Conference, 1990.

*Coates, D. J. and Marchant N. (1990). Growing in a wild state. Landscope 6(1): 49-53.

*Coates, D.J. (1991). Gene flow along corridors. In *Nature Conservation* 2: The role of corridors. Eds D.A. Saunders and R.J. Hobbs. Surrey Beatty, New South Wales, pp. 408-409.

*El-Turbi, J.A., Armstrong, J.A., Gray, A.I. and Waterman, P.G. (1990). Novel 6-methoxymurranganon derivatives from the aerial parts of *Phebalium elatius* ssp. *beckleri*. Phytochemistry 29: 3982-3983.

*El-Turbi, J.A., Armstrong, J.A., Gray, A.I. and Waterman, P.G. (1991). Further coumarins from the aerial parts of *Phebalium elatius* subsp. *beckleri*. Z. Naturforsch, 45C: 927-930.

*Hopper, S.D. (1991). How valuable are linear remnants as records of plant distribution. In *Nature Conservation* 2: The role of corridors. Eds D.A. Saunders and R.J. Hobbs. Surrey Beatty, New South Wales, p. 401.

*Hopper, S.D. (1989). Western Australian rare flora legislation and its implementation. In M. Hicks and P. Eiser (eds). The Conservation of Threatened Species and their Habitats, pp. 120-132. (Australian Committee for IUCN, Canberra).

*Hopper, S.D. (1989). An overview of the bush picking industry. In M.G. Webb and P.D. Dawson (eds), Bush picking of wildflowers: seminar proceedings, Albany July 1988, pp. 1-6 Western Australian Department of Agriculture Miscellaneous Publication No. 11/90 (Department of Agriculture, Perth).

*Hopper, S.D. (1989). Summary. In M.G. Webb and P.D. Dawson (eds). Bush picking of wildflowers: seminar proceedings. Albany July 1988, pp 21-22. Western Australian Department of Agriculture Miscellaneous Publication No. 11/90. (Department of Agriculture, Perth).

*Hopper, S.D. (1990). Conservation status of mallee eucalypts in southern Western Australia. In J.C. Noble, P.J. Joss and G.K. Jones (eds), The Mallee Lands: a conservation perspective, pp. 21-24 (CSIRO, East Melbourne).

*Hopper, S.D. (1991). Fitzgerald reborn. Landscope 6(3): 34-38.

*Keighery, G.J. (1991). Biological notes on *Schoenus capillifolius* (Cyperaceae) a rare and unusual sedge. W. Aust. Nat. 18 : 157-159.

Keighery, G.J. (1991). Pollination of *Hibbertia conspicua* (Dilleniaceae). W. Aust. Nat. 18 : 163-165.

*Keighery, G.J. (1991). *Banksia canei* (Mountain Banksia) in Western Australia. W. Aust. Nat. 18 : 167-168.

*Powell, R. with assistance from Emberson, J., Hopper, S. and McMillan, P. (1990). Leaf and branch: trees and tall shrubs of Perth, pp. 239. (Department of Consrvation and Land Management, Perth).

*Quader, M.A., Armstrong, J.A., Gray, A.I. Hartley, T.G. and Waterman, P.G. (1991). Chemosystematics of *Acradenia* and general significance of acetophenones in the Rutaceae. Biochem. Syst. Ecol, 19 No.2: 171-176.

Sampson, J. and Hopper, S.D. (1990). Endangered Poison Plants of Western Australia. Final Report WWF Project P105, 81 pp. (Department of Conservation and Land Management, Perth).

*Sampson, J., Hopper, S.D. and James, S.H. (1990). Temporal variation in *Eucalyptus rhodantha* pollen pool allele frequencies. Heredity 65 : 189-199.

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
Rare and Endangered Flora surveys	Field surveys; assist in review of schedule, revisions of endangered flora data base. Prepare Wildlife Management Programs	1	Field surveys and conservation status of rare and threatened flora D. Coates S. Patrick S. Hopper 134/91	Several surveys; completed	Continue surveys as time permits
		2	Merredin District survey F. Mollemans D. Coates, P. Brown	Survey completed, reports submitted to ANPWS	Publish Wildlife Management Program
		3	Metropolitan Region survey A. Kelly, A Taylor, M Langley, D. Coates	Surveys completed, reports submitted to ANPWS	Publish Wildlife Management Program
		4	Moora District survey S. Patrick D. Coates 127/91	Detailed surveys commenced	Continue surveys
		5	Scott Plains survey G. Keighery, D. Coates	Surveys completed	Publish report
		6	Rare eucalypt survey A. Kelly, A. Napier, S. Hopper 120/91	Draft/mapping finalised	Submit for publication
Population Biology	Wildlife management Program	7	Acacia anomala D. Coates 128/91	Nil	Prepare Wildlife Management Program/Recovery Plan
		8	Drakaea elastica S. Carstairs, S. Hopper, D. Coates	Field studies near completion, monitoring quadrats established, isozyme studies started.	Complete field and isozyme studies, submit final report to ANPWS
		9	Rhizanthella gardneri S. Carstairs, D. Coates	Field and isozyme electrophoretic studies continued	Complete field/ population studies, Submit final report to ANPWS
		10	Diuris micrantha S. Carstairs, D. Coates	Field population/ecology studies continued	Complete field/ population/ isozyme studies, submit final report to ANPWS
		11	Caladenia 'elegans' S. Carstairs, D. Coates	Started field/ isozyme studies	Complete field/ isozyme studies, submit final report to ANPWS
		12	Caladenia 'caesarea' subsp 'maritima' S. Carstairs, D. Coates	Starts field/ isozyme studies	Complete field/ isozyme studies, Submit final report to ANPWS

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
		13	Diuris purdiei D. Goble-Garrett, D. Coates, K. Dixon	Surveys, population ecology and propagation studies continued	Complete research. Prepare Wildlife Management Program
		14	Population biology and conservation genetics of Banksia cuneata/oligantha/ilicifolia D. Coates 132/91	Population genetic, mating system studies completed for B. cuneata, field studies started on B. oligantha	Prepare Wildlife Management Program/ Recovery Plan for B. cuneata. Start population studies on B. oligantha
		15	Stylidium coroniforme D. Coates 130/91	Population genetic studies near completion	Submit for publication. Prepare Wildlife Management Program
		16	Population biology and conservation genetics of Banksia brownii D. Coates, G. Keighery 131/91	Completed field surveys and collections of seed material	Continue population genetic/ ecological studies
		17	Darwinia carnea G. Keighery, N.G. Marchant	Surveys near completion	Prepare Wildlife Management Program, report to ANPWS
		18	Population biology and conservation genetics of Banksia verticillata D. Coates 129/91	Nil	Start isozyme studies
	Monitoring quadrats	19	Monitoring quadrats on priority Declared Endangered Flora D. Coates, S. Hopper	Nil	Defer subject to resoures
		20	Recovery of DEF on East Mt Barren S. Hopper D. Coates	Established monitoring quadrats	Defer subject to resources
Biosystematics	Phylogenetics and evolution	21	Tetratheca species J. Alford, G. Keighery	Honours thesis completed, Publication accepted by Nuytsia	Prepare publications
		22	Biosystematics and evolution in Stylidium D. Coates 133/91	Completed field surveys of some taxa, continued isozyme/chromosome studies	Continue field studies, Assess conservation status of various taxa, prepare and submit Ms
		23	Taxonomy and phylogeny of Rutaceae J.A. Armstrong PG Wilson 119/91	Chemosystematics of Phebalium and Acradenia published. Description of new species submitted for publication	Start phylogeny and revision of Western Australian genera

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
	Systematics	24	Systematics and biogeography of Western Australian eucalypts S.D. Hopper 125/91	Ms on E. wandoo and allies accepted for publication in Nuytsia	Publish E. wandoo paper, submit paper to Nuytsia describing miscellaneous new taxa. Complete herbarium and field work on E. series cornutae
		25	Systematics of selected Western Australian orchids (Caladenia and allied genera) S.D. Hopper, A. Brown 126/91	Ms describing new taxa completed	Publish as an appendix in the revised edition of Hoffman and Brown's orchid book. Revise Ms and resubmit to Nuytsia
		26	Systematics of kangaroo paws and related plants S.D. Hopper 122/91	Fieldwork on new taxa completed. Photographs for book finalised	Draft papers describing new taxa, addressing generic taxonomy. Draft text of kangaroo paw book
		27	Taxonomic revision of Beaufortia R. Br A.A. Burbidge 138/91	nil	Complete study of type specimens
		28	Darwinia:conservation status of new taxa N.G. Marchant, G.J. Keighery	Surveys completed, new taxa delimited	Prepare manuscripts for publication.
		29	Grevillea taxonomy, conservation status G.J. Keighery	Publication in Nuytsia and another accepted	Prepare MS on Grevillea acuaria complex
		30	Taxonomic research on Liliaceae sens lat and related monocots of WA T.D. MacFarlane 141/91	Nil	Describe new species of Chamaexeros, Wurmbea; prepare paper on Haemodorum
		31	Taxonomy of selected WA grasses T.D. MacFarlane 139/91	New project	Investigate Amphipogon; examine possible new species of Neurachne
		32	Taxonomy of Pultenaea and other legume genera TD MacFarlane 140/91	Studied type and other specimens in various Herbaria	Prepare revision and paper for publication

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
		33	Conservation status of members of the family Rhamnaceae B. Rye 135/91	New project	Survey the family to determine which taxa should be on the priority species list
		34	Taxonomy of the Tiliaceae B. Rye 137/91	New project	Arrange loans of type specimens, draw up list of priority taxa and prepare keys
		35	Taxonomic studies in the Cyperaceae B. Rye 136/91	New project	Survey family and prepare list of priority taxa.
		36	Nomenclatural problems associated with taxa on the Declared Rare Flora presumed extinct list G. Perry 142/91	New project	Start literature survey, arrange loans of type specimens
Environmental Weeds	Surveys	37	Metro region weed surveys G. Keighery	Ad hoc surveys carried out	Continue surveys
Communication	Endangered Flora publications	38	Review rare flora conservation in WA RS73 S. Hopper, D. Coates	nil	Start new literature review on plant conservation genetics
	Other publications, educational material	39	Orchids in major WA conservation reserves S. Hopper, A. Brown 124/91	Surveyed Fitzgerald R NP after fire, published Landscope article	Complete field survey of Stirling Range NP, surveys of recently burnt Kalbarri, Yanchep, Peak Charles and Cape Arid NPs
		40	Book on pollination of WA orchids S. Hopper, A. Brown 121/91	Nil	Complete writing
Wildflower Industry	Management Programs	41	Kangaroo Paws: Anigozanthos pulcherrimus, Macropidia fuliginosa S. D Hopper 123/91	2nd.App Sci Thesis completed. Management program partially drafted	Complete mangement programs for publication.
		42	Banksia coccinea RS29 D Coates	Nil	Defer, subject to resources

FLORA INFORMATION PROGRAM

PROGRAM LEADER

NS Lander

CURRENT RESOURCES (1991/92)

The program comprises 4.20 persons (3.50 professionals and 0.7 technical). Its estimated budget is $219 967 (including $202 267 salaries and $19 700) operating costs.

RESOURCES IN PREVIOUS YEAR

The program comprised 5.0 persons (3.55 professionals and 1.45 technical). Its CRF budget was $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.

Thus during 1990/91 this program has been responsible for providing an identification service to scientists and the public who wished to identify native and naturalised flora; it has also supervised the maintenance of the Community Reference Herbarium at the WA Herbarium. These functions will now pass to the Herbarium Services Program.

ACHIEVEMENTS

The enormous task of preparing the manuscript of the *Flora of the Kimberley Region* is now at typesetting stage. The project, which has taken six years to complete, keys out and describes all of the flowering plants recorded in the Kimberley Region.

Treatments of the genera *Kippistia, Minuria* and *Olearia* for the forthcoming Flora of New South Wales were completed.

Dr Terry Macfarlane completed his tour of duty as Australian Liaison Botanist at the Royal Botanic Gardens, Kew, England. During this year he also spent three months in Paris at the invitation of the Musée d'Histoire Naturel.

A plant identification course was held for the CALM's Northern Forest Region.

A total of 7 671 general enquiries were serviced and in addition, a further 340 forensic enquiries were handled.

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.

To facilitate the identification of native and naturalised Western Australian flora by enabling easy and efficient naming of taxa by means of the Reference Herbarium, expert advice, published guides and computerised identification and information retrieval methods.

20 YEAR GOALS

1. Long-term capture, maintenance and presentation of descriptive taxonomic information on the State's flora, using current computer technology.***

2. Publish regional flora accounts covering the whole of Western Australia.***

3 Publish identification manuals for all threatened taxa and for indigenous plants of economic importance.***

5 YEAR GOALS

1. Develop the framework, methods, tools and standards necessary for the systematic long-term capture, maintenance and presentation of descriptive taxonomic information on the State's flora, using current computer technology.

2. Develop a user-friendly publication format for identification manuals enabling identification of the Western Australian flora.

3. Prepare and publish a pilot study identification manual of the genus *Agonis* (Myrtaceae).

4. Prepare a flora of a region in the lower south west of Western Australia.

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. Contribute to other identification manuals, including Flora of Australia.

8. Publish *Flora of the Kimberley Region*.

9. Edit and publish the Journal *Nuytsia*.

PROJECTS TO BE COMPLETED FROM JULY 1991 TO JUNE 1996

47/91, 48/91, 51/91, 2, 4, 7, 9, 10, 12, 15.

PROPOSED NEW PROJECTS - with additional resources

1. Identification manual for wetland plants of south west Western Australia.

2. Regional flora of the lower south west of Western Australia.

PUBLICATIONS* AND REPORTS 1990/1991

Cranfield, R.J. (1991). List of vascular plants recorded from the Murchison Catchment Survey area 1985-1988. Kingia 1(4): 327-347.

Lander, N.S. (1991). New taxa and new combinations in *Olearia* (Asteraceae: Astereae) from south-eastern Australia. Telopea 4(2): 145-164.

Flora Information Section, Western Australian Herbarium (1991). Sources of Information on the Vegetation and Flora of Western Australia. Department of Conservation & Land Management: Como. [11 pages.]

EDITORIAL 1990/1991

Nuytsia 7(3): 231-394

Kingia 1(2): 135-253 (1991)

Kingia 1(3): 255-319 (1991)

Kingia 1(4): 321-459 (1991)

Primary Objective	5 Year Goals		Projects (RPP No.)	Tasks Completed 1990/91	Targets 1991/92
Flora Research	Regional Floras, Field Guides	1	Flora of the Kimberley Region (J. Wheeler, B. Rye, B. Koch) 47/91	Editing complete; typesetting commenced	Publish Flora
		2	INFORM: an integrated taxonomic multimedia tool for the description of Western Australian Flora (A. Chapman, T. Macfarlane, N. Lander) 48/91	New Project	Review, evaluation and acquisition of software hardware, relevant data set, potential markets; development of standard format for the capture, maintenance, utilisation and distribution of taxonomic data
		3	Identification guides to allergenic, weedy and other economically important plants (S. Patrick) 49/91	Project commenced July 1990	Ongoing
		4	Asteraceae (N. Lander) 50/91	Papers published on Olearia; accounts of Kippistia, Minuria & Olearia for Flora of New South Wales completed.	Publish new taxa; publish account of Olearia for Flora of N.S.W.
		5	Identification guides to threatened and Reserve List taxa (S. Patrick) 51/91	Guide to endemic plants of the Darling Scarp commenced July 1990	Publish guide-book
		6	Flora of the Perth Region, Revision (N. Marchant, J. Wheeler)	Information collected and edited	Ongoing
		7	Field guide to Agonis (Myrtaceae) - (N. Marchant, J. Wheeler) 112/91	Project commenced March 1991; format developed	Complete and publish
		8	Leguminosae and Poaceae (T. Macfarlane) 140/91	Type specimens examined in various herbaria; Pultenaea ericifolia group studied	Complete Flora of Australia manuscript for Western Australian species of Pultenaea

Primary Objective	5 Year Goals		Projects (RPP No.)	Tasks Completed 1990/91	Targets 1991/92
	Taxonomic Studies	9	Myrtaceae (N. Marchant, G. Keighery) 85/91	New species descriptions prepared	Publish Actinodium and Chamelaucium
		10	Droseraceae (N. Marchant) 84/91	New species descriptions prepared	Publish new taxa
		11	Rhamnaceae (B. Rye) 46/91	Project commenced March 1991	Ongoing
Flora Extension	Advisory Service	12	Establishment of new identification system (various program staff)	Project complete (see Flora Services Program)	
		13	Extension of Reference collection (various program staff)	Project complete (see Herbarium Services Program)	-
		14	Manual for preparation of herbarium specimens (S. Patrick)	Revise draft	Publish
		15	Public lectures, extension courses and displays (various program staff)	Numerous lectures given	Present as required
		16	Editing of Nuytsia (K. Kenneally, various program staff)	1 issue published	Publish 2 issues
		17	Editing of Kingia (various program staff)	3 issues published. Project complete (journal discontinued)	

HERBARIUM SERVICES

PROGRAM LEADER

CS Fang

CURRENT RESOURCES (1991-1992)

The program comprises 5.8 persons (0.0 Professional and 5.8 Technical). Its estimated CRF budget is $313 409, including $154 709 salaries and $158 700 operating costs.

BACKGROUND

The Herbarium Services Program was formed in 1991 to separate service activities associated with curation of the State Flora Collection.

The State Collection, the Western Australian Herbarium, houses voucher specimens of the State flora and is comprised of approximately 450,000 specimens of algae, fungi, lichens, mosses, liverworts, ferns and fern allies, gymnosperms, monocotyledons and dicotyledons.

The State Collection services CALM's flora-based research programs, Biogeography Program, Nature Conservation, CALM Operations and Corporate Relations Division.

AIM

To inventory the natural plant diversity of Western Australia by collecting, preserving and databasing voucher specimens of a representative sample of all Western Australian plant taxa.

PRIMARY OBJECTIVES

To service CALM's flora-based research programs by:

- collecting and processing voucher specimens and incorporating them into the State Collection;
- ensuring that all collected specimens are accurately named prior to incorporation into the State collection;
- adopting relevant published research information so that the collection is curated according to current taxonomic information;
- maintain the WAHERB specimen database;
- maintain WACENSUS as the current census of the Western Australian flora;
- safely storing the collections so that specimens are preserved in perpetuity;
- facilitating loan of specimens for taxonomic studies; and
- facilitating identification of flora.

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

1. Provide adequate storage for the State Collection.
2. Ensure that the specimens of each taxon are accurately identified, according to the accepted circumscription of the taxon.

5 YEAR GOALS

1. Improve curatorial procedures to ensure the quality of incorporated material.
2. Expand the Public Access Herbarium so that it has a greater taxonomic coverage of the vascular plant flora.
3. Incorporate backlog specimens.

NATIVE FOREST SILVICULTURE PROGRAM

PROGRAM LEADER

S Crombie

CURRENT RESOURCES (1991/92)

This program comprises 8.65 persons (3.15 Professional and 5.50 Technical). Its CRF budget is $377 073 (including $274 773 salaries and $102 300 operating costs).

RESOURCES IN PREVIOUS YEAR

Staff 9.6 (3.1 Professional and 6.5 Technical). CRF budget was $385 219 ($282 919 salaries and $102 300 operating costs).

BACKGROUND

The Native Forest Silviculture Program was formed in 1990. It reflects the Department's objective of efficiently managing the production of wood form 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 effectiveness of regeneration on difficult sites needs to be documented. 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. Options for improving the success, and reducing the costs, of artificial regeneration require investigation. 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 environment and stand factors affecting wood production should be gained by 1996. 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 has been 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

The Program was reviewed in April 1991 and increased emphasis has been placed on forest and woodland conservation, disturbance ecology and silvicultural systems.

Karri (*Eucalyptus diversicolor*) silvicultural and ecological knowledge was summarised for publication as the Karri Bulletin. This will complement the Jarrah Bulletin produced in 1986 by Abbott and Loneragan and the book "The Jarrah Forest" edited by Dell, Havel and Malajczuk. Karri growth and survival trials have been remeasured and new trials are being established to complete coverage of karri's natural range.

Three methods of measuring water use by forest trees (sap flux by automated heat pulse logging, leaf transpiration by meteorological and stomatal conductance measurements, soil water extraction by neutron probe) have been compared. Reliable measurement of tree water use will be of assistance in determining likelihood of water stress and efficiency of water use in both native forests and plantations. This is a major collaborative project involving CALM, CSIRO, Water Authority of WA and ALCOA.

The effects of firewood collection and of logging on the number of tree hollows suitable for faunal habitat were studied. Data collected are being analysed.

Survey of bushland remnants nominated for the Remnant Vegetation Protection Scheme was completed. The survey found that a significant percentage of remnants had been incorrectly described by the landowners. However, errors in provision of fencing grants to farmers were considered acceptable considering the aims overall benefits of the scheme.

Silvicultural, dieback and vegetation-type surveys were completed on the Yarragil 9A experimental catchment. The catchment is now ready for thinning.

AIM

To provide the sound scientific base necessary to optimize multiple use management of forest and woodland ecosystems in Western Australia

PRIMARY OBJECTIVES

Native Forest Management

To develop silvicultural practices to optimise forest values such as wood and water production, conservation, recreation and visual amenity.

Regeneration and Establishment

To determine how trees in native forests differ in their rates of growth, capacity for regeneration and response to disturbance (e.g. disease, insects, drought)

Forest and Woodland Genetics

To optimize wood production, wood quality, pest insect and disease tolerance by the selection, breeding and production of superior genotypes while conserving genetic resources within native forests and woodlands.

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. To develop models relevant to wood production and hydrological processes which incorporate the extremes of stand stocking, stand structure, insect and fungal impact and to use these models to predict impacts over space and time.

2. To maintain, monitor and analyse long-term growth experiments essential to improving silvicultural management of forests and woodlands.

3. Be able to regenerate difficult sites with jarrah, karri or other desired species.

5 YEAR GOALS

1. Develop regeneration techniques to optimise karri and jarrah stand development.

2. Determine the effect of initial spacing, thinning and fertilizer application on the growth of karri on a range of different sites.

3. Refine methods for thinning jarrah stands.

4. Implement a system for co-ordinating biogeographic, ecological and silvicultural research related to site disturbance (including logging and silvicultural management) and for obtaining of adequate funding for such research.

5. Determining the suitability of jarrah residues for use in commercial products including wood composites (Valwood) and as firewood.

6. Develop priorities and practices for protection and management of remnants of native vegetation on farmland.

7. Determine, using isozyme analysis, the distribution of genetic variation in marri, jarrah and other selected species and formulate a strategy for the efficient management of these genetic resources.

8. Determine the range and influence of genetic variation on form, growth rate and other silviculturally important attributes of karri, marri, jarrah and other selected species using provenance planting trials.

9. 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.

10. Finalise experiments assessing effects of stand density and fertilisation on the growth rates of jarrah poles.

11. Investigate the breeding system of karri and develop treatments to maximize the production of seed from orchards.

12. Be able to model the effects of forest management on the quantity and quality of water produced from water catchments in the jarrah forest.

PROJECTS TO BE COMPLETED FROM JULY 1991 TO JUNE 1996 (numbers refer to the Table following).

Karri
9,43-45, 51-53, 54 (most)

Genetics
55, 56, 60

Jarrah
21, 22-32, 33-41

Native Vegetation Remnants
1-5, 7

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

Implement a scheme of co-ordinated research biogeographic, ecological and silvicultural research to study the effect of forest management on the jarrah forest ecosystem.

Develop priorities for management of native vegetation remnants.

Investigate the effects of thinning on the growth and form of crop trees in a young regrowth karri stand on a low rainfall site.

Assess coppice regrowth after jarrah stand improvement.

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

Effect of initial espacement on growth and form of planted *E. diversicolor* seedlings on a high quality site.

Determine availability of hollows in logs and trees of potential value as fauna habitat in and the effect of firewood harvesting on hollow availability.

Develop regeneration techniques for degraded remnants of native vegetation.

Measure longterm effects of fertiliser on survival, growth and form of karri seedlings.

Determine the reasons for poor regeneration of jarrah on difficult sites.

E. patens seed collection.

PUBLICATIONS *AND REPORTS 1990/91

*Borg, H. and Stoneman, G.L. 1991 Long-term implications for streamflow of changes in vegetation cover and stand height in regenerating karri stands in south-west Australia. Forest Ecology and Management 40:65-73.

*Bradshaw, F. J., Adams, R., Sneeuwjagt, R., Low, K, Havel, J., Bartle, J.R. and Stoneman, G.L. (1990) The jarrah forest: a case study in multiple use. *In*: Forest Management in Australia. Institute of Foresters of Australia, Surrey Beatty Publications.

Chester, G. 1990. Interception of Rainfall in the Jarrah Forest. Honours Thesis, Murdoch University, Western Australia.

*Chester, G. and Crombie, D.S. 1990. Interception of rain in forests: A review of study methods. Land and Water Research News, 7:25-27 (Published by West Australian Steering committee for Research on Land Use and Water Supply).

*Loneragan, O.W. 1990 Historical review of sandalwood (*Santalum speciatum*) research in Western Australia. CALM Research Bulletin Number 4.

Portlock, C.C. 1991. Rottnest Island Management Plan. Mid-Term Review, CALM.

*Ruprecht, J., Schofield, N. and Crombie, D.S. 1990. Early hydrologic response to forest thinning in the jarrah forest. Land and Water Research News, 7:12-16.

Stoneman, G.L. 1990. Forest density reduction in a small catchment of the northern jarrah forest and the effect on water and wood production. M. Sc. Thesis, University of Western Australia.

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
Remnant Native Vegetation	Management of remnant native vegetation.		Wandoo decline (P Pigott)		
		1.	56/86	Data analysed MS in prep	Publish
		2.	63/86	"	Publish
		3.	78/86	"	Publish
		4.	15/87	"	Publish
		5.	56/87	Treatment continued	Complete & publish
		6.	Grazing exclusion (P Pigott)54/86	Monitor	Monitor
			Selection of remnants for protection (P Pigott)		
		7.	20/89	Conducted survey	Report
		8.	30/89	Established	Monitor
Site Classification	Karri site classification		Karri site classification 19/86 (G Inions)	Published	
		9.	9/88 (P Hewett)	Trial mapping complete. Report prepared.	Complete report
Stand Management	Jarrah stand management	10.	Monitoring in disturbed native forest (S Crombie)	Trial aborted	
			Thinning and fertilization (S Crombie)		
		11.	2/88	Measurements completed.	Analyse for publication.
			Compare effectiveness of nitrogen fixation by native legumes with nitrogen fertilization on jarrah growth.	No action	Prepare RPP
			Thinning responses and growth rates (S Crombie)		
		12.	49/65	No action (Maintenance)	No action
		13.	15/66	No action (Maintenance)	No action

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
		14.	17/83	Measurements complete	Put on maintenance, analyse data.
		15.	Determine reasons for understocking and poor stand structure on some sites in NJF	No action	Prepare RPP
		16.	Determine the effect of stump coppice and advance growth on pole and stand increment and site hydroogy.	No action	Prepare RPP
		17.	Assess the relative and total effect of various tree and stand characteristics on the growth rate of jarrah sapings poles and piles.	No action	Prepare RPP
			Hydrology, water yield and quality (S Crombie)		
		18.	1/77	Yarragil 9A surveyed for site type and dieback.	Thin Yarragil 9A.
		19.	16/84	Monitoring continuing	Continue monitoring
		20.	30/85	Mined and rehabilitated	
		21.	Leaf area measurement (K Whitford) 2/88	Surveyed Yarragil 9A.	Revise MS, resubmit.
	Jarrah thinning techniques		Chemical thinning of Jarrah (S Crombie)		
		22.	37/84	Assessment complete.	Analyse and publish.
		23.	34/85	"	
		24.	35/85	"	
		26.	36/85	"	
		27.	39/85		
		28.	40/85		

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
		29.	40/85		
		30.	41/85		
		31.	30/86		
		32.	31/86		
	Jarrah regeneration		Regeneration techniques (P. Hewett)		
		33.	34/80	Projects under review	Finalize reviews
		34.	18/83	"	
		36.	10/83	"	
		38.	12/84	"	
		39.	13/84	"	
		40.	6/86	"	
		41.	43/86	"	
		42.	Identify and remedy regeneration problems in the northern Jarrah forest.	No action	Prepare RPP
	Karri stand management		Karri thinning, spacing and establishment (P Hewett)		
		43.	3/84	Analyses almost complete	Prepare paper
		44.	25/85	Analysis almost complete	Prepare paper
		45.	3/89	Remeasured	Preliminary analysists 1991.
		46.	21/77	No action	No action
		47.	25/86	Experiment destroyed in Permberton wildfire Prepare draft report 1991	Prepare draft report
		48.	57/90	New project, established, measured at 1,4,6 months	Remeasure 12 months
		49.	56/90	" "	Some infill required remeasure 12 months.

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
		50.	/91	New project, planning and initial survey underway	Complete plot establishment, treatments & measurements.
		51.	15/82	Data analysed	Prepare draft report
		52.	13/89	Analysis and preliminary report	Finalize and close
		53.	17/89	New project, established and assessed.	12 month assessment and report.
		54.	24/89	Infilling surveyed	Analyse and prepare report
Tree Breeding	Jarrah genetic diversity		Genotype variation in Jarrah (R Mazanec)		
		55.	38/71	Measured	Analyse
		56.	26/78	Measurement complete	Analyse & prepare MS
		57.	3/87	Mortality count	No action
		58.	6/87	Mortality count	No action
		59.	9/89	Established mortality count	No action
		60.	11/89	Seed collected	Complete project
		61.	Establish Marri Provenance trial	RPP in prep.	Seed reconnaissance and seed collection
		62.	Karri progeny trial	Measured	Prepare RPP
		63.	E. patens	Seed collection	Prepare RPP
Karri genetic diversity			Genotype variation in Karri (D Coates, R. Mazanec)		
		64.	R.S. 28	Initiated studies of mating systems in karri	Continue monitoring
		65.	26/78	Data processed	Measure second trial. Index selection
		66.	Seed production	New project	Prepare RPP
		67.	Propagation of Karri from cuttings	New project	Prepare RPP

PLANT DISEASES PROGRAM

PROGRAM LEADER

B Shearer

CURRENT RESOURCES (1991/92)

This program comprises 9.90 persons (3.4 Professional + 1 Contract Professional + 6.5 Technical + 0.5 Contract Technical). Its CRF budget is $489 333 (including $370 983 salaries and $118 350 operating costs).

RESOURCES IN PREVIOUS YEAR

The 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).

BACKGROUND

The plant diseases program has evolved from studies on the cause of dieback and death of Jarrah first observed in the early 1920s. In addition to the work on death of jarrah, research was undertaken on wood rots in the 1930s. The discovery that *Phytophthora cinnamomi* was associated with jarrah deaths in the late 1960s 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 with 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 disease 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 their importance from assessments of their impact on plant health and timber production.

ACHIEVEMENTS

Results from trials on the control of *Phytophthora cinnamomi* with phosphorous acid continue to be very encouraging. *Banksia grandis* treated with phosphorous acid has contained infection by *Phytophthora cinnamomi*. In comparison infection by *P. cinnamomi* kills untreated *B. grandis* within 12 months. One injection of phosphorous acid has protected trees for at least 4 years (the longest time the trials have been running). In spray trials in an infected stand of endangered *B. brownii*, plants have stopped dying in sprayed plots but continue to die in unsprayed plots.

A functional mycology laboratory has been established at the Manjimup Research Centre. Susceptibility of plant species to *P. cinnamomi* has been assessed in the Walpole-Nornalup National Park and in the South Coast Region.

In screening trials, mortality of *P. cinnamomi* resistant jarrah clones continues to be less than 10%. Susceptible clones have mortality levels of at least 40% with 100% mortality of some clones. Growth of resistant clones is significantly greater than surviving susceptible clones.

A project on survival of *P. cinnamomi* zoospore cysts funded by ALCOA has been completed. Predictive formulae for zoospore cyst survival were developed for each soil type and matric potential and cyst survival in field soil conditions was compared with predicted outcomes.

A trial assessing rate of lesion extension of *P. cinnamomi* in artificially inoculated stems of jarrah in variously thinned plots is continuing. The water relations of the trees in each treatment are being investigated to determine the effects of tree water status on lesion extension.

A project funded by ALCOA of Australia and sand mining companies has identified improved methods for the production of zoospores by *Phytophthora* species. The improved methods will facilitate *Phytophthora* identification.

From mid April 1990 to mid April 1991, 171 cultures were forwarded by the detection service for identification. Eighty one of these were *Phytophthora* species, all of which were identified to species level and added to the database.

Pathogenicity tests have shown that death of *Banksia coccinea* is associated with infection by a *Diplodina* species. Surveys of *B. coccinea* stands around Albany have revealed extensive cankering from *Diplodina*. A number of canker fungi are causing death of *Banksia* species throughout south-western Australia.

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 disease.

PRIMARY OBJECTIVES

Diagnosis

To recognize and assess the effects of disease in any situation of concern. To diagnose the causes of disease 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 cooperate with the public, 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 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. Identify communities, particularly those of limited distribution, which are vulnerable to disease (jointly with Flora Conservation Program).

4. Establish a data base of the distribution and importance of *Phytophthora* species and hosts susceptible to these pathogens (jointly with Flora Conservation Program).

5. Develop, apply and test hazard rating systems for *Phytophthora* species in forest, woodland and heathland communities. Develop the Shearer *P. cinnamomi* hazard rating system for the northern jarrah forest to incorporate the effects of disturbance and silvicultural practices.

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 enquiries relating to diagnosis of disease 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 Departmental 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 Dwellingup Research Centre. Elaine Davison diagnoses diseases and gives advice on problems on nurseries when requested.

PROJECTS TO BE COMPLETED FROM JULY 1991 TO JUNE 1996 (numbers refer to the Table following)

4,7,13,17,18,19,24,26,27,28,31,32,38,48

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

49,12,20,21,22,29,30,42,43

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

9

Together with:

- Biology and control of canker fungi infecting *Banksia coccinea.*
- Heat tolerance of *Phytophthora citricola*, *P. cinnamomi* and *Armillaria luteobubalina*.
- Assessment of improved methods for isolation and identification of *Phytophthora* spp.
- Biology and control of *Phytophthora citricola* in native plant communities affected by mining.

PUBLICATIONS* AND REPORTS 1990/91

*Davison, E.M. and Shearer, B.L. (1989). *Phytophthora* spp. in indigenous forests in Australia. New Zealand Journal of Forest Science 19: 277-289.

*Hill, T.C.J. (1990). Dieback disease and other *Phytophthora* species in the northern Kwongan. In Nature Conservation and Recreation values of the Lesueur are (eds A.A. Burbidge, S.D. Hopper & S. van Leeuwin). EPA Bulletin 424.

McComb, J., Bennett, I., Stukely, M. & Crane, C. (1990). Selection and propagation of jarrah for dieback resistance. A progress report. International Plant Propagater's Conference, Perth.

Morgan, B. (1990). Survival of *Phytophthora cinnamomi* zoospore cysts. Honours Thesis, Murdoch University.

Old, K.M. and Davison, E.M. (1990). Diaporthales as canker pathogens of eucalypts in Australia. Fourth International Mycological Congress, Regensberg.

Peters, B. and Davison, E.M. (1991). Improved production of *Phytophthora* oospores. Unpublished report.

*Shearer, B.L. (1990). Dieback of native plant communities caused by *Phytophthora* species - A major factor affecting land use in south-western Australia. Land and Water Research News No. 5: 15-26.

Wills, R.T. (1990). The impact of *Phytophthora cinnamomi*in the Stirling Range National Park, W.A. In Tree Decline and Revegetation Newsletter (eds E. Davison, P. Hussey & P. Pigott), Department Conservation and Land Management.

Wills, R.T. (1990). The impact of *Phytophthora cinnamomi* and other plant pathogens on ecosystems of the southern sandplain region of Western Australia. In Tree Decline and Revegetation Newsletter (eds E. Davison, P. Hussey & P. Pigott), Department Conservation and Land Management.

Primary Objectives	5 Year Goals		Projects (RPP No)	Tasks Completed 1990-91	Targets 1991-92
Diagnosis	3,4,Service	1	Dieback Detection Service (M Stukely)	Phytophthora spp identified Database developed	Continue identification Update database
	4,Service	2	Nursery diagnosis (E Davison)	Ongoing	Ongoing
	3,4,Service	3	Diagnosis as problems arise (All staff)	Ongoing	Ongoing
	11,14	4	Identification eucalypt canker fungi 55/88 (E Davison)	MS submitted	-
Assessment	6	5	Tree growth, Churchmans & Karnet (E Davison)	Root investigations	Complete of Damage measurements
	6	6	Jarrah root damage by P cinnamomi 14/84 (B Shearer)	Sites assessed	Complete analysis
	4	7	Impact of P cinnamomi in Stirling Range National Park (R Wills)	MS submitted -	-
	3,4	8	Phytophthora impact coast plain 36/89 (B Shearer)	42 sites surveyed	Continue survey
	3,4	9	Impact of Phytophthora spp on South Coast National Parks (R Wills)	RPP prepared. Preliminary assessment commenced	Gain full funding to commence main survey
	4,6	10	Susceptibility of jarrah understorey to P cinnamomi 90/68 (B Shearer)	43 sites assessed	Continue assessment
	4	11	Infection of Banksia by Phytophthora 52/90 (E Davison)	Techniques identified	Further experiments
	6	12	Susceptibility of jarrah copice & advanced growth to P cinnamomi (F Bunny)		New project, prepare RPP
	10	13	Armillaria in Wandoo 75/86 (B Shearer)	Analysis completed	Write up

Primary Objectives	5 Year Goals		Projects (RPP No)	Tasks Completed 1990-91	Targets 1991-92
	10	14	Armillaria in coastal shrubland 90/65(B Shearer)	15 sites assessed	Continue assessment
	11	15	Cankers in arboretum 73/86 (B Shearer)	Survey completed, pathogenicity tests started	Continue pathogenicity tests, analyse
	11	16	Crown decline in tuart 49/87 (B Shearer)	Continue survey	Continue survey
	11	17	Cankers killing Banksia coccinea 3/90 (B Shearer)	Pathogenicity tests & distribution survey	Finish pathogenicity tests & survey
	11	18	Infection of Santalum by Fusarium 53/90 (E Davison)	Experiment unsuccessful	Abandoned
	11	19	Infection of jarrah by Cryphonectria 63/90 (E Davison)	Assess	-
	11	20	Cankers on Banksia (B Shearer)	Sampling commenced	New project, prepare RPP
	11	21	The impact of pathogens King Jarrah Heritage Trail (R Wills)	RPP prepared Preliminary survey underway	Commenced survey
	11	22	Pathogenicity fungi at King Jarrah Heritage Trail (R Wills)	RPP prepared	Set up pathogenicity experiments
Disease Dynamics	6	23	Jarrah Deaths 35/84,43/87 (B Shearer)	Mapping 2 m contours continuing	Enter data into Intergraph relate to climatic data
	2	24	P cinnamomi population dynamics in woodland 4/87, 76/87 (B Shearer)	Sampling completed	Analyse
	2	25	Site hydrology & P cinnamomi dispersal 23/84 (J Kinal)	Rainfall events monitored	Continue measurement
		26	P cinnamomi sporulation 5/89 (B Morgan)	Analyses & write up Finalised	
	2	27	P cinnamomi survival 6/89 (B Morgan)	Analyses & write up finalised	

Primary Objectives	5 Year Goals		Projects (RPP No)	Tasks Completed 1990-91	Targets 1991-92
	28	28	P cinnamomi pine inoculation trials 29/89,30/90,19/91 (M Stukely & E Davison)	Inoculate & monitor	
	2	29	Analysis of climate data of South Coast (R Wills)	RPP prepared Data analysis under way	Complete analysis & write up
	2	30	Phytophthora inoculum production on plant spp after infection (R Wills)	RPP prepared Preliminary survey under way	Gain funding for main survey. Set up experiments
	2	31	Oxygen [] in subsurface flows (E Davison)	Analysis completed	Write up
	2	32	Geomorphology & impact of P. cinnamomi (R.Buehrig)	RPP submitted Analysis completed	Write up
Disease Management	5	33	P cinnamomi hazard system development 40/83 (B Shearer)	System modified for high rainfall zone	Validate changes
	5	34	Mapping hazard 34/87 (B Shearer)	Areas mapped	Use to validate system
	5,6	35	P cinnamomi lesion extension & thinning 23/89 (F Bunny)	Sites treated	Inoculate & measure
	2,5	36	Canopy density & temperature 8/89 (J Kinal)	Sites instrumented	Measure & analyse
	5	37	P cinnamomi on jarrah regeneration (B Shearer)	Suspended	
	7	38	Jarrah resistant to P cinnamomi 42/85 (M Stukely)	Analysed	Write up, monitor
	7	39	Jarrah clones resistant to P cinnamomi 33/90 (M Stukely)	Measure. New trial planted	Monitor & measure
	7	40	Test jarrah provenances for resistance to P cinnamomi 13/91 (M Stukely)	Analysed	Start new Seed series collection

Primary Objectives	5 Year Goals		Projects (RPP No)	Tasks Completed 1990-91	Targets 1991-92
	27	41	Pinus radiata/P cinnamomi screening 30/78 (M Stukely)	Series 15,16,19 inoculated & measured	Analyse. Start next series
	7	42	Seed orchard P cinnamomi resistant jarrah (M Stukely)	Seed collected. Seedlings raised.	Prepare RPP and monitor
	7	43	Determine intraspecic resistance in B brownii to P cinnamomi (M Stukely)		New project,prepare RPP Pilot trial
Control	1	44	Control of P cinnamomi in B grandis & jarrah by phosphorous acid 77/86 (B Shearer)	Effective control demonstrated	Determine changes with time. Test lower doses
	1	45	Control of P cinnamomi in Banksia communities on the south coast by phosphorous acid 26/89 (B Shearer)	Deaths monitored	Monitor mortalities with time
	1	46	Control of Phytophthora spp in Banksia communities north of Perth by phosphorous acid 90/54 (B Shearer)	Sites sprayed	Monitor mortalities with time
	1	47	Control of Armillaria with phosphorous acid 90/66 (B Shearer)	Sites sprayed	Monitor mortalities with time
	1	48	Rhizoctonia control in pine nursery 32/89 (E Davison)	Abandoned	
	1	49	Biological control canker fungi on Banksia (B Shearer)	Antagonist selected	New project, prepare RPP
Communication		50	Video on Armillaria (B Shearer)	Infected sites filmed	Edit

PLANTATION SILVICULTURE PROGRAM

PROGRAM LEADER

J McGrath

CURRENT RESOURCES (1991/92)

This program promprises 13.00 persons (4.50 Professional and 8.50 Technical). Additionally two technical positions are vacant. Its CRF budget is $651 951, (including $481 851, salaries and $170 100, operating costs).

RESOURCES IN PREVIOUS YEAR

This program comprised 24.1 persons (8.4 Professional + 15.7 Technical). Its CRF budget was $913 663 (including $743 563 salaries and $170 100 operating costs).

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 system there was potential to develop a major industry. 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

Growth of *Pinus pinaster* on Bassendean and Spearwood sand dunes can be reliably predicted based on extensive silvicultural and tree breeding trials. Using this information and a management regime to optimize water production, growth rates using a variety of seed sources have been determined. The predicted mean annual increment using a routine seed source is 7.7m^3 /ha/yr. Seed sources from the Joondalup, Mullaloo and the new Manjimup seed orchards will lift this to 10.5, 11.5 and 13.2 m^3/ha/yr respectively. A recent economic

study by Dr G. Malajczuk has shown that it would be profitable to replant *P. pinaster* on Bassendean and Spearwood sites using the genetically-improved seed now available. Internal rates of return in the range of 5-13% (real) or more would result, using a growth rate of 9.5 m^3/ha/yr.

Large scale *Eucalyptus globulus* and *E. botryoides* provenance trials were established.

Forty experiments investigating *E. globulus* establishment were set up in the 1990 planting season. Measurement and data analysis were completed for 43 experiments currently in the ground. Research has resulted in the West Manjimup Plant Propagation Centre adopting the 64 Kwikpot as the new seedling container. Recommendations about the timing of fertilizer application in relation to site, and the benefits of continued weed control have been disseminated to operations staff.

Potassium deficiency was identified as a major growth limitation for *P. radiata* on the deep sandy soils on the south coast. A series of experiments has commenced to examine the extent of nutrient deficiencies in the plantations on the south coast.

The soil survey system developed from the Blackwood Valley drought survey has been tested by research staff and is ready for use by operations staff.

Substantial progress was made in analysing and writing up improvement and thinning data for *Pinus pinaster*. Bulletins on Provenance Studies and Tree Improvement have been submitted to the Scientific Editor and a paper on Gains from Improvement was completed.

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 State and ensure that management of these has 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.

14. Develop establishment techniques and silvicultural management practices which optimize the economic returns from short rotation eucalypt pulpwood plantations.

PROJECTS TO BE COMPLETED FROM JULY 1991 TO JUNE 1996
(numbers refer to the Table following).

1,2,3,4,5(part: 9/82, 19/82, 1/85, 16/85, 17/85, 33/87, 18/88) 6(part : 8/85, 9/87, 10/87) 7(part : 27/65, 7/66, 12/66) 8(part 2/86) 10(part: 16/58, 20/65, 54/66, 20/68, 16/69) 11(3/65, 21/65) 12(part of 22/71, 30/78, 39/83)

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

1. South coast *P. radiata* fertilizer requirements.

2. *E. viminalis* provenance trial.

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

1. Hapso hormonal treatment of seed production.

2. Flowering and propagation studies with *E. globulus*.

3. Land evaluation system for tree crops in the south west.

4. Nutrition studies of *E. globulus* .

5. Nutrient analysis in older pines.

PUBLICATIONS* AND REPORTS 1990/91

*Ellis, G.R. (1990). Research into the establishment of eucalyptus plantations on farmland in the south west of Western Australia In "Wood Production in Land Management". Proc. Australian Forest Development Institute Conference, Bunbury, Oct. 1990.

*McGrath, J.F. (1990). Site assessment for *Pinus radiata* plantations in the Blackwood Valley region of Western Australia. In Wood Production in Land Management". Proc. Australian Forest Development Insitute conference, Bunbury, Oct. 1990.

*Moore, R.W. (1990). Timber production from wide-spaced agroforests. In. "Wood Production in Land Management". Proc. Australian Forest Development Institute Conference, Bunbury, Oct. 1990.

*Moore , R.W. and Russell R. (1990). The "Three Norths" forest protection system-China. Agroforestry Systems 10:71-78.

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
Site Classification	Pine site classification	1.	Drought survey of Blackwood Valley 43/88 (J McGrath)	System tested in field. Report prepared	Publish externally
		2.	Soil-productivity relationships in south coast pine plantations. (R Harper)	RPP prepared	Complete soil and tree assessment, write paper
	Land evalualtion	3.	Land evaluation system for plantation establishment.	New project. Prepare RPP, prepare draft recommendations.	Have system in use by operations personnel
	E. globulus site classification	4.	E. globulus site assessment yield prediction and growth modelling (G Inions PhD project)	Data analysed	Complete thesis preparation
Stand Management	P. radiata nutrition	5.	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, pruned	Continue measurements
			23/83	Terminated	
			1/85	Measurements and sampling continued	Prepare MSS on phase 1. of experiment
			17/85	Sampling, measurement & nutrient analyses continued	Analyse data
			33/87	No action	Prepare report
			18/88	No action	Prepare report
		6.	Nutrition of older pines and nutrition x fertilizer interactions (J McGrath) 8/85	Measurement of 50 plots continued	Continue annual measurement. Establish another experiment in this series.
			9/87	Remeasured. Burnt by wildfire, 76 trees sampled for stem analysis.	Terminate expt. Write paper.

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
			10/87	Burnt by wildfire 96 trees sampled for stem analysis	Terminated. Evaluate data for possible publication
			11/87	Continued sampling & measurements	Replicate on other site types (Harvey and Blackwood)
			Thinning and fertilizing regimes for 13 year old Pinus radiata on the Donnybrook sunklands 15/89	Measured	Continue monitoring
			64/90	RPP prepared. Experiment established & fertilized	Remeasure
	P. radiata stand management	7.	Plantation silviculture (R Moore)		
			27/65	Trial inspected - low level monitoring	
Ongoing			7/66		
"					
"			12/66		
"					
"			2/82	Pruning completed.	Monitor tree growth
			5/82	Thinning & pruning carried out, height & diameter measured	Monitor tree growth
			45/82	Height and diameter measured	Continue annual measurements. Analyse data
			3/83	Pruning treatments carried out. Height & diameter measured	Analyse data & write progress report
			6/83	Height & diameter measured. Report written	Monitor

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
			7/83	Review & terminate	Continue monitoring
			28/83	Height & diameter measured	Analyse data & write progress report
			30/83	Height & diameter measured.	Monitor
			14/84	Pruned	Monitor
	Agroforestry (R Moore)	8.	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	Monitored	Monitor
			264/53	Monitored	Monitor
			264/54	Trees pruned 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	Measure volume of eucalypts
			10/81	Height & diameter measured	Measure volume of 3 eucalypt species
			43/82	Pruned	Monitor
			2/86	Culling & pruning carried out.	Renovate pasture (WADA)
			27/87	Culled and pruned	Measure height and diameter.
			58/88	Data collection and analysis	Final report

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
			59/88	Data collection	Process data and report
			NSCP grant (D Bicknell)		
			60/88	Data collected	Report
	Comparison of species performance	9.	Arboreta & species trials (R Moore)		
			25/67	Tree performance monitored	Monitor
			26/67	Tree performance monitored	Monitor
			27/67	Tree performance monitored.	Monitor
			44/82	Fertilized	Monitor
	P. pinaster stand management	10.	P. pinaster silviculture and hydrology (T Butcher)		
			16/58	Study completed	Prepare for publication
			20/65	Stuood)dy completed	Collate data; plan utilization study
			48/66	No action	No action
			17/67	No action	Continue monitoring
			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	No action
			23/73	No action	No action
			20/76	No action	Process data & review
			21/76	No action	Continue bi-annual measurements

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
			22/76	No action	Continue bi-annual measurements
			26/80	No action	Process data for review
			2/81	No action	Process data for publication
			7/82	No action	No action
			25/83	No action	Measure height & review
			29/83	No action	Review
Tree Breeding	Pine breeding	11.	P. pinaster genetics (T Butcher)		
			3/65	Publish	No action
			21/65	1. Publish 2. Index selection.	1. Revise Breeding Plan 2. Conduct combined index selection 3. Establish a gene pool 4. Publish
			5/72	Publish	No action
			Pedigree S2	Data analysis	Pinaster growth model.
		12.	P. radiata genetics (T Butcher)		
			21/71	No action	No action.
			22/71	Planted 15 ha progeny trials at Busselton, Kirup and Boddington	1. Plant 2ha of cuttings (RS 40) 2. Plant cuttings/seedling trial RX19 3. Control crossing of nucleus population selections
			19/72	Data analysis	Selection
			29/78	Data collated	Analyse results & prepare for joint publications
			30/78	1. Cytoplasmic inheritance study. 2. Screening of search 1985 selections.	1. STBA selections 2. Publish
			25/79	Data collated	No action

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
			28/82	No action	Plan diameter and BSTAF assessments13.
	Propagation of pine genotypes	13.	Pine propagation (T Butcher)		
			19/62	Monitor	1. Monitor 2. Graft new selections for clone bank 3. Review
			34/68	1. Mass pollination of HAPSO 2. Chemical emasculation 3, Cutting Hedges 4. Plant 3.5 ha of HAPSO planted	1. Mass pollination 2. Mass pollen extinction study 3. Chemical emasculation 4. Cutting hedges 5. Publish
	Eucalypt breeding	14.	Genetic improvement of Eucalyptus globulus (T Butcher, R Mazanec) 147/91		
			Breeding Plan	Formalize Breeding Strategy	Publish breeding strategy.
			EG03	Intensive volume, form and wood quality assessment. Combined Index Selection and cloning for seed orchards and clone banks	No action
			EG05 and EG06	Height, diameter and form assessment. Index selection	Clone best selections.
			EG07 and EG15	Commence initial height diameter and form assessment	Monitor
			EG16 to EG23	Plant 30 ha of breeding population tests at 3 sites	Monitor
			EG24 to EG26	Raised seedlings in nursery	1. Plant 10ha of E. globulus salt tolerant phenotypes 2. Procure seedlets of the King Island population and the W.A. and Portugal races
			Genetic improvement (T Butcher & R Mazanec) 27/80 (globulus)	Orchard fertilized	No action

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
		6/81 (wandoo)	Monitored	Monitor
		24/82 (wandoo)	Monitored	"
		25/82 (wandoo)	No Action	"
		38/82 (maculata)	"	Complete analysis, write report
		40/82 (wandoo)	"	Monitor
		40/82 (wandoo)	"	"
		38/83 (resinfera)	"	Complete analysis, write report
		32/84 (globulus)	Performance evaluation	Ongoing growth measurements
		33/84 (accedens)	No action	No action
		34/84 (camaldulensis)	No action	Monitor
		4/86 (accedens)	Terminate (destroyed by haul road)	-
		5/86 (pilularis)	Monitored	Complete analysis, write report
		53/88 (muellerana)	Mortality count	Monitor
		54/88 (muellerana)	Mortality count	Monitor
		8/87 (saligna)	Mortality count	Measure
		5/87 (sideroxylon)	Mortality count	Growth measurement
		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
	15.	Propagation of E. globulus (T Butcher & R Mazanec)		

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
			Clonal seed orchard	2 ha of clonal seed orchard at 2 sites planted. Grafting program of 1500 ramets.	1. Plant 3ha of clonal seed orchard at 3 sites 2. Graft 1500 ramets 3. Tissue culture best selections for seed orchard
			Open pollinated seedling seed orchard (OPSSP)	Planted 12 ha at 3 sites.	Monitor
			Flowering studies	New project	1.Prepare RRP 2.Control pollination
			Cutting propagation	New project	Prepare RPP
Technique Development		16.	Pulpcropping practices (J Bartle)		
			27/89	Monitored	Measure trees
			35/89	Measured & assessed	Prepare report
			28/89	No action	Measure trees
			29/89	Monitored	Monitor
			36/90	Assessed treatments	Further screening & trial work
			37/90	Measured trees	Prepare report
			38/90	Assessed expt	Prepare report
			39/90	Monitored	Monitor-long tern expt
			40/90	Measured expt	Prepare report
			41/90	" "	" "
			42/90	" "	Continue measurement, prepare report
			43/90	Monitored	Monitor-long term expt.
			44/90	Measured trees	Prepare report
			45/90	" "	" "
			46/90	" "	" "
			47/90	" "	" "
			48/90	" "	" "
			49/90	No action	Measure

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
			50/90	Measured trees	Prepare Report
			51/90	" "	Continue measurement-long term expt
	Species selection/Genetc improvement	17.	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	Initial assessment	Monitor
Integrated Land/Catchment Management	Production and conservation benefits	18.	NAP project (J Bartle)		
			11/90	Monitor borefield	Continue monitoring
			12/90	Monitor runoff	Continue monitoring
			13/90	Monitor	Manage with view to future measurement of production

RESEARCH TECHNIQUES PROGRAM

PROGRAM LEADER

M Choo

CURRENT RESOURCES (1991/92)

This program comprises 6.80 persons (2.70 Professional + 4.10 Technical). Its estimated CRF budget is $357 956 (including $232 196 salaries and $125 750 operating costs).

RESOURCES IN PREVIOUS YEAR

The program comprised 5.1 persons (4.0 Professional + 1.1 Technical). Its budget was $313 716 ($187 966 salaries + $125 750 operating costs).

BACKGROUND

The advent of sophisticated, relatively cheap electronic processing power has led to its rapid and widespread application by research scientists. It is fundamental to the efficient management of resources, and achievement of goals, that Scientists maximise the opportunities presented by today's rapid advances in software and hardware.

It is equally important that Scientists adopt a structured, systematic and modern approach to experimental and survey design, analysis and modelling.

The Research Techniques Program provides the technological support needed by other Scientists in these areas and develops new methods that enhance the capability of the Division to meet the expectations of the Department. Its members apply a systematic approach to policy, support, advice and expertise throughout the Research Division. Program members are increasingly involved with research, either collaborative or through their own research projects.

ACHIEVEMENTS

In the past year more than 90 research project plans have been assessed and modified where necessary. Some extend into the next century.

Data drawn from the whole range of research activities have been analysed, thus contributing to many scientific publications.

A method to determine numbers of the marine snail *Drupella cornus* was developed for use at the Ningaloo Marine Park. A new, more efficient method of calculating the Soil Dryness Index was developed. A scientific paper on quantifying defoliation was written, and a paper reviewing statistical methods in the Research Division was submitted to RDPG. This review will help to determine priorities for statistical training within the Division.

Significant progress has been made in automating Herbarium procedures. A new system for databasing incoming specimens has streamlined data collection and processing. Work has commenced on a project to enable electronic capture and processing of data on the W.A. flora. A major project to integrate the Green Census and the CAVP index into WACENSUS was completed.

A significant new project has commenced to standardize taxonomic nomenclature and coding within CALM. This will result in greater integrity of data, and more efficient information exchange with non-CALM bodies.

The goal of providing each Research Scientist with access to at least one micro computer was achieved in 1990/91. The program continued to provide technical and planning support for this computer network. Training courses were conducted regularly at the major research centres. Levels of computer literacy, expertise and usage continued to increase. Laptop computers are now an integral part of field work and are becoming indispensable to efficient research.

Hardware and software continue to be upgraded and there is greater integration within the Division.

Program staffing has again increased and there is now support by qualified professional staff at every Research Centre. This paves the way for a significant increase in the levels of computer usage, efficiency of research, as well as greater professional 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.

PRIMARY OBJECTIVES

Research

To raise and maintain standards of research methodology, planning and analysis and to ensure efficient experimental design. 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.

Integrated Environment

To provide an integrated environment for the capture, processing, analysis and dissemination of information at Centre, Divisional and Departmental levels.

Assessment

By assessing new products, to ensure that the most appropriate, cost-effective and up to date hardware and software is used in the Division.

Training

To increase computer literacy and expertise amongst research staff and to introduce them to new products so that they benefit from new computing technology.

Communication

To communicate and integrate with other groups within CALM and appropriate external organisations to allow for exchange of research findings, ideas, data, software and other products.

20 YEAR GOALS

1. Integrate into Research Division improved systems for information management as they are developed. **

2. Ensure that research projects are designed so that they produce the required results.

3. Establish and continue to upgrade a network for 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 collaborating with other research scientists on projects that require complex computing, design or analysis techniques. **

6. Integrate the management of corporate databases developed or maintained by the Division so as to maximise their usefullness to all users.

FIVE YEAR GOALS

1. Improve research in the Division by developing new research methods that address design or analytical problems.

2. Keep up to date the capacity for rapid processing, storage and analysis of data.

3. Raise standards of research planning and analysis.

4. Improve the efficiency of Research Division personnel by training them in the use of computers experimental design and project planning.

5. Develop and maintain an up-to-date information base to improve the information processing and retrieval requirements of the Research Division and the Department.

6. Integrate Research databases with the Department's corporate databases and make all corporate information available across the Division/ Department.

7. Service and support facilities that are used to produce high quality publications (reports, graphs and other illustrations).

8. 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.

9. Develop & implement GIS based systems to satisfy specialised research functions and integrate these with corporate data.

10. Establish a network that will support communications between the major research centres and the Department's host computers.

11. Establish local area networks at the major research centres.

12. Extend communications to computers on an intra/inter government basis (e.g. SNA network) to provide ready access to non-sensitive information.

13. Assess Research Project Proposals for design efficiency and maintain an inventory of all current projects.

PROJECTS TO BE COMPLETED FROM JULY 1991 TO JUNE 1996 (Numbers refer to the Table following)

1-3, 5-22, 24-25, 27-31.

PUBLICATIONS* AND REPORTS 1990/91

Burgman, M. and Gioia, P. (1991) User manual for the Declared Endangered Flora database management system, CALM Wildlife Branch/ Research Division, 21pp.

Chapman, A. (1991) WAHERB Specimen Database Users Guide, CALM Research Division, 33pp.

*Gioia, P. (1991) Computers, Research and Pretty Pictures, Australian Ranger Bulletin, Vol. 6, No. 2, 1991.

Gioia, P. (1991). Species codes, the census and other problems, CALM Research Division. Discussion paper, 10pp.

Gioia, P. (1991) Declared Endangered Flora administrator's manual, CALM Wildlife Branch/Research Division, 5pp.

Williams, M.R. (1991). Review of the use of statistical methods, CALM Research Division. (Paper prepared for Research Division Policy Group, 6pp).

Williams, M.R. and Woods, Y. (1991). Review of PC statistical software, CALM Research Division. (Paper prepared for Research Division Policy Group, 14pp)

Yung, F.H. (1991) Waterbird Database System Userguide, CALM Research Division, 16pp.

Yung, F.H. (1991) Volunteers Time Recording User Guide, CALM Research Division, 5pp.

Yung, F.H. (1991) Duck Count Survey User Guide, CALM Research Division, 5pp.

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks Completed 1990-91	Targets 1991-92
Research	New research methods	1	Leaf damage (Williams)	Assessment of methods for assessing defoliation completed and written up	Publication
		2	Soil dryness index (Williams)	More efficient method for calculating the SDI developed	Publish, and implement within CALM
		3	Drupella (Williams and Osborne)	Novel method for quantifying D. cornus numbers developed	Publish
			Enhance population estimation using triangulation method (Yung) 94/91	Converted to Husky Hunter BASIC to be used in the field	Ongoing upgrades as required
	Raise standards of research	4	Research methods notes (Williams)	Three notes in Research News	Continue to write notes on interesting methodological problems
		5	Research Project Proposal form (Williams)	Amendments made	Monitor compliance with RPP aims
		6	Data analysis	Collaborative effort on numerous data analysis tasks	Lower priority given to analysis tasks. Modify five year goals to include data analysis
		7	RPP system (Choo) 98/91	Oracle based system investigated	Move RPP system to VAX/Oracle
Integrated environment	Maintain computing facilities	8	Upgrades and evaluations	SUN 386i upgraded to SPARC workstation	-
				Software installation and replacement at all centres	Continue to provide new or upgraded software
		9	Review of statistical packages and requirements of Research Division (Williams and Woods)	Evaluation of PC statistical software. Report prepared for R.D.P.G.	Implement recommendations. Continue projects to evaluate software as necessary
		10	PC obsolescence and replacement program (Choo and Williams)	Draft PC policy written	Finalise policy, implement replacement program
	Integrate research databases	11	SEDIT - Species Editing Utility (Gioia) 100/91	Developed and implemented utility.	Integrate SEDIT to utilize new historical information in WACENSUS. Write user manual

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks Completed 1990-91	Targets 1991-92
		12	Species coding guide-lines 2/91 (Gioia)	Plant census prototype developed	Test and modify as required. Write user manual
				Animal census - collaborative effort initiated with WA Museum	Obtain data from museum. Develop and test prototype. Write user manual
				Discussion paper written on species coding guidelines	Further develop guide-lines and request R.D.P.G. endorsement
		13	HERBIE - Herbarium specimen labelling utility (Gioia) 103/91	Implemented a PC-based database and labelling system for Herbarium specimens. Integrated HERBIE with WAHerb	Maintain and extend HERBIE as required. Write user manual
	Develop and maintain information base	14	Declared Endangered Fauna database system (Gioia) 102/91	Developed data entry form. Established requirements for database system	Develop, test and document system
		15	Register of corporate data (Gioia) 97/91	-	Develop a form for surveying Research Division's corporate data. Develop ORACLE database system
		16	Waterbird database system (Yung)	Developed database system for waterbird data. Added RAOU data to system	Investigate feasibility of adding data from other sources
		17	Duck count data analysis (Yung)	Analysis of duck count data completed using SAS. Estimation of duck numbers provided	Maintain duck count reporting system as required
		18	Wetland monitoring - salinity (Yung)	Developed system for plotting salinity vs depth using SAS/GRAPH	Convert system to use SYGRAPH.
		19	Declared Endangered Flora database system (Gioia)	System developed, implemented and documented	-
		20	WACENSUS (Gioia, Chapman and Wilson)	Integration of Green census with CAVP index to become WACENSUS	Maintain and extend WACENSUS to incorporate other data sources (e.g. A.P.N.I.)

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks Completed 1990-91	Targets 1991-92
	Maintain uniform cohesive computing approach within the Division	21	Desktop publishing	Pagemaker installed at Herbarium. Ventura 2.0 installed at Como. Ventura 1.1, Word For Windows installed at Woodvale	Rationalise desktop publishing within Division
	Develop and maintain GIS based systems	22	Equipment	Acquired plotters and digitizers	Continue to acquire equipment as required
		23	GIS research (Gioia)	Research into applications of GIS	Prepare paper on GIS development framework within the Division
		24	TAXAPLOT - a taxon plotting system (Gioia) 96/91	Feasibility study initiated.	Complete study and develop system if appropriate
		25	GIS data accumulation (Gioia) 95/91	-	Accumulate datasets for GIS base map and consolidate into state-wise lat/long map base
	Reduce manual chores through computerization	26	TRAK - Radio tracking utility (Gioia) 99/91	Moved NUMTRAK from TEKTRONIX to PC	Investigate feasibility of incorporating home range analysis techniques into NUMTRAK and generalising program for applicability to any animal
	Facilitate electronic transfer, and extend communications	27	Herbarium connectivity (Chapman)	Herbarium connected to CALM VAX	Integrate Herbarium fully with VAX network
		28	Local area networks (Gioia) 19/91	-	Investigate feasibility of implementing local area networks in Research Division
	Maximize opportunities offered by modern electronic equipment	29	INFORM (48/91, Chapman)	Initial assessment of use of multimedia in the electronic capture and presentation of flora data	Begin development
		30	Satellite telemetry (Woods)	Location system tested at Manjimup	Continue to monitor developments in remote sensing technology
Training	Extend and enhance training of Research Division staff	31	Paradox training (Choo)	Courses held at Manjimup, Dwellingup, Herbarium and Woodvale Research Centres	Conduct at all centres

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks Completed 1990-91	Targets 1991-92
		32	Harvard graphics training (Choo)	Courses held at Manjimup and Herbarium	Conduct at all centres
		33	Microsoft Word training (Gioia)	In-house course held at Manjimup	Conduct courses as required
		34	Statistics workshop (Williams)	Needs identified	Conduct linear models workshop for Division
		35	GIS, VAX and other training	-	Conduct as required

WETLANDS AND WATERBIRDS PROGRAM

PROGRAM LEADER

J Lane

CURRENT RESOURCES (1991/92)

This program comprises 2.70 persons (1.90 Professional + 0.8 Technical). Its estimated CRF budget is $160 355 (including $11 655 salaries and $43 800 operating costs).

RESOURCES IN PREVIOUS YEAR

This program comprised 3.60 persons (1.90 Professional + 1.7 Technical). Its budget was $199 624 ($155 824 salaries + $43 800 operating costs).

BACKGROUND

Western Australia has a great diversity of wetland types - greater than that of any other Australian State - ranging from the extensive mangal, 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

During the past year funding was obtained for a major survey of the invertebrate aquatic fauna and fringing and emergent flora of wetlands of the south coast, from Cape Naturaliste to Albany. This work is to be completed by early 1992. Further funding is likely to be obtained in 1991-92 for surveys of wetland-associated vertebrates (principally fish and frogs) and submerged aquatic flora of the region. Knowledge of the conservation values of the wetlands of the south coast will be greatly improved by this work.

The aquatic fauna of Two Peoples Bay Nature Reserve was documented. Forty-two species of waterbird, eight species of fish and 118 species of aquatic invertebrate have been recorded. This work will be published in a departmental Research Bulletin on Two Peoples Bay in 1992.

Work continued on a long-term multi-disciplinary study of Lake Gregory in the Great Sandy Desert. Collections of aquatic invertebrates and waterbird counts have been made in October 1989, when the lake was saline and about to dry out and in June 1990, after the lake had re-flooded and was fresh. Approximately 80 000 birds were counted on both occasions and the number of aquatic invertebrates was high, especially after the lake re-flooded. Geological work is about to begin. Cores taken from the lake can be used to study past climatic conditions. Small invertebrate fossils in the cores can be used to study how the ecology of the lake and the fauna within it have changed with climate.

Research undertaken by scientists of Murdoch University, with partial funding and supervision from CALM, has identified a more environmentally acceptable alternative to the organophosphate Temephos for midge (chironomid) control. This work has also demonstrated the importance of good catchment management (particularly reductions in nutrient discharge) in long term control of midge populations.

A wetland-waterbird database, incorporating data obtained from the 1981-85 surveys of waterbird usage of Wetland Nature Reserves of the South West and from subsequent surveys, has been established. It is intended that historical and contemporary data will be added as and when funding permits, and that this will be the major State repository for data concerning waterbird usage of Western Australian wetlands.

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.

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 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 for annual assessment of the abundance of waterfowl and for identification of important waterbird sites in south western 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 (eg. Lake Gregory) of probable international importance.

4 Monitor water levels and water quality of a sample of south-west wetlands. Use these data to assess the condition of wetlands.

5. 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.

6. Assess the conservation values of different habitats in Leschenault Inlet and the effect of mosquito control on those values for waterbirds and invertebrates.

7. 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.

8. Examine food selection in waterbirds in relation to the invertebrate prey available to gain some understanding of how invertebrate species composition and abundance affect waterbird distribution.

9. In collaboration with other State and Local Government authorities, develop more effective and environmentally acceptable methods of midge (chironomid) nuisance control.

10. 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.

11. 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.

12. Investigate potential for lowering of salt loads of the Yenyenning Lakes system through experimental manipulation of Qualandary Crossing outflows (Yenyenning Lakes Interdepartmental Working Group).

13. Preparation of waterbird habitat protection guidelines for Vasse and Wonnerup Estuaries.

14. Analyse and publish results of Australian Pelican banding and wing-tagging program.

PROJECTS TO BE COMPLETED FROM JULY 1991 TO JUNE 1996
(numbers refer to the Table following)

1-4,7,11-14,16,17-21

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 1990/91

*Burbidge, A.A. and Halse, S.A. (1990). Summary of papers presented and general discussion. In The Natural Features of Lake Gregory : a preliminary review (ed. S.A. Halse), pp. 32-34. Department of Conservation and Land Management Occasional Paper 2/90.

* Halse, S. (1990). Review of bird pest research in Western Australia. In Proceedings of the national bird pest workshop, Armidale 1990 (ed. P. Fleming, I. Temby, J. Thompson), pp. 34-37. Department of Conservation, Forests and Lands, Victoria.

*Halse, S.A. (1990) (ed). The Natural Features of Lake Gregory : A Preliminary review". W.A. Department of Conservation and Land Management Occasional Paper 2/90.

*Halse, S.A. (1990). Waterbirds at Lake Gregory : available data and information required. In The natural features of Lake Gregory : A preliminary review (ed. S.A. Halse), pp. 20-29. W.A. Department of Conservation and Land Management Occasional Paper 2/90.

*Halse, S.A., Jaensch, R.P., Munro, D.R. and Pearson, G.B. (1990). Annual waterfowl counts in south-western Australia - 1988/89. W.A. Department of Conservation and Land Management Technical Report 25.

Lane, J.A.K. (1991). Biological advice related to consideration of a possible duck hunting season in the South West and Eucla Land Divisions in 1991.

Jaensch, R.P. and Vervest, R.M. (1990). Waterbirds at remote wetlands in Western Australia, 1986-8. Part one : Lake Argyle and Lake Gregory. Royal Australasian Ornithologists Union Report No. 32.

Jaensch, R.P. and Vervest, R.M. (1990). Waterbirds at remote wetlands in Western Australia, 1986-8. Part Two: Lake MacLeod, Shark Bay, Camballin Floodplain and Parry Floodplain. Royal Australasian Ornithologists Union Report No 69.

*Marchant, N.G. and Halse, S.A. (1990). The flora of Lake Gregory. In Natural features of Lake Gregory : A preliminary review (ed. S.A. Halse, pp. 12-16 W.A. Department of Conservation and Land Management Occasional Paper 2/90.

*Story, A.W., Bunn, S.E., Davies, P.M. and Edward, D.H. (1990). Classification of the macroinvertebrate fauna of two river systems in south western Australia in relation to physical and chemical parameters. Regulated Rivers: Research and Management 5: 217-232.

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
Wetland Values	Remote wetlands	1	Kimberley & North West (RAOU, J Lane)	Published reports (RAOU).	Project completed
		2	Lake Gregory (S Halse) 40/91	Additional waterbird and invertebrate surveys, liaise with hydrogeological study and Mulan community	Analyse invertebrate and water chemistry data, continue fieldwork and liaison.
	Seasonal usage	3	Waterbird use of wetlands of Swan Coastal Plain (S Halse, A Storey & RAOU) 25/91	Data collection continued, preliminary analysis undertaken, 1000 birds colour-marked.	Finish data collection, analyse, prepare preliminary reports.
	Invertebrate conservation status	4	Ostracod taxonomy (S Halse)	None	Submit species descriptions for publication (subject to co-author's contribution), continue surveys, describe new species.
		5	South-west surveys (S Halse) 38/91	Surveyed aquatic fauna of Two Peoples Bay, submitted publication.	UWA to publish. Continue to analyse and publish earlier work.
			South coast aquatic invertebrate (and emergent flora) surveys (J Lane)	External funding acquired and projects initiated	Completion of surveys and preparation of reports.
Status of Waterbird Population	Annual abundance	6	November & March counts (S Halse, RAOU) 24/91	1989/90 work prepared for publication and 1990/91 counts completed.	Analyse and submit for publication 1990/91 counts and find funding for 1992 count.
	Duck banding	7	Analysis of historical data (S Halse)	Re-submitted revised paper on annual survival rates.	
	Pelicans	8	Analysis of banding and tagging program. (J Lane) 32/91	Design computerised database for banding and tagging records.	Data entry and validation.
Wetland Ecosystem Dynamics	Wetland monitoring	9	Sept & Nov surveys (J Lane)	Sept & Nov 1990 surveys undertaken	Do Sept & Nov 1991 survey
	Environmental parameters	10	RAOU waterbird survey analysis (S Halse, M Williams)	Continuing to prepare paper on waterbird habitat preferences	Submit for publication
	Impact of Mosquito Control	11	Leschenault Inlet (S Halse)	Further analysis of data, consultant's report prepared on attributes of Preston River area.	Submit for publication

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
	Ducks and salinity	12	Breeding success in south-western Australia (S Halse)	Continued work on techniques as part of Swan Coastal Plain Project.	None (program on hold)
	Food selection	13	Duck in fresh water (S Halse)	None	Continue on ad-hoc basis.
		14	Wader diet at Roebuck Bay (S Halse, G Pearson) 39/91	Preliminary collection and identification of invertebrates on mudflats, preliminary dietary work.	Seek funding for additional work.
	Midge nuisance control	15	Midge Research Steering Committee (J Lane)	Field testing of growth regulators.	Complete Committee's research program and end Committee.
	Herdsman pesticides	16	Organochlorines in swamphens (S Halse)	None	Co-author to publish.
	Wetland vegetation	17	Longterm monitoring (S Halse)	Submitted for publication.	
	Lead shot	18	Gizzard and wing bone analyses (J Lane)	Wing bone and gizzard analyses completed.	Data analysis and report preparation.
	Yenyenning Lakes	19	Experimental flow control (J Lane)	Commenced preparation of final report.	Complete final report.
	Vasse-Wonnerup Estuaries	20	Preparation of conservation strategies (J Lane)	Strategies drafted.	Finalize strategies.
		21	Saltwater crocodile populations (RS12-13) (J Lane)	Nil	Contribute to preparation of crocodile management plan.

WOOD UTILIZATION PROGRAM

PROGRAM LEADER:

GR Siemon

CURRENT RESOURCES (1991/92)

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 4.8 persons (3.3 Professional + 1.5 Technical). Budget was under 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 Industries Federation (W.A.), reviews the research program each two months.

The Department has an ongoing commitment to wood utilization research.

ACHIEVEMENTS

Research into the VALWOOD® process continued, with assessment of different adhesives and of stability in panels under different environmental conditions. Timber from nine-year-old Tasmanian blue gum was successfully converted into VALWOOD®, and other eucalypt species from the Eastern States are being assessed.

The CALM dryers were shown to have considerable commercial potential, and drying schedules for different species and thickness of timber were developed. Other drying research assessed ultrasonic methods for determining moisture content and treatment of timber before drying to increase the rate of drying. A major study of brown wood in karri included identifying fungi which subsequently decay the wood and adversely affect its utilization.

Research findings are 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. Six WURC Reports and nine Technical Reports were published.

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 State's 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. Improve log grading systems.

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 1991 TO JUNE 1996 (numbers refer to the Table following)

3,4,5,7 (1,2,6 are ongoing)

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

1. Assessment of other species for VALWOOD;

2. Assessment of alternative adhesives for VALWOOD;

3. VALWOOD structural products;

4. Moisture meter for furniture;

5. Drying craftwood;

6. Drying schedules for sawn timber;

7. Sirograder

8. Colour stabilisation in timber.

PUBLICATIONS * AND REPORTS (1990-91)

Brennan, G.K. (1990). Powder post borer (*Lyctus* spp.) attack on dry timber. W.U.R.C. Report No. 19.

Brennan, G.K. and S.L. Ward (1990). Recovery from regrowth jarrah sawlogs. W.U.R.C. Technical Report No. 20.

Brennan, G.K., B.R. Glossop and L.R. Mathews (1990). Stockpiling of regrowth jarrah and karri logs using different schedules. W.U.R.C. Report No. 16.

Brennan, G.K., B.R. Glossop and W.R. Hanks (1990). Drying regrowth eucalypts using a low temperature batch kiln. W.U.R.C. Report No. 20.

Kent, D.L. (1991). GUMTREE©. General utilisation model of timber resources economic evaluation. W.U.R.C. Technical Report No. 21.

Kent, D.L. (1991). Predicting the profitability of small hardwood sawmills which dry timber. W.U.R.C. Technical Report No.22.

Mathews, L.R. (1990). VALWOOD® processing - a preliminary investigation. W.U.R.C. Report No. 17. Limited distribution.

Mathews L.R. (1991). Drying of VALWOOD® boards in a veneer dryer. W.U.R.C. Technical Report No. 25.

McDonald, T.J.G. (1991). Development of a solar, low cost, timber drying system. W.U.R.C. Technical Report No. 23 Limited distribution.

Newby , P. (1991). Practical aspects of producing VALWOOD® blanks. W.U.R.C. Technical Report No. 26.

Newby, P. and G.K. Brennan (1990). Moisture content fluctuations of regrowth jarrah and karri under different environmental conditions. W.U.R.C. Report No. 18.

Raper, S.J. (1990). Sawmilling of red mahogany grown on a rehabilitated minesite. W.U.R.C. Technical Report No. 19.

Thomson, A. B. and G. McKenzie-Smith (1990). Sawn recoveries from crown logs of radiata pine. W.U.R.C. Report No. 15.

White, K.J. (1990). Overview of the Central Gippsland sawmilling industry. W.U.R.C. Technical Report No. 18.

White, K.J. (1991). Growth stress evaluation of regrowth jarrah. W.U.R.C. Technical Report No. 24.

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
S.E.P.S. Sawmilling	Protection prior to processing	1			
-					
-	Techniques of conversion	2	Sawmilling		
-			7/86 (G Brennan)	W.U.R.C. Technical Report No. 32 prepared (regrowth jarrah sawmilling)	
-			18/87 (G Brennan)	W.U.R.C. Technical Report No. 29 prepared (regrowth karri sawmilling)	
-					
-			4/89 (K White)	Data on sawmillling regrowth jarrah analysed	Complete report
Seasoning	Developing efficient drying schedules	3			
-			9/86 (G Brennan)	WURC Report No. 19 (Review of Lyctus)	Ongoing joint trial with CSIRO
			6/88 (G Brennan)	WURC Report No. 20 (drying to fibre saturation point)	Ongoing research
			31/89 (B Glossop)	W.U.R.C. Report No. 21 (treating timber before drying)	Ongoing
			33/89 (G Brennan) For. Resources	State wide trial of equilibrium moisture control commenced	Ongoing
Wood Properties	Quantify physical and mechanical properties	4	Strength 26/86 (G Siemon)	W.U.R.C. Technical Report No. 34 prepared (Curtin Univ. co-operation)	Ongoing - sample for more tests
		5	Durability 41/86 (G Siemon)	Joint CALM/CSIRO trial	Ongoing
		6	Wood quality 46/88 (E Davison)	Interim report prepared on brown wood in karri - harvest inoculated trees	Ongoing Sawmilling study will be done

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1990-91	Targets 1991-92
			14/89 (E Davison)	Field survey of incidence of brown wood in regrowth karri (delayed by financial constraints)	Commence
			58/90 (E. Davison)	Commenced study on fruiting fungi from karri brown wood and rots	Ongoing
			15/90 (B Glossop)	W.U.R.C. Report No. 22 prepared (ultrasonic moisture meter)	Ongoing
		7	Density 6/88 (G Brennan)	W.U.R.C. Technical Report No. 28. (wood density & moisture contents)	Ongoing
Product Development	Develop processes for added-value products	8	49/88 (P Newby)	W.U.R.C. Technical Report No. 27 (stability of jarrah VALWOOD)	
-			50/88 (P Newby)	W.U.R.C. Technical Report No. 27 (e.m.c. effect on VALWOOD)	
-			52/88 (P Newby)	W.U.R.C. Technical Report 26 (VALWOOD production)	
-			25/89 (P Newby)	Research planned (manufacturing karri VALWOOD)	Ongoing
			16/90 (G Brennan)	Continuation of trials (treated E. globulus fence posts)	Ongoing. Extend trial. Prepare interim report
Residues	Suitability of regrowth residues for markets	9	Residues (A Thomson)	W.U.R.C. Technical Report No. 30 (drying rates of firewood)	-
Mature Hardwoods	Quantify physical properties	10	2/89 (G Siemon)	Data on veneer recoveries analysed	Prepare report
Softwoods	Quantify physical properties	11	Softwoods 30/82 (G Siemon)	Wood density assessment continued	Ongoing sampling from geographic range
	Techniques of conversion	12	21/88 (A Thomson)	W.U.R.C. Report No. 15 (pine crown log sawn recovery)	

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*
RDPG	*Research Division Policy Group*
RCM	*Research Centre Manager*
PL	*Program Leader*
SE	*Scientific Editor*

N.B. Source of funding is from Consolidated Revenue Funds (CRF) unless otherwise indicated.

EXECUTIVE AND RESEARCH SUPPORT

EXECUTIVE

Professional Total = 5.45

A.A. Burbidge (Program Leader)	DR	Woodvale	65%
I. Abbott (RDPG)	PRS	Como	60%
J. Armstrong (RDPG)	SPRS	Herbarium	60%
P. Christensen (RDPG)	SPRS	Como	80%
M Choo (PL)	SRS	Woodvale	10%
D. Coates (PL)	SRS	Woodvale	10%
S. Crombie (PL)	RS	Dwellingup	20%
J. Farr (PL)	RS	Manjimup	10%
J. Friend (PL)	SRS	Woodvale	10%
G. Friend (PL)	SRS	Woodvale	10%
S. Hopper (RDPG)	SPRS	Woodvale	60%
G. Keighery (PL)	SRS	Woodvale	10%
N. Lander (PL)	PRS	Herbarium	10%
J. Lane (PL)	PRS	Woodvale	10%
J. McGrath (PL)	SRS	Como	20%
N. Marchant (RDPG)	PRS	Herbarium	30%
B. Maslin (PL)	PRS	Herbarium	10%
B. Shearer (PL)	PRS	Dwellingup	10%
A. Start (RDPG)	PRS	Woodvale	50%

Technical & Clerical Total (CRF) = 5.00

D. Brockwell	Herbarium	100%
J. Dorlandt	Como	50%
C. Fang (PL)	Herbarium	10%
C. Farrell	Woodvale	100%
G. Godfrey	Como	50%
J. Pryde	Woodvale	100%

RESEARCH SUPPORT

Professional Total = .50

S Crombie (RCM)	RS	Dwellingup	10%
L. McCaw (RCM)	RS	Manjimup	20%
M Williams (RCM)	RS	Como	20%

Technical & Clerical Total = 12.05

C. Anderson	Woodvale	100%
R. Bowles	Dwellingup	50% (of 2.5 days/week = 50%)
L. Cade	Woodvale	100%
J. Dorlandt	Como	10%
B. Giles	Dwellingup	50% (of 2.5 days/week = 50%)
R. Giles	Dwellingup	30%
J. Healey	Manjimup	100%
P. Heslewood	Woodvale	100%
R. Hick	Woodvale	100%

M. Lewis (SE)		Como	100%
M. Lyons		Woodvale	10%
I. McPharlin		Herbarium	100%
J. Rayner		Woodvale	100%
J. Rolfe		Woodvale	20%
G. Pearson		Woodvale	20%
M Pree		Manjimup	50% (of 2.5 days/week = 50%)
R. Sokolowski (RCM)		Woodvale	50%
A. Williams		Woodvale	5%
A. Wincza		Dwellingup	10%
J. Nicholson		Como	100%

BIOGEOGRAPHY

Professional Total = 5.35

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%
K. Kenneally	PRS	Herbarium	20%
N. McKenzie	PRS	Woodvale	90%
K. Morris	SRS	Woodvale	40%
S. van Leeuwen	RS	Karratha	50%
G. Wardell-Johnson	SRS	Manjimup	50%

Technical Total = 4.8

J. Alford		Woodvale	80%
T. Annels		Manjimup	50%
B. Bromilow		Karratha	50%
A. Brown		Woodvale	50%
P. Fuller		Woodvale	10%
M. Lyons		Woodvale	90%
J. Rolfe		Woodvale	60%
C. Vellios		Manjimup	50%
I. Wheeler		Manjimup	50%

ECONOMIC ENTOMOLOGY

Professional Total = 1.3

J. Farr (Program Leader)	RS	Manjimup	90%
I. Abbott	PRS	Como	40%

Technical Total = 3.0

T. Burbidge		Como	100%
S. Dick		Manjimup	100%
Vacant		Manjimup	100%
P. Van Heurck		Como	100%

FAUNA CONSERVATION

Professional Total = 4.80

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	PRS	Woodvale	100%
N. McKenzie	PRS	Woodvale	10%
K. Morris	SRS	Woodvale	60%
R. Prince	SRS	Woodvale	100%
G. Wardell-Johnson	SRS	Manjimup	50%
EXTERNALLY FUNDED			
D. Algar	RS	Woodvale	50%
G. Hall	RS	Woodvale	100%
N. Marlow	RS	Woodvale	100%
S. Turner	RS	Fisheries Dept, Waterman	100%
L. Whisson	RS	Woodvale	100%

Technical Total = 6.15

A. Annels		Manjimup	50%
P. Fuller		Woodvale	50%
T. Leftwich		Woodvale	100%
M. Onus		Woodvale	100%
J. Rolfe		Woodvale	20%
N. Thomas		Woodvale	100%
A. Williams		Woodvale	95%
I. Wheeler		Manjimup	50%
C. Vellios		Manjimup	50%

FIRE

Professional Total = 5.00

G. Friend (Program Leader)	PRS	Woodvale	90%
P. Christensen	SPRS	Manjimup	20%
A.A. Burbidge	DR	Woodvale	10%
N. Burrows	SRS	Woodvale	100%
L. McCaw	RS	Manjimup	80%
D. Pearson	RS	Woodvale	100%
A. Start	PRS	Woodvale	50%
S. van Leeuwen	RS	Karratha	50%

Technical Total = 8.45

R. Bromilow		Karratha	50%
P. Fuller		Woodvale	35%
M. Langley		Woodvale	60% (of 3 days/week = 100%)
G. Liddelow		Manjimup	100%
K. Maisey		Woodvale	100%
D. Mitchell		Woodvale	100%
J. Neal		Manjimup	100%
A. Robinson		Manjimup	100%
R. Smith		Manjimup	100%
B. Ward		Manjimup	100%

EXTERNALLY FUNDED

B. Scourse		Woodvale	100% (of 3 days/week = 60%)

FLORA COLLECTIONS

Professional Total = 2.90

B Maslin (Program Leader)	PRS	Herbarium	80%
J. Armstrong	SPRS	Herbarium	10%
K. Kenneally	PRS	Herbarium	70%
B. Koch	RS	Herbarium	50% (of 2.5 days/week = 50%)
P. Wilson	PRS	Herbarium	80%

EXTERNALLY FUNDED

R. Cowan (part-time)		Herbarium	100% (of 3 days/week = 60%)
M. Trudgen (part-time)		Herbarium	100% (of 2 days/week = 40%)

FLORA CONSERVATION

Professional Total = 4.50

D. Coates (Program Leader)	SRS	Woodvale	85%
J. Armstrong	SPRS	Herbarium	30%
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	75%
N. Marchant	PRS	Herbarium	20%
B. Maslin	PRS	Herbarium	10%
S. Patrick	RS	Herbarium	60%
G. Perry	SRS	Herbarium	100%
P. Wilson	PRS	Herbarium	20%

EXTERNALLY FUNDED

S. Carstairs		Herbarium	100% (of 3 days/week = 60%)
D. Goble-Garrett		Herbarium	100% (of 2.5 days/week = 50%)
A. Kelly		Herbarium	100%
F. Mollemans		Herbarium	100%

Technical Total = 1.65

J. Alford		Woodvale	20%
A. Brown		Woodvale	50%
R. Cranfield		Herbarium	20%
P. Fuller		Woodvale	5%
R. Sokolowski		Woodvale	50%
P. Spencer		Herbarium	20%

FLORA INFORMATION PROGRAM

Professional Total = 3.75

N. Lander(Program Leader)	PRS	Herbarium	90%
A.A. Burbidge	DR	Woodvale	10%
K. Kenneally	PRS	Herbarium	10%
T Macfarlane	SRS	Herbarium	25%
N. Marchant	PRS	Herbarium	50%
S. Patrick	RS	Herbarium	40%
B. Rye	RS	Herbarium	50% (of 2.5 days/week = 50%)
J. Wheeler	SRS	Herbarium	100%

Technical Total = .70

S. Curry		Herbarium	20%
W. Searle		Herbarium	50% (of 2.5 days/week = 50%)

HERBARIUM SERVICES

Technical/Clerical Total = 4.80

C. Fang (Program Leader)		Herbarium	90%
R. Cranfield		Herbarium	80%
S. Curry		Herbarium	80%
V. Hamley		Herbarium	100%
C. Parker		Herbarium	50% (of 2.5 days/week = 50%)
P. Spencer		Herbarium	80%

NATIVE FOREST SILVICULTURE

Professional Total = 3.15

S. Crombie(Program Leader)	RS	Dwellingup	70%
D. Coates	PRS	Herbarium	5%
P Hewett	RS	Manjimup	100%
R. Mazanec	RS	Dwellingup	40%
P. Pigott	RS	Narrogin	100%

Technical Total = 5.50

T. Birmingham		Dwellingup	40%
R. Giles		Dwellingup	70%
M Mason		Dwellingup	40%
C. Portlock		Dwellingup	100%
J Rooney		Manjimup	100%
C. Ward		Manjimup	100%
K. Whitford		Dwellingup	100%

PLANT DISEASES

Professional Total = 3.40

B. Shearer (Program Leader)	PRS	Dwellingup	90%
E. Davison	PRS	Como	50%
M. Stukely	RS	Como	100%
R. Wills	RS	Manjimup	100%

EXTERNALLY FUNDED

F. Bunny		Como	100%

Technical Total = 6.50

R. Buehrig		Dwellingup	100%
C. Crane		Como	100%
M. Dillon		Dwellingup	100%
R. Fairman		Dwellingup	100%
J. Kinal		Dwellingup	100%
F. Tay		Como	50%
H. White		Manjimup	100%

EXTERNALLY FUNDED

B. Smith		Como	50%

PLANTATION SILVICULTURE

Professional Total = 4.50

J. McGrath (Program Leader)	SRS	Busselton	80%
J. Bartle	PRS	Como	10%
T. Butcher	SRS	Como	100%
R. Harper	RS	Albany	(contract)100%
R. Mazanec	RS	Dwellingup	60%
R. Moore	SRS	Busselton	100%

EXTERNALLY FUNDED

J. Bartle (VATPAS)	PRS	Como	90%
D Bicknell	RS	Esperance	100%
G. Ellis (VATPAS)	RS	Manjimup	100%

Technical & Clerical Total 8.50

T. Birmingham	Dwellingup	60%
M Cully	Manjimup	100%
I Dumbrell	Busselton	100%
R Hingston	Busselton	100%
M. Mason	Dwellingup	60%
B. Read	Busselton	80%
J. Stritoff	Como/Wanneroo	100%
S. Suffling	Como	50% (of 2.5 days/week = 50%)
A. Wills	Como	100%
L. Wong	Como	100%

EXTERNALLY FUNDED

D. Burton (VATPAS)	Como	100%
J. Dorlandt (VATPAS)	Como	15%

RESEARCH TECHNIQUES

Professional Total = 4.70

M.Choo (Program Leader)	SRS	Woodvale	90%
A. Chapman	RS	Manjimup	100%
P. Gioia	RS	Woodvale	100%
M. Williams	RS	Como	80%
M. Yung	RS	Woodvale	100%

Technical Total = 2.10

A. Wincza	Dwellingup	90%
Y. Woods	Manjimup	100%
B Read	Busselton	20%

WETLANDS AND WATERBIRDS

Professional Total = 1.9

J. Lane (Program Leader)	PRS	Woodvale	90%
S. Halse	SRS	Woodvale	100%

EXTERNALLY FUNDED

A. Storey	RS	Woodvale	100%

Technical Total = 0.8

G. Pearson	Woodvale	80%

WOOD UTILIZATION

Professional Total = 3.50

G. Siemon (Program Leader)	PRS	Como	100%
G. Brennan	RS	Harvey	100%
E. Davison	SRS	Como	50%
B. Glossop	RS	Harvey	100%

Technical & Clerical Total = 5.25

J. Dorlandt	Como	25%
G. Godfery	Como	50%
T. Jones	Como	100%
T. McDonald	Como	100%
J. Pitcher	Harvey	100%
C. Summerell	Harvey	100%
F. Tay	Como	50%

Appendix II
Current Research Projects

F indicates the RPP supports CALM's Forest Resources Management Primary Program
N indicates the RPP supports CALM's Nature Conservation and Wildlife Management Primary Program.

RPP No	TITLE	PRINCIPAL INVESTIGATOR
BIOGEOGRAPHY		
20N	Biogeography patterns vs soil attributes	N McKenzie
52N	Establishment of monitoring program in CALM	A Hopkins
56N	Atlas of all Western Australian Proteaceae (except *Banksia*)	A Hopkins
59N	Report on survey work at Tutanning Nature Reserve	A Hopkins
60N	Report on survey work at Middle Island/Recherche Archipelago	A Hopkins
60N	Report on survey work at Mount Lesueur	A Hopkins
63N	Report on survey work at Two Peoples Bay	A Hopkins
75N	Cooloomia Nature Reserve	AA Burbidge *et al*
92N	Biogeography of the flora of southern Nullarbor	G Keighery
94N	Islands: Lancelin to Dongara	GJ Keighery
95N	Stirling Range and Environs Flora	GJ Keighery
99N	Ecological Survey of proposed Boonanaring Reserve	AH Burbidge & GJ Keighery
120N	Extending the Nullarbor data base: do the patterns change?	N McKenzie *et al.*
121N	Assemblage changes over 12 months at Cocklebiddy	N McKenzie *et al.*
121N	Lizard litter patch guilds	N McKenzie
122N	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
125N	Biological survey of sites on the Mandora palaeoriver and Radi Hills, Great Sandy Desert	N McKenzie
126N	Late Holocene mammal fauna of the Irwin & Carnarvon districts, Western Australia **(consultancy let by)**	N McKenzie
127N	Fitzgerald River National Park Survey-F.R.N.P.S. Association consultants	N McKenzie
128N	Buccaneer Archipelago	N McKenzie *et al.*
129N	Automatic bat assemblage sampling	N McKenzie
132N	Biological survey of islands in the north-west	K Morris
132N	Vertebrate Fauna Survey of Dampier Archipelago	K Morris
132N	Vertebrate Fauna of Monte Bello Islands	K Morris
132N	Management Guidelines for Monte Bello Islands	K Morris
141N	Dorre Island and Associated Shark Bay Islands - Ecological Survey	R Prince
1/83N	Distribution and taxonomic status of the Geocrinia	G Wardell-Johnson
1/83N	Trial mapping of community-types in regenerating Karri forest	G Wardell-Johnson
44/88N	Endemic Forest Eucalypt survey	G Wardell-Johnson
7/90N	Assemment of biological data of A-Class conservation reserves considered for opening the Bailey Procedures	N Gibson
8/90N	A detailed regional survey of the coastal communities of the Warren Botanical Sub District	N Gibson
9/90N	Investigation of the community dynamics of Kwongan vegetation	N Gibson
10/90N	Development of a catalog of the national parks and nature reserves of Western Australia	N Gibson
3/91N	Cape Arid Survey	AH Burbidge *et al.*
22/91N	Coolcalalaya Survey	AH Burbidge
32/91N	Yanchep National Park Survey	AH Burbidge
57/91N	Analysis software for survey data	N McKenzie
59/91N	Bat assemblage structure studies disturbance and determinism	N McKenzie
60/91N	Rainforest Survey	N McKenzie *et al.*
67/91N	Walpole-Nornalup National Park survey	G Wardell-Johnson
70/91N	Conservation status and biology of granite rock endemics of the Wheatbelt	S Hopper

RPP No	TITLE	PRINCIPAL INVESTIGATOR
ECONOMIC ENTOMOLOGY		
20/84F	Leaf dynamics of Jarrah in relation to impact of Jarrah Leafminer.	I Abbott
27/84F	Effect of Jarrah Leafminer on growth of Jarrah incipient ground coppice after fire.	I Abbott
2/85F	Comparison of insect damage to Jarrah ground coppice in the southern and northern Jarrah forests.	I Abbott
23/85F	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
32/85F	External symptoms of infestation of Karri by the borer *Tryphocaria acanthocera*	I Abbott
24/86F	The impact of repeated defoliations on the wood growth of Jarrah saplings.	I Abbott
59/86F	Survey of the incidence of infestation of the borer *Tryphocaria acanthocera* in even-aged Karri.	I Abbott
61/86F	Crown deterioration of Jarrah poles in the southern Jarrah forest following grazing of leaves by insects.	J Farr
19/87F	Effect of fire on Gumleaf Skeletonizer, Jarrah Leafminer and other invertebrates of Jarrah crowns in the southern Jarrah forest.	J Farr
44/87F	Damage to Jarrah foliage caused by Jarrah Leafminer in Collie District.	I Abbott
45/87F	Crown condition and wood growth of codominant/subdominant Jarrah poles resistant and susceptible to Jarrah Leafminer infestation in Collie District.	I Abbott
47/87F	Survey of Jarrah Leafminer in Jarrah forest between Collie and Dwellingup.	I Abbott
48/87F	Survey of Gumleaf Skeletonizer in Jarrah forest between the currently infested zone and Greenbushes, Mayanup and Nannup.	J Farr
20/88F	Operational scale testing of the effectiveness of a single Autumn fire in controlling Jarrah Leafminer.	I Abbott
39/88F	Survival of *Uraba lugens* on W.A. eucalypts	J Farr
41/88F	Fecundity of *Uraba lugens* in relation to pupal mass.	J Farr
42/88F	Spatial distribution of *Uraba lugens* pupae in relation to its Jarrah host.	J Farr
22/89F	Impact of prescribed fire on infestation by Jarrah Leafminer	I Abbott
5/90F	Impact of recent logging of Jarrah forest on the population density of Jarrah leafminer	I Abbott
22/90N	Life cycle of *Cardiaspina brunnea*	J Farr
23/90N	Population monitoring of *Cardiaspina brunnea* on *Eucalyptus occidentalis*	J Farr
24/90N	Crown decline of *Eucalyptus occidentalis* due to infestation with *Cardiaspina brunnea*	J Farr
25/90N	Adult emergence of *Cardiaspina brunnea*	J Farr
26/90N	Stage of development of *Cardiaspina brunnea*	J Farr
1/91F	Spatial variation in rate of parasitization of Jarrah leafminer larvae	I Abbott
36/91F	Impact of prescribed spring fire on rate of parasitization of Jarrah leafminer in heavily infested Jarrah forest	I Abbott
37/91F	Impact of Autumn (dry soil) burning on the abundance of Jarrah leafminer in Collie District	I Abbott
FAUNA CONSERVATION		
17-18/86N	Conservation of the Ground Parrot in Western Australia	AH Burbidge
39-41/86N	Numbat study: habitat and food sources	JA Friend
42-43/86N	Numbat study: translocation and re-establishment	JA Friend
43-44/86N	Ecology of the Western Barred Bandicoot	JA Friend
104/86N	Rockwallaby conservation - wheatbelt & other areas	JE Kinnear
105-106/86N	Ecology of Predation by the Fox	JE Kinnear
106-8/86N	Rock-wallaby conservation - Dampier Archipelago	JE Kinnear
108-9/86N	Rock-wallaby conservation - Eastern Pilbara	JE Kinnear
111/86N	Fox biology and control	D Algar
130/86N	Chiropteran Studies: *Mormopterus* taxonomy	N McKenzie
133/86N	Conservation of WA marine turtles	RIT Prince
141/86N	Banded Hare-wallaby, stage 3	RIT Prince
142/86N	Biogeography of dugong and seagrass	RIT Prince
142-4/86	Dunong conservation	RIT Prince
1424/86N	Management of dugong and marine turtle exploitation	RIT Prince
7/91N	Breeding seabirds database	AA Burbidge
8/91N	Re-introduction of the Greater Stick-nest Rat	KD Morris

RPP No	TITLE	PRINCIPAL INVESTIGATOR
28/91N	Eradication of *Rattus* on Barrow and Middle Islands	KD Morris
29/91N	Monitoring Lesser Noddy etc on Pelsaert I.	AA Burbidge
30/91N	Ecology and conservation of small mammals on Barrow I	KD Morris
33/91N	Conservation of the Chuditch	KD Morris
34/91N	Western Swamp Tortoise: population monitoring	AA Burbidge
35/91N	Western Swamp Tortoise: captive breeding	AA Burbidge
42/91N	Conservation of the Red-tailed Phascogale	JA Friend & GR Friend
64/91N	Island mammal database	AA Burbidge & I Abbott
65/91N	Taxonomy and zoogeography of Australian landhoppers	JA Friend
77/91N	Life history of *Drupella* at Ningaloo	S Turner

FIRE PROGRAM

28/78F	Forest fire behaviour under dry fuel conditions (Jarrah)	N Burrows
2/84F	Karri regrowth fuels	L McCaw
7/84N	Regeneration of heartleaf thickets	G Wardell-Johnson
8/84N	Fire, season and termite activity.	G Wardell-Johnson
15/85F	Fire damage to regenerated Karri stands	L Mc Caw
21/85F	Prescribed fire behaviour in regenerated Karri stands.	L McCaw
12/86N	Effects of five fire regimes on forest understorey species.	N Burrows
18/86F	The combustion rate of forest fuels.	N Burrows
22/86N	Karri forest bird community study.	G Wardell-Johnson
47/86F	Fuel studies in southern wetlands.	N Burrows
59-62	Computerized fire management system - Tutanning Nature Reserves.	A Hopkins
15/87N	Effects of various fire control straegies in heathland and shrubland vegetation.	L McCaw
23/87N	The effect of fire on *Lambertia rariflora*	N Burrows
46/87N	The formation of hollows in karri and marri trees.	G Wardell-Johnson
20/88N	Effects of mosaic burns on birds in hummock grasslands	AA Burbidge
22/88N	Fire behaviour in heathlands and shrublands.	L McCaw
31/88N	Effects of fire on reptiles, frogs and small mammals in the Stirling Range National Park.	G Friend
32/88N	Effects of season of burn and fire size on desert vertebrates.	D Pearson
33/88N	Effects of fire season and intensity on floral succession in Queen Victoria Spring Nature Reserve	D Pearson
34/88N	Effects of patch burning on lizards in hummock grasslands.	D Pearson
36/88F	Computerized fire management system - forest regions.	J Beck
37/88N	Aboriginal knowledge of fire management on hummock grasslands.	D Pearson
38/88N	Effects of fire on medium - sized desert mammals.	P Christensen
62/88N	Fire effects on vegetation - Stirling Range National Park	L McCaw
15/89N	Monitoring post fire vegetation response in the Gibson Desert and Plumbridge Lakes Nature Reserves	N Burrows
16/89N	Fire effects on invertebrates in the Stirling Ranges National Park	G Friend
17/90N	Effects of prescribed burning on small vertebrates in Tutanning Nature Reserve	G Friend
18/90N	Effects of prescribed burning on invertebrates in Tutanning Nature Reserve	G Friend
19/90N	Effects of prescribed burning on invertebrates in Durokoppin and East Yorkrakine Nature Reserves	G Friend
20/90N	Effects of fire regime on ground dwelling invertebrates in Jarrah forest	G Friend
21/90N	Effects on prescribed burning on *Phascogale calura* (externally funded)	G Friend
59/90N	Regeneration of suitable habitat for the Tammar Wallaby using prescribed fire	P Christensen
60/90N	Effects of patch-burning and feral predator control on the survival of rare mammals re-introduced to the Gibson Desert Nature Reserve	P Christensen
52/91N	Fire effects studies on vegetation, Tutanning Nature Reserves.	A Hopkins
53/91N	Fire studies in shrublands at Stirling Range National Park.	A Hopkins
54/91N	Fire Mulga Study	S van Leeuwen/ T Start

RPP No	TITLE	PRINCIPAL INVESTIGATOR
FLORA COLLECTIONS		
115/91N	The clarification of the taxonomy of *Tegicornia* and some sections in the genus *Halosarcia* (Chenopodiaceae)	P Wilson
116/91N	The taxonomy of the *Helipterum - Helichrysum* group (Asteraceae) in Australia	P Wilson
117/91N	Research curation of the family Rutaceae in the WA Herbarium	J Armstrong
143/91N	Botanical survey of Greenough District	K Kenneally
144/91N	Flora of Australia : *Acacia*	B Maslin
145/91N	Generic status of *Acacia* : an assessment	B Maslin
146/91N	Taxonomy of *Acacia tumida* and its allies	B Maslin
FLORA CONSERVATION		
119/91N	Taxonomy and Phylogeny of Rutaceae	J Armstrong
120/91N	Rare and poorly known WA eucalypt survey	S Hopper
121/91N	Book on pollination of Western Australian Orchids	S Hopper
122/91N	Systematics of Kangaroo Paws and related plants (Haemodoraceae subfamily Conostylidoideae)	S Hopper
123/91N	Wildlife Management Program for *Anigozanthos pulcherrimus* and *Macropidia fuliginosa*	S Hopper
124/91N	Orchids in major WA Conservation Reserves	S Hopper
125/91N	Systematics and biogeography of Western Australian eucalypts	S Hopper
126/91N	Systematics of selected Western Australian orchids (*Caladenia* and allied genera).	S Hopper
127/91N	Rare Flora Management Plan for the Moora District	S Patrick
128/91N	Population biology and conservation genetics of *Acacia anomala*	D Coates
129/91N	Population biology and conservation genetics of *Banksia verticillata*	D Coates
130/91N	Population biology and conservation genetics of *Stylidium coroniforme*	D Coates
131/91N	Population biology and conservation genetics of *Banksia brownii*	D Coates
132/91N	Population biology and conservation genetics of *Banksia cuneata*, Banksia oligantha and *Banksia ilicifolia*	D Coates
133/91N	Biosystematics and evolution in *Stylidium*	D Coates
134/91N	Field surveys and conservation status of rare and threatened flora	D Coates
135/91N	Conservation status of members of the family Rhamnaceae	B Rye
136/91N	Taxonomic studies in the Lyperaceae	B Rye
137/91N	Taxonomy of the Tiliaceae	B Rye
138/91N	Taxonomic revision of *Beaufortia* R.Br.	AA Burbidge
139/91N	Taxonomy of selected WA grasses	T Macfarlane
140/91N	Taxonomy of Pultenaea and other legume genera	T Macfarlane
141/91N	Taxonomic research on Liliaceae sens. lat. and related monocots of W.A.	T Macfarlane
142/91N	Assessment of the nomenclatural problems associated with names on schedule "Protected Flora Declared as Rare Flora - Item 2 Taxa Presumed to be Extinct"	G Perry
FLORA INFORMATION		
46/91N	Taxonomic studies in the family Thamnaceae	B Rye
47/91N	Flora of the Kimberley Region	JR Wheeler *et al.*
48/91N	INFORM: an integrated taxonomic multimedia tool for the description of Western Australian Flora	A Chapman *et al*
49/91N	Identification guide to allergenic plants	S Patrick
50/91N	Revision of *Olearia*	NS Lander
51/91N	Identification guide to endemic plants of the Darling Scarp	S Patrick
84/91N	Taxonomic and evolutionary studies in Droseraceae and Bylilis	N Marchant *et al.*
85/91N	Taxonomic studies in *Myrtaceae*	N Marchant/ G Keighery
112/91N	Flora writing pilot project the genus *Agonis*	J Wheeler
113/91N	Flora of the Walpole-Nornaluyp National Park	J Wheeler
118/91N	Preparation of "Flora of Australia" contributions	T Macfarlane
140/91N	Flora of Australia treatments of Leguminosae and Poaceae taxa	T Macfarlane

RPP No	TITLE	PRINCIPAL INVESTIGATOR

PLANT DISEASES

40/83F	Prediction of impact of *P. cinnamomi* from site indicators	B Shearer
14/84F	Assessment of dieback damage to jarrah roots	B Shearer
42/85F	Resistance of *E. marginata* to *P. cinnamomi*	M Stukely
72/86F	Injection of *Banksia seminuda* with fungicide	B Shearer
73/86F	The association of pathogens with mortality of *Eucalyptus*	B Shearer
75/86F	The impact of *Armillaria luteobubalina* in the Wandoo forest	B Shearer
76/86F	Population dynamics of *P. cinnamomi* in jarrah/*Banksia*	B Shearer
77/86F	The effect of phosphorous acid on *P. cinnamomi* lesion	B Shearer
04/87F	Comparison on rate of spread of dieback in jarrah/banksia	B Shearer
34/87F	Validation of *P. cinnamomi* hazard rating in northern jarrah	B Shearer
35/87F	Phenology of *P. cinnamomi* hazard indicators	B Shearer
43/87F	Quantification of jarrah deaths with time from aerial photo	B Shearer
49/87F	An investigation of the cause of death & decline of tuart	B Shearer
08/89F	Canopy density, soil temperature & *P. cinnamomi*	J Kinal
23/89F	Extension of *P. cinnamomi* and thinning	F Bunny
26/89N	Protect *B. brownii*, *B. baxteri*, *B. coccinea* by phosphorous acid	B Shearer
36/89N	Impact *Phytophthora* spp. coastal plain Perth to Cape Leeuwin	B Shearer
03/90N	Cankers of *B. baxteri* and *B. coccinea*	B Shearer
33/90F	Field trials *P. cinnamomi* resistant jarrah clones	M Stukely
52/90N	Infection of *Banksia* by *Phytophthora*	E Davison
54/90N	Control *Phytophthora* species in *Banksia* communities North of Perth of phosphorous acid	B Shearer
63/90F	Infection of jarrah by *Cryphonectria*	E Davison
65/90N	Assessment of impact of *Armillaria* in woodlands & shrublands of coastal plain	B Shearer
66/90N	Control of *Armillaria* in coastal shrubland by phosphorous acid	B Shearer
68/90N	Susceptibility of jarrah forest understorey to *P. cinnamomi*	B Shearer
13/91F	Screening jarrah provenances for *P. cinnamomi* resistance	M Stukely
14/91F	Geomorphology and impact of *P. cinnamomi*	B Shearer
15/91N	Impact of *Phytophthora cinnamomi* national parks, south coast	R Wills
16/91N	Survival, inoculum *P. cinnamomi* in roots hosts	R Wills
17/91F	Pathogenicity fungi isolated from King Jarrah Heritage Trail	R Wills
18/91N	Impact fungi vegetation King Jarrah Heritage Trail	R Wills
23/91N	Analasis climatic data & activity pathogenic fungi	R Wills
73/91F	Differential susceptibility jarrah coppice & advanced growth	F Bunny

PLANTATION SILVICULTURE

Pine

16/58F	*P. pinaster* growth trial at Gnangara.	T Butcher
19/62F	*P. pinaster* seed orchards No. 1 Joondalup, No 2 Mullaloo No 3 Manjimup	T Butcher
3/65F	*P pinaster* provenance trial at Gnangara	T Butcher
20/65F	Basal area control of thinning in *P. pinaster,* Bassendean sands	T Butcher
21/65F	*P. pinaster* progeny trials widespread throughout SW Australia	T Butcher
27/65F	*P. radiata* early thinning for particle board	R Moore
7/66F	*P radiata* non-commercial thinning	R Moore
12/66F	*P. radiata* first thinning study	R Moore
48/66F	Establishment of large pilot plots for *P. pinaster*	T Butcher
54/66F	Basal area control of thinning in *P. pinaster,* Spearwood sands	T Butcher
17/67F	*P. pinaster* response to phosphate on leached Bassendean sands	T Butcher
25/67F	Bussel's arboretum at Collie	R Moore
26/67F	Meribup arboretum at Manjimup	R Moore
27/67F	Asplin's arboretum at Nannup	R Moore
20/68F	Hydrology in *P. pinaster* stands	T Butcher
34/68F	*P. radiata* seed orchard at West Manjimup, HAPSO and clone bank	T Butcher
16/69F	Pine establishment trial at Mt Cooke.	T Butcher
21/71F	*P. radiata* international gene pool progeny test (RS4 and RS5)	T Butcher
22/71F	*P. radiata* progeny trials throughout SW Australia	T Butcher
29/71F	Productivity of second rotation pine at Gnangara and Grimwade	T Butcher
8/72F	Fertiliser and thinning for *P. pinaster* on Bassendean grey sand	T Butcher

RPP No	TITLE	PRINCIPAL INVESTIGATOR
19/72F	*P. radiata* genetics yield trial	T Butcher
20/72F	*P. pinaster* genetics yield trial	T Butcher
15/73F	Grazing and forestry combination in Blackwood Valley	R Moore
23/73F	Subsequent fertilisation of *P. pinaster* on yellow sands	T Butcher
10/75F	Agroforestry plan for Chapman's Lease.	R Moore
20/75F	Pilot plots of *P. radiata* at Moore River	T Butcher
20/76F	Early fertilization of P. pinaster on marginal sites	T Butcher
21/76F	Fertilization of adolescent *P. pinaster* on yellow sands	T Butcher
23/76F	Fertilization of adolescent *P. pinaster* on grey sands	T Butcher
2/78F	Agroforestry trial at Wonnerup	R Moore
20/78F	Agroforestry regimes with P. radiata	R Moore
29/78F	*P. radiata* provenance trial at Busselton [RX. 6(1979)]	T Butcher
30/78F	*P radiata* genetic variation in dieback resistance	T Butcher/ M Stukely
25/79F	Provenance trials of *P. taeda* and *P. serotina* in sunkland	T Butcher
4/80F	Agroforestry trial jarrahwood	R Moore
7/80F	Strip planting of pines for agroforestry	R Moore
26/80F	*P. pinaster* high pruning trial	T Butcher
2/81F	Timing of fertiliser for maximum response in *P. pinaster*	T Butcher
4/81F	Agroforestry trial in Wellington Catchment	R Moore
10/81F	Agroforestry species trial Vasse 2	R Moore
2/82F	Silviculture alternatives for fuel reduced buffers	R Moore
5/82F	Comparison of silvicultural regimes for Sunkland *P. radiata*	R Moore
7/82F	*Pinus pinaster* second rotation studies	T Butcher
9/82F	Forms of nitrogen nutrition for *P. radiata*	J McGrath
19/82F	Phosphorus regimes for pastured pine	J McGrath
21/82F	Pine progeny trials in the Wellington catchment	T Butcher
33/82F	Pine cuttings for agroforestry	R Moore
43/82F	Agroforestry trials at Esperance	R Moore
44/82F	Phase 3 pine species trial for Sunkland (4 species)	R Moore
45/82F	Effect of pruning on wide spaced *P. radiata*	R Moore
3/83F	Comparison of form and set lift pruning in *P. radiata*	R Moore
6/83F	Effect of *P. radiata* thinning on wind stability	R Moore
7/83F	Early thinning of *P. radiata* on clover in Sunklands	R Moore
15/83F	Combination of Alnus sp. and *P. radiata*	J McGrath
25/83F	Adjacent 1R/2R pinaster on good/marginal sands at Yanchep	T Butcher
29/83F	Cultivation and fertilisation of marginal *P. pinaster* sites at Pinjar	T Butcher
28/83F	Effect of initial stocking on future growth of *P. radiata* crop trees	R Moore
30/83F	*P. radiata* non commercial thinning	R Moore
39/83F	Screening established *P. radiata* for dieback resistance	M Stukely
14/84F	Sunkland site trial *P. radiata* Phase III	P Jenkins
1/85F	Effect of nitrogen supply on *P. radiata* growth	J McGrath
8/85F	*P radiata* response to N and P after thinning on red loams	J McGrath
17/85F	Phosphorus supply and concentration in *P. radiata* needles	J McGrath
2/86F	Timber and agricultural production from two stand densities of pine agroforestry in the Manjimup area	R Moore
9/87F	Timing of fertilization in thinned *P. radiata*	J McGrath
10/87F	Frequency of fertilization in thinned *P. radiata*	J McGrath
11/87F	The effect of thinning and fertilization on growth of *P. radiata*	J McGrath
33/87F	Initial Fertilizer requirements for *P. radiata* on the South-Coast	J McGrath
18/88F	Initial weed control and fertilization of *P. radiata* on the South Coast	J McGrath
43/88F	Drought survey in the Blackwood Valley pine plantations	J McGrath
15/89F	Thinning and fertilizing regimes for 13 year old *P. radiata* on the Donnybrook sunklands	J McGrath
64/90F	Potassium rate trial for *P. radiata*	J McGrath
22/71F	Search 85 radiata breeding population	T Butcher
Hardwood		
14/76F	Rehabilitation species trial	JR Bartle
12/78F	"	"
31/78F	"	"
27/80F	*E. globulus* provenance trial	T Butcher
4/81F	1981 Agroforestry trial - Wellington catchment	R Moore
6/81F	*E. wandoo* progeny trial.	R Mazanec/ T Butcher
10/81F	Agroforestry species trial (Vasse 2)	R Moore
24/82F	*E. wandoo* provenance/family trial on bauxite pit site at Jarrahdale	R Mazanec/ T Butcher

RPP No	TITLE	PRINCIPAL INVESTIGATOR
25/82F	*E. wandoo* provenance/family trial on Wellington catchment (Souths Farm)	R Mazanec/ T Butcher
38/82F	*E. maculata* provenance trials	R Mazanec
40/82F	Geographic variation in *E. wandoo*	R Mazanec/ T Butcher
38/83F	*E resinifera* provenance trial	R Mazanec
32/84F	*E globulus* family/provenance trial	R Mazanec/T Butcher
33/84F	*E accedens* family/provenance trial	R Mazanec
34/84F	*E camaldulensis* provenance trial	
5/85F	*E. wandoo* gene pool	R Mazanec/ T Butcher
4/86F	*E. accedens* family/provenance trial	R Mazanec
5/86F	*E pilularis* family/provenance trial	R Mazanec
2/87F	Eucalypt Agroforestry Trial (Busselton, Dinninup and Middlesex)	R Moore
5/87F	*E. sideroxylon* family/provenance trial	R Mazanec
8/87F	*E saligna* family/provenance trial	R Mazanec
10/88F	*E. microcarpa* family/provenance trial	R Mazanec
48/88F	*E. microcarpa* provenance trial	T Birmingham/ R Mazanec
53/88F	*E. muellerana* family/provenance trial	R Mazanec
54/88F	*E. muellerana* family/provenance trial	R Mazanec
11/89F	*E. botryoides* family/provenance trial	R Mazanec
27/89F	Tree growth response to blasting Peel hardpan	J Bartle
28/89F	Tree growth response to subsoil ripping	J Bartle
29/90F	Yield testing prospective pulpwood species, provenances and clones	J Bartle/G Ellis
35/89F	Tree Regrowth response to cutting trenches in Peel hardpan	J Bartle
11/90F	Integration of plantations of *Eucalyptus globulus* on farmland and its effect on groundwater and impact on production of adjacent pasture	J Bartle
12/90F	Integration of plantations of *E. globulus* on farmland and its effect on drain runoff quantity and quality (with particular emphasis on phosphorus leaching).	J Bartle
13/90F	Comparison of production of plantation of *E. globulus* on farmland with standard farm practice on the leaching sands of the Swan Coastal Plain.	J Bartle
36/90F	Post planting control of recurrent weeds in *E. globulus* plantations using pre and post emergent herbicides applied with a side delivery nozzle.	G Ellis
37/90F	Comparison of thirteen pre-plant herbicide treatments, plus control, on the establishment and growth of *E. globulus* seedlings.	G Elliis
38/90F	The use of controlled release "Marshall suSCon" insecticide granules in the control of African Black Beetle in *E. globulus* plantations	G Ellis
39/90F	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
40/90F	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
41/90F	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
42/90F	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
43/90F	Plaid density design for investigation of the effect of stocking density and espacement on the productivity of *E. globulus* plantation.	G Ellis
44/90F	The effect of mounding and scalping on the survival and early growth of *E. globulus* seedlings established in deep, grey siliceous sands on the Swan Coatal Plain.	G Ellis
45/90F	N P factorial fertilizer trial plus comparison with formulated fertilizer mixes - DAP. Agras Cu Zn Mo. Slow release tree tablet	G Ellis
46/90F	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
47/90F	The benefits of various levels of post planting manual weed control in the establishment of *E. globulus* plantations.	G Ellis
48/90F	Comparison of Roundup/Oust and Roundup/Simazine herbicide sprays for the establishment of *E. globulus* seedlings on farmland.	G Ellis

RPP No	TITLE	PRINCIPAL INVESTIGATOR
49/90F	The role of lime, phosphorus and potassium in the establishment of *E. globulus* plantations on ex-bush acid sands	G Ellis
50/90F	DAP, Agras + Co Zn Mo, tree tablet fertilizer timing trial	G Ellis
51/90F	The short and long term benefits of weed control in the establishment of *E. globulus* plantations	G Ellis
147/91F	WA cooperative *E. globulus* breeding population trials	T Butcher/R Mazanec

NATIVE FOREST SILVICULTURE

Jarrah Forest

49/65F	Growth rates of pile-sized jarrah in even-aged forest at various stockings	S Crombie
15/66F	Jarrah pole thinning - young poles (chalk)	S Crombie
1/77F	Forest stand manipulation to increase water production	S Crombie
24/82F	Enrichment planting trial	G Strelein
20/82F	Comparison of the effects of a number of alternative silviculture prescriptions	S Crombie
17/83F	Seasonal growth of jarrah	S Crombie
18/83F	Jarrah seeding establishment trial	G Strelein
19/83F	Fertilizing seeded jarrah	G Strelein
20/83F	Jarrah planting establishment trials	G Strelein
23/83F	Jarrah site classification project	G Strelein
12/84F	Jarrah fertilizer trials 1984	G Strelein
13/84F	Jarrah espacement and lignotuber development trial	G Strelein
16/83F	Hydrological study of the Yarragil catchment relating quality and quantity of landscape and forest treatments	S Crombie
37/84F	Comparison of round-up and Tordon timber control for killing standing jarrah and marri poles in summer	S Crombie
30/85F	Rehabilitation of the dieback degraded Warren Catchment and its effect on water quality and quantity	S Crombie
34/85F	The effect of delays between notching and application of roundup herbicide	S Crombie
35/85F	Effect of concentration of herbicide and stand density on efficacy of Round-up for killing jarrah stump coppice by foliar spray	S Crombie
36/85F	The effect of notch spacing on the success of notching with Round-up herbicide	S Crombie
37/85F	Comparison of Round-up and Tordon timber control for killing standing jarrah and marri poles in winter	S Crombie
39/85F	The effect of Round-up dose on its ability to kill standing jarrah and marri poles in winter using the notching method	S Crombie
40/85F	The effect of coverage of foliar spray of Round-up on its ability to kill coppice	S Crombie
41/85F	The effect of fire on the success of notching jarrah and marri with Round-up herbicide	S Crombie
3/86F	Response of hydrologically important measures of forest density	S Crombie
6/86F	Jarrah lignotuber and root development study	G Strelein
30/86F	Effect of Round-up dose on ability to kill standing jarrah and marri	S Crombie
31/86F	Effect of Round-up dose	S Crombie
43/86F	Effects of site preparation inoculation and timing of fertilizer	G Strelein
3/87F	Study of genetic variation in growth and form of jarrah	R Mazanec
6/87F	Jarrah family/provenance trials	R Mazanec
2/88F	Jarrah pole thinning (Inglehope)	S Crombie
11/89F	Survey of genetic structure of main range jarrah forest using isozymes	R Mazanec
17/89F	Effect of fertilizer on successful regeneration of *E. marginata* using broadcast seeding and mechanical disturbance	P Hewett
20/89N	Verification of the field interpretations and assessment for the WA remnant vegetation protection scheme	P Pigott
30/89F	Ecology of remnant salmon gum (*Eucalyptus salmonaphloia* (F. Muell) woodland near Lake Taarblin (WA)	P Pigott
6/90N	Preliminary assessment of soil seed banks of remnant salmon gum (*Eucalyptus salmonaphloia* (F. Muell)) of woodlands near Lake Taarblin	P Pigott

Karri Forest

28F	Genetic variability and breeding systems in karri	D Coates
26/78F	Karri provenance trials	R Mazanec
15/82F	Karri spacing experiment: Nairn	P Hewett

RPP No	TITLE	PRINCIPAL INVESTIGATOR
3/84F	The effect of thinning, fertilization, and coppice control on growth and form of crop trees	P Hewett
25/85F	Basal area thinning experiment - Treen Brook	P Hewett
19/86F	Karri site classification	G Inions
25/86F	Karri spacing experiment : Muirillup	P Hewett
3/89F	The effect of thinning and fertilizing on the growth and form of crop trees on a 21 year old regrowth karri stand	P Hewett
13/89F	Sheltercup sowing of *E. diversicolor* seed in regeneration coupes	P Hewett
24/89F	Success of infilling karri (*E. diversicolor*) seedlings in 1yr old coupes	P Hewett

RESEARCH TECHNIQUES

2/91N	Standardization of Taxon names and codes in CALM	M Choo
95/91N	Consolidating a State-wide Lat/Long Map Base	P Gioia
96/91N	TAXAPLOT	P Gioia
97/91N	Register of Research Division Corporate Datasets	P Gioia
98/91N	Database of Research Project Plans	M Choo
99/91N	TRAK - animal radio tracking utility - feasibility study	P Gioia
100/91N	SEDIT - A species editing utility	P Gioia
101/91N	Networking PCs in Research Division	P Gioia
102/91N	Declared and Endangered Fauna Register	P Gioia
103/91N	HERBIE	P Gioia

WETLANDS AND WATERBIRDS

24/91N	Annual counts of ducks, swans and coots in south-western Australia	S Halse
25/91N	Study of waterbird usage of Swan Coastal Plain wetlands and the environmental factors controlling usage of the wetlands	S Halse
32/91N	Analysis of results of pelican banding and wing-tagging project	J Lane
38/91N	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
39/91N	Study of distribution of waders of Roebuck Bay and Eighty-mile Beach in relation to abundance of invertebrate prey	S Halse
40/91N	Multidisciplinary study of waterbirds, aquatic invertebrates, hydrology and palaeohistory of Lake Gregory to prepare management guidelines	S Halse

WOOD UTILIZATION

30/82F	Wood quality of pinaster and radiata pine	G Siemon
9/86F	Effect of drying method on Lyctus susceptibility of W.A. sheoak and regrowth karri	G Brennan
26/86F	Strength properties of regrowth eucalypts	G Siemon
41/86F	Durability of Western Australian grown timber species	G Siemon
6/88F	Seasoning - Pre-drying eucalypt timbers from green to below fibre saturation point (f.s.p.) using a batch kiln	G Brennan P Newby
46/88F	Brown wood in karri	E Davison
4/89F	Sawn graded recoveries from a sawmilling trial of regrowth jarrah and karri	K White
14/89F	Field survey of incidence of brown wood in regrowth karri	E Davison
25/89F	Stability of regrowth and mature karri panels constructed from boards	P Newby
31/89F	Effect of pre-steaming and hot water soaking on the drying behaviour of jarrah boards	B Glossop
33/89F	An equilibrium moisture content survey of timber in Western Australia	G Brennan
15/90F	Field testing on an ultrasonic moisture meter	B Glossop
16/90F	Treating *E. globulus* fence posts using four timber preservatives	G Brennan
58/90F	Attempts to omit fungi from Karri brown wood and rots	E Davison

Appendix III

Directory of Expertise of Permanent Professional and Technical Staff

ABORIGINAL LIAISON	BURBIDGE, A.A., FULLER, P., PEARSON, D., PRINCE, R., START, T.
ACACIAS	MASLIN, B.
AGROFORESTRY	MOORE, R.
ALLERGENIC PLANTS	PATRICK S
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	PIGOTT, P.
ARID ZONES SEE ALSO DESERTS	
ARID ZONES - ECOLOGY	START, T., Van LEEUWEN, S.
ARID ZONES - FLORA - IDENTIFICATION	CRANFIELD, R., Van LEEUWEN, S.
ARID ZONES - FLORA - SURVEYS	CRANFIELD, R., Van LEEUWEN, S
ARID ZONES - MAMMALS	PEARSON, D.
ARID ZONES - MAMMALS (SMALL), ARID ZONES - REPTILES	PEARSON, D.
ARMILLARIA	SHEARER, B.
ASTERACEAE - HELICHRYSUM	WILSON, P.
ASTERACEAE - HELIPTERUM	WILSON, P.
ASTERACEAE - OLEARIA	LANDER, N.
BANDICOOTS	FRIEND, T. THOMAS, N.
BATS	START, T.
BEAUFORTIA	BURBIDGE, A.A.
BIOGEOGRAPHY	MCKENZIE, N.
BIOGEOGRAPHY - FAUNA - ISLANDS	MORRIS, K. BURBIDGE, A.A.
BIOGEOGRAPHY - ISLANDS	ABBOTT, I. BURBIDGE, A.A.
BIOGEOGRAPHY - PLANTS	GIBSON, N.
BIOLOGICAL SURVEY TECHNIQUES	LEFTWICH, T., ONUS, M.
BIOMETRICS	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. LANE, J.
BIRDS - SEABIRDS	BURBIDGE, A.A., HALSE, S., FULLER, P.
BIRDS - WATERBIRDS	LANE, J., HALSE, S., PEARSON, G.
BOTANICAL HISTORY	CURRY, S., MARCHANT, N.
BURCHARDIA	MACFARLANE, T.
BUTTERFLIES	WILLIAMS, M., WILLIAMS, A.

CANKERS	SHEARER, B.
CANNABIS IDENTIFICATION	PATRICK, S.
CAPTIVE BREEDING	FRIEND, T.
CHAMAEXEROS	MACFARLANE, T.
CHAMELAUCIUM	KEIGHERY, G., MARCHANT, N.
CHEMICAL ANALYSIS	McGRATH, J., WONG, L.
CHEMICAL USAGE	BIRMINGHAM, T., ROONEY, J.
CHENOPODIACEAE	WILSON, P.
CHROMOSOMAL TECHNIQUES	COATES, D.
CLADISTICS	ARMSTRONG, J.
COLCHICACEAE - BURCHARDIA	MACFARLANE, T.
COLCHICACEAE - WURMBEA	MACFARLANE, T.
COMMUNITY ECOLOGY	McKENZIE, N.
COMPUTING	CHOO, M., GIOIA, P., CHAPMAN, A., YUNG, M., WOODS, Y. WINZA A, READ, B.
CONSERVATION BIOLOGY	COATES, D., GIBSON, N. Van LEEUWEN, S.
CORALS	
CROCODILES	BURBIDGE, A.A. LANE, J.
CROWN DECLINE (FORESTS)	SHEARER, B.
CRUSTACEA	FRIEND, T
CUNNINGHAM, ALAN	CURRY, S.
CYTOGENETICS	COATES, D.
DARWINIA	KEIGHERY, G., MARCHANT, N.
DASYPOGONACEAE - CHAMAEXEROS	MACFARLANE, T.
DASYPOGONACEAE - LOMANDRA	MACFARLANE, T.
DATABASES FOR FLORA INFORMATION	CHAPMAN, A; LANDER, N; MACFARLANE, T
DATA HANDLING	READ, B.
DESERTS	BURBIDGE, A.A., FULLER, P.
DESERTS see also ARID ZONES	
DIEBACK IMPACT	CROMBIE, S.
DIETARY ANALYSIS	LEFTWICH, T., ONUS, M.
DILLENIACEAE - HIBBERTIA	WHEELER,J.
DISTURBANCE ECOLOGY	FRIEND, G., PIGOTT, P.
DRAGONFLIES	START, T.
DROSERA	MARCHANT, N,
DUCKS	HALSE, S., LANE, J., PEARSON, G.
DUGONGS	PRINCE, R.
DWELLINGUP PLOT REGISTER	DILLON, M.
EARTHWORMS - ECOLOGY	ABBOTT, I.
EDITING	LEWIS, M.
ENDANGERED FAUNA	BURBIDGE, A.A. FRIEND T, THOMAS, N.
ENDANGERED FLORA	BROWN, A., COATES, D., HOPPER, S., PATRICK, S., Van LEEUWEN, S.
EUCALYPTS - IDENTIFICATION	HOPPER, S.
EUCALYPTUS GOMPHOCEPHALIA	PIGOTT, P.
EVOLUTIONARY BIOLOGY	COATES, D.

FLORA INFORMATION - DATABASES	CHAPMAN, A; LANDER, N; MACFARLANE, T
FLORA - ISLANDS	KEIGHERY, G., ALFORD, J.
FLORA - KIMBERLEYS	KENNEALLY, K., KOCH, B.
FLORA - NATURALIZED	PERRY, G. KEIGHERY, G., ALFORD, J.
FLORA - NATURALIZED - WESTERN AUSTRALIA	PATRICK, S.
FLORA - PILBARA	Van LEEUWEN, S.
FLORA - RARE	BROWN, A., CPATES. D., HOPPER, S., PATRICK, S., Van LEEUWEN, S.
FLORA - RARE - SURVEYS	CRANFIELD, R.
FOREST - CROWN DECLINE	SHEARER, B.
FOREST - ECOLOGY	CHRISTENSEN, P.
FOREST - HYDROLOGY	BUTCHER, T.
FOREST - HYGIENE	SHEARER, B.
FOREST - JARRAH	CROMBIE, S., KOCH, B., MAZANEC, R.
FOREST - JARRAH - ECOLOGY	ABBOTT, I.
FOREST - JARRAH - FAUNA	MASON, M.
FOREST - JARRAH - HYDROLOGY	PORTLOCK, C.
FOREST - JARRAH - WATER RELATIONS	GILES, R.
FOREST - KARRI - SILVICULTURE	HEWETT, P.
FOREST - KARRI - WATER RELATIONS	CROMBIE, S.
FOREST - LEAF AREA	WHITFORD, K.
FOREST - PATHOLOGY	CHRISTENSEN, P., CROMBIE, S. DAVISON, E, SHEARER, B.
FOREST - RISK & HAZARD RATING	SHEARER, B.
FOXES - BIOLOGY	ALGAR, D.
FOXES - CONTROL	ALGAR, D.
GENETICS	COATES, D.
GRANITE OUTCROPS - PLANTS	HOPPER, S.
HABITAT - FAUNA RELATIONSHIPS	FRIEND, G.
HAEMODORACEAE - HAEMODORUM	MACFARLANE, T.
HAEMODORACEAE - TRIBONANTHES	MACFARLANE, T.
HAEMODORUM	MACFARLANE, T.
HELICHRYSUM	WILSON P.
HELIPTERUM	WILSON, P.
HIBBERTIA	WHEELER, J.
HORTICULTURE - NATIVE PLANTS	BROWN, A.
HUMMOCK GRASSLAND - FLORA	PEARSON, D. Van LEEUWEN, S.
HYDROLOGY	BUTCHER, T.
HYDROLOGY - JARRAH FOREST	PORTLOCK, C.
INSECTS	FARR, J.
INSECTS - ECOLOGY	ABBOTT, I.
INSECTS - IDENTIFICATION	BURBIDGE, T., Van HEURCK, P.
INSECTS - MIDGES - CONTROL	LANE, J., PEARSON, G.

MAMMALS - ARID ZONES	PEARSON, D.
MAMMALS - FOREST	MAISEY, K.
MAMMALS - SPECIES STUDIES	FRIEND, T.
MANJIMUP PLOT REGISTER	ROBINSON, A.
MARIJUANA IDENTIFICATION	PATRICK, S.
MICROBIOLOGY	KINNEAR, J.
MIDGES - CONTROL	LANE, J., PEARSON, G.
MIMOSACEAE - ACACIA	MASLIN, B.
MINING - REHABILITATION	MAZANEC, R.
MOSQUITOES - CONTROL	HALSE, S., PEARSON, G.
MOUNT LESUEUR	Van LEEUWEN, S.
MULGA WOODLANDS	START, A., Van LEEUWEN, S.
MULGA WOODLANDS	Van LEEUWEN, S.
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., KEIGHERY, G., ALFORD, J.
NATURE RESERVE MANAGEMENT	START, T.
NOISY SCRUB BIRD	BURBIDGE, A.A.
NOISY SCRUB BIRD - TRANSLOCATION PROGRAM	WHEELER, I.
NUMBATS	FRIEND, T. THOMAS N
OLEARIA	LANDER, N.
OPERCULARIA	KEIGHERY, G.
ORCHIDS - BIOLOGY	BROWN, A.
ORCHIDS - IDENTIFICATION	BROWN, A., HOPPER, S.
PHASCOGALES	FRIEND, T. THOMAS, N.
PAPILIONACEAE - PULTENEAE	MACFARLANE, T.
PELICANS	LANE, J., PEARSON, G.
PERUP FIELD COURSE	LIDDELOW, G.
PESTICIDES	HALSE, S., LANE, J.
PESTS - BIRDS	HALSE, S.
PHYTOCHEMISTRY	ARMSTRONG, J.
PHYTOGEOGRAPHY	HOPPER, S., KEIGHERY, G.
PHYTOPHTHORA	SHEARER, B.
PILBARA REGION FAUNA/FLORA	Van LEEUWEN, S.
PINE - SILVICULTURE	HINGSTON, R., MOORE, R., MCGRATH, J.
PLANT NUTRITION	MCGRATH, J.
PLANTS SEE ALSO FLORA, TREES	
PLANTS (NATIVE) - HORTICULTURE	BROWN, A.

PLANTS - AQUATIC	MARCHANT, N.
PLANTS - BIOGEOGRAPHY	GIBSON, N. KEIGHERY, G.
PLANTS - BIOLOGY	LYONS, M.
PLANTS - CHEMISTRY	ARMSTRONG, J., MCGRATH, J., WONG, L.
PLANTS - DISEASES	CRANE, C., 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	ARMSTRONG, J., COATES, D., 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 - 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, R., ONUS, M.
POPULATION DYNAMICS - WATERBIRDS	HALSE, S., LANE, J.
POPULATION DYNAMICS - PLANTS	Van LEEUWEN, S.
PROTEIN ELECTROPHORETIC TECHNIQUES	COATES, D.
PROVENANCE VARIATION & TESTING	MAZANEC, R.
PULTENEAE	MACFARLANE, T.
RADIO COLLAR CONSTRUCTION	THOMAS, N.
RADIO TRACKING	BROMILOW, R., FRIEND, T., LEFTWICH, T., ONUS, M. THOMAS, N.
RADIO TRACKING ANALYSIS TECHNIQUES	FRIEND, T. THOMAS, N.
RARE FLORA	BROWN, A., COATES, D., HOPPER, S., PATRICK, S., Van LEEUWEN, S.
RARE FLORA - SURVEYS	CRANFIELD, R.
RECHERCHE ARCHIPELAGO	BURBIDGE, A.A.
RECRUITMENT	

REGELIA	BURBIDGE, A.A.
REHABILITATION	MAZANEC, R.
REMNANT BUSHLAND - WEEDS	PIGOTT, P., KEIGHERY, G., ALFORD, J.
REPTILES SEE ALSO FAUNA	
REPTILES - ARID ZONES	PEARSON, D.
REPTILES - DISTRIBUTION	ROLFE, J.
REPTILES - FIRE EFFECTS	FRIEND, G., MITCHELL, D. PEARSON, D.
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.
SCUBA DIVING	THOMAS, N.
SHARK BAY REGION	PRINCE, R., KEIGHERY, G.
SHOREBIRDS (WADERS)	LANDE, J., PEARSON, G.
SILVICULTURE	MCGRATH, J.
SILVICULTURE - HARDWOOD	CHRISTENSEN, P., CROMBIE, S.
SILVICULTURE - SOFTWOOD	BUTCHER, T., CHRISTENSEN, P., HINGSTON, R., JENKINS, P., MOORE, R.MCGRATH, J.
SOIL ZOOLOGY	FRIEND, T.
SPECIES SELECTION (PLANTS)	MAZANEC, R.
SPECIES STUDIES (MAMMALS)	FRIEND, T.
STATISTICS	READ, B., WHITFORD, K.
STATISTICS - MATHEMATICAL	WILLIAMS, M.
STIRLING RANGES	KEIGHERY, G., FRIEND, G., MITCHELL, D.
TAXIDERMY	WILLIAMS, A.
TAXONOMIC METHODS	FRIEND, T.
THYMELAEACEAE	RYE, B.
TORTOISES	BURBIDGE, A.A.
TORTOISES - WESTERN SWAMP	BURBIDGE, A.A., FULLER, P.
TREES SEE ALSO FLORA, PLANTS	
TREES - BREEDING	BUTCHER, T., SANDERS, C., STRITOF, MAZANEC, R.
TREES - CROPPING SYSTEMS FOR FARMS	BARTLE, J., MOORE, R.
TREES - EVAPOTRANSPIRATION	BARTLE, J.
TREES - GENETICS	BUTCHER, T., MAZANEC, R.
TREES - GROWTH	CROMBIE, S., MCGRATH, J.
TREES - WATER RELATIONS	MCGRATH, J.,CROMBIE, S.
TREMANDRACEAE - WESTERN AUSTRALIA	ALFORD, J.
TRIBONANTHES	MACFARLANE, T.
TUART	PIGOTT, P.

TURTLES- FRESHWATER	BURBIDGE, A.A.
TURTLES - MARINE	PRINCE, R.
TUTANNING RESERVE	FRIEND, G., MITCHELL, D.
TYPE SPECIMEN COLLECTION	KOCH, B
URBAN RESERVE MANAGEMENT	PIGOTT, P.
VERTEBRATES (SMALL)	FRIEND, G., MITCHELL, D.
VERTEBRATES - SURVEYS	WILLIAMS, A.
WADERS - MIGRATORY AND RESIDENT	LANE, J., PEARSON, G.
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.
WATERBIRDS	HALSE, S., LANE, J., PEARSON, G.
WEEDS - REMNANT BUSHLAND	PIGOTT, P., KEIGHERY, G., ALFORD, J.
WESTERN SWAMP TORTOISE	BURBIDGE, AA, FULLER, P.
WETLANDS	HALSE, S., LANE, J., PEARSON, G.
WHEATBELT	HOPKINS, A., FRIEND, G., MITCHELL, D.
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 Forest Research Group (Secretary)	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 Forest Research Group	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		
ALLAN BURBIDGE Threatened Fauna Scientific Advisory Committee Nature Conservation Strategy Working Group Metropolitan Corridor Environmental Audit Steering Group Naretha Parrot Captive Breeding Committee		RAOU WA Group Committee
ANDREW BURBIDGE Corporate Executive Research Division Policy Group Finance & Budget Committee Staffing Committee Classification Review Committee Conservation Lands Acquisition Committee Nature Conservation and National Parks Trust Account Committee Threatened Fauna Scientific Advisory Committee Western Swamp Tortoise Recovery Team (Chair) Forest Strategy Steering Committee Dieback Disease Coordinating Committee	Commonwealth Endangered Species Advisory Committee	ANZAAS, State Executive Committee IUCN Species Survival Commission: Australian Marsupials and Monotremes Specialists Group (Chair) IUCN Tortoise & Freshwater Turtle Specialist Group IUCN Species Survival Commission: regional member

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	
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 Forest Research Group (Chair)	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 Forest Research Group	Research Steering Committee - Bauxite Sub-committee AFC-RWG9 Forest Hydrology	Australasian Plant Pathology Society WA Regional Councillor
JANET FARR Forest Research Group		
GORDON FRIEND Roadside Vegetation Conservation Workshop Committee CALM/CSIRO Research Co-ordinating Committee		
TONY FRIEND Dryandra State Forest Planning Team Threatened Fauna Scientific Advisory Committee Animal Experimental Ethics Committee	Numbat Breeding Management Advisory Committee CONCOM WG on Endangered Fauna Port Geographe Western Ringrail Project Technical Committee (Convenor)	IUCN Species Survival Commission: Re-introduction Specialist Group (Australasian Section Chair) Captive Breeding Specialist Group Editorial Advisory Committee Wildlife Research
NEIL GIBSON	Interdepartmental Committee on Mineral Exploration in D'Entrecasteaux National Park	
BRETT GLOSSOP	Joint Timber Seasoning Committee	
STUART HALSE Corridor Steering Group	Gnangara Mound Wetlands Technical Subcommittee Land Salination Working Group (Research Steering Committee on Land Use and Water Supply) WAWA Research Projects Steering Committee Mosquito Control Committee	Australian Society for Limnology Executive
PENNI HEWETT	AFC - RWG4 - Native Forest Silviculture (Secretary)	

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
GREG KEIGHERY	CONCOM Weeds Group Stirling/Porongurup Mgt Planning Team	Vice/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
JACK KINNEAR	Co-operative Research Centre for Biological Control of Vertebrate Populations (Scientific Principal)	
NICHOLAS LANDER Nuytsia Editorial Board		
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	
MARIANNE LEWIS Scientific Publications Editorial Committee (Secretary)		
STEPHEN van LEEUWEN Pilbara Region Fire Planning Committee Pilbara Region Strategic Planning Committee		
TERRY MACFARLANE		Australian Systematic Botany, CSIRO Editorial Committee
NEVILLE MARCHANT Nuytsia Editorial Board		Secretary, South-east Asian Botanical Program (UNESCO) Member, Scientific Advisory Board, Asian Co-ordinating Group for Chemistry
JOHN MCGRATH Plantation Management Group Forest Research Group	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 (AFC-RWG 11)	International Tree Crops Institute (Committee Member)
KEITH MORRIS Animal Experimentation Ethics Committee (Secretary)	Montebello Islands Planning Team Advisory Council - Centre for metabolism and reproduction of Australian Fauna NW Island Management Committee	IUCN Special Survival Commission: Rodent Specialist Group, Captive Breeding Specialist Group

SUSAN PATRICK 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		
BOB PRINCE Kangaroo Management Review Group of Fauna Committee, NPNCA Dampierland Aboriginal Training Program - Project Work Marine Working Group		IUCN Species Survival Commission, Sirenia Specialist Group Marine Turtle Specialist Group IUCN Special Survival Commission: Sirenia Specialist Group, Marine Turtle Specialist Group
BRYAN SHEARER Dieback Photography Committee	Research Steering Committee - Forest Management Sub-committee Department of Agriculture - P. cinnamomi Working Party AFC -RWG7 - Forest Pathology	
GRAEME SIEMON WURC Management Committee Standards Australia State Committee Forest Research Group	Wood Fibre Research Advisory Group (representing the Standing Committee of the Australian Forestry Council FIF(WA) Research 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	
MIKE STUKLEY	Research Steering committee - Bauxite Sub-committee	
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		
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
YVONNE WOODS		Southern Forest Region Computer Users 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	Timber Seasoning Working Group	
GRANT PEARSON	Mosquito Control Review Committee	
JIM ROLFE Threatened Fauna Scientific Advisory Committee Woodvale Safety Committee		
RON SOKOLOWSKI Wildflower Industry Review Committee		
ANDY WILLIAMS Firearms Policy Committee		

Appendix V
Allocation of Time by 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, R	80	10	5	5
Brown, A	60	30	10	
Buehrig, R	95	5		
*Burbidge, AA	20	35	5	40
*Burbidge, AH	80	15	5	
Burbidge, T	90	5	5	
*Burrows, N	70	15	10	5
*Butcher, T	80	10	10	
Calvert, G	100			
*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	50	10	10	30
Cully, M	90			10
Curry, S.		50	50	
*Davison, E	70	25	5	
Dick, S	83	5	2	
Dillon, M	94	5	1	
Dumbrell, I	100			

	Research Activities	Extension within CALM	Extension outside CALM	Administration
Fairman, R	98	2		
*Farr, J	85	10	5	
Freeman, I	98	2		
*Friend, G	80	15	5	
*Friend, J	70	10	10	10
Fuller, P	90	5	5	
*Gibson, N.	80	15	5	
Giles, R	70			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		
*Hopper, S	25	15	20	40
*Keighery, G	60	20	10	10
*Kenneally, K	70	10	10	10
Kinal, J	98	2		
*Kinnear, J	80	10	10	
*Koch, B (0.5 FTE)	90	5	5	
*Lander, N	75	10	5	10
Langley, M	100			
*Lane, J	50	20	20	10
Leftwich, T	100			
Liddelow, G	70	15	15	
Lyons, M	80	5	5	10
*Macfarlane, T	90	10		
Maisey, K	90	10		
*Marchant, N	40	15	15	30
*Maslin, B	80	5	5	10
Mason, M	95	5		
*Mazanec, R	95	5		
*McCaw, L	70	5	5	20
McDonald, D	100			
*McGrath, J	50	20		30
*McKenzie, N	80	10	10	
Mitchell, D	90	10		
*Moore, R	60	20	20	
*Morris, K	80	10	10	
Neal, J	90	10		
Onus, M	95	5		
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	
*Pigot, P	60	20	20	

	Research Activities	Extension within CALM	Extension outside CALM	Administration
Portlock, C	80		20	
*Prince, R	80	10	10	
Read, B	80	10		10
Robinson, A	90	5	5	
Rolfe, J	85	2.5	2.5	10
Rooney, J	70	5	5	20
*Rye, B (0.5 FTE)	90	5	5	
Searle, J (0.5 FTE)		50	50	
*Shearer, B	78	10	2	10
*Siemon, G	30	10	10	50
Smith, R	100			
Sokolowski, R	65	15		20
Spencer, P		50	50	
*Start, T	35	15	10	40
Stritof, J	100			
*Stukely, M	60	40		
Tay, F	75	25		
Thomas, N	95		5	
Van Heurck, P	90	5	5	
*Van Leeuwen, S	80	10	5	5
Vellios, C	100			
Ward, B	90	10		
Ward, C	100			
*Wardell-Johnson, G	70	15	15	
*Wheeler, J	90	5	5	
Whitford, K	70	10	20	
Williams, A	90			10
*Williams, M	90	10		
Wills, A	100			
*Wills, R	80	15		5
*Wilson, P	90	5	5	
Wong, L	90			10
*Woods, Y	100			

Appendix VI
Benefits of Research - Some Case Studies

Each revision of the Research Plan will include a 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.

Flora Information Program

The first of the regional floras produced by the Western Australian Herbarium, The Flora of the Perth Region, was published in 1987. The second, The Flora of the Kimberely Region, has been completed and will be published in the coming year, subject to funding. This flora, which has taken some five years to research, provides identification keys, descriptions, distributions, habitat notes and illustrations of all 2 000 vascular plants occurring in the Kimberley Region.

Following a workshop on flora writing in 1989 it is clear that an even more user-friendly format is needed for future projects of this kind. To this end, such a format has now been devised. This will be applied and developed further by means of a pilot treatment of the genus *Agonis* (Myrtaceae). It is intended that this approach will subsequently be used in order to secure funding to prepare accounts of extended regions in the lower south west of the State.

During 1989-1990 CALM Senior Research Scientist, Dr Terry Macfarlane served as the Australian Botanical Liaison Officer (ABLO) at the Royal Botanic Gardens, Kew, England. This position is staffed a year at a time by a succession of Australian taxonomic botanists who are appointed on a competitive basis.

Taxonomic researchers frequently need to consult the large amount of reference material held in British and other European institutions. The ABLO thus provides a rapid professional consultancy service for locating, interpreting and photographing specimens, publications and other archival material. The ABLO also has an opportunity for his or her own research, and the professional development possibilities offered by one of the world's largest centres for taxonomy. The post is valued by the Royal Botanic Gardens, Kew, as an indication of Australia's commitment to the care, maintenance and responsible use of the great collections in their charge, and because that institution derives a number of benefits from the scheme.

During his term, Terry Macfarlane investigated and answered scores of queries relating to our flora from Australian colleagues and, to a lesser extent, from European sources. Research was carried out on the families Poaceae and Leguminosae. Arrangements for improved access for Australians to a specialised literature current awareness service were successfully negotiated. A large number of photographs of type specimens of Western Australian plants were obtained for the Western Australian Herbarium.

Contribution of Silviculture to Forest Production

The forest is the home of many species of plants and animals. It is a continually changing home however as plants establish, mature, senesce and finally die and animal populations change in response to the changing environment which results.

Silviculture has the potential to change the native forest environment by removing or encouraging trees and changing their species mix, favouring development of dense or thin understorey (with different cover and grazing value) and by changing the timescales over which the trees and other organisms of the forest move through their lifecycle.

Changes to the forest environment resulting from silviculturable practice are to a large extend determinable. Thus while the basic silvicultural tools are relatively unchanging (eg fuel-reduction burning, site preparation and planting, gap creation, logging and firewood harvesting) their application can be altered to produce different forest environments.

Research into silvicultural practices in native forests is necessary to determine how a particular type of forest can be produced and to find the limits to such changes. Forest managers can then move to achieve

the type of forest required to preserve the biological, aesthetic and other valued forest attributes and products.

The type of forest required is difficult to determine. The current forest is a reduced, fragmented remnant of the original. It is also under increasing pressure from people who wish to recreate in it, take timber and firewood from it and protect their property from fires or animals within it.

Native Forest Silvicultural Research is providing information regarding the amount of forest resources available on a replacement basis (eg from thinning trials showing the rates of timber growth or water yield). Research is now also examining how much of this resource has values to the other forest inhabitants (eg possums, birds) by studying the occurrence and formation of nesting hollows in trees and logs.

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