DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

DIVISION OF RESEARCH

DRAFT FIVE YEAR PLAN JULY 1987 - JUNE 1992

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CONTENTS

1 INTRODUCTION

1.1 Background

The Research Division was formed through the amalgamation of research branches from the Forests Department and the wildlife portion of the Department of Fisheries and Wildlife when CALM was created in 1985. At first Research was part of the Policy Wing of the Department and was led by the Director of Research and Planning, but an internal reorganization in 1986 led to the formation of a new Division placed in the Operations Wing.

At the time of the reorganization it was proposed that the production of a rolling five year plan would be the best way of clearly describing what is done now, consulting relevant people and defining research priorities before deciding on the allocation or reallocation of resources. The proposal was agreed to by the Policy Directorate.

The Department's Corporate Plan requires that each functional group within the Department prepare its own Strategic Plan. This Five Year Plan fulfills this requirement for the Division of Research.

1.2 Organization of the Division

The Division of Research is one of five Divisions in the Operations Wing of the Department, under the overall control of the General Manager. The Division is led by the Chief of Research and a corporate team consisting of two Senior Principal Research Scientists and two Principal Research Scientists. Internal organization is on the basis of Research Programs, each led by a Program Leader. Staff are located at five Research Centres (Busselton, Como, Dwellingup, Manjimup, Woodvale), each under the administrative control of a Research Centre Manager, and at two Regional Headquarters (Kalgoorlie, Karratha), which are administered by Woodvale. Some Como Research Centre staff are located at Narrogin and Wanneroo District Offices.

The program structure for the Division has only been recently adopted. It was designed to achieve the following objectives:

* to integrate the two research groups that came together with the formation of CALM.

* to foster better review and planning of research between workers in related subjects.

* to achieve better coordination with other CALM Divisions and with external research organizations.

* to enable clearer definition of priorities and greater mobility of resources across the research spectrum.

Twelve programs have been established. Four are ecosystem based, six are process or goal based and two are service based. The programs and program leaders are as follows:

Ecosystem based:	jarrah	I Abbott
	karri	L McCaw
	pine	J McGrath
	wetlands and waterbirds	J Lane
Process/goal based	biogeography	N McKenzie
	fauna conservation	R Prince
	flora conservation	S Hopper
	fire	N Burrows
	plant diseases	J Tippett
	rehabilitation	J Bartle
Services	computing	M Choo
	executive and administrative support	Chief of Division

These programs were selected after examination of various classification systems. It was found that a mixture of ecosystem and process/goal subjects conveniently encompassed most present and projected research. However, no classification of this sort is perfect and boundaries between some programs are unclear. Cross links and common areas occur between programs, some of which are nearly important enough to justify program status, e.g. plant nutrition; others possibly justify program status but at present have little or no staff resources, e.g. marine studies. Some research scientists have existing obligations in several programs. In some cases this is an inefficient use of time and more effective working arrangements will gradually evolve.

1.3 Resources

In 1986/87 the Division utilized 36.05 professional and 69.25 technical and clerical staff totalling 105.3 persons (full time equivalent). Some of these persons were casuals or part-time. The total budget in 1986/87 was $4 583 563, consisting of $2 975 248 for salaries, $313 015 for wages and $1 295 300 for other costs (research, travel and plant). Research accounted for 7.1% of the Department's total budget.

Summary of Resources 1986/87

Program	No of people (FTE)	Salaries	Wages	Other	Total	Percent
Biogeography	7.05	215 000	5 930	115 635	336 565	7.3
Fauna Conservation	9.3	215 000	26 396	201 165	442 561	9.7
Fire	12.35	349 489	8 520	117 750	475 759	10.4
Flora Conservation	3.75	120 447	-	63 600	184 047	4.0
Jarrah	15.7	397 336	22 794	71 200	491 330	10.7
Karri	6.25	208 685	9 300	25 850	243 835	5.3
Pine	12.55	379 436	85 940	102 200	567 576	12.4
Plant Diseases and Pests	7.15	188 282	55 395	100 200	343 877	7.5
Rehabilitation	5.25	214 718	11 200	51 500	277 418	6.1
Wetlands & Waterbirds	3.55	115 234	-	58 500	173 734	3.8
Computing	3.0	135 413	-	147 600	283 013	6.2
Executive & Admin.	16.45	436 208	87 540	240 100	763 848	16.6
Totals	105.3	2 975 248	313 015	1 295 300	4 583 563	100.0

2. AIM AND PRIMARY OBJECTIVES OF THE RESEARCH DIVISION

Overall Aim:

To ensure that conservation and land management are carried out according to sound, well-researched scientific principles (CALM Corporate Plan, Section 3).

Overall Primary Objectives:

CONSERVATION

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

MANAGEMENT OF BIOLOGICAL RESOURCES

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

PRODUCTION

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

BIOLOGICAL RESOURCES

To provide and maintain a biogeographical inventory of the plants, animals and ecosystems of Western Australia and to develop an understanding of the factors that affect their distribution and abundance.

ECOLOGY

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

COMMUNICATION

To communicate results of research effectively by production of scientific, technical and educational publications, input into the land management planning process, liaison with

other CALM staff, other Departments and the public, involvement with scientific and other conferences and by any other means available.

ADVICE

To provide expert advice on relevant conservation and land management matters to the Department, other Departments and the public.

3. CURRENT RESEARCH AND SERVICE PROGRAMS

Each existing research program is described and discussed below. The format followed provides a description of current Aims, Objectives and Goals, discusses shortcomings in available knowledge, allows clear identification of resources that will become available through completion of current projects over the five year period of this plan, and lists new projects proposed by each Program, in order of priority.

The two service programs are then described with Research Computing following a similar format to research programs and the Executive and Administrative Support Program following its own format.

3.1 BIOGEOGRAPHY PROGRAM

Program Leader: N.L.McKenzie

Current Resources

This program comprises 7.05 persons (3.45 professional + 3.6 technical staff). Its budget is $336 565 ($215 000 salaries, $5 930 wages and $115 635 other).

Aim

To describe and monitor the patterns of distribution of Western Australia's biota.

Primary Objectives

DATA-BASE

Through a systematic program of ecological surveys, to provide and maintain up-to-date a 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 should allow explicit, quantitative research into biogeographic patterns across Western Australia.

RESERVE SYSTEM DESIGN AND LAND-USE ADVICE

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

MANAGEMENT PLANNING

To analyse the data-base to assess the conservation status of communities and species and to provide data and interpretation to planners and managers so management is carried out according to sound scientific principles. To assist with the preparation of management plans.

MONITORING

To research changes in the composition of the biota in relation to the variety of disturbances associated with various land-use regimes, to promote improvement in management practices.

COMMUNICATION

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

Twenty Year Goals

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

2. Monitor, at 5 to 10 year intervals, the sites already installed.

3. Continue small area surveys as the need arises.

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

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

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

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

Five Year Goals

1. Undertake surveys of the Gardner, Carnarvon and Fortescue Phytogeographic Districts to improve the State-wide representation of the biogeographic data-base and propose new conservation reserves. Extend the system of benchmark quadrats into other districts as time and funding allow; when possible, upgrade the descriptions of sites sampled during the 1970s so they can be included.

2. Undertake detailed ecological surveys at various localities (including islands and waters) of Departmental interest and responsibility to assist land-use and management planning decisions. Publish and/or disseminate the results of ecological surveys in a form suitable for use/interpretation in the development of the conservation reserves system and in management planning.

3. 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 heterogeneity of the quadrats? Sampling methodologies?

4. 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 use by managers needing information.

Scope of Existing Program

DATA BASE

Available information on the majority of the State's natural districts is extremely limited. Additional ecological surveys of districts are badly needed. 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 managements and management researchers. At present our resources (budget allocation and staff) are too small to carry out an ecological 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 at least two districts simultaneously (there are 23 Phytogeographic Districts currently recognised in W.A.).

At present the Department has practically no research projects involving the marine environment. In particular it has no projects aimed at evaluating marine park proposals and boundaries, complementary to the ones of many years standing in terrestrial, freshwater and some estuarine environments. Marine projects will require the employment of specialist staff, since this expertise is not available within the Division at present.

No invertebrate surveys are presently incorporated into routine biological surveys, although data are sometimes collected on specific groups, e.g. terrestrial molluscs in Kimberley rainforest patches.

RESERVE SYSTEM DESIGN AND LAND-USE ADVICE

This area is closely correlated with the development of an adequate data-base. The number of requests for ad hoc surveys, so that advice can be given on a specific problem, is likely to be much larger than can be accommodated with existing resources.

MANAGEMENT PLANNING

The management planning requirements of the CALM Act place an increased burden on the Program to provide information on the biological resources of the areas being investigated, prior to plan development. Lack of these data may inhibit plan production.

MONITORING

The draft policy for biological monitoring of selected sites on Departmental land will require increased effort from this program.

COMMUNICATION

There is a backlog of unpublished data (see Appendix II) that needs publication. Time available for writing up is constrained by the number of new projects being taken on. Publication is also constrained by a lack of funds for internal publishing - most biological survey data, by its very nature, cannot be published externally.

Proposed new projects

1. Rainforest survey.

   1.0 professional (3 people), 1.0 technical staff (2 people), $20 000 per annum, 3.0 years. N.L. McKenzie, A.H. Burbidge, G. Keighery. Average of $100 000 per

year from Commonwealth Government plus 1.0 professional staff (3 people) and 0.2 technical staff per year from external institutions (CSIRO, W.A.Museum, W.A. Herbarium (Dept. of Agriculture) and Chicago Field Museum).

Part of the W.A. National Rainforest Conservation Program. The first systematic, quantitative study to describe and research the species composition, biological patterns in, and physical scalars of W.A.'s rainforest resources -- to provide baseline description of the resource to determine management requirements and commence a monitoring program to conserve this rich community, which has such a high conservation profile worldwide.

2. Cape Arid Survey.

0.6 professional (3 people), 0.6 technical staff (3 people), $10 000 per annum, 1.5 years. G. Keighery, A.H. Burbidge, N. McKenzie (RS 128).

Connect the Nullarbor, Eastern Goldfields and Fitzgerald River National Park ecological survey data-bases. Provide a set of benchline monitoring quadrats representing this National Park prior to the invasion of Phytophthora cinnamomi ("die-back"). Provide an inventory of the biological richness of the Park, clarify the status of the plant and vertebrate organisms of the Park in a regional context, and provide a model of the gradients that explain the patterning of the biota across the Park in terms of scalars of the physical environment so that explicit management planning can be commenced.

3. Perup Fauna Priority Area Survey.

0.2 profesional, 1.5 technical (7 people), $10 000 per annum, 1.5 years. G. Wardell-Johnson (RWP 5/78).

An ecological survey to determine correlates between species and habitat attributes and to classify the Area into like units based on species assemblages. A quadrat based ecological survey offering the same opportunities in management as the Yanchep National Park survey and others described earlier, but focussing particularly on attributes associated with the presence of Woylies and other rare and endangered species.

4. Survey of remaining islands in the Dampier Archipelago and of the Burrup Peninsula.

0.3 professional (1 person), 0.6 technical (2 people), $10 000 per annum, 5 years. K. Morris.

Many of the islands of W.A. support populations of native species that no longer occur, are threatened with extinction, or do not breed on the mainland. Yet many have never been surveyed by biologists and are coming under increased public usage for recreation etc. This is an urgent problem, exacerbated in the North-west by its rapidly increasing population.

5. Written contributions to management plans for island nature reserves in the North-west.

0.1 professional (1 person), 0.1 technical staff, $2 000 per annum, 5 years. K. Morris.

It is essential that a person familiar with the biota and disturbances confronting islands in the North-west actually contribute to management plans. In the case of geographically remote areas with a vocal, local population anxious to maximise their recreational access to the reserves, it is both efficient and politic that the Departmental person with whom they have direct day-to-day access is involved. When we have a person who satisfies both these criteria, their input to the management plan has to be substantial.

6. Methodologies in ecological survey (RS 120).

6a. Biological patterns versus soil attributes. 0.2 professional (N.L. McKenzie), 0.1 technical staff, $6000 per annum (a consultant), 1 year. 0.1 external professional staff per annum (CSIRO).

Gather the necessary data to analyse the importance of a variety of soil "gestalt" attributes (depth, compaction and drainage) as scalars of the biological patterns observed in the Nullarbor District Survey. An essential step in the selection of attributes to be recorded at benchmark monitoring sites - the need to select attributes and establish monitoring sites has been endorsed by the Policy Directorate.

6b. Identification of W.A. bats by their sound. 0.05 professional (N.L. McKenzie & family), $300 per annum, 3 years. 0.05 external professional staff per year (U.W.A.).

Record the ultrasonic signal that characterizes each of W.A.'s bat species using existing CALM equipment. Develop a computer-based system to analyse the tapes and, thus, an automatic method of inventory bat assemblages to facilitate my on-going studies on the affect of a variety of disturbers on the community structure of W.A. mammals. A study fundamental to the development of the Ecological Survey strategies currently used in the Biogeography Program.

7. Yanchep National Park survey. 0.3 professional (2 people), 0.3 technical (2 people), $2 000 per annum, 1 year. A.H. Burbidge, G Keighery. Park Rangers will be introduced to survey techniques during the study.

No systematic survey of the wildlife of Yanchep National Park has been undertaken yet the Park is visited by more people than any other conservation reserve in W.A. An ecological survey to inventory the species and communities of the Park, and assess the conservation status and values of its biota in the context of the entire North Swan Coastal Plain, is long overdue and essential to allow the production of an ecologically based management plan. The survey will involve establishing a set of benchmark monitoring quadrats covering the range of community-types present, so that the affect of imposed management strategies and of policies adopted to control access and use of the Park by the public can be measured in terms of changes in the richness and species composition of its assemblages.

8. Irwin & Carnarvon District Survey.

2.0 professional (3 people), 2.5 technical (3 people), $40 000 per annum, 1.5 years. N.L. McKenzie (RS 126), G.Keighery, A.H. Burbidge. Estimated additional $70 000 external funding required, much of this to employ additional biologists needed to make up three field survey teams (external staff will be invited) and cover the operational costs of establishing the quadrats at the beginning of the study.

Provision of a data base covering the Districts at the northern extreme of the South-west Land Division. To model the biota of the region, identify the scalars of the physical environment that can be used to predict its biological patterns, establish and describe a set of benchmark quadrats covering its diversity. No systematic ecological survey of these Districts has ever been undertaken. One is urgently needed to allow: land-use decisions and assessment of the existing system of conservation reserves; assessment of the conservation status of the organisms and communities present to identify the priority of their management needs; long term monitoring of the biota.

9. Pilbara & Ashburton District Survey.

2.0 professional, 2.5 technical, $40 000 per annum, 2 years. N.L. McKenzie, G. Keighery, A.H. Burbidge. Estimated additional $40 000 external funds required for purposes described in previous project proposal. There will be liason with regional staff on design, detail required and involvement.

Provision of a data base covering the pastoral Districts of the North-west; part of a strategy to provide an ecological data base covering the diversity of landscape-types, and imposed land-uses, found in W.A.. To model the biota of the region, identify the scalars of the physical environment that can be used to predict its biological patterns, establish and describe a set of benchmark quadrats covering its diversity. No systematic ecological survey of these Districts has ever been undertaken. One is urgently needed to allow: land-use decisions and assessment of the existing system of conservation reserves; assessment of the conservation status of the organisms and communities present so explicit decisions can be made on their priority for management resources; long term monitoring of the biota.

10. Monitor management programs implemented on the Dampier Archipelago and other island nature reserves in the North-west.

0.1 professional (1 person), 0.1 technical staff, $7 000 per annum, 5 years. K. Morris.

The disturbance experienced by the islands in this Archipelago has required a number of management measures. An on-going assessment of the success of these strategies is essential from the viewpoint of both the biota on islands concerned and developing our understanding of their value in the context of island management problems state-wide.

11. Conservation planning for Buccaneer Archipelago and associated mainland areas.

0.3 professional, 0.3 technical, $50 000 per annum, 2 years. R.I Prince. 2.0 externally funded staff involved.

Surveys of terrestrial and marine system for management planning and land-use decisions. The involvement and training of local Aboriginal communities is an important part of the project; CALM has relatively little experience at involving Aboriginals in conservation projects, yet there is no doubt that it will be essential to the long term success of conservation measures both of plant and animal communities and of species such as dugon in areas outside the South-west Land Division.

12. Survey of conservation status of granite outcrop plants.

0.2 professional, 0.2 technical staff, $10 000 per year, 5 years. S.Hopper.

Many species are restricted to isolated, almost insular, granite outcrop communities scattered through the semi-arid of South-western W.A. Increasingly, the vegetation on and abutting these outcrops is being cleared for agriculture and invaded by exotic weeds. We urgently need to establish composition, richness and patterning (beta diversity) of these communities so that reservation and other management and protection measures can be implemented. We also need to begin monitoring a selection so that the sorts of changes that are occurring can be identified.

13. Survey of other island reserves or proposed island reserves in the North-west.

0.1 profesional, 0.1 technical, $10 000 per year, 5 years. K. Morris.

The importance of islands to conservation in W.A., the absence of data on many of our islands, and the benefits of ecological survey data were discussed for project proposal No. 7 (see above).

14. Establishment of further monitoring sites on islands of the Recherche Archipelago.

0.1 professional, 0.1 technical, $4 000 per annum, 5 years. A. Hopkins.

The importance of monitoring the biota of islands was discussed above. The Recherche Archipelago is a major conservation resource on W.A.'s south coast and is subject to a variety of human caused disturbances.

15. Ecological Survey Methodologies (see earlier).

6c. Lizard litter-patch studies. 0.05 professional (N. McKenzie), 3 years. Data is derived from sampling carried out as part of usual survey work therefore no extra staff or resources needed except time for analysis.

A study to investigate the affect of disturbances on the community structure of low mobility, heterothermic vertebrates that live in patches of leaf litter under eucalypt trees. To examine influence of disturbance on assemblage composition and structure and its likely influence on classifications derived from our ecological survey data.

Projects to be Completed 1987 - 1991

RS refers to page numbers in the 1985 CALM Summary of Wildlife Research. RWP refers to Research Working Plan numbers.

(a) DATA COLLECTED AND ANALYSED, BUT WRITE-UP INCOMPLETE

1 Flora Lists of York/Northam Reserves - G. Keighery (RS 93). 1987

2. Dampier Archipelago Management Plan - K. Morris (RS 132). 1987

3. Ecological Survey of Southern Beekeepers Reserve - A.H. Burbidge (RS 15). 1987

4. Nullarbor District ecological survey - N. McKenzie, G. Keighery & A.H. Burbidge 1987

5. Cooloomia Nature Reserve - A.A. Burbidge, S. Hopper (RS 75). 1988

6. Salisbury Island - A.A. Burbidge, J. Kinnear, N. McKenzie 1988

7. Census of Australian Plants - G. Keighery (RS 92). 1988

8. Islands: Lancelin to Dongara - G.J. Keighery (RS 94). 1988

9. Jibberding/White Wells proposed reserve - A.A. Burbidge 1988

10. Ecological Survey of proposed Boonanaring Reserve - A.H. Burbidge (RS 15). 1988

11. Report on survey work at Mount Lesueur - A Hopkins (RS 60). 1988

12. Eastern Goldfields (six cell reports) - N. McKenzie, A.A. Burbidge RS 121. 1989

13. Buccaneer Archipelago - N. McKenzie, A. Hopkins, A. Burbidge, J. Lane RS 128. 1989

14. Stirling Range and Environs Flora - G. Keighery (RS 95). 1989

15. Dorre Island and Associated Shark Bay Islands - Ecological Survey - R. Prince (RS 141). 1989

16. Searching versus Pitfall Trapping in Southern Forests Surveys - G. Wardell-Johnson (RWP unallocated). 1989

17. Bird census results in Southern Forests Surveys - G. Wardell-Johnson. (RWP unallocated) 1989

18. Report on survey work at Tutanning Nature Reserve - A. Hopkins (RS 59). 1989

19. Report on survey work at Two Peoples Bay - A. Hopkins (RS 63). 1989

20. Report on survey work at Middle Island/Recherche Archipelago - A. Hopkins (RS 60). 1990

21. Atlas of all Western Australian Proteaceae (except Banksia) - A. Hopkins (RS 56). 1990

22. Vertebrate Fauna Survey of Dampier Archipelago - K. Morris (RS 132). 1991

23. Vertebrate Fauna of Monte Bello Islands - K. Morris (RS 132). 1991

24. Management Guidelines for Monte Bello Islands - K. Morris (RS 132). 1991

25. Interactions of Fire and Site on Vegetation in the Walpole-Nornalup National Park - G. Wardell-Johnson (RWP unallocated) 1992

26. Bird Communities of the Walpole-Nornalup National Park - G. Wardell-Johnson (RWP unallocated) 1992

(b) PROJECTS WITH DATA OR ANALYSIS STILL INCOMPLETE

1. Design and sampling methodologies for ecological surveys - N. McKenzie (RS 20)

Heterogeneity of Nullarbor quadrats - N. McKenzie, A. Hopkins, G. Keighery (RS 121) 1988

Biogeography of the flora of southern Nullarbor - G. Keighery (RS 92) 1989

Physical scalars of biological patterns in the Nullarbor - N. McKenzie (RS 124) 1989

Ground-truthing the Nullarbor data-base - N. McKenzie (RS 124) 1989

Extending the Nullarbor data base: do the patterns change? - N. McKenzie, G. Keighery, A.H. Burbidge (RS 120). 1990

	Assemblage changes over 12 months at Cocklebiddy - N. McKenzie, G. Keighery (RS 121).	1989
	Bat assemblage structure studies : disturbance and determinism - N. McKenzie (RS 129).	1990
2.	Ad hoc flora surveys of selected crown lands - S. Hopper (RS 74).	1987-91
3.	Reserve surveys (occasional Planning Branch requests) - G. Keighery (RS 99).	1987-91
4.	Biological survey of islands in the north-west - K Morris (RS 132).	1988-91
5.	Biogeography of Dugong and Seagrasses in northern Western Australia - R. Prince (RS 142).	1989
6.	Biological surveys of selected conservation reserves and for other conservation issues (to service Planning Branch and other particular site survey requests)- A.H.Burbidge (RS 15).	1987-91
7.	Sampling small ground-dwelling vertebrates - A.H. Burbidge (RS 16).	1988
8.	Walpole-Nornalup National Park survey - G. Wardell-Johnson, see Walpole coastal survey working plan. RWP (unallocated).	1989
9.	Establishment of monitoring program in C.A.L.M. - A. Hopkins (RS 52).	1988
10.	Fitzgerald River National Park Survey - F.R.N.P.S. Association consultants, N. McKenzie (RS 127).	1988
11.	Biological survey of sites on the Mandora palaeoriver and Radi Hills, Great Sandy Desert - N. McKenzie and external staff (RS 125).	1989
12.	Late Holocene mammal fauna of the Irwin & Carnarvon districts, Western Australia - consultancy let by N. McKenzie (RS 126).	1988
13.	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 (RS 122).	1988
14.	Acquire up-to-date microtomputer software to pre-process (append and edit) and analyse	

large matrices of ecological survey data. Maintain and develop expertise in the use of these procedures for a wide variety of data types - N. McKenzie (developmental). 1988

15. Acquire computer tape of the RAOU Atlas of Australian Birds data base for Western Australia - A.H. Burbidge (developmental). 1987

16. Bibliography on, and appraisal of, the contemporary status of the vertebrate fauna of the northern Irwin and southern Carnarvon districts. Consultancy let by A.H. Burbidge (developmental). 1988

17. Vegetation of Dryandra State Forest - consultancy let by G. Keighery (see previous listing). 1991

New Projects to be Started 1987 - 1991

Ecological Survey Methodologies: Sep 1986 - Sep 1991

Biogeog. patterns vs soil attributes

Automatic bat assemblage sampling

Lizard litter patch guilds

Rainforest Survey	Nov 1986 - Jun 1989
Cape Arid Survey	Apr 1987 - Dec 1988
Yanchep National Park Survey	May 1987 - May 1988
Recherche Monitoring Sites	May 1987 - Jun 1991
Dampier-Burrup Archipel. Survey	Jul 1987 - Jun 1991
Monitoring/Managm't Dampier Archi.	Jul 1987 - Jun 1991
Management Plans: N.W. Islands	Jul 1987 - Jun 1991
Buccaneer Archipel. Managm't Plan	Jul 1987 - Jun 1989
Granite Outcrop Plant Surveys	Jul 1987 - Jun 1991
North-West Island Surveys	Jul 1987 - Jun 1991
Perup Priority Area Survey	Apr 1988 - Nov 1989
Irwin-Carnarvon District Survey	Nov 1988 - Jun 1990
Pilbara-Ashburton District Survey	Nov 1989 - Nov 1991

3.2 FAUNA CONSERVATION PROGRAM

Program Leader: Dr R.I.T. Prince

Current resources

This program comprises 9.3 persons (3.95 professional + 5.35 technical). Its budget is $442 561 ($215 000 salaries, $26 396 wages and $201 165 other).

Aim

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

Primary Objectives

KNOWLEDGE

To increase knowledge of the fauna and the ecosystems in which the different species occur so that population dynamics and the consequences of management activities may be properly assessed and, if necessary, modified.

RARE AND ENDANGERED SPECIES

To identify rare and/or endangered species and seek understanding of factors affecting the status of these populations and to prepare wildlife management programs for species that require management.

EXPLOITED SPECIES

To provide a sound basis for conservation and management of exploited fauna and to prepare wildlife management programs for exploited species.

FERAL ANIMALS

To research methods and provide management programs for control of feral and other exotic species adversely affecting fauna conservation.

COMMUNICATION

Effectively communicate results of research by way 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.

Twenty Year Goals

1. Extend and expand work aimed at understanding biology and ecology of selected fauna species and communities.

2. Extend and continue conservation programs for rare and/or endangered species.

3. Extend and expand work necessary to achieve effective management of adverse impacts of feral exotic fauna on conservation of the native fauna.

4. Develop research programs for invertebrate terrestrial fauna and expand marine fauna research.

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 towards effective conservation.

6. Continue monitoring of impacts of exploitation on managed kangaroo populations.

7. Develop and utilize modelling and similar methodology as aid to synthesis and interpretation of ecological research data.

Five Year Goals

1. Identify additional relict populations if such exist of current rare/endangered fauna species.

2. Develop management programs for selected rare and/or endangered species involving translocation and re-establishment or captive breeding where necessary.

3. Develop effective control programs for selected feral exotic fauna adversely affecting conservation of native fauna.

4. Increase understanding of the biology and ecology of selected fauna.

5. Develop and evaluate monitoring techniques required for research and management of selected fauna.

6. Develop management programs for exploited species other than kangaroos, especially in regard to conservation of relict and vulnerable fauna and traditional Aboriginal exploitation.

7. Achieve greater public involvement in broad scale field research programs.

Scope of Program

The indigenous vertebrate fauna of Western Australia, excluding fish, is comprised of over 1000 species. There are approximately: 475 birds; 135 mammals, including nearly 70 marsupials; 360 reptiles; and 70 amphibians. The dingo is the only mammal species 'not protected'. In addition, sixteen species of venomous land snakes and all seasnakes are 'not protected'. Conversely, 43 mammals, including 27 marsupials (40%), 11 other land mammals (15%) and 5 marine mammals, 40 birds (8%), 19 land dwelling reptiles (5%) and one marine turtle, and one frog species are declared fauna "likely to become extinct, ... rare, or otherwise in need of special protection..." pursuant to Section 14(2)(ba) of the Wildlife Conservation Act 1950 (as amended). Only beetles of the family Buprestidae and ants of the genus Nothomyrmecia among the extensive invertebrate fauna are presently included in the category of 'protected fauna'.

Of the recognized fauna, most species occupy land other than that dedicated for conservation (CALM land). Few even of the 'rare' species are confined solely to CALM land. The Departmental responsibility for conservation of the State's fauna thus implies a responsibility for conservation of species at large throughout the State for the most part. Fauna conservation work therefore spans the whole range, from management of abundant species such as the larger kangaroos on rangelands to protection and restoration of populations of species such as the noisy scrub-bird which until recently have been solely confined to conservation reserves. Discovery of populations of some 'rare' 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.

It cannot be said that a fauna research program has previously existed. Rather, work that is identified within the strictures of the now formalized program area has focussed on a range of issues within the broad area of responsibility outlined above.

The 'rare' species have perhaps received the greatest attention, but not all are amenable to an intensive formal research program internalized within the CALM organization. Species orientated programs may also not result in readily obtained improvements in conservation status. The approach to 'rare' species must therefore remain flexible, but will need resource commitments within CALM because the problems that are likely to be posed are not usually amenable to quick resolution.

Research into adverse impacts of exotic species on indigenous fauna has so far focussed on predators. The impact of enhanced 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. Wildlife conservation has tended to hide behind agricultural interests in considering the potential

adverse impacts of exotic species in the past. There is increasing evidence that this shield is being withdrawn.

Rare species are not however the sole group requiring attention. There is no infallible method for predicting which of current abundant species might be tomorrow's rare fauna. There is a public need to act responsibly in management of kangaroos, and CALM would be considered derelict in its duty to ignore this. Conservation of the large kangaroos is indeed dependent on maintaining the abundance of fauna at large.

Management of fauna on CALM lands presents another aspect of this problem. While CALM continues to manage land for production it will be seen to have a duty to minimize the effects of this management on other species.

Research aimed at management of conservation reserves in ways benefiting particular species has generally been part of 'rare' species work in the past. Wider studies relevant to this aspect of fauna conservation overlap various other programs, particularly fire and flora conservation.

Research on marine fauna has to date focussed on few species. Work on dugong principally involves aspects of 'rare' fauna conservation and management of traditional exploitation by some coastal Aboriginal communities. Marine turtle research has only commenced in the past year. Additional information on some seal and whale species has also been obtained from various sources in the past, but generally resources allocated to marine based research have been minimal. More importantly, with CALM's new role in marine conservation, there is as yet no firm base for research in this field. On the land, the same circumstance applies to conservation research on the invertebrate animals currently excluded from the official fauna of the State.

In concluding this review of the scope of the fauna research program it is also most important to note that whilst establishment costs for the majority of staff currently involved in the program are provided by CALM, a very large part of project operational costs for work being done by staff of the former wildlife research group is being covered by external funding. Without this support work could not proceed.

Proposed New Projects

Title	Goal	Staff Prof.	Staff Tech.	Costs Annual	Duration (yrs)
Ecological studies of three species of tree rats in the Mitchell Plateau region, Kimberley, W.A.	4	0.1	-	5000	1-2

Projects to be completed 1987 to 1991

Completion	Project	Goal	Duration of Project
1987	*SW crocodile 1986 monitoring	R+E	1 year (p/t)
1988	*Mormopterus sp. taxonomy	K	10 years (p/t)
	*Pitfall trapping methods - GRF	K	3 years (p/t)
	*Decline of WA mammals	K	5 yrs (p/t)
	*East Pilbara Rock Wallabies	R+E	5 yrs (p/t)
	*Rock Wallabies, Dampier Arch.	R+E	5 yrs (p/t)
	*Noisy Scrub-bird translocation (Stage 2)	R+E	5 yrs (p/t)
	*Western Barred-bandicoot	R+E	2 years (p/t)
	*Numbat habitat and food resources	R+E	7 years
	[a]Conservation of Chuditch	R+E	3 years
	*Fox as predator[a]	F	8 years
1989	*Population monitoring methods seabirds	K	3 years (p/t)
	[a][b]Aboriginal management programs for Dugong and marine turtles	R+E	5 years (p/t)
	[a][b]Exotic rats on islands	F	6 years (p/t)
1990	*Breeding studies Western Swamp-tortoise	R+E	10 years (p/t)
	*Rock Wallaby conservation studies	R+E	10 years (p/t)

1991	[b]Banded Hare-wallaby trans-location	R+E	5 years initial plus Stage 3 to do, 4 yrs - (all p/t)
	[b]Ground Parrot conservation; pre-liminary studies	R+E	6 years (p/t)
	*Western desert fauna; initial studies	R+E	5 years (p/t)
	[a]Marine turtle [b]conservation, 1st stage	K	6 years (p/t)
	*Monitoring of seabirds initial studies	K	6 years (p/t)
	*Pilbara island mammals, initial	R+E	6 years (p/t)

Key: *Current internal funding adequate or funding secured.

[a]External resources currently important.

[b]Requires further support and/or secured funding to proceed to completion.

Staff resources released - minimal.

Current Projects extending beyond 1991

Project	Goal	Location
Barrow Island fauna	K	CALM land
Australian land-hoppers, taxonomy and zoogeography	K	At large
Western Swamp-tortoise	R+E	CALM land
Salt-water Crocodile populations	R+E	At large
Woylie populations	R+E	CALM land
Status and surveys rare/endangered fauna	R+E	At large

Kangaroo management programs	E	At large

All of the above represent general commitments to meet CALM responsibilities and may be regarded as requiring maintenance funding.

New projects to be started 1987 to 1991

1987	*Ecological studies of three species of tree rats...	K	1-2 years (p/t)

Key: * External funds secured

No other new projects are currently proposed in view of difficulty in maintaining continuity of funding for established projects and the limited technical staff items available at Woodvale Research Centre.

New projects that might be contemplated with existing professional staff in the future will have to match expertise available. This should pose no serious problem of priority ratings given the level of resourcing of fauna research but will still require provision of adequate operating funds.

Current resources are allocated:

Fox, rock wallaby	40%
Woylie	5%
Numbat	10%
Turtles, Dugong	10%
Rats	5%
Kangaroo	5%
Crocodiles	5%
Others	10%
General maintenance	10%

3.3 FIRE PROGRAM

Program Leader: N. Burrows

Current Resources

This program comprises 12.34 persons (4.55 professional + 7.80 technical staff). Its budget is $475 759 ($349 489 salaries, $8 520 wages and $117 750 other).

Aim

To understand the role of fire in ecological processes as a basis for predicting effects of various fire regimes on the biota. To describe fire behaviour in all vegetation types

and to develop fire suppression techniques so as to safely implement prescribed fires to achieve defined goals.

Primary Objectives

FIRE BEHAVIOUR, DETECTION AND SUPPRESSION

To develop fuel characteristic and fire behaviour prediction models for major vegetation types throughout the State. To assist with thr development of operational guidelines for wildfire detection 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, and especially on rare flora and fauna species, and to prepare relevant management guidelines. To identify critical plant and animal species and communities that may be readily monitored and used as biological indicators of the relationship between fire and the environment.

FIRE MANAGEMENT

To develop computer-based management systems that integrate fire behaviour, suppression, effects and relevant resource information for a range of biomes.

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.

Twenty-year goals

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 current and future research projects may be subdivided into four themes, in approximate order of priority thus:

(i) Fire behaviour, detection and suppression
(ii) Fire Ecology
(iii) Monitoring
(iv) Fire management.

Themes 1 and 2 are generally of equal priority.

(i) Fire behaviour, detection and suppression

Studies encompassing this theme will be completed in most of the vegetation types of the south-west and the arid zone viz. forests, wheatbelt woodlands, heathlands, Banksia woodland and hummock grasslands. Effort will progressively be concentrated on the remaining vegetation types - mulga woodlands, tropical savanna woodlands and tall shrublands (Table 1).

(ii) Fire ecology

Because of the long-term nature of fire ecology research, work in the south-west vegetation types will continue, much of it being less-intensive monitoring of long-established study sites. As with Theme 1, studies will commence in mulga and savanna woodlands and tall shrublands (Table 1).

(iii) Monitoring

As with Theme 2, monitoring is a long-term project and the future status of various studies will be similar (and closely linked) to those for fire ecology. It is expected that the development of simple field assessment techniques will be completed for south-west types and Banksia woodlands, and will continue in wheatbelt woodlands, heath and hummock grasslands (Table 1).

(iv) Fire management systems

A computer-based fire management system should be well established for the south-west forest vegetation types, and well into the development phase within wheatbelt woodlands, heath and hummock grasslands. As for Themes 1 and 2 fire management studies will be commencing in the remaining vegetation types (Table 1).

Five Year Goals

1. Undertake a review of fire research in Western Australia. The review will aim to:

   (i) summarize and document existing knowledge, and

   (ii) identify gaps in knowledge and review fire research priorities.

2. The low shrublands (kwongan or heath) and hummock grasslands have been identified as the most important areas requiring fire research effort over the next five years. Fire ecology studies (Theme 2) in these vegetation types have commenced and will continue within this five year time frame. Concurrent work in fire behaviour and suppression (Theme 1) is now of high priority.

TABLE 1: Status of Research Goals in the next twenty years.
LEGEND: 0 = No effort 1 = Studies to commence 2 = Studies to continue 3 = Studies complete

PRIMARY OBJECTIVE	VEGETATION TYPES								
	FORESTS	WOODLAND (Wheatbelt)	LOW SHRUBLAND (Heath)	LOW WOODLAND (Mulga)	BANKSIA WOODLAND	SAVANNA SHRUBLAND (Kimberley)	TALL GRASSLAND (Pindan)	HUMMOCK GRASSLAND (Spinifex)	SUCCULENT STEPPE (Saltbush)
3.1 FIRE DANGER RATING SYSTEM	3	3	3	1	3	1	1	3	0
3.2 FIRE BEHAVIOUR PREDICTION SYSTEM	3	3	3	1	3	1	1	3	0
3.3 FUEL MODEL	3	3	3	1	3	1	1	3	0
3.4 DEFINING FIRE HAZARD	3	3	3	1	0	1	1	3	0
3.5 KNOWLEDGE OF FIRE WEATHER	3	3	3	1	0	1	1	3	0
3.6 WILDFIRE SUPPRESSION TECHNIQUES	3	3	3	1	0	1	1	3	0
3.7 REPORTING AND ACHIEVING FIRE OCCURRENCE	3	3	3	1	3	1	1	3	0
3.8 SHORT AND LONG TERM FIRE EFFECTS	2	2	2	1	0	1	1	2	0
3.9 FIRE REGIME EFFECTS ON HABITAT	2	2	2	1	0	1	1	2	0
3.10 FIRE EFFECTS ON DEMOGRAPHIC PATTERNS OF PLANTS AND ANIMALS	2	2	2	1	0	1	1	2	0
3.11 RARE FLORA AND EFFECTS OF FIRE	2	2	2	1	0	1	1	2	0
3.12 CRITICAL PLANT AND ANIMAL BIOLOGICAL INDICATORS	2	2	2	1	0	1	1	2	0
3.13 SIMPLE FIELD ASSESSMENT TECHNIQUES	3	2	2	1	3	1	1	2	0
3.14 COMPUTER FIRE MANAGEMENT SYSTEMS	3	2	2	1	0	1	1	2	0
3.15 MONITORING PROGRAM	2	2	2	1	0	1	1	2	0

3. Future research in the south-west forest areas should concentrate on fire effects on plants and animals (Theme 2) and on the development of computer based management systems which integrate fire behaviour, fire suppression and fire effects (Theme 4).

4. A system for monitoring the long-term effects of various fire regimes needs to be developed, initially based around fire effects/ecology studies in the south-west forests, woodlands and heathlands (Theme 3).

Table 2 shows the level of fire research in various vegetation types over the past five years, whilst Table 3 shows how these studies will progress and develop in other vegetation types over the next five years.

Scope of existing program

1. Fire behaviour, detection, and suppression

The forest areas of the south-west have been relatively well served by fire research. There is a need, however, to develop better, fully integrated fire management systems. In other parts of the state most major biomes have received little or no research effort. Those requiring immediate attention are heathlands and hummock grasslands/mulga.

2. Fire ecology

There is a need to continue and increase the research effort on the effects of fire regimes in south-west forest ecosystems. Fire has, and will continue to be, most extensively and frequently used as a management tool in these forest areas. However, several other major vegetation types also require effort on the effects of fire, particularly heathlands, woodlands and hummock grasslands.

3. Monitoring

Currently there is little or no provision for the long-term monitoring of the effects of prescribed burning in any of the major biomes throughout the State. There is an urgent need for such systems to be developed, preferably integrated with the proposed Departmental system of monitoring sites and in conjunction with management staff.

4. Fire Management Systems

A strong fire management infra-structure is in place for forest areas. Further work must concentrate on computer-based, fully integrated systems. Heathlands, woodlands and hummock grasslands require basic fire behaviour and suppression knowledge, as well as identifying fire-sensitive indicator species.

TABLE 2: Status of Research Goals in the next twenty years.
LEGEND: 0 = No effort 1 = Studies to commence 2 = Studies to continue 3 = Studies complete

PRIMARY OBJECTIVE	VEGETATION TYPES								
	FORESTS	WOODLAND (Wheatbelt)	LOW SHRUBLAND (Heath)	LOW WOODLAND (Mulga)	BANKSIA WOODLAND	SAVANNA SHRUBLAND (Kimberley)	TALL GRASSLAND (Pindan)	HUMMOCK GRASSLAND (Spinifex)	SUCCULENT STEPPE (Saltbush)
3.1 FIRE DANGER RATING SYSTEM	2	0	0	0	1	0	0	0	0
3.2 FIRE BEHAVIOUR PREDICTION SYSTEM	3	0	0	0	1	0	0	0	0
3.3 FUEL MODEL	3	1	1	0	1	0	0	0	0
3.4 DEFINING FIRE HAZARD	1	0	0	0	0	0	0	0	0
3.5 KNOWLEDGE OF FIRE WEATHER	2	0	0	0	1	0	0	0	0
3.6 WILDFIRE SUPPRESSION TECHNIQUES	2	0	0	0	1	0	0	0	0
3.7 REPORTING AND ACHIEVING FIRE OCCURRENCE	2	0	0	0	1	0	0	0	0
3.8 SHORT AND LONG TERM FIRE EFFECTS	3	2	2	0	0	0	0	1	0
3.9 FIRE REGIME EFFECTS ON HABITAT	2	2	2	0	0	0	0	1	0
3.10 FIRE EFFECTS ON DEMOGRAPHIC PATTERNS OF PLANTS AND ANIMALS	2	2	1	0	0	0	0	1	0
3.11 RARE FLORA AND EFFECTS OF FIRE	1	1	1	0	0	0	0	0	0
3.12 CRITICAL PLANT AND ANIMAL BIOLOGICAL INDICATORS	1	2	2	0	0	0	0	0	0
3.13 SIMPLE FIELD ASSESSMENT TECHNIQUES	2	1	1	0	1	0	0	0	0
3.14 COMPUTER FIRE MANAGEMENT SYSTEMS	2	2	0	0	0	0	0	0	0
3.15 MONITORING PROGRAM	1	1	1	0	0	0	0	1	1

Proposed New Projects

High Priority

A Fire behaviour/suppression

i) Fire behaviour and suppression studies in heathlands. 1.0 professional, 2.0 technical staff, $17 200 per annum, 5 years (encompasses Tables 1 to 3 objectives 3.1 to 3.6).

This study will develop reliable fire behaviour systems for use by managers for prescribed burning and wildfire control. It will also examine fire pre-supression and suppression strategies for heathlands.

ii) Fire behaviour in hummock grasslands/mulga communities. 1.0 professional, 2.0 technical staff, $12 500 per annum, 5 years (encompasses Tables 1 to 3 objectives 3.1 to 3.6).

This study will aim to describe fuel, weather and fire behaviour to facilitate the prescription of appropriate patch burns. The work will also provide managers with fire behaviour models for predicting fire hazard and wildfire behaviour.

B Fire ecology

i) Fire effects on rare flora. 1.0 professional, 2.0 technical staff, $10 500 per annum, 5 years (encompasses Tables 1 to 3 objectives 3.10 and 3.11).

To identify a range of rare flora and examine life form strategies and responses to various fire regimes.

ii) Critical plant and animal biological indicators 1.0 professional, 2.0 technical staff, $6 500 per annum, 3 years (encompasses Tables 1 to 3 objectives 3.10 and 3.12).

To identify a range of plant and animal species in various ecosystems whose abundance and distribution show a close relationship with fire regimes.

C Monitoring

iii) Monitoring effects of prescribed burning in national parks and nature reserves. 1.0 professional, 1.0 technical staff, $10 000 per annum. 5+ years (encompasses Tables 1 to 3 objectives 3.8, 3.9, 3.11, 3.12, 3.13 and 3.15).

This project aims to set up permanent sites for examining the long-term effects of various fire regimes and includes the evaluation of simple field assessment techniques, and development of a general fire effects monitoring system.

TABLE 3: Status of Research Goals in the next twenty years.
LEGEND: 0 = No effort 1 = Studies to commence 2 = Studies to continue 3 = Studies complete

PRIMARY OBJECTIVE	VEGETATION TYPES								
	FORESTS	WOODLAND (Wheatbelt)	LOW SHRUBLAND (Heath)	LOW WOODLAND (Mulga)	BANKSIA WOODLAND	SAVANNA SHRUBLAND (Kimberley)	TALL GRASSLAND (Pindan)	HUMMOCK GRASSLAND (Spinifex)	SUCCULENT STEPPE (Saltbush)
3.1 FIRE DANGER RATING SYSTEM	3	1	1	0	3	0	0	1	0
3.2 FIRE BEHAVIOUR PREDICTION SYSTEM	3	1	1	0	3	0	0	1	0
3.3 FUEL MODEL	3	2	2	0	3	0	0	1	0
3.4 DEFINING FIRE HAZARD	3	1	0	0	0	0	0	1	0
3.5 KNOWLEDGE OF FIRE WEATHER	3	1	1	0	0	0	0	1	0
3.6 WILDFIRE SUPPRESSION TECHNIQUES	3	1	1	0	0	0	0	0	6
3.7 REPORTING AND ACHIEVING FIRE OCCURRENCE	2	1	1	0	2	0	0	1	0
3.8 SHORT AND LONG TERM FIRE EFFECTS	2	2	2	0	0	0	0	2	0
3.9 FIRE REGIME EFFECTS ON HABITAT	2	2	2	0	0	0	0	2	0
3.10 FIRE EFFECTS ON DEMOGRAPHIC PATTERNS OF PLANTS AND ANIMALS	2	2	2	0	0	0	0	2	0
3.11 RARE FLORA AND EFFECTS OF FIRE	2	2	2	0	0	0	0	1	0
3.12 CRITICAL PLANT AND ANIMAL BIOLOGICAL INDICATORS	2	2	2	0	0	0	0	1	0
3.13 SIMPLE FIELD ASSESSMENT TECHNIQUES	2	2	2	0	3	0	0	1	0
3.14 COMPUTER FIRE MANAGEMENT SYSTEMS	2	2	0	0	0	0	0	1	0
3.15 MONITORING PROGRAM	2	2	2	0	0	0	0	1	0

Medium Priority

A Fire management systems

i) Development of computer-based fire management systems for selected forest, woodland and heathland areas. 1.0 professional, 1.0 technical staff, $7 000 per annum, 3 years (encompasses Tables 1 to 3 objective 3.14).

To fully evaluate fire management systems such as PREPLAN in the northern jarrah forest, and to adapt such systems to suit various reserves (e.g. Tutanning) and other forest areas of the south-west (e.g. Perup).

Projects to be completed 1987-1991

Project numbers refer to Appendix 2

1987

1. Slash burning guides for P. radiata plantations (N. Burrows, RWP 19/78).

2. The Mount Soil Dryness Index for use in W.A. (N. Burrows, RWP 36/83).

27. Documenting wildfire history in forests (N. Burrows, RWP 68/86).

7. Prescribed fire to control pine wildings (N. Burrows, RWP 16/86).

28. Rate of fuel accumulation in Banksia woodlands (N. Burrows, RWP 17/86).

33. A computer-based wildfire information storage and retrieval system (N. Burrows, RWP 15/86).

13. Fire-caused injury to Jarrah and Marri (N. Burrows, RWP 18/78).

9. Aspects of fire behaviour in Banksia woodland (N. Burrows, RWP ?).

29. Pitfall trapping, sampling methodology (G. Friend, RS 34).

23. Fire effects studies, Two Peoples Bay Nature Reserve, including preparation of management plan. (A. Hopkins, RS 63)

25. Fire effects studies, Recherche Archipelago. (A. Hopkins, RS 60).

1988

5. The combustion rate of forest fuels (N. Burrows, RWP 18/86).

6. The development of spot fires in the forest (N. Burrows, RWP 14/86).

8. Fire in regenerated Karri stands (L. McCaw, RWP 21/85 or 15/85?).

35. Development of computerized land management systems, Tutanning (A. Hopkins, part of RS 61).

24. Fire effects studies, Tutanning Nature Reserve Management Plan (A.Hopkins, RS 59,62).

11. Describing fuels in kwongan at Tutanning (A. Hopkins, part of RS 61).

1989

3. Forest fire behaviour under dry fuel conditions (N. Burrows, RWP 28/78).

4. Identifying and describing biotic fire descriptors (N. Burrows, RWP ?).

14. The effect of fire on *Lambertia rariflora* (N. Burrows, RWP ?).

19. Spatial dynamics of lizards and scales of sampling (G. Friend, new).

26. Fire effects studies, Eneabba and Mt Lesueur - Mt Lesueur management plan (A. Hopkins part of RS 60).

1990

22. Fire, season and termite activity (G. Wardell-Johnson, RWP 8/84).

1991

21. Fire and the Tammar (G. Wardell-Johnson, RWP 7/84).

Over the next five years approximately 2.5 professional staff and approximately 4 technical staff will be released from current projects and thus be available to undertake new projects.

New Projects 1987 - 1991

Three of the six projects listed above (Proposed new projects) will be commenced within the next 5 years. These plans have assumed that no resources will be removed from or transferred to the Fire Program. The projects are:

1. Fire behaviour and suppression studies in heathlands (L. McCaw, commencing 1987).

2. Fire behaviour in hummock grasslands/mulga communities (N. Burrows, commencing 1988).

3. Monitoring effects of prescribed burning on nature reserves (G. Friend, commencing 1987 on Boyagin Nature Reserve as a small-scale preliminary study to evaluate field assessment techniques).

3.4 FLORA CONSERVATION PROGRAM

Program Leader: S.D. Hopper

Current Resources

This program comprises 3.75 persons (1.9 professional + 1.85 technical). Its budget is $120 447 ($120 447 salaries, no wages and $63 600 other).

Aim

To undertake research on the conservation and management of the indigenous flora of Western Australia.

Primary Objectives

FLORA DATA-BASE

To establish and maintain a data base on the geographical distribution and conservation status of Western Australia's native flora and plant communities.

RARE AND ENDANGERED FLORA

To undertake research on rare and endangered flora systematics, geographical distribution, genetics, population ecology and management techniques (e.g. fire, mechanical disturbance, weed competition, grazing regimes, pest and disease control, propagation and re-establishment in the wild), and to recommend on land acquisition, management techniques, future research and conditions for Ministerial permits to take with a view to producing rare flora wildlife management plans. To prepare wildlife management programs for species that require management.

WILDFLOWER INDUSTRY

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

PUBLIC INVOLVEMENT

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

COMMUNICATION

To communicate the results of research 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.

Twenty Year Goals

Endangered Flora Wildlife Management Plans

1. Prepare plans for all declared endangered flora.

2. Establish a network of permanent monitoring quadrats on all declared endangered flora.

Flora Data Base

3. Maintain a comprehensive data base for declared endangered flora.

4. Undertake surveys and implement findings on poorly known species at risk.

Public Involvement

5. Involve the public in monitoring and surveys of all declared endangered flora and other groups of flora suitable for atlas projects.

Wildflower Industry Wildlife Management Plans

6. Provide plans for all major species utilized in the wildflower industry.

7. Continue monitoring of effects of the industry on native flora.

8. Undertake research on the management of selected priority species.

Five Year Goals

1. Endangered flora management plans

   1a. Produce 10 Endangered Flora Wildlife Management Plans that are either species, reserve or CALM Region based

1b. Establish a network of permanent monitoring quadrats on all species for which Endangered Flora Wildlife Management Plans are produced.

1c. Produce a colour book on the Declared Endangered Flora.

2. Flora Data Base

2a. Develop a computerized data base for declared rare flora and an ability to map geographical distributions using FLORAPLOT.

2b. Undertake field surveys of poorly known high priority species at risk, and to review the schedule of declared rare flora annually.

2c. Carry out studies on the biosystematics and conservation status of Western Australian flora.

3. Public Involvement

3a. Publish the Banksia atlas and Orchid atlas.

3b. Complete an endangered eucalypt atlas.

3b. Seek public involvement in the monitoring of declared endangered flora.

4. Wildflower Industry Management Plans

4a. Produce, through the letting of consultancies, three Wildlife Management Plans on species used in the industry.

4b. Conduct an annual review of the Australian National Parks and Wildlife Service's statistics on Western Australian cut flowers exported under permit from their legislation.

4c. Review research priorities after proclamation of the proposed flora licencing amendments to the Wildlife Conservation Act.

4d. Undertake research on the management of Boronia megastima and other priority species in relation to commercial harvesting techniques.

5. Research Communication

5a. Publish educational material, field guides to eucalypts and orchids of five national parks, and books on trees and tall shrubs of Perth and on orchid pollination.

5b. Establish field herbaria in all CALM regional and district offices and ranger stations.

5c. Assist in training of CALM staff in field operations relating to flora conservation.

Scope of Existing Program

Western Australia has a vascular flora world renowned for its richness (c. 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. In most cases, the taxonomy, geographical distribution, reproductive 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. With the completion of 10 years' survey (1977-1987) of these areas it is intended now to concentrate more on studies of population dynamics and management of selected endangered flora of varying life histories. This will be achieved by establishing permanent monitoring quadrats, undertaking population ecology/genetic studies and developing a computer data base on endangered flora. It is also intended to undertake limited research on more common flora where conservation problems are developing. These include effects of dieback and wildflower picking on Banksias; fragmentation of the range of widespread eucalypts by clearing; impact of beekeeping; competition by weeds with keystone species, and impacts on granite outcrop species.

Proposed New Projects

Priority

1. Survey of endangered and poorly known flora of cereal growing areas undergoing active clearing. 1.0 professional, 1.0 technical officer, $40 000 over 3 years.

   This project will attempt to keep up with the pace of ongoing agricultural land clearance and focus on local endemics of the wheatbelt and urban areas, with a view to producing Wildlife Management Plans on the most endangered taxa.

2. Survey of endangered and poorly known flora of the Karri region. 1.0 professional, 1.0 technical officer; $25 000 over 2 years.

   The precise locations and abundance of karri region endemics will be documented, with an emphasis on orchids and other herbs that have not received the

detailed attention of CALM staff, and the aim of developing Wildlife Management Plans where appropriate.

Maintain a comprehensive computerized data base for declared endangered flora and review the schedule annually. 1.0 professional; $5 000 per year (ongoing).

3. A computerized data base will be established and maintained to ensure efficient handling of incoming survey and biological data, its effective transmission to operations staff, and the annual review of the schedule.

4. Biology and management of selected plants heavily exploited in the wildflower industry (including Boronia megastigma, Banksia coccinea, Dryandra polycephala etc.). 1.0 professional, 1.0 technical officer; $40 000 over 3 years.

The small number of heavily exploited species that may be at risk from commercial harvesting will be investigated with a view to preparing Wildlife Management Plans on each.

5. Biology and control of invasive introduced environmental weeds. 1.0 professional, 1.0 technical officer; $40 000 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.

6. Impact of beekeeping on native flora and fauna. 1.0 professional, 1.0 technical officer; $65 000 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 on CALM lands will be developed.

Projects to be completed 1987 to 1991

Five Year Goal No.

1987

1a. Endangered Flora Wildlife Management Plan for Acacia anomala. D.J. Coates.

1a. Endangered Flora Wildlife Management Plan for Drakaea jeanensis. S.D. Hopper.

2c. Phylogenetic and breeding system studies in the genus Eremaea (Myrtaceae). D.J. Coates, RS 30.

2c. Distribution and ecology of Dryandra (Proteaceae). A.J.M. Hopkins, RS 56.

2c. A revision of Caladenia, Drakaea and allied genera of orchidaceae in Western Australia. S.D. Hopper, RS 78.

2c. Generic relationships and evolution of Caladenia, Chloraea and allied orchids. S.D. Hopper and consultant, RS 79.

2c. A revision of Eucalyptus wandoo and allied species (Eucalyptus series Subcornutae). M.I.H. Brooker (CSIRO, Forest Research), S.D. Hopper, RS 80.

2c. Eucalypts of Western Australian salt lakes, including the new series Rigentes with three new species. M.I.H. Brooker (CSIRO, Forest Research). S.D. Hopper.

3a. Banksia atlas. A. Taylor, S.D. Hopper.

3a. Atlas of the Western Australian flora pilot project (orchids). S.D Hopper, RS 76.

5a. Orchids of the Stirling Range National Park. A.P. Brown and S.D. Hopper.

Staff resources released: 0

1988

1a. Two Endangered Flora Wildlife Management Plans. D.J. Coates and S.D. Hopper.

1a. Genetic variation in outlying populations of Jarrah and co-existing allied rare species. S.D. Hopper, RS 82.

1a. Bird pollination, nectar flow and the mating system of Eucalyptus caesia. S.D. Hopper and external researchers, RS 82.

1a. Conservation status, morphometrics and allozyme variation in Eucalyptus macrocarpa and allied species. S.D. Hopper and external researchers, RS 83.

1a. Eucalyptus carnabyi - rare hybrid or relict species? S.D. Hopper, RS 87.

1a. Determination of the hybrid status of some rare flora. D.J. Coates, S.D. Hopper, RS 28.

1a. Reproductive biology and management of Eucalyptus rhodantha. J. Sampson, S.H. James (University of Western Australia), S.D. Hopper, developmental.

1c. Book on rare and endangered W.A. flora. S.J. Patrick (consultant botanist) and S.D. Hopper.

2b. Conservation status and biology of granite rock endemics of the Karri forest. S.D. Hopper.

2c. Eucalypts of the Great Victoria Desert. S.D. Hopper, RS 88.

2c. Twenty new eucalypts from Western Australia. M.I.H. Brooker (CSIRO, Forest Research), S.D. Hopper, RS 81.

4d. Reservation status of commercially exploited taxa. S.D. Hopper, RS 71.

4d. Harvesting techniques used in the wildflower trade. S.D. Hopper, RS 72.

4d. Conservation of two kangaroo paw species. M.App.Sci. students Curtin University, Supervisors and S.D. Hopper, RS 72.

5a. Presumed extinct and very rare wheatbelt plants. S.J. Patrick (consultant botanist) and S.D. Hopper, RS 68.

5a. Orchid Pollination Book. S.D. Hopper, A.P. Brown, B.A. and A.G. Wells.

5a. Native trees and tall shrubs of Perth - guide and atlas. R.J. Powell, S.D. Hopper, RS 77.

5a. Establishment of field herbaria in all regional and district offices and ranger stations. R.E.S. Sokolowski and S.D. Hopper, RS 32.

Staff resources released: 0

1989

1a. Two Endangered Flora Wildlife Management Plans. D.J. Coates and S.D. Hopper.

1d. Review of rare flora conservation in Western Australia. S.D. Hopper and D.J. Coates, RS 73.

2b. Conservation status and biology of granite rock endemics of the wheatbelt. S.D. Hopper.

2c. Conservation, ecology and biology of Western Australian Tremandraceae. J.J. Alford and G.J. Keighery, RS 95.

2c. Revision and conservation status of Beaufortia and Regelia. A.A. Burbidge, RS 8.

2c. Hyrbidization and gene exchange in a Stylidium contact zone. D.J. Coates, RS 31.

3b. Atlas or rare and endangered W.A. eucalypts. S.D. Hopper.

4d. Wildflower Industry Wildlife Management Plan for Anigozanthos pulcherrimus and Macropidia fuliginosa. S.D. Hopper.

5a. Orhids of metropolitan Perth. A.P. Brown and S.D. Hopper, RS 78.

5a. A guide to the Eucalypts of the Stirling Range. S.D. Hopper, RS 87.

Staff resources released: Ø

1990

1a. Two Endangered Flora Wildlife Management Plans. D.J. Coates and S.D. Hopper.

2b. Conservation status and biology of granite rock endemics of the pastoral region. S.D. Hopper.

5a. Orchids of Kalbarri, Leeuwin-Naturaliste, Walpole-Nornalup, Fitzgerald River and Cape Le Grand National Park. A.P. Brown and S.D. Hopper.

Staff resources released: Ø

1991

1a. Two Endangered Flora Wildlife Management Plans. D.J. Coates and S.D. Hopper.

1a. Conservation status and genetic variability in four dominant but rapidly declining species. D.J. Coates, RS 30.

2b. Conservation status and biology of granite rock endemics on the south coast. S.D. Hopper.

2c. Biogeography and taxonomy of creeping triggerplants (Stylidiaceae). A.H. Burbidge, RS 18.

4d. Conservation status and genetic variability in six commercially exploited, geographically restricted and dieback susceptible species. D.J. Coates, RS 29.

Staff resources released: Ø

New Projects to be Started, 1987-91

Nil. Completion of the above plus continuation of the following ongoing projects will occupy fully all available staff over the next five years.

Ongoing Projects

1a. Conservation genetics of rare flora. D.J. Coates, RS 25.

1a. Genetic systems of rare flora. D.J. Coates, RS 26.

1a. Germ plasm storage program for rare, endangered and rapidly declining flora. D.J. Coates and S.D. Hopper, RS 27.

1b. Life history and eco-geographic studies of rare flora. D.J. Coates, S.D. Hopper and G.J. Keighery, RS 26.

2a. Additions and deletions to the declared endangered flora. S.D. Hopper, RS 66.

2a. Data base on rare and geographically restricted plants of Western Australia. S.D. Hopper and various consultant botanists, RS 69.

2b. Undertake field surveys of poorly known high priority species at risk. S.D. Hopper, D.J. Coates, G.J. Keighery, S.J. Patrick, A.P. Brown and R.E. Sokolowski.

2c. Taxonomy of new Western Australian Eucalypts. M.I.H. Brooker (CSIRO, Forest Research), S.D. Hopper, RS 81.

2c. Pollination biology of the Australian flora. S.D. Hopper, RS 90.

2c. Garden escapes, naturalized flora of Western Australia. G.J. Keighery, RS 96.

2c. Systematics of Western Australia flora. G.J. Keighery, RS 97.

2c. Biology of Western Australian plants. G.J. Keighery, RS 97.

4c. Licensing and management of the wildflower industry. S.D. Hopper, D.J. Coates, RS 70.

5a. Flora posters, leaflets, magazine articles and public lectures. S.D. Hopper, D.J. Coates, G.J. Keighery, RS 74.

3.5 JARRAH PROGRAM

Program Leader: I. Abbott

Current Resources

This program comprises 15.7 persons (3.95 Professional + 11.75 Technical). Its budget is $491 330 ($397 336 salaries, $22 794 wages and $71 200 other).

Aim

To ensure that current and future management of the jarrah forest ecosystem has a sound scientific basis.

Primary Objectives

SILVICULTURE

To elucidate how the jarrah forest can be logged, regenerated and thinned in the presence of fungal diseases and insect pests. To determine how existing stands of jarrah differ in their rates of wood growth, capacity for regeneration, and resistance to fungal disease and insect pests and other disturbances.

PRODUCTION

To ascertain the optimal relationship among stand basal area, yield of utilizable wood, and water quantity and quality within catchments.

UTILIZATION

To ensure that wood harvested from the jarrah forest is used efficiently.

ECOLOGY

To understand the factors governing the regeneration of the jarrah ecosystem.

CONSERVATION

To ensure that no indigenous plant or animal species declines in abundance over the whole jarrah forest as a result of forest management.

PUBLIC INVOLVEMENT

To foster a sympathetic attitude from the public to current management of the jarrah forest ecosystem, and to involve the public in appropriate research projects.

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, and the community at large, and involvement in training courses and public seminars.

Twenty Year Goals (In order of priority, *** = high, ** = medium, * = low)

*** 1. Devise models for jarrah forest protection and production, incorporating the extremes of stand stocking, stand structure, insect and fungal impact, tree form, thinning schedules, nutrition, regeneration strategies, water usage, fire regimes, and yield of utilizable wood.

*** 2. Identify precisely those parts of the jarrah forest that should not be mined or logged because of the unacceptable risk of damage to nature conservation values, increased salinity, fungal infection or insect infestation.

*** 3. Eliminate all wastage of usable wood in the forest.

** 4. Minimize the economic impact of insects and fungi using cheap, simple silvicultural methods.

** 5. Enhance conservation values in the forest by planting jarrah and other indigenous tree species back into disturbed areas. If possible, these are to be genotypes resistant to the major pests and diseases.

* 6. Compile a checklist of all formally named indigenous and exotic plant and animal species present in the jarrah forest, and an atlas of their distribution.

Five Year Goals (In order of priority, *** = high, ** = medium, * = low).

*** THEME A. Ensure that existing timber and water resources are protected.

*** 1. Determine the effect of different thinning prescriptions on subsurface hydrology and soil temperature.

*** 2. Determine the annual cycle of abundance of skeletonizer and other folivores and their predators and parasitoids.

*** 3. Determine the ecological and economic significance of reduction in crown size and wood growth caused by defoliating insects.

** 4. Compare the insect fauna, and damage to the leaves, of the jarrah canopy and the jarrah advance growth, with special emphasis on leaf miner and skeletonizer.

** 5. Monitor the expansion of leaf miner into the jarrah forest north of Collie.

*** THEME B. Decide which stands can be managed most safely and most profitably.

*** 6. Develop a detailed site-vegetation classification of the southern jarrah forest, suitable for use by forest managers.

*** 7. Identify site indicators (particularly understorey plant species) and develop a hazard rating of jarrah stands for Phytophthora.

*** 8. Identify jarrah stands most vulnerable to defoliating insects, and devise silvicultural methods to promote their resistance to these insects.

*** 9. Identify individuals of jarrah that are at best genetically resistant to or at worst tolerant of Phytophthora, leaf miner and skeletonizer.

** 10. Determine the effect of proposed thinning prescriptions on hazard of Phytophthora in different site types.

** 11. Determine the hydrological response of sites with Phytophthora hazard ratings 2 and 4.

** 12. Predict tree and stand leaf area from tree diameter and extend this relationship to a regional scale using aerial or satellite photography.

** 13. Determine if the rate of transpiration per unit leaf area is greater in thinned stands than in unthinned stands, and whether this is more so in the low rainfall zone than in the high rainfall zone.

* 14. Relate hydrological response to profile characteristics.

* 15. Examine the variability in leaf water potential and stomatal conductance in terms of height in the canopy and dominance status.

*** THEME C Increase the productivity (quantity and quality of wood and water) of these stands.

*** 16. Determine the effect of stand density and fertilization on the growth rates of jarrah poles.

*** 17. Determine the relationship between stand density and quality and quantity of water produced from jarrah catchments.

*** 18. Develop ways of using thinnings that are currently not of commercial value.

*** 19. Develop and improve techniques of milling and seasoning regrowth jarrah (both thinnings and crop trees).

** 20. Determine whether substantial genetic variation in growth and form of jarrah exists. If so, select those fast-growing genotypes with good form for reclaiming dieback and mined sites.

** 21. Establish long-term provenance trials using seed collected from both the northern and southern jarrah forests.

* 22. Define more closely the relationship between water potential and growth of the jarrah pole in the high and low rainfall zones.

* 23. Relate variation, among site types, in mineral nutrients, carbohydrates and water content in the stems of jarrah to resistance to Phytophthora.

* 24. Refine chemical methods of non-commercially thinning jarrah stands.

** THEME D Ensure that a new stand develops adequately after logging.

*** 25. Promote the development of adequate dynamic regeneration of jarrah on heavy scrub types in the southern jarrah forest.

** 26. Improve the development of dynamic jarrah regeneration using seeding, fertilizer and various planting methods.

* 27. Establish the relationships among shoot development, lignotuber size, root development, nutrition and ectomycorrhizal development of the young jarrah plant.

* THEME E Ensure the survival (over the whole jarrah forest) of all indigenous fauna and flora.

Current research is being conducted within the Fire and Fauna programs.

5 year goals to be completed, 1987-92

The intention is that the 27 five year goals listed will be achieved by 1992, provided that resources are not further diminished.

5 yr goal No.	Current Research Project No.(App.II)	Duration	Cost Index * (p.a.)	Technical Staff (p.a.)
1	33	ongoing	moderate	Ø.5
2	7,2,8,11,13	annual sampling only from 1988	moderate	Ø.8
3	1,3,4,6,10,14,15,16	ongoing	moderate	Ø.5
4	9	data being analysed	- -	
5	5	ongoing	moderate	Ø.2
6	57	MS being edited	- -	
7	36	ongoing	moderate	1.5
8	5,8,9	ongoing	moderate	Ø.8
9	49,51	ongoing	moderate	Ø.5
10	33	ongoing	moderate	Ø.5
11	37	ongoing	moderate	Ø.5
12	17	terminates 89-90	moderate	Ø.95-1.Ø
13	17	88-91 only	medium 1988-9 mod thereafter	1.Ø
14	37	ongoing	minor-moderate	nil
15	17	87-88 only	minor	Ø.Ø5
16	17,18,19,21,22	ongoing	high 87-88, thereafter minor	1.Ø
17	20,23	ongoing	ext	Ø.9.(87-89) 1.Ø (89-9Ø) thereafter 2.Ø
18	41,44,46,47,48	ongoing	ext	1.Ø
19	39,40,42,43,45	ongoing	ext	1.5
20	49,50,51	ongoing	moderate	nil 1987-8 thereafter Ø.25
21	52	terminating 89-9Ø	moderate	Ø.17
22	62	1987-88	minor-moderate	Ø.5
23	38	data being analysed	- -	
24	26-32	87-89 only	moderate	Ø.1
25	59,61	ongoing	minor	Ø.25
26	53,54,55,56,58	ongoing	minor	Ø.5
27	60	ongoing	minor	Ø.25

* minor <$1 000, moderate $1 000 - 10,000, medium $11 000 - 25 000, high >$25 000.
ext = funded from external funds

Scope of existing program.

No conservation research is at present being conducted within the jarrah program. However relevant research is being performed within the Fauna and Fire programs on managing three species of rare mammal in jarrah forest east of Manjimup.

Most of the projects listed below follow logically from the current 5 year goals. Others are new initiatives (Projects 1,6,7,13,17) which are, however, high in the list of 20 year research goals. Projects 1-18 are essential for any sensible future management of the jarrah forest ecosystem.

Proposed New Projects

List of proposed new goals, 1987 - 92 (None of these yet has an approved RWP).

High priority

[Projects have not been ranked within each Priority category]

1. Examine geographic variation in jarrah using electrophoretic techniques and determine levels of outcrossing prevalent in the jarrah forest.

2. Examine the heritability of resistance or tolerance in jarrah to P. cinnamomi, leafminers and gumleaf skeletonizer.

3. Refine the testing of jarrah seedlings and clones for resistance to P. cinnamomi.

4. Develop a P. cinnamomi hazard rating system for the central and upper southern jarrah forest.

5. Determine the growth and mortality rates of jarrah poles growing on dieback-affected and dieback-free sites.

6. Determine if the reserve system in the jarrah forest is adequate and representative of site-vegetation complexes, fauna, flora, stand structure etc.

7. Develop appropriate disease and pest management programs for conservation MPA's in jarrah forest.

8. Formulate a plan for controlling jarrah leafminer, by combining the results of the 25 year study by CSIRO (report due 1988) with those from research conducted by CALM. The most urgent need is to reduce the rate of spread into the forest north of Collie.

9. Formulate a plan for controlling gumleaf skeletonizer, after evaluating by experiment the efficacy of fire, thinning, birds, parasitoids, bacteria, fungi and viruses in controlling the insect.

10. Devise a stand hazard rating system for jarrah leafminer and gumleaf skeletonizer, suitable for use by Operations and Inventory.

11. Determine the reasons for poor regeneration of jarrah on certain sites in the northern jarrah forest and formulate remedial measures.

12. Determine the reasons for understocking and poor structure on some sites in the northern jarrah forest, and devise ways of improving productivity of these sites.

Medium priority

13. Determine the effect of silvicultural practices and of fungal and insect pests on wood quality.

14. Assess whether outbreak densities of defoliating insects reduce the abundance of other invertebrate species, and hence of bird populations.

15. Determine which factor(s) (climatic change, deforestation, logging, fire regime) initiated the 1960's outbreak of jarrah leafminer and the 1982/3 outbreak of gumleaf skeletonizer in the southern jarrah forest.

16. Investigate the impact of repetitive defoliation by insects on nutrient levels in, and physiological condition of, the jarrah pole.

17. Compare the effectiveness of nitrogen fixation by native legumes with nitrogen fertilization on the growth of intensively managed jarrah stands.

18. Determine the effect of stump coppice and advance growth in thinned jarrah stands on pole and stand increment and site hydrology (soil moisture storage patterns).

Low priority

19. Assess the relative and total effect of various tree and stand characteristics on the growth rate of jarrah saplings, poles and piles.

20. Assess the genetic resistance of jarrah seedlings to canker fungi.

Proposed Project No.	Duration (yrs)	Cost index (p.a.)	Staff * (p.a.)
1	0.2	Mod	0.2P + 0.2T
2	2	Mod	0.1P + 0.1T
3	2	Mod	0.5P + 0.5T
4	3	Mod	1.0P + 3.0T
5	10	Mod	0.1P + 0.1T
6	10	Mod	0.1P + 0.1T
7	10	Mod	0.9P –
8	begin 1988	Mod	0.1P –
9	5	High	2.0P + 2.0T
10	2	Mod	0.1P + 1.0T
11	2	Medium	0.5P + 1.0T
12	2	Medium	0.5P + 1.0T
13	3	Medium	1.0P + 1.0T
14	2	Medium	– 1.0T
15	0.5	Minor	1.0P –
16	2	Moderate	0.5P + 1.0T
17	5	Mod	(0.2P + 0.1T 1st yr (0.1P + 0.1T next 4yr
18	5	Medium	(0.3P + 0.6T 1st yr (0.1P + 0.2T next 4yr
19	1	Mod	0.5P + 0.3T
20	1 (pilot trial)	Minor	0.1P + 0.1T

* P = professional, T = technical
minor <$1 000, moderate $1 000 – 10 000, medium $11 000 – 25 000, high > $25 000.

3.6 KARRI PROGRAM

Program Leader: Lachlan McCaw

Summary of Current Resources

This program comprises 6.25 persons (2.6 professional + 3.65 technical). Its budget is $243 835 ($208 685 salaries, $9 300 wages and $25 850 other).

Aim

To provide a sound scientific basis for planning and implementing sustainable management of the karri ecosystem.

Primary Objectives

RESOURCES

To produce an inventory of the biological and physical resources of the karri ecosystem. To understand the factors that determine the distribution and abundance of these resources so that priorities for land use can be allocated on a scientific basis.

MANAGEMENT

To provide techniques to integrate the activities managed by CALM in order that recognised values of the karri ecosystem are protected and maintained.

PRODUCTION

To examine a range of stand management strategies and evaluate the effect of each of the quantity, quality, utilisation and timing of wood production during a rotation. To understand the factors governing the sustainable production of other resources from the karri ecosystem (e,g, water, honey, recreational experience).

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, and the community at large, and involvement in training courses and public seminars.

Twenty Year Goals

A Resources

1. Develop a comprehensive data base of the plants and animals of the karri ecosystem and identify the factors that determine the distribution and abundance of important species.

B Management

2. Develop a model to integrate forest stand growth, understorey dynamics and fauna population characteristics that is capable of predicting the response of the ecosystem to different types and intensities of manipulation or disturbance.

3. Determine the optimum strategy for distribution and management of conservation reserves in the karri ecosystem.

C Production

4. Develop silvicultural practices to maximise merchantable volume increment in stands designated for wood production.

5. Eliminate wastage of utilisable wood in forest operations.

6. Minimise the economic losses caused by pests and diseases of karri.

7. Ensure high genetic quality of karri propogating material (seed, cutting, seedling stock).

Five Year Goals

(a) RESOURCES

1. Determine the key edaphic, climatic and topographic factors that influence the growth of karri.

2. Determine the composition and foraging ecology of bird communities in the main belt of the karri forest, including specific examination of the residency and site fidelity of those species utilising the understorey as habitat.

3. Develop a preliminary data base of the vascular plant floristics of the karri ecosystem with initial emphasis on the outlying occurrences. Update the 1986 listing of flora from the Warren Phytogeographical District and distribute the list in a form suitable for use on microcomputer.

4. Determine the distribution and maintenance of genetic variability in karri, including those families established in provenance trials.

5. Prepare an inventory of the fungi associated with wood defects in karri.

(b) MANAGEMENT

1. Determine the relationship between bird community composition and changes in the structure and floristics of the vegetation caused by forest operations.

2. Formulate a strategy for efficient management of the genetic resources of karri.

3. Determine the impact of forest harvesting and regeneration operations on the floristics and structure of the forest understorey.

(c) PRODUCTION

1. Determine the effect of initial espacement, thinning

and fertiliser application on the growth of karri. Establish further trials to investigate key aspects of karri silvics.

2. Develop a model that can predict the productive potential of a site at the commencement of the rotation.

3. Improve techniques for sawing, seasoning and preservative treatment of karri.

4. Provide guidelines for fuel reduction burning of regenerated stands and determine the impact of burning on stand growth and productivity. Interactions between silviculture and fire will be considered.

5. Conduct an assessment of the economic importance of wood defects in karri, particularly those caused by fungi and wood borers.

6. Collaborate with operations staff to ensure production of healthy plants from the nursery.

7. Investigate the breeding systems of karri and develop treatments to maximise the production of seed from orchards.

8. Evaluate the use of cuttings technology for use in karri breeding work.

Scope of Existing Program

1. There has not been any detailed investigation of the dynamics of plant and animal populations in forest that has been logged and regenerated, except for the current bird study and several minor mammal studies. About half of the area of available karri forest is currently available for wood production and has, or will be subject to this type of disturbance. Knowledge of the dynamics of important populations is required for:

   (i) predicting, on a regional scale, the impact of the conversion of old growth and selectively cutover forests.

   (ii) establishing baseline information about regenerated stands, as a preliminary step to examining the impact of subsequent management practices likely to be undertaken in these stands e.g. thinning, prescribed burning.

2. Most of the existing silvicultural trials have been undertaken on the high quality sites characteristic of pure stands of karri. However, a large proportion of the karri forest estate consists of mixed karri/marri and karri/marri/jarrah stands on poorer soils where responses to silvicultural treatment may vary. Knowledge of these responses will be important in planning wood production strategies.

3. A high proportion of cutover stands will continue to be regenerated by artificial means (direct seeding, planting). Seed production areas have been established but there needs to be increased research into techniques for maintaining and improving the quality of growing stock.

4. Fire is now widely used to achieve site preparation and protection objectives in the karri forest, and will probably increasingly be used for specific vegetation and habitat management purposes. While the response of some plant and animal groups to single fire events is understood, the longer term effects of different fire regimes have not been investigated in any detail. Work of this type could also be undertaken with resources available from the Fire Program.

Proposed New Projects

(a) RESOURCES

1. Survey of karri wood rots

0.5 professional, 0.5 technical, $5000 per annum, 4 years (funding, excluding salaries, will be available from the Public Interest Project administered by the Wood Utilisation Research Centre).

This project aims to identify the causes of commonly observed wood rots and timber defects in karri. Economic implications of timber defect will be assessed. The association between the level of defect and factors such as site, fire history, and silvicultural practice will be investigated and should form the basis for recommendations designed to minimise defect in growing trees.

(b) MANAGEMENT

1. Vegetation and animal population dynamics in regenerated stands -

0.5 professional, 1.0 technical, $2500 per annum, 1 year review, followed by 2 - 3 years to establish new studies.

The aim of this project will firstly be to review and consolidate existing information regarding plant and animal population dynamics in the first 30 years following clearfelling. This review should provide a basis to determine requirements for further study. Investigation of the impacts of stand management techniques such as thinning and prescribed burning will be commenced.

(c) PRODUCTION

1. Silvicultural trials in mixed karri/marri stands -

0.5 professional, 1.0 technical, $5000 establishment costs over 2 years, then will require assessment every 2 - 3 years.

The project will investigate the growth response of mixed stands to different intensities and types of thinning and fertiliser application.

2. Nursery assistance -
0.05 professional, 0.05 technical, $1000 per annum, duration 4 years.

The project will involve ongoing liaison with operations staff to overcome disease problems in the karri nursery.

3. Develop techniques to increase production from seed orchards

0.05 professional, 0.05 technical, $2500 annually for 2 years, estimated duration 5 years.

Treatments such as pollarding, irrigation and fertiliser application will be investigated to determine the extent to which seed production from orchards can be increased. Families with desirable traits will be selected for controlled pollination experiments designed to maximise genetic gain. Breeding populations will be established for each of the major river valleys, and recombined to facilitate selection of new lines.

4. Propogation of karri from cuttings -
0.05 professional, 0.05 technical, $1000 per annum, estimated duration 5 years.

This project is exploratory in nature and will extend on previous studies which demonstrated the potential to propogate karri from cuttings.

Projects to be completed 1987 - 1991

1987 - Karri site classification (0.5 professional, 1.0 technical released).

1988 - Measurement of karri provenance trials (RWP 26/78).

1989 - Karri silvicultural trials in mixed stands.

1990 - Prescribed burning of regenerated stands (0.10 professional, 0.05 technical).

1991 - Nil.

Projects to be Started 1987 - 1991

1987	A (1)	Survey of karri wood rots (using staff recently transferred into the Division and external finance)
	C (1)	Silvicultural trials in mixed karri/marri stands.
	C (2)	Nursery assistance
1988	C (3)	Techniques to increase seed production from orchards.
	C (4)	Propogation of karri from cuttings.
1989		Nil
1990		Population dynamics of selected plants and animals in regenerating stands.
1991		Nil

3.7 PINE PROGRAM

Program Leader: John McGrath

Summary of current resources

This program comprises 12.55 persons (2.85 professional + 9.7 technical). Its budget is $567 576 ($379 436 salaries, $85 940 wages and $102 200 other).

Aim

Provide management with the information base necessary to optimize wood production and utilization from the State's softwood plantations.

Primary Objectives

TREE BREEDING

To optimise wood production, wood quality and disease tolerance by development and production of superior genotypes.

SILVICULTURE

Determine optimum silvicultural regimes (establishment, pruning, thinning and fertilization) for P. pinaster and P. radiata plantations and ensure that these regimes are compatible with other land use values such as water yield. Understand the effects of silvicultural manipulations

(stocking, thinning and pruning) on the interaction between pine and disease.

UTILIZATION

Determine the impact of silvicultural practices on wood quality and thus the recovery of sawn timber.

COMMUNICATION

Provide CALM management with advice on plantation management problems. Communicate research findings both within and outside the department by way of scientific and technical papers, management guides, seminars or any other means.

Twenty Year Goals

1. Develop models to describe the growth of pine stands in WA. Such models should be flexible enough to take into account different silvicultural regimes and different growth rates on different sites. The ultimate aim of such a model should be to predict the volumes and quality of logs that are produced by various silvicultural regimes.

2. All plantations (both new and second rotation) should be established with genotypes which have superior wood quality, faster growth rates and are tolerant of disease organisms.

3. Silvicultural strategies should be manipulated to provide trees with the desired wood quality and log sizes. Such silvicultural manipulations should maximise the economic returns to the State.

4. Utilisation research should be aimed at maximising recovery of wood.

5. Management of pine plantations should minimise any deleterious effects on other forest values such as water supply, water quality.

Five Year Goals

1. Ensure that the genotypes used in plantations provide the best possible growth rates, wood quality and disease resistance.

   (i) Develop new technology for seed orchard management (both HAPSO and conventional) to ensure the supply of improved genotypes for plantation establishment.

   (ii) Establish an effective vegetative propogation (cutting) system to help speed the introduction of

improved genotypes to plantations (both P. radiata and P. pinaster).

(iii) Develop new breeds of P. radiata that are tolerant of P. cinnamomi, are straighter, smaller branched and more productive than the genotypes that are currently used.

(iv) Expand the genetic base of the breeding population of WA P. radiata by the selection of "plus trees" in WA and the introductioon of genetic material from other sources.

(v) Screen W.A., interstate and overseas P. radiata populations for tolerance to P. cinnamomi.

(vi) Determine the mode of inheritance of P. radiata tolerance to Phytophthora cinnamomi.

(vii) Plan for the long-term genetic development of Pinus pinaster to ensure continuing gains in the future while maintaining genetic diversity.

2. Provide the information necessary to develop management systems that optimise wood production from P. radiata plantations.

(i) Estimate the response of mature P. radiata to fertilization and describe the interaction between stocking and fertilization.

(ii) Determine the relationship between stand density (both stems per hectare and basal area), tree form and tree growth rate for P. radiata.

(iii) Determine if nutrient concentrations in foliage of young trees can be used as an indicator of tree nutrient status and thus used to predict fertilizer requirements.

(iv) Can thinning for chipwood be economically incorporated into a regime that aims to maximise the return from sawlogs.

(v) Determine the optimum fertilizer applications for young P. radiata on the range of sites on which P. radiata is grown (Hills, Sunkland, South coast etc.).

(vi) Determine how stand density affects pasture growth.

(vii) Estimate the input of nitrogen from a legume pasture (understorey) to a pine plantation during a rotation.

(viii) How does the yield of different pine species compare under various planting regimes and on different soil types.

(ix) Determine if clearing the sunklands native forest for pine plantations affects the yield and quality of stream and groundwater.

(x) Methods of competition control in plantations established on ex-bush sites. Data collection is complete.

3. Ensure that the softwood produced from the plantations is of sufficient quality to meet the requirements of the timber industry.

(i) Determine the impact of silvicultural practices on wood quality and thus the recovery of sawn timber.

(ii) Determine the effect of the frequency and intensity of pruning on tree growth, branch size and size of the knotty core.

4. Provide the information necessary to develop management systems that optimise wood production from P. pinaster plantations.

(i) Determine optimum thinning and pruning strategies for P. pinaster sawlog production on the Swan Coastal Plain.

(ii) Determine the optimum nutrition regimes for P. pinaster on various coastal plain soils.

(iii) Determine if the range of P. radiata and P. pinaster can be successfully extended north to the Moore River.

(iv) Establish appropriate pine tending regimes to enable management of the Gnangara mound aquifer as a water resource for Perth.

Scope of existing projects

1. With the extension of pine planting to the south coast region it is necessary to determine the growth rates, fertilizer requirements and the interaction between stocking rates and fertilizer response for this area. The differences in climate and soils between the west and south coast regions indicate that growth rates and growth patterns will differ considerably between the two regions.

2. The management of the department's plantations would be improved by the development of growth models for both P. radiata and P. pinaster. The considerable body of knowledge of growth rates and response to silvicultural manipulation already accumulated, could be used to begin developing these models.

3. Improved varieties of pine are being developed that will increase the productivity of plantations. New technology for seed orchards and cuttings need to be developed to speed the introduction of this improved genetic material to plantations.

4. The relationship between stocking (site occupancy) and fertilizer response needs to be determined for P. radiata on a range of different sites. This information will lead to more accurate predictions of fertilizer responses and thus more efficient fertilizer use.

5. The majority of softwood produced in WA comes from relatively fast grown plantations, thus a large proportion of the resource is juvenile wood which presents greater utilization problems than mature wood. Utilization research should be directed towards minimising problems in the utilization of juvenile wood.

Proposed New projects

Goal	Project	Priority	Resource Requirements Staff Prof.	Staff Tech.	Financial ($)	Duration (yrs)
2	Pine growth models.	1	1	2	75,000	5
2	Interaction between stocking & fertilisation in P. radiata.	2	0.5	1-2	50,000	6-8
2	Nutrient requirements of P. radiata on the south coast. 1. Initial requirements.	3	0.1	0.5	15,000	3
3	Sawmilling study of pedigree P. pinaster.	4	0.1	0.1	10,000	1
3	Sawn graded recovery of timber from P. radiata crown logs.	5	0.1	0.1	10,000	1
1	Chemical control of flowering in P. radiata.	6	-	0.1	5,000	3
2	Testing of foliage nutrient analysis as a method of determining tree nutrient status in older trees.	7	0.25	1.0	20,000	3-4
2	Nutrient requirements of P. radiata on the south coast. 2. Subsequent requirements.	8	0.1	0.5	15,000	5
2	Determination of growth rates and growth patterns of south coastal P. radiata.	9	0.1	0.5	5,000	3

Note: Few new projects are planned for Goal 1 (Genetic improvement). The emphasis between the various parts of this goal will change, however most of the projects necessary to achieve these goals are in place. For Goal 4 (P. pinaster silviculture) no new initiatives are planned - it is just a matter of publishing the data that has been collected.

Projects to be completed 1987-91.

Planned year of completion	Project (From 5 Year Goals).
1988	1 (ii) Vegetative propogation.
	2 (iii) Nutrient deficiency diagnosis in young

		pines.
	2 (x)	Methods of competition control.
1989	1 (iv)	W.A. "Plus tree" selection.
1990	4 (i)	P. pinaster optimum thinning and pruning.
	4 (ii)	P. pinaster optimum nutrition.
	4 (iii)	Range of P. pinaster and P. radiata.
	4 (iv)	Pine tending and aquifer management.
1991	1 (vi)	Mode of inherritance tolerance in P. radiata.
	1 (vii)	Long term genetic development of P. pinaster.
	2 (v)	Optimum fertilization of P. radiata on various sites.

Note : The staff and financial input on most of the P. radiata silviculture projects (Part 2 of 5 Year Goals) is quite low as the major inputs occur when establishing these long term experiments.

New projects to be started 1987 to 1991

Commencement	Project	Priority
1987/88	Pine growth models	1
1987/88	Interaction between stocking and fertilizer.	2
1987	Sawmilling of P. pinaster.	4
1987	Timber recovery from P. radiata crown logs.	5
1987/88	Chemical control of flowering	6
1988	P. radiata nutrient requirements on south coast (Initial).	3
1989	Nutrient analysis in older P. radiata.	7
1990	P. radiata nutrient requirements on south coast (Subsequent)	8
1990	Determination of growth rates and growth patterns on south coast.	9

3.8 PLANT DISEASES AND PESTS PROGRAM

Program Leader: Joanna Tippett

Current Resources

	CRF	Funded Externally	TOTAL
Human			
Professional staff	2.35	.9	3.25
Technical staff	4.80	2.4	7.20
	7.15	3.3	10.45
Financial			
Salaries	188,282	76,798	265,080
Wages	55,395		55,395
Other	100,200		100,000
TOTAL	343,877	76,798	420,495

Aim

To diagnose causes and to assess, understand and advise on plant diseases in native plant communities, plantations and nurseries.

Primary objectives

DISEASE DIAGNOSIS, CAUSES AND EFFECTS

To recognise and assess the effects of disease in any situation of concern. To diagnose the causes of disease or damage in native plant communities, plantations and nurseries. To research the causes of both abiotic and infectious diseases. To determine the identity of pathogens and study their epidemiology. To define factors affecting host resistance, disease expression and impact.

MONITORING

To survey and monitor, to enable predictions to be made as to the potential impact and the economic importance of diseases.

EXTENSION SERVICES

To advise on the control of pathogens or advise as to the most appropriate methods of managing the vegetation to minimize mortalities and damage, both in the short and long term. To contribute information as to how areas are to be best managed to maintain stable communities and healthy trees and to ensure that they are not predisposed to disease.

CONSERVATION

To study and advise on the conservation of any indigenous plant species or communities considered to be seriously threatened by disease.

COMMUNICATION

To communicate the results of research in the form of publications, educational literature, committee representation, training courses and seminars and to liaise and co-operate with the public, staff of other organisations and CALM personnel.

Twenty Year Goals

1. Extrapolate from the base of information on P. cinnamomi in the northern Jarrah forest to other areas of the State. Examples: (i) Assess the impact of P. cinnamomi in the southern Jarrah forest and determine whether there will be any cummulative long term effects due to presence of the pathogen.

2. Monitor regeneration stands of karri and pine for disease.

3. Ensure that the present system of aerial photography is used in the monitoring of health of vegetation. Example: The spread of P. cinnamomi in areas where conservation of vegetation is of utmost importance.

4. Participate in the surveillance of forests and plantations for outbreaks of introduced insect pests and pathogens. Monitor and research any species which cause significant amounts of damage.

5. Assess the effects of pathogens on the performance of trees and shrubs especially those of economic importance. Example: Ensure that the yield of P. radiata is not significantly reduced due to the activity of P. cinnamomi (and other pests and diseases).

6. Determine the causes of defects that detract from the quality of timber.

7. Determine causes of rural tree decline and advise on ways to reverse the process.

8. Establish a fungal herbarium and a system to ensure that an inventory of diseases that occur in native communities and plantations can be made.

9. Determine ways to enhance the resistance of woody plants to disease.

10. Develop more refined and effective methods of detecting and identifying pathogens in the field.

Five Year Goals

1. *Phytophthora cinnamomi* - *Eucalyptus marginata*, (Jarrah)

Monitoring and assessment

1.1 Monitor the spread of disease in a number of areas infected with *P. cinnamomi*.

1.2 Determine the effects of *P. cinnamomi* on jarrah growth on a range of sites and quantify the amount of damage in root systems.

1.3 Determine conditions which result in tree death and show that rate of decline and symptom development varies with site.

Epidemiology

1.4 Determine the influence of site and climate on rate of spread of *P. cinnamomi*.

1.5 Determine the effect of different soil profiles on spread of *P. cinnamomi*.

1.6 Determine temperature and moisture levels at depth in soil profiles in relation to recovery of inoculum.

1.7 Develop a model of sporulation and survival of *P. cinnamomi* inoculum to be used with information on subsurface flows of water in mid- and upper-slope positions.

Management and control

1.8 Test and apply the hazard rating system developed to predict consequences of *P. cinnamomi* being introduced into different areas.

1.9 Develop the hazard rating system for predicting effects of disturbance and silvicultural practices on growth and susceptibility of jarrah.

1.10 Determine silvicultural methods of enhancing the resistance of jarrah stands.

2. *P. cinnamomi* in native plant communities (other than jarrah forest).

Monitoring and Assessment

2.1 Determine the distribution of *P. cinnamomi* in selected areas and establish a list of susceptible species.

2.2 Determine mechanisms and rate of spread of *P. cinnamomi* in heath and woodland communities.

Management

2.3 Test methods of controlling the spread of P. cinnamomi from "spot" infections where large areas of otherwise uninfected vegetation have been put at risk.

2.4 Identify communities, particularly those of limited distribution, which are vulnerable to disease.

3. P. cinnamomi - Pinus radiata

The Interaction

3.1 Determine how P. cinnamomi invades P. radiata, and determine the conditions that affect susceptibility and result in tree death.

3.2 Ascertain why trees in established plantations die after stands have been thinned.

Management

3.3 Determine yield improvements to be gained by using P. radiata stock selected for resistance to P. cinnamomi.

3.4 Develop silvicultural methods to minimize mortality and yield losses in existing plantations of P. radiata susceptible to P. cinnamomi.

4. Diseases in departmental plant nurseries

4.1 Establish a system for the prevention of diseases in plant nurseries.

5. Armillaria luteobubalina

5.1 Monitoring and assessment. Monitor the ecology and impact of A. luteobubalina in jarrah and wandoo communities.

5.2 Management. Make recommendations on ways of minimizing the growth and establishment of this pathogen in forest stands.

6. Phytophthora species other than P. cinnamomi.

6.1 Record distribution and determine the importance of Phythophthora species other than P. cinnamomi in native plant communities.

7. Botryosphaeria ribis and other organisms that cause crown damage.

Monitoring and assessment

7.1 Determine the role of pathogens such as B. ribis in the performance of Eucalyptus spp. in Departmental arboreta.

7.2 Assess the incidence of cankers (causing twig and branch death) in E. calophylla (marri). (Identify the causal organisms and determine conditions favouring all stages of disease development).

7.3 Determine the importance of Botryosphaeria ribis and other fungi causing crown damage to eucalypts.

7.4 Management. Advise on the suitability of Eucalyptus spp. in the rehabilitation of disturbed or diseased areas of vegetation.

8. Insect pests

8.1 Determine the significance of infestation by the lerp Cardiaspina on Eucalyptus occidentalis in national parks and nature reserves in the Great Southern of S.W. Australia.

The Detection Service

Members of the Diseases & Pests Programme will continue to take responsibility for maintaining the Detection Service.

Soil samples are tested for the presence of P. cinnamomi. Currently 1 000 samples per year are tested. Identification of P. cinnamomi and other species of Phytophthora requires a qualified person and currently Mike Stukely is spending up to 30% of his time "reading" the plates set up at Dwellingup. This is an important service. The wages of a part-time technical assistant are provided for out of the Dwellingup station budget (currently $14 000).

Scope of existing program.

1. Jarrah dieback. We have a basic knowledge of the disease in the jarrah forest environment which must now be applied so that the forest can be best managed in the presence of the disease.

2. Dieback threatens many communities in the South West of the State and it is critical that the disease be studied in areas important for conservation. Although our understanding of the disease in the jarrah forest will hasten our understanding of the disease in other areas there are a number of projects specific to heath and woodland communities, on a range of soil profiles other than laterite, which should be initiated as soon as possible.

3. Dieback control methods should be developed and tested.

4. Work on diseases other than dieback caused by P. cinnamomi should not be neglected. There are a range

of diseases which effect regeneration and the health and growth of commercial species.

5. Surveillance and disease monitoring should be undertaken with co-operation from personnel in other branches of the department.

6. The detection service must be supported as it provides information on distribution and presence of P. cinnamomi for management. The fungus should not be spread further in the course of operations.

Proposed new projects.

Goal

1.2 Determine the effects of P. cinnamomi on jarrah growth on a range of sites.

0.1 professional, 0.5 technical, $5 000 pa, 5 years.

The aim is to develop methods to assess changes in canopy size and growth efficiency in infected areas with a moderate hazard rating.
Benefits : The long term effects of P. cinnamomi infection to moderate hazard sites can be assessed.

1.7 Develop a model of sporulation and survival of P. cinnamomi inoculum to be used with informative on subsurface flows of water in a variety of soil profiles.

0.2 professional, 2 technical, $20 000 pa, 3 years.

1.9 Develop the Shearer hazard rating system for predicting effects of disturbance and silvicultural practices on growth and susceptibility of jarrah.

0.5 professional, 2 technical, $20 000 pa, 3 years.

Benefits : Will aid operators by extending the present hazard rating system to account for the effects of disturbance.

1.10 Determine silvicultural methods of enhancing the resistance of jarrah stands.

0.5 professional, 1 technical, $40 000 pa, 3 years.

Provide operations with the greatest number of options to manipulate site factors that will favour the host and suppress the pathogen.

2.1 Determine the distribution of P. cinnamomi in selected conservation areas and establish a data base of susceptible species.

0.1 professional, 1 technical, $10 000, 5 years.

2.2 Determine mechanisms and rate of spread of *P. cinnamomi* in heath and woodland communities. Study population dynamics of the pathogen in a range of environments.

0.5 professional, 0.5 technical, $3000 5 years.

2.3 Test methods of controlling the spread of *P. cinnamomi* from spot infections where large areas of otherwise uninfected vegetation have been put at risk.

0.1 professional, 0.5 technical, $30 000 5 years.

2.4 Identify communities, particularly those of limited distribution which are vulnerable to disease.

0.2 professional, .25 technical, $10 000 5 years.

3.3 Determine yield improvement to be gained by using *P. radiata* stock selected for resistance to *P. cinnamomi*.

0.1 professional, 0.2 technical $10 000 5 years

4.1 Establish a system to help in the prevention of diseases in departmental plant nurseries.

0.1 professional, <$5 000 2 year.

5.1 Monitor ecology and impact of *A. luteobubalina* on the jarrah forest.

0.1 professional, 0.2 technical, <$5 000 5 years.

6.1 Record distribution and determine importance of *Phytophthora* species other than *P. cinnamomi* in native plant communities.

0.2 technical <$5 000 3 years.

7.1 Assess the incidence of cankers causing twig and branch death in *E. calophylla* (marri). Identify causal organisms and determine conditions favouring all stages of disease development.

0.5 professional, 1 technical, $10 000 5 years.

7.3 Determine the importance of *Botryosphaeria ribis* and other fungi causing crown damage in eucalypts.

0.5 professional, 0.5 technical, $5000 pa 5 years.

8.1 Determine the significance of the lerp *Cardiaspina* on Eucalyptus occidentalis in national parks and nature reserves in the Great Southern of S.W. Australia.

1 professional, 1 technical, $5 000 2 years.

Projects to be completed 1987-1991. (by Goals)

Jarrah dieback	1.3	1988
	1.4	1988
	1.5	1988
	1.6	1988
	1.8	1989
	1.9	1991
P. cinnamomi-pines	3.1	1988
	3.2	1989
Diseases nurseries	4.1	1988
Crown damage	7.1	1988

Projects to be Started 1987 - 1991.

Jarrah dieback	1.2	1987
	1.7	1989
	1.9	1989
	1.10	1988
Dieback - national parks heath & woodlands.	2.1	1987
	2.2	1987
	2.3	1987
	2.4	1987
Pines - *P. cinnamomi*	3.3	1988
Armillaria	5.1	1988
Other *Phytophthora* species.	6.1	1987
Crown damage, marri	7.1	1989
	7.3	1989
Lerps-*E. occidentalis*	8.1	1988

3.9 REHABILITATION PROGRAM

Program leader: John Bartle

Current Resources

		No	$
Staff:	professional (FTE)	2.55	83 660
	technical (FTE)	2.70	59 930
	professional (contract)	1.00	31 878
	Technical (contract)	2.00	39 250
		8.25	214 718

Wages	11 200
Other	51 500
	277 418

Aim

To provide a sound scientific basis for:

- managing activities causing disturbances to the environment.
- rehabilitating the disturbed land.
- evaluating the consequences of disturbances and rehabilitation.

The aim of rehabilitation will generally be to regenerate self-regulating ecosystems consistent with the purpose for which the land is to be managed.

Primary Objectives

PLANNING AND COORDINATION

Identify all examples of disturbance which may require research. Clarify the contribution to research which may come from other agencies. Seek to co-ordinate and integrate the research and development being undertaken by various agencies.

TECHNIQUE DEVELOPMENT

Develop suitable site treatments and vegetation establishment techniques for disturbed land. Identify appropriate species taking account of likely successional changes. Develop appropriate post rehabilitation management practices such as fertilization, fire, silviculture.

MODELLING

Gain an understanding of key processes in ecology, hydrology and dieback to guide development of practices and to generate models to be able to predict the long term impact of disturbance and rehabilitation.

MONITORING

Establish monitoring systems to evaluate the attainment of the land use objectives vis-a-vis adjacent similar undisturbed land, and to validate models.

MANAGEMENT

Integrate rehabilitation practices into on-going land

management for the area/region using predictive modelling and detailed management planning.

COMMUNICATION

To communicate research results in scientific, technical and educational publications, to participate in planning and development for application of results to management, to be involved with other CALM sections, other Departments, institutions and appropriate scientific and public forums to seek opportunity for exchange of information.

Twenty Year Goals

1. Develop the capacity for local and regional prediction of biological and land use impacts of various forms of disturbance and rehabilitation.

2. Validate models with comprehensive monitoring of representative operations over the long term.

3. Integrate predictive modelling into land use planning.

4. Achieve complete integration of prescribed activities causing disturbance into land use planning and management.

Five Year Goals

1. Bauxite mining

(a) develop a quantitative understanding of jarrah forest biological and hydrological processes especially with repsect to dieback and salinity, and to determine how these are changed by bauxite mining and rehabilitation. (Research Steering Committee Working Group projects).

(b) use process knowledge and experiment to refine mining, rehabilitation and associated land use management practices. (Working group projects).

(c) use process knowledge to develop models and predict local and regional impacts of mining especially with respect to dieback and salinity. (Working group projects),

(d) facilitate integration of bauxite mining into jarrah forest land use planning and management. (Tacey project).

(e) commence comprehensive monitoring and evaluation of the biological and land use consequences of the new integrated bauxite mining management (e.g. Urbrae project).

(f) refine species and provenance selection for the major species used in rehabilitation. (14/76, 26/79, 31/78, 6/81, 24/82, 25/82, 26/82, 40/82, 38/82, 1/84, 32/84, 34/84, 4/86, 5/86, 5/87, 6/87).

(g) evaluate the production and utilization potential of major rehabilitation species.

2. Reforestation of farmland and integration of trees into farming systems.

(a) improve establishment methods with particular focus on saline/waterlogged sites, and direct seeding. (44/86, 46/86, RS 35, 48/86, 70/86, 16/87, N4/87, N1/87).

(b) refine species and provenance selection for the major species used in replanting. (14/76, 26/77, 31/78, 6/81, 24/82, 25/82, 26/82, 40/82, 38/82, 1/84, 32/84, 34/84, 4/86, 5/86, 5/87, 6/87).

(c) define the problem of rural tree decline and develop regeneration techniques for degraded or grazed native woodlands. (78/86, 53/86, 63/86).

(d) clarify the processes of salt transport and storage in reforested saline/waterlogged soil profiles. (56/86, 48/86).

(e) determine the production of timber and grazing possible under various trees in farmland regimes. (264/54, 264/52, 5/81, 43/82).

(f) determine the water balance and water quality benefits of various planting/species regimes. 264/53, 264/51).

(g) establish the optimal silvicultural practices for reforested farmland, agro-forestry and shelterbelts. (4/81).

(h) develop optimum shelter belt arrangements for farmland. (43/82).

3. Other mining and disturbance

(a) Maintain familiarity with all current mining activities in CALM lands (mineral sands, gold, coal, and tin) and of the rehabilitation procedures undertaken. Be prepared to present critical review of these procedures to guide management and to initiate or specify research which may be required. (RS 35).

(b) Maintain familiarity with all current quarrying activities in CALM lands (gravel, stone, clay, sand) and other disturbance (disease and pest damage, coastal dune erosion, roadside batters) with a view to providing critical review and suggestions for improvement in rehabilitation.

Scope of Existing Programs

1. Bauxite research has passed through a stage of intensive technique development and mining and rehabilitation now consist of an elaborate set of practices. Too little effort has been expended on integrating these practices with other land use practices in mined areas. Also, with the exception of the small and less complex Worsley operation, no comprehensive monitoring of total impacts has been commenced. Process-oriented research relating to hydrology/salinity and dieback will continue.

2. Trees in farmland research is mainly foccussed on technique development. In some areas of agro-forestry and catchment protection evaluation of systems is underway. The process-oriented hydrology research has been designed to produce results applicable to catchment protection in general.

3. With the exception of sands mining at Eneabba little research is being conducted by CALM at other mining and quarrying areas. Both coal mining at Collie and tin mining at Greenbushes appear to be the most pressing priorities for improved rehabilitation and possibly research.

Proposed New Projects

1. Monitoring of bauxite mining impact (goal 1e) Commence integrated monitoring of the impact of bauxite mining in good quality jarrah forest. Staff: 0.1P + 0.1T, medium cost, long term duration from 1987 (Bartle). Part of a major project to be co-ordinated by the Research Steering Committee.

2. Species and provenance selection (goals 1f and 2b) (i)

i) Establish species trials to explore new species x site combinations.

- eucalypt species trials on jarrah forest sites including bauxite pit x low rainfall bauxite pit x high rainfall and dieback site x low rainfall. Staff : 0.2 P + 0.4 T and moderate cost in year of establishments only. Long term duration from 1987. Support available from Alcoa & Worsley (Mazanec, Bartle).

- non-eucalypt species trials on farmland for production and protection. Staff : 0.1 P + 0.2 T and moderate cost in year of establishment only. Long term duration from 1989. Rural Credits Development Fund research grant applied for (Brown, Moore, Ritson).

- potential pulpwood species for catchment protection on southern rivers and Peel-Harvey Inlet. Staff : 0.1 P + 0.1 T and moderate cost in year of establishment only. Long term duration from 1989 (Ritson, Moore, Bartle).

ii) Establish provenance trials of prospective rehabilitation species. On going project based on seed collections from CSIRO commissioned by Alcoa. Trials proposed in the following species sequence : E. marginata, accedens (1988), microcarpa, cladocalyx (1989), viminalis (1990). Staff : 0.2 P + 0.4 T and moderate cost in year of establishment only. Long term duration 2-4 trials per annum (Mazanec).

iii) Establish seed orchards and seed production areas for rehabilitation species in common use. Staff : 0.1 P + 0.1 T and moderate cost in year of establishment only. Long term duration. In association with Manager Silviculture (Mazanec).

3. Shelterbelt design (goal 2h).

To develop optimum shelterbelt design and production for West Australian agricultural areas. Staff : 0.1 P + 0.2 T, moderate cost and long term duration commencing 1988 if application to National Soil Conservation Program for funds is successful (Moore, Brown).

4. Regenerate remnant native woodland (goal 2c).

To investigate, diagnose problems and regenerate representative areas of native woodland remnants in farming districts. Staff : 0.2 P + 0.2 T, moderate cost and medium to long-term duration (Brown, Ritson, Hopkins). Application pending with Rural Credits Development Fund.

5. Utilization of rehabilitation species (goal 1g).

To determine the durability and strength properties of major rehabilitation species. Staff : 0.05 P + 0.1 T, moderate cost and 3-5 years duration to 1991. Part of the externally funded Wood Utilization Research Program (Brennan).

6. Agro-forestry economics (goal 2g).

Economic evaluation of pine agro-forestry in the 700-900 mm rainfall zone with a focus on south coast catchments. Staff : 0.1 P + 0.1 T, moderate expense and less than 1 year duration.

7. Tree establishment (goal 2a).

Address specific problem sites and steps in the establishment of trees and shrubs on farmland.

- Wodgil sandplain
- heavy saline clays

8. Coal mine rehabilitation (goal 3a).

To contribute to the development of rehabilitation procedures after coal mining at Collie. Staff : 0.5 P + 1.0 T moderate expense and medium term duration (5 years).

Projects to be completed 1987 to 1991

Goal	Project No	RWP No	Year
2a	1	44/86	88
	2	46/86	87
	3	12/87	88
	4	13/87	88
	5	14/87	88
	6	RS/35	91
	7	49/86	91
	9	52/86	91
	10	7/87	91
	11	21/87	91
	12	16/87	88
2c	1	58/86	88
	2	63/86	87
	3	78/86	91
	4	15/87	88
2d	1	48/86	91
	2	51/86	91
2f	3	4/84	88

New projects to be started 1987 to 1991.

Project No is as listed in proposed new projects.

Project No	Brief title	Goal	Year
1	Bauxite monitoring	1e	1987
2(i)	Species trials - jarrah	1f	1988
2(ii)	Provenance trials	1f	annually to 1991
3	Shelterbelt design	2h	1988
4	Regenerate native woodland	2c	1987
5	Rehab. species utilization	1g	1988

WETLANDS AND WATERBIRDS PROGRAM

Program Leader: J. Lane

Summary of Current Resources

This program comprises 3.55 persons (1.7 professional + 1.85 technical). Its budget is $173 734 ($115 234 salaries and $58 500 other).

Aim

To undertake studies that will assist in the conservation of Western Australia's wetland ecosystems, and the maintenance of waterbird populations.

Primary Objectives

1. 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.

2. STATE OF THE WETLANDS

To develop procedures for periodic assessment of the "state of the wetlands", i.e. the rate of loss (or gain) of particular wetland types.

3. STATUS OF WATERBIRD POPULATIONS

To develop procedures for periodic assessment of the status (abundance and distribution) of the State's 130 species of waterbirds, particularly those species of ducks which are harvested. To determine key factors affecting the status of waterbird species, both common and rare, so that existing population sizes can be maintained, through management if necessary.

4. MANAGEMENT OF HUNTING

To undertake studies needed to ensure that management of waterfowl hunting is soundly based, and to facilitate more active involvement of hunters in the creation and protection of waterbird habitats.

5. WETLAND ECOSYSTEM DYNAMICS

To develop an increased understanding of the functioning of wetland ecosystems (e.g. significance of hydrological and nutrient cycles, dynamics of aquatic plant and animal communities) in order that advice on management principles may be more soundly based.

6. SPECIFIC PROBLEMS

To investigate specific wetland management problems as they

arise (e.g. midge and mosquito control, impact of recreational boating, use of lead shot by hunters, causes of major mortalities of waterbirds) and to advise on management options.

7. 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.

8. COMMUNICATION

To communicate the results of research 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.

Twenty Year Goals

To achieve the program's Primary Objectives.

Five Year Goals

1. Annually assess conditions for waterfowl breeding in south-western Australia as a basis for determination of duck shooting seasons.

2. Establish a volunteer-based program (500+ observers) for annual assessment of the abundance of waterfowl, particularly game species of ducks, in south-western Australia.

3. Determine the conservation value (principally the level of usage by waterbirds) of remote wetlands (Lakes Gregory, Argyle, McLeod etc.) of probable international importance.

4. Assess seasonal usage by waterbirds of a number of important, poorly known, wetland sites in south-western Australia.

5. Analyse results of 1981-1985 RAOU Waterbird Survey project as first step in identifying the general environmental parameters within a wetland that affect its usage by waterbirds.

6. Assess the conservation status of the lentic invertebrate fauna in the south-west through wetland surveys and then examine how various environmental parameters (eg. salinity, nutrients) affect the distribution of species.

7. Analyse and publish results of the Fisheries and Wildlife (Riggert) duck banding project. Funded by ANPWS States Assistance Grant ($24 000).

8. Study in the field 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.

9. Study in more detail the effect of salinity on various species of duck that cover the full spectrum of salinity tolerance using experimental and laboratory investigations so as to understand exactly why salt prevents species using wetlands.

10. Examine food selection in waterbirds in relation to the invertebrate prey available to gain some understanding of how changes in invertebrate species composition that result from salinization would affect waterbird distribution.

11. Determine the breeding status (number of breeding colonies, locations and size) of the Great Egret (Egretta alba) in Western Australia.

12. Develop methods of monitoring midge (chironomid) larvae numbers on metropolitan wetlands in order that control programs may, to that extent, be soundly based.

13. 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.

14. 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.

15. Complete "History of Duck Hunting in Western Australia" publication.

16. Publish results of Peel-Harvey, Leschenault Inlet and south-west estuaries waterbird surveys.

17. Analyse and publish results of the 1973-1987 duck season "bag" surveys.

18. Analyse and publish results of the Fisheries and Wildlife pelican breeding status and movements study.

Scope of Existing Program

For historical reasons the Program has, until quite recently, been concerned primarily with the collection of data needed

i) to identify the conservation value (principally as waterbird habitat) of specific wetlands and thereby to assist in the struggle to protect these habitats from inappropriate forms of development or use, and

ii) to facilitate responsible management of annual duck hunting seasons.

A number of small studies directed towards the resolution of specific issues such as midge (chironomid) and mosquito control, bulrush (Typha) management, use of organochlorines to control Argentine Ants at Lake Herdsman, etc have also been conducted. Program members have also been much involved in wetland reservation, management, management planning, policy issues and resolution of conflicts. This was particularly the case pre 1985 (i.e. in Fisheries and Wildlife Department days) when those matters were within the Wildlife Research Branch's area of responsibility. To a lesser extent this involvement continues.

With the formation of CALM and the structural separation of research, management, management planning and policy functions into different Divisions it is now appropriate for the Program to increase its emphasis on research and to be less involved in functions (except perhaps policy development) which are properly the responsibility of other branches. A few remaining routine management activities, such as water level control at Lake Chittering and water quality monitoring at Lake Muir should certainly be transferred to the Operations Division.

There is also a need for the Program to expand its scope to include more fundamental research aimed at improving our knowledge of wetland ecosystem processes and the life histories, population dynamics, physiological tolerances and habitat requirements of various key species of wetland fauna and flora, as these relate to management. A valuable start has been made with the recent appointment of Dr S. Halse to the Program.

With the formation of CALM and the recent absorption of the Department of Conservation and Environment into the Environmental Protection Authority and the redefinition of its role, it may also be appropriate for the Wetlands and Waterbirds Research Program to broaden its scope to take in such projects as the development of procedures for the periodic assessment of the state of the wetlands (Proposed New Project 1.1). Certainly this important project needs to be undertaken by some arm of State government.

Proposed New Projects

Projects are grouped according to priority.

Priorities have been determined on the basis of perceived importance and urgency of the topic in relation to achievement of the Program's Primary Objectives.

Resource requirements and proposed duration of each project are provided.

It would not be possible to undertake all proposed new projects during the 1987-1992 period without a substantial increase on existing allocations to the Program. What follows is a "selection list" as a basis for discussion.

We are particularly keen to receive District, Regional, Branch and Divisional Managers' comments on the aim, scope and priority of these proposed new projects. Suggestions of alternative or additional projects will also be welcomed.

1. High Priority

i) Wetlands of Swan Coastal Plain - Their role in the conservation of Waterbird Populations (PO 1,3 and 7): These wetlands are threatened by intensification of development, particularly groundwater extraction. Annual and seasonal patterns of use by waterbirds of individual wetlands and of the wetland system need to be determined if resource allocation and management decisions are to be soundly based. Mapping of the wetlands is underway (Semeniuk : Water Authority). CALM Scientist and RAOU team of 200+ waterbird volunteers needed 1989-1992 to survey waterbird usage of key sites (those not yet studied) plus a representative sample of wetland types. Resource requirements: CALM Scientist and RAOU Co-ordinator plus $45K per annum for 4 years. Propose joint funding by W.A. Water Authority and CALM. Proposed development late 1987.

ii) State of the Wetlands (relates to Primary Objectives 1. and 2). The aim of this project is to develop procedures for periodic assessment (5 or 10 year intervals) 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 targeted on areas of greatest need. Resource requirements: Initial phase; 1 Research Scientist, _ Assistant plus $10K for 1 year. Second Phase; 1 Research Scientist, 1 Assistant plus $10K per annum for 2 years. (EPA role?)

iii) Great Duck Count continuation (1989-1992) (PO 1, 3, 4 and 7). There is an ongoing need for annual assessment of abundance of harvested species of waterfowl. Development of procedures is due for completion in 1988. Resource requirements (1989-1992) (to fund RAOU coordinator and 500+ volunteers): $10K per annum.

iv) Ecological significance of fringing vegetation of salinized wetlands (PO 1, 5 and 6): Many wetlands of the State's south-west are fringed by emergent vegetation (Melaleuca, Casuarina, Eucalyptus etc.) which has been killed by rising water levels and salinities. Little to no regeneration is occurring. It is highly probable that this vegetation performs

important ecological functions (eg invertebrate food supplies for warerbirds, bird nesting sites, shelter). In time this dead vegetation will be lost due to breakdown and decay. Studies are needed to determine the importance or otherwise of compensating for this loss and means by which this might be achieved. Resources required: 1 Research Scientist and _ Tech. Officer plus $10K per annum for 3 years.

v) Physiological tolerances of key emergent species (PO 5 and 6): Emergent species of tree (Melaleuca, Casuarina, Eucalyptus), and shrub play a key role in the maintenance of waterbird populations by providing essential nesting and roosting sites, shelter and substrate for invertebrate communities. Little is known of their physiological tolerances, particularly in relation to inundation and salinity. These tolerances need to be determined if wetlands are to be successfully managed. Resource requirements: 1 Research Scientist and _ Tech. Officer plus $10K per annum for 3 years.(eg Lakes Toolibin, Ludlow and Chittering. Batini/Mattiske).

vi) Impact of recreational use (water sports) on conservation values of wetlands (PO 6): Increased demands for recreational access (powerboats, sailboats, canoes, sailboards, model boats, skiing, swimming etc.) pose a serious and worsening threat to waterbird usage of many important wetlands (e.g. Swan River tidal flats, permanent lakes of Perth and country). Studies are needed to assess existing and potential impacts if effective controls on recreational use are to be implemented. Resource requirements: 1 Research Scientist and _ Tech. Officer plus $10K per annum for 3 years.

vii) Assessment of conservation values of fringing marshes of south-west estuaries. (PO 1, 2 and 6). Few wetland types are as seriously threatened as the fringing marshes of south-west estuaries. Yet these marshes are valuable as waterbird habitats, fish nursery areas, components of estuarine ecosystems, and in their own right. Assessment of conservation values is required, together with classification, mapping, inventory and periodic assessment of the state of the resource. Resource requirements: initially 1 Research Scientist and $15K per annum for 1_ years. (Waterways Commission funding, joint funding?)

viii) Continuation of detailed assessment of conservation value of key waterbird sites e.g. Guraga, Preston and Clifton. Expansion to include wetlands of National Parks. (PO 1, 3 and 4). Although joint CALM/RAOU studies during the past six years have revealed and documented the importance of many important waterbird sites, it is clear that many more sites have yet to be "discovered" and their usage by waterbirds determined. Waterbird usage of a number of "recognized" sites is

also inadequately known. Current Project 5, presently funded to December 1988, is aimed at filling these gaps. It is possible that continuation beyond 1988 will be needed if Primary Objective 1 is to be accomplished. Resource requirements: $5K per annum for 3 years (1989-1991) (Contract RAOU).

ix) Importance of waterfowl and benthic communities in transfer of nutrients from sediments to the water column (PO 5). Eutrophication is the major problem confronting managers of coastal plain wetlands. Evidence of eutrophication is often minimal in spite of a long history of high nutrient inputs because lake sediments act as a sink. However, once levels in the sediments become high enough they stop acting as a sink and instead constantly release nutrients into the water column with the result that there are acute symptoms of eutrophication that cannot be controlled by management of the catchment. Predicting these eutrophication problems and effective remedial action require a thorough understanding of the fluxes between sediments and water column, including major processes - such as waterfowl digging 'swan holes' - that increase the rate of nutrient release into the water column. The project would be carried out jointly with University of W.A. Resource requirements: $10K per annum for 2 years.

x) Oral history of Wheatbelt wetlands. (PO 1, 2, 5 and 7): Wetlands of the Wheatbelt Region have undergone massive changes, principally increases in salinity and inundation, due to land clearing. The agricultural consequences of land clearing have been well documented however there has been very little documentation of the changes which salinization and increased inundation have had on wetland flora and fauna. Preliminary interviews (K. Wallace, J. Lane) have shown that older members of the rural community with an interest in wildlife have a wealth of knowledge concerning these changes. This knowledge has intrinsic heritage value and would also be of assistance in understanding and managing the wetland resources. Documentation is required if this knowledge is not to be lost to current and future generations. Resource requirements: 1 Researcher plus $5K for one year. (Commonwealth funding?)

xi) Midge Control (PO 5 and 6): Perth is unusual in having numerous midge-producing wetlands surrounded by existing and proposed urban development. Present midge control methods - principally aerial application of organophosphate insecticide ("Abate") - pose environmental problems. There is a need to improve present methods and develop new ones. Direction and nature of future research will be considered on completion of current (1987/88) Murdoch/CALM studies (Current Project 10).

2 Medium Priority

i) Determination of causes of larger-scale mortalities of waterbirds on metropolitan wetlands. Resource requirements: Consult with Agriculture Department. Services of veterinarian/microbiologist required at time of large-scale mortalities.

ii) Evaluation of conservation status of the Chestnut Teal (Anas castanea). Resource requirements: 1 Research Scientist plus $10K for two years. (Priority may be raised depending upon outcome of 1987 Great Duck Count).

iii) Management of farm dams and other privately owned wetlands for waterbird breeding. Research into ecological characteristics of productive breeding sites. Resource requirements: _ Research Scientist, _ Technical Officer plus $10K per annum for 3 years.

iv) North-south movements of waterbirds (PO 1, 3 and 4): This project would provide management information for waterbird conservation and duck hunting. Ducks are known to move throughout Australia in response to climatic conditions. The patterns of movement and their causes have to be understood to interpret results of duck counts (used to monitor abundance of game species). The current analysis of duck-banding data will do this for east-west movements but there are no factual data concerning north-south movements in W.A. There are large duck populations in the Kimberley and anecdotal information suggests populations sizes in the south-west are affected far more by north-south movements than east-west ones. In fact, a lot of east-west movement may occur via the north. These movements are not restricted to ducks; although there is no evidence, it is highly probable (and very significant from a management viewpoint) that for many species in the south-west, such as Sacred Ibis and Great Egrets, the bulk of recruitment is from the north. Resource requirements: 1 Technical Assistant plus $10K per annum for 2 years.

v) Black Swan project. This is a large multidisciplinary study proposed by the Zoology Department, University of W.A., for which CALM has expressed support. If the project proceeds, it is anticipated that the Program will participate in whatever ecological studies seem most appropriate. Resource requirements: $5K per annum for 5 years.

vi) Assessment of "state of the river banks" particularly in agricultural areas of the south-west. (PO 1, 2 and 6). The rivers of the south-west agricultural areas (wheatbelt and coastal plain) have been progressively degraded by unrestricted stock access, clearing and "channelization" for so many years that this situation is now accepted by many as the norm. This is possibly

Western Australia's most neglected problem in the area of wetland management. The conservation values of these seasonal rivers and their perennial pools have scarcely been considered. There is a dire need for an initial assessment of the magnitude of the problem. Resource requirements: 1 Research Scientist plus $10K per annum for 2 years.

vii) Inventory of invertebrate fauna and aquatic flora of proposed Wetlands of International Importance. (FO 1).

Low Priority

i) Assessment of potential for creation of major wetlands through low weir construction. e.g. Yenyenning Lakes. Resource requirements: 1 officer (engineer) plus $10K for 1 year. (Joint funding with Sport and Recreation Department?)

ii) Addition of historical records of waterbird usage of CALM-managed and other wetlands to RAOU/CALM data base. Improve access to data base. Computerization of CALM Wetland Nature Reserve index and integration with wetland monitoring program data base. Resource requirements: One computer analyst plus $1K for 4 months.

iii) Expansion of study into ingestion of lead pellets by waterbirds. Resource requirements (and need for project) unknown until 1988.

iv) Possible secondary poisoning of raptors by embedded/ingested lead shot. Resource requirements (and need for project) unknown until 1988.

v) Analysis and publication of opening day bag check (duck shooting season) data.

Projects to be completed 1987-1991

1. Publication of results of 1981-85 RAOU Survey of Waterbird Usage of Wetland Nature Reserves. R. Jaensch and J. Lane, RS 116.

2. Annual assessment of abundance of ducks, swans and coot. J. Lane, RS 117.

3. Assessment of waterbird usage of remote wetlands of probable international importance. J. Lane, RS 118.

4. Surveys of invertebrate species in south-west wetlands. S. Halse, RS 48.

5. Assessment of seasonal usage by waterbirds of a number of important, poorly known, waterbird sites in south-western Australia. J. Lane, RS 118.

6. Analysis of results of RAOU Waterbird Survey Project S. Halse, RS 47.

7. Analysis of Riggert/Fisheries and Wildlife 1960-1975 duck banding data. S. Halse, RS 49.

8. Diet of ducks in fresh and saline wetlands. S. Halse, RS 48, developmental.

9. Breeding status of egrets (Egretta spp.) in Western Australia. J. Lane, RS 118A.

10. Development of procedures for monitoring of chironomid (midge) larval numbers of Forrestdale Lake Nature Reserve. J. Lane, RS 114.

11. Herdsman Lake pesticide study. S. Halse, new

12. Ingestion of lead shot by waterbirds. J. Lane, new.

Staff Resources Released

None

Proposed Projects to be started 1987-1991 (Existing Resources)

First look at "Proposed New Projects" section above and provide comments. Then we will knock this into better shape!

1. Wetlands of the Swan Coastal Plain - Use by Waterbirds.

2. Annual Assessment of Abundance of Harvested Species of Waterfowl (the Great Duck Count). Continuation.

3. Detailed Assessment of Waterbird Usage of Key Waterbird Sites. Continuation.

4. Use of saline lakes by ducks for breeding and drought-refuge.

5. Experimental study of salinity tolerance of ducks.

6. Black Swan Project.

7. Determination of Relative Nuisance Value of Forrestdale Lake Midge species.

8. Addition of Historical Records to RAOU/CALM wetland data base.

9. Analysis and publication of opening day bag check (duck shooting season) data.

3.11 RESEARCH COMPUTING

Program Leader: M. Choo.

Summary of Current Resources

The program comprises 3.0 professional and 2.9 technical staff. Its budget is $283 013 ($135 413 salaries plus $147 600 other).

Aim

To set up and maintain an integrated computing environment that will provide the Research Division with the processing power and facilities necessary for it to more effectively and professionally perform its Aim, Primary Objectives and Research Projects.

Primary Objectives

HARDWARE AND SOFTWARE

To provide an integrated environment where the capture, processing, analyses and dissemination of information is fully automated, ie. elimination of mundane manual workloads.

TRAINING

To develop computing skills and expertise within the Research Division and provide expert knowledge in systems and softwares tailored to meet specific research requirements.

COMMUNICATIONS

To communicate and integrate with other research organisations to allow for exchange ideas, softwares and other products and to access data-bases.

Twenty Year Goals

1. Automation

   Achieve a major reduction in the level of mundane manual chores performed by research staff, by computerisation of almost all aspects of the reseacher's workload ranging from data collection, processing and analyses to the information dissemination phase.

2. Geographical Information Systems (G.I.S.)

   Provide a comprehensive G.I.S. system to satisfy the

cartographic requirements of research. Information on coastline, shires and CALM managed land will be readily accessible, and the system will provide standard G.I.S. information handling facilities (e.g. map production, overlaying and windowing). Facilities will exist for the researcher to produce maps and charts (on screen and hardcopy).

3. System Integration

Provide the mechanism for integration of the various systems currently used for information management, (ie. integration of data recording devices (eg. electronic data recorders) with data storage devices (eg. diskettes, tapes) and information dissemination devices (eg. plotters). Integrate photographic media with magnetic media (ie. electronic storage of films & slides) together with computerised catalogues that will allow fast retrieval of recorded information.

4. Networks

Establish a network of computer communications to provide instant electronic communication with the outside world (ie. other scientific organizations and data-bases).

Five Year Goals

1. Information Management and Analyses

1.1 Information Handling & Processing

Provide facilities for handling, processing and analyses of large volumes of data. Provide research personnel with modern computer-based analytical tools and facilities.

1.2. Information Base

Provide and maintain an up-to-date information base to satisfy the information processing and retrieval requirements of the Research Division.

2. Information Sharing and Dissemination

2.1 Document Processing

Provide immediate (or acceptable) turnaround time for all personnel during the various stages in the production of documents. Provide facilities for production of publication quality outputs (reports, graphs and other illustrations).

2.2 Office Automation

Provide the ability to consolidate and extract information held within host computers and micro

computers, and to directly transfer information to/from word processors for incorporation into into documents (eg tables & charts).

2.3 Communications

Extend communications to more computers on an inter/intra government basis (eg SNA network) to provide ready access to non sensitive information. Provide facilities for information dissemination (eg. graphics and presentation packages).

3. Computer Literacy and Training

3.1 Training

Provide the resources (hardware, software and staff) to raise computer literacy among research staff in computing, statistics and modelling, and to promote better understanding of computers among those who have yet to realise their full potential in this area. This will result in the more effective use of research resources and enable research personnel to keep abreast of developments in the research arena.

4. Professionalism and Productivity

4.1 Efficiency & Productivity

Restructure the researcher's workload by reducing time spent on data collection and manipulation, thereby allowing the researcher to spend his/her time in a more productive manner; ie organising, planning, analysis and information dessimination.

Scope Of Existing Projects

For historical reasons, the current projects of the program are specific to each research centre and are not research program based. These will have to be extended to embrace other programs.

The following limitations apply to all projects:-

a. Availability of expertise
b. Availibility of computing staff
c. Availibility of Hardware/Softwares (funds).

1 Information Management and Analyses

1.1 Information Handling & Processing

Field Data Recorders: Acquisition of more field units (eg. Huskey Hunters) and the development of data capture systems for each Research Program would greatly increase efficiency.

1.2 Information Base

There is a need to establish databases to satisfy the information management requirements of each research program and continue to develop systems in the following areas:-

a. Animal Ecology
b. Biological Survey
c. Electronic Field Data Capture
d. Fire Ecology
e. Fauna Conservation
f. Flora Atlas
g. Flora Conservation
h. Kangaroo Returns
i. Land Management Model - Perup
j. Metric Rothermal System
k. Pine Modelling
l. Soil Dryness Index
m. Vegetation Survey
n. Waterbirds Survey
o. Wetland Monitoring
p. Wildflower Returns.

1.3 Analyses

There is a need to provide facilities and expertise to automate and computerise Statistical Analyses and Numerical Analyses.

2 Information Sharing and Dissemination

The office environment should be automated to allow and facilitate:-

a. Communications between computers and Word Processors at Research Centres.

b. Communications between Softwares (eg. between MULTIMATE & DISPLAYWRITE).

3 Computer Literacy and Training

We need to extend and enhance training of Research personnel by encouraging computer based training and conducting training workshops on a regular basis. This will increase the level of staff expertise in these areas.

4 Professionalism and Productivity

There should be more full time professional computing staff at the major research centres (Woodvale, Manjimup & Dwellingup). These personnel will ensure a uniform cohesive computing approach within the Division. They will identify research requirements, plan, coordinate,

develop, install and maintain major systems. They will also keep abreast of modern technology have the responsibility of transferring their knowledge and expertise to research staff. This will directly lead to an increase in the level of efficiency, the level of professionalism and job satisfaction.

Proposed New Projects

1 Information Management and Analyses

1. Lap Top Computers: Acquisition of IBM compatible battery operated lap top computers. These units will be used as host computers at base camp during field trips for downloading data from data recorders, and for satisfying all the processing requirements during a field trip.

2. Sound Recognition: Introduce sound recognition units that will be left at various sites for fixed durations to record sounds produced by subjects on study (eg. bats or birds). These will be integrated to host computers and the recorded information subsequently analysed.

3. Analog computers: analog computers will be used to control various parameters (eg. temperature & humidity) under experimental conditions.

4. Digitising Tablets: Provide facilities to transfer odd shaped objects (eg. bat wings) to the computer for display and to perform calculations (eg. surface area & volume).

5. System Integration: Integrate systems within CALM to allow access of information from various sources.

2 Office Automation

Integrate the office automation environment to allow and facilitate:-

1. Document Processing

   Provide text readers to enable input of information from external sources (including already published materials).

   Integration of TEXT and GRAPHICS within a document and production of publication quality outputs (documents, transpirancies & slides).

2. Communications between Research Centres as well as between Research Centres and Publications.

3 Communications

Provide communications both within CALM and to the outside via communications lines. This will enable staff to receive/send information from/to various sources/destinations.

4 Geographical Information Systems (G.I.S.)

Provide cartographic systems which will enable research staff to select any study area, set filters to those parameters required (eg. access paths), and to send the resultant maps to high resolution outputs devices (eg. screen & plotters). All cartographic functions (eg. windowing & zooming) will be supported.

5 Networks

Set up a network of microcomputers for each major research centre (Woodvale, Manjimup & Dwellingup). These networks will be linked into the computers at the Como State Operations Headquarters and from there to the proposed government SNA network. Information from other Government Departments (eg. Land Administration) should then be accessible.

Projects to be completed 1987 to 1991

Projects within the computing program are defined to cover specific research functions rather than tasks. These functions do not change over time and for this reason, most of the projects listed do not have completion dates that are 'fixed'. Rather, these projects are of an evolving nature and are implementated in phases.

Projects to be completed 1987 to 1991

	Description	Completion Date	Staff Released
1.	Information Handling & Processing		
P1	Field Data Recorders: Acquisition of more field units (eg. Huskey Hunters) and the development of systems for each Research Program.	ongoing	-
2.	Information Base		
P2	Establish databases to satisfy the information management requirements of each research program. Continue to develop systems in the following areas:-	ongoing	-
	a. Animal Ecology b. Biological Survey c. Electronic Field Data Capture d. Fire Ecology e. Fauna Conservation f. Flora Atlas g. Flora Conservation h. Kangaroo Returns i. Land Management Model - Perup j. Metric Rothermal System k. Pine Modelling l. Soil Dryness Index m. Vegetation Survey n. Waterbirds Survey o. Wetland Monitoring p. Wildflower Returns.		
3.	Analyses		
P3	Provide facilities and expertise to automate Statistical Analyses, Numerical Analyses and Taxonomy.	ongoing	-
4.	Information Sharing and Dissemination		
	1. Office Automation		
P6	a. Communications between computers to Word Processors at Research Centres.	1988/89	.2
P4	b. Communications between Softwares (eg. between MULTIMATE & D/WRITE).	1987/88	.2
5.	Computer Literacy and Training		
P5	1. Training	ongoing	-

Note: P1 - P6 are priority ratings.

New Projects to be Started 1987 to 1991

Description	Priority	Staff	Cost	Start Date
1. Information Management and Analyses				
1. Introduction of Lab Top Computers	***	-	Mod.	87/88
2. Use of sound recognition devices	*	.2	Mod.	88/89
3. Use of analog computers for research	*	.3	Mod.	89/90
4. Introduce Digitising Tablets with interface to PC & host computers.	**	.3	Mod.	88/89
3. Integrate systems within CALM to allow access of information from various sources.	*	.3	Min.	90/91
2. Office Automation				
1. Provide text readers	***	.1	mod.	87/88
2. Integration of TEXT and GRAPHICS within a document and producing publication quality outputs.	***	.2	mod.	87/88
3. Communications				
1. Establish communications between Research Centres/ Publications.	***	.3	mod.	87/88
4. Geographical Information Systems (G.I.S.)				
1. Provide G.I.S. systems to satisfy the cartographic requirements of the Division.	***	1.0	mod.	87/88
5. Networks				
1. Set up a network of microcomputers for Woodvale, Manjimup & Dwellingup.	**	1.0	mod.	88/89

3.12 EXECUTIVE AND ADMINISTRATIVE SUPPORT PROGRAM

Program Leader: Chief of Division

Current Resources

This program comprises 16.45 persons (3.2 professional, 13.25 clerical and technical). Its budget is $763 848 ($436 208 salaries, $87 540 wages and $240 100 other).

Aim

To direct, lead and administer the Division of Research.

Primary Objectives

EXECUTIVE

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

POLICY

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

ADMINISTRATION

Through the Division's Administration, Staff and Finance team, to administer the day to day operations of the Division.

COMMUNICATION

To ensure that research is applied and communicated to users.

Scientific Publishing

The publication and dissemination of scientific and technical papers and reports is a major function of the 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 will not be accepted by such journals, but is of sufficient standard to be published, will continue to be produced by the Department.

Scientific publishing is overseen by the Scientific Publishing Editorial Committee (SPEC). Current membership is:

Dr S.D. Hopper (Chairperson)
Ms M. Lewis (Scientific Editor) (Secretary)
Dr I.J. Abbott
Dr A.A. Burbidge
Dr P.E. Christensen

Ms Lewis is a member of the Information Branch. She spends 95% of her time on scientific publishing, including editing of publications emanating from other Divisions.

The 1986/87 budget allocation for scientific publishing was $38 000. There is a considerable backlog of publications awaiting funding and a large number of papers in preparation so it is clear that a greater proportion of the Division's funds need to be allocated to publishing. It is proposed that the allocation for Research Division's scientific publishing be transferred from Services Division to Research Division to enable greater flexibility and the allocation of additional finance when necessary.

4. DEPARTMENTAL PRIORITIES FOR RESEARCH

Research priorities should be allocated according to explicit criteria, which should be able to deliver an objective and decisive priority allocation at any level (program, goal, theme, project).

For ease of use, criteria are arranged into categories depending on which level of research activity is being considered. Criteria are ranked in order of importance within each category.

A Generally applicable criteria

1. Relevance.

   Research must be relevant to CALM's goals and objectives.

2. Spread of research activity.

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

3. Linking funding to performance.

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

4. Innovation potential.

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

5. 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 utilize fully the skills available.

6. Matters of high public concern.

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

7. Integration with research outside CALM.

   Research within CALM will be co-ordinated and integrated with related work being conducted by other agencies. Higher priority will be given to programs/projects which augment or stimulate relevant external research.

8. 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.

B. Criteria for ranking research themes

1. Theme must be relevant.

The theme must be relevant and pertinent to the research program and to CALM's management responsibilities.

2. Cost effectiveness.

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

3. The scale of the problem.

The theme 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.

4. Demand for results.

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

A. Criteria for ranking projects within themes

1. Cost effectiveness.

The expected benefit should greatly exceed the cost.

2. Is the project experimental?

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

3. Project design.

Extremes of experimental treatments should be examined.

D. Criteria for terminating projects within themes

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

2. No effort has been made to put the research on an experimental basis.

3. The project does not look like producing anything of value.

4. Resources do not now allow successful completion of the project.

5. THE NEED FOR NEW PROGRAMS

A large proportion of proposed projects can be efficiently placed within existing programs. However, there is one major area of proposed research, Marine Conservation, that urgently needs a program of its own.

Questions that are being asked include

- Which areas should become marine parks?
- What effect does recreational fishing have on an area of marine park?
- What areas within existing or proposed marine parks are most sensitive to disturbance? What areas can be zoned for public recreation?

In order to answer these and other related questions there is a need for both long-term monitoring of selected marine ecosystems and an understanding of the population biology of selected marine organisms. At present the Department is seeking to get data relevant to some of the above by letting contracts to external organizations. This should be considered only a stop gap measure partly because it will eventually become cost inefficient without coordination by internal experts and partly because internal experts will be more efficient at answering relevant questions and advice-giving.

A commitment to marine research will require the employment of specialist staff, since this expertise is not available within the Research Division at present.

There are two ways of tackling a move into marine research. The first is to commence work within an existing program and the second is to start a new program immediately. If it is unlikely that sufficient resources will be allocated to justify a new program at this time it is proposed that marine research work commence in the Biogeography Program. If significant resources can be allocated in the near future it would be preferable to employ an experienced person capable of being a program leader and set up a new program now.

PEOPLE ALLOCATED TO RESEARCH AND SERVICE PROGRAMS

Biogeography

Research Scientists

N. McKenzie, SRS	Woodvale	95%
G. Keighery, RS	Woodvale	75%
A.H. Burbidge, RS	Woodvale	80%
A.A. Burbidge, SPRS	Woodvale	10%
A. Hopkins, SRS	Woodvale	10%
S. Hopper, SRS	Woodvale	15%
K. Morris, RS	Karratha	40%
G. Wardell-Johnson, RS	Manjimup	20%

Technical Staff

J. Alford	Woodvale	75%
(vacant)	Woodvale	80%
A. Brown	Woodvale	15%
A. Danks (position now abolished)	Woodvale	25%
P. Fuller	Woodvale	25%
G. Liddelow	Manjimup	35%
C. Vellios	Manjimup	50%
I. Wheeler	Manjimup	30%
J. Miragliotta	Karratha	25%

Fauna Conservation

Professional

R. Prince, SRS	Woodvale	80%
J. Kinnear, SRS	Woodvale	80%
A.A. Burbidge, SPRS	Woodvale	25%
A.H. Burbidge, RS	Woodvale	15%
J. Friend, RS	Woodvale	100%
D. Algar, RS	Woodvale	25%
N. McKenzie, SRS	Woodvale	5%
G . Friend, RS	Woodvale	5%
D. Pearson, RS	Kalgoorlie	20%
K. Morris. RS	Karratha	25%
G. Wardell-Johnson, RS	Manjimup	10%

Technical

P. Fuller	Woodvale	70%
M. Onus	Woodvale	80%
A. Williams	Woodvale	90%
R. Bromilow (wages)	Woodvale	100%
(vacant)	Woodvale	15%
D. Grace	Kalgoorlie	20%
T. Leftwich	Manjimup	90%
K. Maisey	Manjimup	30%

I. Wheeler	Manjimup	15%
J. Miragliotta	Karratha	25%

Fire

Professional

N Burrows, SRS	Manjimup	70%
L McCaw, RS	Manjimup	90%
G Wardell-Johnson, RS	Manjimup	25%
A Hopkins, SRS	Woodvale	75%
G Friend, RS	Woodvale	95%
J Kinnear, SRS	Woodvale	20%
D Pearson, RS	Kalgoorlie	80%

Technical

A Annels	Manjimup	10%
K Maisey	Manjimup	40%
J Neal	Manjimup	100%
A Robinson	Manjimup	100%
R Smith	Manjimup	95%
B Ward	Manjimup	95%
C Ward	Manjimup	20%
L Wong	Como	10%
S McArthur	Como	10%
J Brown	Woodvale	100%
D Mitchell	Woodvale	100%
M Onus	Woodvale	20%
D Grace	Kalgoorlie	80%

Flora Conservation

Professional

S Hopper, SRS	Woodvale	80%
D Coates, RS	Woodvale	90%
G Keighery, RS	Woodvale	10%
A A Burbidge, SPRS	Woodvale	5%
A H Burbidge, RS	Woodvale	5%

Technical

A Brown	Woodvale	85%
J Alford	Woodvale	10%
P Fuller	Woodvale	5%
R Sokolowski	Woodvale	85%
(vacant)	Woodvale	5%

Jarrah

Professional

I Abbott, SRS	Como	95%
G Siemon, PRS	Como	30%

M Stukely, RS	Como	20%
S Crombie, RS	Como	10%
B Shearer, SRS	Dwellingup	40%
R Mazanec, RS	Dwellingup	40%
G Stoneman, RS	Dwellingup	100%
G Brennan, RS	Bunbury	60%

Technical

L Wong	Como	50%
P van Heurck	Como	100%
C Crane	Como	20%
T Burbidge	Como	100%
B Davies	Como	10%
S McArthur	Como	50%
T Birmingham	Dwellingup	40%
R Buerhrig	Dwellingup	40%
A Byrne	Dwellingup	70%
D Devlin (wages)	Dwellingup	50%
M Dillon	Dwellingup	40%
R Fairman (wages)	Dwellingup	50%
R Giles	Dwellingup	30%
J Kinal	Dwellingup	50%
G Maranta	Dwellingup	20%
M Mason	Dwellingup	40%
C Portlock	Dwellingup	100%
M Reynolds	Dwellingup	100%
A Smith (contract)	Dwellingup	50%
K Whitford	Dwellingup	80%
P Skinner	Manjimup	30%
B Ward	Manjimup	5%
C Ward	Manjimup	50%

<u>Karri</u>

Professional

L. McCaw, RS	Manjimup	10%
G. Inions, RS	Manjimup	100%
G. Wardell-Johnson, RS	Manjimup	25%
R. Mazanec, RS	Dwellingiup	20%
P. Christensen, SPRS	Como	10%
G. Siemon, SRS	Como	10%
E. Davison, RS	Como	80%
D. Coates, RS	Woodvale	10%
G. Keighery, RS	Woodvale	10%

Technical

A. Annels	Manjimup	70%
G. Liddelow	Manjimup	30%
K. Maisey	Manjimup	15%
P. Skinner	Manjimup	50%
R. Smith	Manjimup	5%
C. Vellios	Manjimup	30%
P. Walsh	Manjimup	50%
I. Wheeler	Manjimup	30%

T. Birmingham	Dwellingup	20%
M. Mason	Dwellingup	20%
L. Wong	Como	15%
S. McArthur	Como	15%
J. Alford	Woodvale	10%
R. Sokolowski	Woodvale	5%

Pine

Professional

J McGrath, SRS	Como	80%
T Butcher, SRS	Como	90%
M Stukely, RS	Como	20%
G Siemon, PRS	Como	30%
R Moore, RS	Busselton	65%

Technical

J Stritof	Wanneroo	90%
G Calvert	Wanneroo	100%
C Sanders	Wanneroo	100%
J Ipsen	Busselton	100%
P Jenkins	Busselton	70%
R Hingston	Busselton	90%
B Copeland	Busselton	70%
R Butcher	Busselton	90%
J Bopp	Busselton	90%
(vacant)	Como	100%
S McArthur	Como	25%
C Crane	Como	20%
L Wong	Como	25%

Plant Diseases and Pests

Professional

CRF

J. Tippett	SRS	Como	100%
I. Abbott	SRS	Como	5%
E. Davison	SRS	Como	20%
M. Stukely	RS	Como	60%
B. Shearer	SRS	Dwp.	45%
G. Keighery	RS	Wdvl.	5%

Externally Funded.

S. Crombie	Como	90%

Technical

CRF

C.Crane	Como	20%	F. Bunny	Como	100%
F. Tay	Como	20	B. Davies	Como	90
T. Hill	Como	100	A. Smith	Dwp.	50
H. Warren	Dwp	30			
J. Maranta	Dwp	20			
P. Somerford	Dwp	90			
A. Byrne	Dwp	30			

R. Buehrig	Dwp	30
J. Kinal	Dwp	50
M. Dillon	Dwp	40
J. Alford	Wdvl.	5%

Rehabilitation

Professional

J. Bartle	70%
G. Brennan	10
P. Brown	100
A. Hopkins	15
R. Mazanec	100
R. Moore	20

Technical

T. Birmingham	40
J. Bopp	10
G. Butcher	10
B. Copeland	20
T. Goff	100
B. Hingston	10
P. Jenkins	20
G. Maranta	20
M. Mason	40
P. Albone	100
N. Pettit	100

Wetlands and Waterbirds

Professional

J. Lane, PRS	Woodvale	70%
S. Halse, RS (Contract)	Woodvale	100%

Technical

D. Munro	Woodvale	95%
G. Pearson	Woodvale	90%

Research Computing

Professional

M. Choo,	Woodvale	100%
P. Gioia,	Woodvale	100%
D. Ward, RS	Como	100%

Technical

P. Walsh	Manjimup	90%
Y. Woods	Manjimup	90%
P. Somerford	Dwellingup	10%

K. Witford	Dwellingup	10%	
B. Copeland	Busselton	90%	

Executive and Administrative Support

Professional

Chief of Division		(vacant)	
AA Burbidge, SPRS	Woodvale	50%	
P Christensen, SPRS	Como	90%	
G Siemon, SRS	Como	30%	
J Bartle, SRS	Como	50%	
J McGrath, RS	Como	20%	
J Lane, PRS	Woodvale	30%	
S Hopper, SRS	Woodvale	5%	
B Shearer, SRS	Dwellingup	15%	
N Burrows, SRS	Manjimup	30%	

Technical and clerical

J Dorlandt	Como	100%	
M Wilke	Como	100%	
M Dillon	Dwellingup	20%	
R Giles	Dwellingup	70%	
G Maranta	Dwellingup	40%	
H Warren	Dwellingup	70%	
A Annels	Manjimup	10%	
R Hopkins	Manjimup	100%	
M Pree	Manjimup	100%	
L Simmonds	Manjimup	100%	
L Cade	Woodvale	100%	
M Churches (wages)	Woodvale	100%	
C Frost (part time)	Woodvale	100%	of 1.5 days per week (=30%)
R Hick (part time)	Woodvale	100%	of 3 days per week (=60%)
J Imms	Woodvale	100%	
C Mathews	Woodvale	100%	
D Munro	Woodvale	5%	
G Pearson	Woodvale	10%	
J Pryde	Woodvale	100%	
R Sokolowski	Woodvale	10%	

APPENDIX II

CURRENT RESEARCH PROJECTS BY FIVE YEAR GOALS

Biogeography

(a) DATA COLLECTED AND ANALYSED, BUT WRITE-UP INCOMPLETE

GOAL NO. 1

4. Nullarbor District ecological survey - N. McKenzie, G. Keighery & A.H. Burbidge

12. Eastern Goldfields (six cell reports) - N. McKenzie, A.A. Burbidge RS 121.

GOAL NO. 2

6. Salisbury Island - A.A. Burbidge, J. Kinnear, N. McKenzie (RS unlisted).

1 Flora Lists of York/Northam Reserves - G. Keighery (RS 93).

22. Vertebrate Fauna Survey of Dampier Archipelago - K. Morris (RS 132).

2. Dampier Archipelago Management Plan - K. Morris (RS 132).

8. Islands: Lancelin to Dongara - G.J. Keighery (RS 94).

9. Jibberding/White Wells proposed reserve - A.A. Burbidge (RS unlisted).

10. Ecological Survey of proposed Boonanaring Reserve - A.H. Burbidge (RS 15).

11. Report on survey work at Mount Lesueur - A Hopkins (RS 60).

5. Cooloomia Nature Reserve - A.A. Burbidge, S. Hopper (RS 75).

13. Buccaneer Archipelago - N. McKenzie, A. Hopkins, A. Burbidge, J. Lane RS 128.

14. Stirling Range and Environs Flora - G. Keighery (RS 95).

15. Dorre Island and Associated Shark Bay Islands - Ecological Survey - R. Prince (RS 141).

24. Management Guidelines for Monte Bello Islands - K. Morris (RS 132).

3. Ecological Survey of Southern Beekeepers Reserve - A.H. Burbidge (RS 15).

18. Report on survey work at Tutanning Nature Reserve - A. Hopkins (RS 59).

19. Report on survey work at Two Peoples Bay - A. Hopkins (RS 63).

20. Report on survey work at Middle Island/Recherche Archipelago - A. Hopkins (RS 60).

21. Atlas of all Western Australian Proteaceae (except Banksia) - A. Hopkins (RS 56).

23. Vertebrate Fauna of Monte Bello Islands - K. Morris (RS 132).

26. Bird Communities of the Walpole-Nornalup National Park - G. Wardell-Johnson (RWP unallocated)

GOAL NO. 3

25. Interactions of Fire and Site on Vegetation in the Walpole-Nornalup National Park - G. Wardell-Johnson (RWP unallocated)

16. Searching versus Pitfall Trapping in Southern Forests Surveys - G. Wardell-Johnson (RWP unallocated).

17. Bird census results in Southern Forests Surveys - G. Wardell-Johnson. (RWP unallocated)

GOAL NO. 4

7. Census of Australian Plants - G. Keighery (RS 92).

(b) PROJECTS WITH DATA OR ANALYSIS STILL INCOMPLETE

GOAL NO. 1

9. Fitzgerald River National Park Survey - F.R.N.P.S. Association consultants, N. McKenzie (RS 127).

8. Establishment of monitoring program in C.A.L.M. - A. Hopkins (RS 52).

15. Walpole-Nornalup National Park survey - G. Wardell-Johnson, see Walpole coastal survey working plan. RWP (unallocated).

10. Late Holocene mammal fauna of the Irwin & Carnarvon districts, Western Australia - consultancy let by N. McKenzie (RS 126).

5. Acquire computer tape of the RAOU Atlas of Australian Birds data base for Western Australia - A.H. Burbidge (developmental).

13. Bibliography on, and appraisal of, the contemporary status of the vertebrate fauna of the northern Irwin and southern Carnarvon districts. Consultancy let by A.H. Burbidge (developmental).

GOAL NO. 2

4. Biological surveys of selected conservation reserves and for other conservation issues (to service Planning Branch and other particular site survey requests)- A.H.Burbidge (RS 15).

2. Ad hoc flora surveys of selected crown lands - S. Hopper (RS 74).

3. Reserve surveys (occasional Planning Branch requests) - G. Keighery (RS 99).

6. Biological survey of islands in the north-west - K Morris (RS 132).

17. Vegetation of Dryandra State Forest - consultancy let by G. Keighery (see previous listing).

14. Biogeography of Dugong and Seagrasses in northern Western Australia - R. Prince (RS 142).

16. Biological survey of sites on the Mandora palaeoriver and Radi Hills, Great Sandy Desert - N. McKenzie and external staff (RS 125).

GOAL NO. 3

1. Design and sampling methodologies for ecological surveys - N. McKenzie (RS 20)

Heterogeneity of Nullarbor quadrats - N. McKenzie, A. Hopkins, G. Keighery (RS 121)

Ground-truthing the Nullarbor data-base - N. McKenzie (RS 124)

Biogeography of the flora of southern Nullarbor - G. Keighery (RS 92)

Physical scalars of biological patterns in the Nullarbor - N. McKenzie (RS 124)

Assemblage changes over 12 months at Cocklebiddy - N. McKenzie, G. Keighery (RS 121).

Extending the Nullarbor data base: do the patterns change? - N. McKenzie, G. Keighery, A.H. Burbidge (RS 120).

Bat assemblage structure studies : disturbance and determinism - N. McKenzie (RS 129).

7. Sampling small ground-dwelling vertebrates - A.H. Burbidge (RS 16).

GOAL NO. 4

11. 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 (RS 122).

12. Acquire up-to-date microcomputer software to pre-process (append and edit) and analyse large matrices of ecological survey data. Maintain and develop expertise in the use of these procedures for a wide variety of data types - N. McKenzie (developmental).

Fauna Conservation

Goal: Knowledge of Fauna

a) Short term and/or concluding

Chiropteran Studies, Mormopterus taxonomy. N.L. McKenzie, RS 130

Population monitoring, seabirds. A.A. Burbidge, developmental.

Pitfall trapping methodology.
a) A.H. Burbidge, RS 16-17.
b) D. Pearson, developmental.
c) see also G.R. Friend, RS 34 (Fire Program).

Patterns of decline in the W.A. mammal fauna. A.A. Burbidge & N.L. McKenzie, RS 8.

b) Medium term

Marine turtle conservation

a) Kimberley and overview. R.I.T. Prince, RS 144-145.
b) Pilbara. K.D. Morris, RS 132-133.

c) Long term, ongoing

Monitoring of breeding seabird populations and status of W.A. seabirds. A.A. Burbidge and S.A. Halse. developmental.

Barrow Island fauna. K.D. Morris, A.A. Burbidge, RS 11-12.

Australian landhoppers, taxonomy and zoogeography. J.A. Friend, RS 44.

Rare & Endangered Species

a) Short-term and/or concluding.

Eastern Pilbara Rock-wallabies. J.E. Kinnear, RS 108-9.

Population monitoring, Saltwater Crocodiles. A.A. Burbidge, RS 12-13.

b) Medium term

Translocation and re-establishment of rare species

a) Numbat. J.A. Friend, RS 42-3.

b) Rock-wallabies - Dampier Archipelago. J.E. Kinnear, RS 108.

c) Banded Hare-wallaby. R.I.T. Prince, RS 141.

d) Western desert mammals. D.J. Pearson, developmental.

e) Mammals of Pilbara Islands. K.D. Morris, developmental.

f) Noisy Scrub-bird. Operations staff in association with A.A. Burbidge, RS 10-11, and Wildlife Management Program No. 2.

Ground Parrot Conservation. A.H. Burbidge, RS 17-18.

Western Swamp tortoise - breeding. A.A. Burbidge, RS 9-10.

Western Barred-bandicoot - ecology. J.A. Friend, RS 43-44.

Numbat habitat and food sources. J.A. Friend, RS 39-41.

Rock-wallaby conservation. J.E. Kinnear, RS 103, 104-105.

Conservation of Chuditch, Dasyurus geoffroii. M. Serena and T. Soderquist in association with A.A. Burbidge, RS 147-149.

Development of management programs for wildlife subject to Aboriginal exploitation

a) Dugong and marine turtles. R.I.T. Prince, RS 142-145.

b) Western Desert fauna. D.J. Pearson, developmental.

c) Long term, ongoing

Western Swamp Tortoise populations. A.A. Burbidge, RS 9-10.

Saltwater Crocodile populations. A.A. Burbidge, RS 12-13.

Woylie populations

a) Perup MPA. G. Wardell-Johnson, RWP 4/78, 6/78, 2/83.

b) Other populations - South West. J.E. Kinnear, J.A. Friend, RS 102, developmental.

Assessment of status and surveys of rare and/or endangered fauna

a) A.A. Burbidge, RS 7, developmental.
b) D.J. Pearson, developmental.
c) Others, as required.

Exploited Species

a) Short term and/or concluding
Nil

b) Medium term
Nil

c) Long term, ongoing

Monitoring - Kangaroo Management Programs. J.E. Kinnear and R.I.T. Prince with SOHQ and computer staff.

Feral Animals

a) Short term and/or concluding
Nil

b) Medium term

Feral animal control

a) Fox as predator. J.E. Kinnear and D. Algar, RS 104, 105-111.

b) Exotic rats on islands. K.D. Morris, RS 134-5 and developmental.

c) Long term, ongoing
Nil

Fire

Fire behaviour, detection and suppression

1. Slash burning guides for P. radiata plantations. N. Burrows, RWP 19/78.

2. The Mount Soil Dryness Index for use in W.A. N. Burrows, RWP 36/83.

3. Forest fire behaviour under dry fuel conditions. N. Burrows, RWP 28/79.

4. Identifying and describing biotic fire descriptors. N. Burrows.

5. The combustion rate of forest fuels. N. Burrows, RWP 18/86.

6. The development of spot fires in the forest. N. Burrows, RWP 14/86.

7. Prescribed fire to control pine wildlings. N. Burrows, RWP 16/86.

8. Fire in regenerated Karri stands. L. McCaw, RWP 21/85 or 15/85.

9. Aspects of fire behaviour in Banksia woodlands. N. Burrows, RWP?

10. Arid zone fire behaviour. D. Pearson, RS 136.

11. Describing fuels in kwongan at Tutanning. A. Hopkins, part of RS 61.

Fire ecology/fire effects

12. Forest fire effects study. N. Burrows, RWP 12/86.

13. Fire-caused injury to Jarrah and Marri. RWP 18/78.

14. The effect of fire on Lambertia rariflora. N. Burrows, RWP

15. Fire ecology, Tutanning Nature Reserve. G. Friend and A. Hopkins, RS 34.

16. Fire ecology, Kellerberrin area. G. Friend and A. Hopkins, RS 35.

17. Fire ecology, Perup area. G. Friend, RS 36.

18. Niche relationships of small lizards. G. Friend, RS 37.

19. Spatial dynamics of lizards and scales of sampling. G. Friend (no ref).

20. Impact of fire regimes on desert biota. D. Pearson, RS 137.

21. Fire and the Tammar. G. Wardell-Johnson, RWP 7/81.

22. Fire, season and termite activity. G. Wardell-Johnson, RWP 8/84.

23. Fire effects studies, Two Peoples Bay Nature Reserve. A. Hopkins, RS 63.

24. Fire effects studies, Tutanning Nature Reserve. A. Hopkins, RS 53, 59, 62.

25. Fire effects studies, Recherche Archipelago. A. Hopkins, RS 60.

26. Fire effects studies, Eneabba and Mt Lesueur. A. Hopkins, RS 60.

Monitoring

27. Documenting wildfire history in forests. N. Burrows, RWP 68/86.

28. Rate of fuel accumulation in Banksia woodlands. N. Burrows, RWP 17/86.

29. Pitfall trapping, sampling methodology. G. Friend, RS 34.

30. Ecological data-base for herpetofauna. G. Friend (no ref).

31. Arid zone aerial burning and its monitoring. D. Pearson, RS 138.

32. Long-term population fluctuations of the Woylie. G. Wardell-Johnson, RWP 2/83.

23. Fire effects studies, Two Peoples Bay Nature Reserve. A. Hopkins, RS 63.

24. Fire effects studies, Tutanning Nature Reserve. A. Hopkins, RS 53, 59, 62.

25. Fire effects studies, Recherche Archipelago. A. Hopkins, RS 60.

26. Fire effects studies, Eneabba and Mt Lesueur. A. Hopkins, RS 60.

Fire management systems

33. A computer-based wildfire information storage and retrieval system. N. Burrows, RWP 15/86.

34. Traditional Aboriginal burning. D. Pearson, RS 136.

35. Development of computerized land-management systems. A. Hopkins, part of RS 61.

Flora Conservation

Goal No.1. ENDANGERED FLORA WILDLIFE MANAGEMENT PLANS

1. Endangered Flora Wildlife Management Plan for *Acacia anomala*. D.J. Coates.

2. Endangered Flora Wildlife Management Plan for *Drakaea jeanensis*. S.D. Hopper.

3. Eight Endangered Flora Wildlife Management Plans. D.J. Coates and S.D. Hopper.

4. Genetic variation in outlying populations of Jarrah and co-existing allied rare species. S.D. Hopper, RS 82.

5. Bird pollination, nectar flow and the mating system of *Eucalyptus caesia*. S.D. Hopper, RS 82.

6. Conservation status, morphometrics and allozyme variation in *Eucalyptus macrocarpa* and allied species. S.D. Hopper and external researchers, RS 83.

7. *Eucalyptus carnabyi* - rare hybrid or relict species? S.D. Hopper, RS 87.

8. Determination of the hybrid status of some rare flora. D.J. Coates, S.D. Hopper, RS 28.

9. Reproductive biology and management of *Eucalyptus rhodantha*. J. Sampson, S.H. James (University of Western Australia), S.D. Hopper, developmental.

10. Conservation status and genetic variability in four dominant but rapidly declining species. D.J. Coates, RS 30.

11. Conservation genetics of rare flora. D.J. Coates, RS 25.

12. Genetic systems of rare flora. D.J. Coates, RS 26.

13. Germ plasm storage program for rare, endangered and rapidly declining flora. D.J. Coates, S.D. Hopper, RS 27.

14. Life history and eco-geographic studies of rare flora. D.J. Coates, S.D. Hopper, G.J. Keighery, RS 26.

15. Book on rare and endangered W.A. flora. S.J. Patrick (consultant botanist) and S.D. Hopper.

16. Review of rare flora conservation in Western Australia. S.D. Hopper and D.J. Coates, RS 73.

2. FLORA DATA BASE

17. Additions and deletions to the declared endangered flora. S.D. Hopper, RS 66.

18. Data base on rare and geographically restricted plants of Western Australia. S.D. Hopper and various consultant botanists, RS 69.

19. Undertake field surveys of poorly known high priority species at risk. S.D. Hopper, D.J. Coates, G.K. Keighery, S.J. Patrick, A.P. Brown, R.E. Sokolowski.

20. Eucalypts of the Great Victoria Desert. S.D. Hopper, RS 88.

21. Twenty new eucalypts from Western Australia. M.I.H. Brooker (CSIRO, Forest Research), S.D. Hopper, RS 81.

22. Conservation, ecology and biology of Western Australian Tremandraceae. J.J. Alford and G.J. Keighery, RS 95.

23. Taxonomy of new Western Australian Eucalypts. M.I.H. Brooker (CSIRO, Forest Research), S.D. Hopper, RS 81.

24. Pollination biology of the Australian flora. S.D. Hopper, RS 90.

25. Garden escapes, naturalized flora of Western Australia. G.J. Keighery, RS 96.

26. Systematics of Western Australia flora. G.J. Keighery RS 97.

27. Biology of Western Australian plants. G.J. Keighery, RS 97.

28. Eucalypts of Western Australian salt lakes, including the new series Rigentes with three new species. M.I.H. Brooker (CSIRO, Forest Research). S.D. Hopper.

29. Revision and conservation status of Beaufortia and Regelia. A.A. Burbidge, RS 8.

30. Hybridization and gene exchange in a Stylidium contact zone. D.J. Coates, RS 31.

31. Biogeography and taxonomy of creeping triggerplants (Stylidiaceae). A.H. Burbidge, RS 18.

32. Phylogenetic and breeding system studies in the genus Eremaea (Myrtaceae). D.J. Coates, RS 30.

33. Distribution and ecology of Dryandra (Proteaceae). A.J.M. Hopkins, RS 56.

34. A revision of Caladenia, Drakaea and allied genera of orchidaceae in Western Australia. S.D. Hopper, RS 78.

35. Generic relationships and evolution of *Caladenia*, *Chloraea* and allied orchids. S.D. Hopper and consultant, RS 79.

36. A revision of *Eucalyptus wandoo* and allied species (*Eucalyptus* series *Subcornutae*). M.I.H. Brooker (CSIRO, Forest Research), S.D. Hopper, RS 80.

37. Conservation status and biology of granite rock endemics on the south coast. S.D. Hopper.

38. Conservation status and biology of granite rock endemics of the pastoral region. S.D. Hopper.

39. Conservation status and biology of granite rock endemics of the wheatbelt. S.D. Hopper.

40. Conservation status and biology of granite rock endemics of the Karri forest. S.D. Hopper.

3. PUBLIC INVOLVEMENT

41. Banksia atlas. A. Taylor, S.D. Hopper, RS 151.

42. Atlas of the Western Australian flora pilot project (orchids). S.D. Hopper, RS 76.

43. Atlas of rare and endangered W.A. eucalypts. S.D. Hopper.

4. WILDFLOWER INDUSTRY WILDLIFE MANAGEMENT PLANS

44. Licensing and management of the wildflower industry. S.D. Hopper, D.J. Coates, RS 70.

45. Reservation status of commercially exploited taxa. S.D. Hopper, RS 71.

46. Harvesting techniques used in the wildflower trade. S.D. Hopper, RS 72.

47. Conservation of two kangaroo paw species. M.App.Sci. students Curtin University, Supervisors and S.D. Hopper, RS 72.

48. Wildflower Industry Wildlife Management Plan for *Anigozanthos pulcherrimus* and *Macropidia fuliginosa*. S.D. Hopper.

49. Conservation status and genetic variability in six commercially exploited, geographically restricted and dieback susceptible species. D.J. Coates, RS 29.

5. RESEARCH COMMUNICATION

50. Presumed extinct and very rare wheatbelt plants. S.J. Patrick (consultant botanist), S.D. Hopper, RS 68.

51. Orchid Pollination Book. S.D. Hopper, A.P. Brown, B.A. and A.G. Wells.

52. Native trees and tall shrubs of Perth - guide and atlas. R.J. Powell, S.D. Hopper, RS 77.

53. Establishment of field herbaria in all regional and district offices and ranger stations. R.E.S. Sokolowski and S.D. Hopper, RS 32.

54. Orchids of metropolitan Perth. A.P. Brown, S.D. Hopper, RS 78.

55. A guide to the Eucalypts of the Stirling Range. S.D. Hopper, RS 87.

56. Orchids of the Stirling Range National Park. A.P. Brown and S.D. Hopper.

57. Orchids of Kalbarri, Leeuwin-Naturaliste, Walpole-Nornalup, Fitzgerald River and Cape Le Grand National Parks. A.P. Brown and S.D. Hopper.

58. Flora posters, leaflets, magazine articles and public lectures. S.D. Hopper, D.J. Coates, G.J. Keighery, RS 74.

Jarrah

1. Height growth of jarrah incipient ground coppice in relation To (simulated) grazing intensity. I. Abbott, RWP 18/84.

2. Comparison of two methods of sampling foliage. I. Abbott 19/84.

3. Leaf dynamics of jarrah in relation to impact of jarrah leafminer. I. Abbott 20/84.

4. Effect of jarrah leafminer on growth of jarrah incipient ground coppice after fire. I. Abbott 27/84.

5. Comparison of insect damage to jarrah ground coppice in the southern and northern jarrah forests. I Abbott 2/85.

6. Comparison of insect damage to six species of eucalypt near Manjimup. I. Abbott 3/85.

7. Quarterly assessment of insect damage and selected chemical properties in relation to ageing of the jarrah leaf. I. Abbott 4/85.

8. 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 23/85.

9. Comparison of insect abundance 12m above ground (in canopy of subdominant jarrah poles) and within 2m of the ground. I. Abbott 24/85.

10. The impact of repeated defoliations on the wood growth of jarrah saplings. I. Abbott 24/86.

11. The parasitoids of gumleaf skeletonizer in the southern jarrah forest. Their identification, relative abundance, target in the life cycle of U. lugens and effect on mortality. P. Van Heurck 28/86.

12. Avian predators of the caterpillars of the gumleaf skeletonizer. I. Abbott 39/86.

13. Egg laying habits of Uraba lugens in jarrah in the so jarrah forest of Western Australia. T. Burbidge 40/86.

14. Diameter growth of jarrah poles resistant and susceptible to jarrah leafminer. I. Abbott 57/86.

15. Long term impact of folivorous insects (especially the jarrah leafminer) on jarrah wood growth in the southern jarrah forest. I. Abbott 60/86.

16. Crown deterioration of jarrah poles in the southern jarrah forest following grazing of leaves by insects. I. Abbott 61/86.

17. Jarrah pole thinning (Inglehope). G. Stoneman 12/65.

18. Growth rates of pile-sized jarrah in even-aged forest at various stockings. G. Stoneman 49/65.

19. Jarrah pole thinning - young poles (Chalk). G. Stoneman 15/66.

20. Forest stand manipulation to increase water production. G. Stoneman 1/77.

21. Comparison of the effects of a number of alternative silvicultural prescriptions. G. Stoneman 20/82.

22. Seasonal growth of jarrah. G. Stoneman 17/83.

23. Hydrological study of the Yarragil catchment relating quality and quantity of landscape and forest treatments. G. Stoneman 16/84.

24. Comparison of Round-up and Tordon timber control for killing standing jarrah and marri poles in summer. G. Stonemen 37/84.

25. Rehabilitation of the dieback degraded Warren catchment and its effect on water quality and quantity. G. Stoneman 30/85.

26. The effect of delays between notching and application of roundup herbicide. G. Stoneman 34/85.

27. Effect of concentration of herbicide and stand density on efficacy of Round-up for killing jarrah stump coppice by foliar spray. G. Stoneman 35/85.

28. The effect of notch spacing on the success of notching with Round-up herbicide. G. Stoneman 36/85.

29. Comparison of Round-up and Tordon timber control for killing standing jarrah and marri poles in winter. G. Stoneman 37/85.

30. The effect of Round-up dose on its ability to kill standing jarrah and marri poles in winter using the notching method. G. Stoneman 40/85.

31. The effect of coverage of foliar spray of Round-up on its ability to kill coppice. G. Stoneman 40/85.

32. The effect of fire on the success of notching jarrah and marri with Round-up herbicide. G. Stoneman 41/85.

33. Response of hydrologically important measures of forest density. G. Stoneman 3/86.

34. Effect of Round-up dose on ability to kill standing jarrah and marri. G. Stoneman 30/86.

35. Effect of Round-up dose. G. Stoneman 31/86.

36. Prediction of impact of P. cinnamomi from site indicators. B. Shearer 40/83.

37. Hillslope hydrology differences between a high and moderate Phytophthora cinnamomi impact area. B. Shearer 23/84.

38. Examination of the seasonal variation in the concentration of mineral nutrients and carbohydrates in the stem of jarrah. J. McGrath 42/83.

39. Compare depth of sapwood with the depth of CCA preservative penetration into jarrah regrowth logs. G. Brennan/G. Siemon 26/84.

40. Ecologizer trial with eucalypts. G. Brennan/G. Siemon 12/85.

41. Investigation of moisture variations, growth stress changes, and log degrade in hardwood thinnings. G. Brennan/G. Siemon 18/85.

42. Seasoning of mature jarrah by tunnel kilning and by laboratory high temperature kilning. G. Brennan/G. Siemon 27/85.

43. Seasoning of regrowth jarrah, karri and marri by tunnel kilning and by laboratory high temperature kilning. G. Brennan/G. Siemon 28/85.

44. Sawmilling and veneer slicing trial using thinning from Inglehope plots, Dwellingup District. G. Brennan/G. Siemon 7/86.

45. Moisture content of jarrah logging residues. G. Brennan/G. Siemon 8/86.

46. Assessment of volume and product recovery after sawmilling of stockpiled regrowth jarrah, marri & karri, mature jarrah and freshly felled regrowth jarrah sawlogs. G. Brennan/G. Siemon 20/86.

47. Strength properties of regrowth eucalypts. G. Brennan/ G. Siemon 26/86.

48. Durability of W.A. - grown timber species. G. Brennan/ G. Siemon 41/86.

49. Resistance of jarrah to P. cinnamomi. M. Stukely 42/85
50. Causes of jarrah leaf size variation. R. Mazanec 2/87.

51. Study of genetic variation in growth and form of jarrah. R. Mazanec 3/87.

52. Jarrah family/provenance trials. R. Mazanec 6/87.

53. Enrichment planting trial. G. Strelein 24/80.

54. Jarrah seeding establishment trial. G. Strelein 18/83.

55. Fertilizing seeded jarrah. G. Strelein 19/83.

56. Jarrah planting establishment trials. G. Strelein 20/83.

57. Jarrah site classification project. G. Strelein. 23/83.

58. Jarrah fertilizer trials 1984. G. Strelein 12/84.

59. Jarrah espacement and lignotuber development trial. G. Strelein 13/84.

60. Jarrah lignotuber and root development study. G. Strelein 6/86.

61. Effects of site preparation, inoculation and timing of fertilizer. G. Strelein 43/86.

62. An hydraulic model of root, stem, branch and leaf tissue of jarrah. S. Crombie 64/86.

Karri

1. Karri site classification, G. Inions, RWP 19/86.

2. Karri floristics, G. Keighery, new.

3. Karri bird study, G. Wardell-Johnson, RWP 22/86. 4. Endemic karri flora, G. Keighery, commenced late 1986. 5. Genetic variability of karri populations, D. Coates, RS 28.

(b) MANAGEMENT

1. Karri bird study, G. Wardell-Johnson, RWP 22/82. 2. Karri provenance trials, R. Mazanec, RWP 26/78.

(c) PRODUCTION 1. Karri silviculture stand management, G. Inions,
RWP 21/77, RWP 15/82, RWP 3/84, RWP 25/85. 2. Growth model, G. Inions, new.
3. Karri utilisation research, G. Brennan, RWP 18/85,
RWP 28/85, RWP 20/86, RWP 26/86, RWP 41/86, RWP 9/86. 4. Prescribed burning of regenerated stands, L. McCaw,
RWP 2/84, RWP 15/85, RWP 21/85. 5. Karri borer study, I. Abbott, RWP 32/85, RWP 59/86.

Pine

Goal No. 1

1. P. pinaster seed orchards No. 1 (Joondalup) & No.2 (Mullaloo). T. Butcher, RWP 19/62.

2. P. pinaster provenance trial at Gnangara. (TB) 20 1965 Basal area control of thinning in P. pinaster at Gnangara. T. Butcher, RWP 3/65.

3. P. pinaster progeny trials widespread throughout SW Australia. T. Butcher, RWP 21/65.

4. P. radiata seed orchard at West Manjimup. T. Butcher, RWP 34/68.

5. P. radiata international gene pool progeny test (RS4 & RS5). T. Butcher, RWP 21/71.

6. P. radiata progeny trials throughout SW Australia. T. Butcher, RWP 22/71.

7. P. radiata genetics yield trial. T. Butcher, RWP 19/72.

8. P. pinaster genetics yield trial. T. Butcher, RWP 20/72.

9. P. radiata provenance trial at Busselton

[RX.6(19790)]. T. Butcher, 29/78.

10. P. radiata genetic variation in dieback resistance. T. Butcher, M. Stukely RWP 30/78.

11. Provenance trials of P. taeda & P. serotina in Sunkland. T. Butcher, RWP 25/79.

12. Pine progeny trials in the Wellington Catchment. T. Butcher, RWP 21/82.

13. Screening established P. radiata for dieback resistance. M. Stukely, RWP 39/83.

Goal No. 2

1. P. radiata early thinning for particle board. R. Moore. 27/65.

2. P. radiata non-commercial thinning. R. Moore, RWP 7/66.

3. P. radiata first thinning study. R. Moore, RWP 12/66.

4. Bussel's arboretum at Collie. R. Moore, RWP 25/67.

5. Meribup arboretum at Manjimup. R. Moore, RWP 26/67.

6. Asplin's arboretum at Nannup. R. Moore, RWP 27/67.

7. Grazing and forestry combination in Blackwood Valley. R. Moore, RWP 15/73.

8. Agroforestry plan for Chapman's Lease. R. Moore, RWP 10/75.

9. Agroforestry trial at Wonnerup. R. Moore, RWP 2/78.

10. Agroforestry regimes with P. radiata. R. Moore, RWP 20/78.

11. Agroforestry trial jarrahwood. R. Moore, RWP 4/80.

12. Strip planting of pines for agroforestry. R. Moore, RWP 7/80.

13. Agroforestry trial in Wellington Catchment. R. Moore, RWP 4/81.

14. Agroforestry species trial Vasse 2. R. Moore, RWP 10/81.

15. Silviculture alternatives for fuel reduced buffers. R. Moore, RWP 2/82.

16. Comparison of silvicultural regimes for Sunkland *P. radiata*. R. Moore, RWP 5/82.

17. Forms of nitrogen nutrition for *P. radiata*. J. McGrath 9/82.

18. Phosphorus regimes for pastured pine. J. McGrath. RWP 19/82. 19. Pine cuttings for agroforestry. R. Moore, RWP 33/82.

20. Agroforestry trial at Esperance. R. Moore, RWP 43/82.

21. Phase 3 pine species trial for Sunkland (4 species). R. Moore, RWP 44/82.

22. Effect of pruning on wide spaced *P. radiata*. R. Moore, RWP 45/82.

23. Comparison of form and set lift pruning in *P. radiata*. R. Moore, RWP 3/83.

24. Effect of *P. radiata* thinning on wind stability. R. Moore, RWP 6/83.

25. Early thinning of *P. radiata* on clover in Sunklands. R. Moore, RWP 7/83.

26. Combination of *Alnus* sp. and *P. radiata*. J. McGrath RWP 15/83.

27. Supply & distribution of phosphorus in young *P. radiata* tops. J. McGrath. RWP 23/83.

28. Nutrient accumulation and distribution in *P. radiata*. J. McGrath RWP 24/83.

29. Effect of initial stocking on future growth of *P. radiata* crop trees. R. Moore, RWP 28/83.

30. *P. radiata* non commercial thinning. R. Moore, RWP 30/83.

31. Sunkland site trial *P. radiata* Phase III. P. Jenkins RWP 17/84.

32. Nitrogen source, distribution and effect on *P. radiata* growth. J. McGrath, RWP 1/85.

33. *P. radiata* response to N and P after thinning on red loams. J. McGrath, RWP 8/85.

34. *P. radiata* nutrient uptake for different fertiliser timings. J. McGrath, RWP 16/85.

35. Phosphorus supply and concentration in *P. radiata* needles. J. McGrath, RWP 17/85.

36. Form and growth rate of selected cuttings of routine seedlings of P. radiata in agroforestry. R. Moore, RWP 1/86.

37. Timber and agricultural production from two stand densities of pine agroforestry in the Manjimup area. R. Moore, RWP 2/86.

Goal No. 3

1. Wood quality of pinaster and radiata pines. G. Siemon, RWP 30/82.

2. Sawn graded recoveries from P. radiata grown in agroforestry stands. G. Siemon, RWP 42/86.

Goal No. 4

1. P. pinaster free growth trial at Gnangara. T. Butcher, RWP 16/58.

2. Establishment of large pilot plots for P. pinaster. T. Butcher, RWP 48/66.

3. Basal area control of thinning in P. pinaster. T. Butcher, 17/67.

4. P. pinaster response to phosphate on leached Bassendean sands. T. Butcher, RWP 54/66.

5. Hydrology in P. pinaster stands. T. Butcher, RWP 20/68.

6. Pine establishment trial at Mt Cooke. T. Butcher, RWP 16/69.

7. Productivity of second rotation pine at Gnangara and Grimwade. T. Butcher, RWP 29/71.

8. Fertiliser & thinning for P. pinaster on Bassendean grey sand. T. Butcher, RWP 8/72.

9. Subsequent fertilisation of P. pinaster on yellow sands. T. Butcher, RWP 23/73.

10. Pilot plots of P. radiata at Moore River. T. Butcher, RWP 20/75.

11. Early fertilisation of P. pinaster on marginal sites. T. Butcher, RWP 20/76.

12. Fertilisation of adolescent P. pinaster on yellow sands. T. Butcher, RWP 21/76.

13. Fertilisation of adolescent P. pinaster on grey sands. T. Butcher, RWP 22/76.

14. P. pinaster high pruning trial. T. Butcher, RWP 26/80.

15. Timing of fertiliser for maximum response in P. pinaster. T. Butcher, RWP 2/81.

16. Adjacent 1R/2R pinaster on good/marginal sands at Yanchep. T. Butcher, RWP 25/83.

Plant Diseases and Pests

Goal No.

1.1 Long-term monitoring of Phytophthora cinnamomi. B.L. Shearer, RWP 34/83.

1.2 Assessment of root damage to jarrah trees growing on P. cinnamomi infected sites. B.L. Shearer, RWP 14/84.

1.4) Hillslope hydrology differences between a high and

1.6) moderate Phytophthora cinnamomi impact area. B.L. Shearer, RWP 23/84.

1.1 Long-term monitoring of Phytophthora cinnamomi impact in a moderate impact area. B.L. Shearer, 24/84.

1.1 Long-term monitoring of Phytophthora cinnamomi in a moderate and high impact area. B.L. Shearer, RWP 25/84.

1.3 Changes of Phytophthora cinnamomi impact with time and climatic event. B.L. Shearer, RWP 35/84.

1.1 Long-term monitoring of a concave area near Deer Rd for P. cinnamomi impact. B.L. Shearer, RWP 9/85.

3.1) Factors effecting susceptibility of Pinus radiata to
3.2) invasion by P. cinnamomi. J.T. Tippett, M. Stukely, RWP 62/86.

1.3 An hydraulic model of root, stem, branch and leaf tissue of jarrah (E. marginata). D.S. Crombie, RWP 64/86.

1.2) Water relations of jarrah dieback. D.S. Crombie, RWP
1.3) 65/86.

1.3 Effect of simulated rainfall on established P. cinnamomi lesions in E. marginata roots. J. Tippett, RWP 66/86.

2.3 Can P. cinnamomi infection of Banksia seminuda be prevented from spreading by infecting healthy

trees with the fungicide Fosetyl-al. B.L. Shearer, RWP 72/86.

7.1 The association of pathogens with mortality of Eucalyptus species planted in arboreta. B.L. Shearer, RWP 73/86.

5.1 Impact of Armillaria luteobubalina in the wandoo forest. B.L. Shearer, RWP 75/86.

2.2 Population dynamics of Phytophthora cinnamomi in jarrah-banksia communities on sandy soils of the coastal plain south of Pinjarra. B.L. Shearer, RWP 76/86.

2.3 The effect of phosphorus acid on lesion development of Phytophthora cinnamomi in Banksia grandis. B.L. Shearer, RWP 77/86.

2.3 Treatment of isolated outbreaks of Phytophthora cinnamomi. J.T. Tippett, RWP submitted.

2.2 Patterns of invasion and survival of P. cinnamomi in Banksia attentuata growing on deep sands. J.T. Tippett, RWP submitted.

6.1 The distribution of Phytophthora species north of Perth, their pathogenicity and impact. J.T. Tippett and T. Hill, RWP submitted.

Rehabilitation

1. Bauxite mining

1a All research relating to this goal is conducted under the auspices of the Research Steering Committee. Projects are usually large, long term studies in which CALM has substandard input to planning and review but less to their execution. Some projects are a major CALM responsibility and cross program boundaries. These have been listed in the jarrah program (project Nos. 20, 23, 25, 33, 37) and pests and diseases (goals 1.4 and 1.6) Bartle is the senior CALM representative on the Research Steering Committee.

1b As for 1a.

1c As for 1a.

1d Development of local-scale planning procedures to integrate mining and rehabilitation into jarrah forest land use planning and management. W. Tacey.

1f 1. Rehabilitation species trials. J. Bartle RWP 14/76, 12/78 and 31/78.

2. E. globulus provenance trial. T. Butcher/R. Mazanec,

3. Wandoo progeny trial. T. Butcher/R. Mazanec 6/81, 24/82, 25/82.

4. E. maculata provenance trials. R. Mazanec 38/82.

5. Geographic variation in E. wandoo. T. Butcher and R. Mazanec 40/82.

6. E. resinifera provenance trial. R. Mazanec 1.

7. E. globulus provenance trial. R. Mazanec 32/84.

8. E. accedens provenance trial. R. Mazanec 33/84.

9. E. camaldulensis provenance trial. R. M.

10. E. wandoo gene pool. T. Butcher/R. Mazanec 5/85.

11. E. accedens provenance trial. R. Mazanec 4/86.

12. E. pilularis provenance trial. R. Mazanec 5/86.

13. E. sideroxylon provenance trial. R. Mazane.

14. Study of the genetic variation in growth and form of E. marginata. R. Mazanec 3/87.

15. E. marginata provenance trials. R. Mazanec 6/8.

16. E. saligna provenance trial. R. Mazanec 8/87.

2a 1. Broadscale direct seeding techniques to establish native vegetation on established farmland in the wheatbelt. P. Brown 44/86.

2. Comparison of insects and vertebrates as removers of native seed on established pasture sites in the wheatbelt. P. Brown 46/86.

3. Optimum sowing time for sowing seed of native species in the Narrogin area. P. Brown 12/87.

4. Assessment of the effect of superphosphate on the germination of a variety of eucalypt and acacia species. P. Brown 13/87.

5. Field assessment of the sowing depth and post-sowing harvesting on tree seed germination P. Brown 14/87.

6. Examination of methods for revegetation of former farmland in the central wheatbelt. A. Hopkins RS 35.

7. P86 species performance on high mounds at Ricetti Farm. P. Ritson 49/86.

8. High mound arboretum. Ricetti Farm. P. Ritson 50/86.

9. A triple and species trial. P. Ritson. 52/86.

10. Mound height trial. P. Ritson 7/87.

11. Spacing trial on high mounds. P. Ritson 21/87.

12. Fertilization for establishment trials. P. Ritson 16/87.

2b. (included in 1f)

2c. 1. A pilot study to collect insect species boring E. wando P. Brown, P. Albone 58/86.

2. Effects of ring barking on E. wandoo stems. P. Brow Albone 63/86.

3. Quarterly assessment of insect damage and selected chemical properties in relation to aging of the wandoo leaf. P. Brown, P. Albone 78/86.

4. Field assessment of fungal canker damage to wandoo on the Darling Scarp. P. Brown and P. Albone 15/87.

5. Grazing exclusion trials in native forest. P. Ritson 54/86.

2d. 1. Changes in the TSS content and soil physical conditions in high mounds. P. Ritson 48/86.

2. Effects of salt leaching from low mounds on tree establishment. P. Ritson 51/86.

2e. 1. Flynn agroforestry trial : to determine the levels of tree, pasture and sheep production under four densities of three species of trees. R. Moore, CSIRO and WAWA 265.54.

2. Well bucket agro-forestry trial : to determine the levels of tree, pasture and sheep production under low densities of pine in mature plantations. R. Moore, CSIRO 264.52.

3. To determine ways to integrate trees and farming using various eucalypts and pines. R. Moore 4/81.

4. To demonstrate grazing water eucalypts at various tree densities R. Moore WAWA 5/81.

2f. 1. To determine the effect of species, size and landscape position of blocks of trees on water table depth and salinity. R. Moore CSIRO 264.53.

2. To determine the effect of a hillscope planting on water table depth and salinity. R. Moore, WAWA 264.51.

3. Variation in transpiration between species growing over a shallow saline ground water. J. Bartle WAWA 4/84.

2g. Included in 2e.

2h. + to determine the growth rate of P. radiata, P. p range of densities and arrangements and to identify problems and demonstrate practices to Esperance farmers. R. Moore Ag Dept. 43/82.

3a 1. revegetation with native species after sands mining at Eneabba. A. Hopkins. RS 35.

Wetlands and Waterbirds

Current research projects and current involvements of a non-research nature are listed separately.

Current Research Projects

1. Annual assessment of conditions for waterfowl breeding. J. Lane, RS 116.

2. Publication of results of 1981-85 RAOU Survey of Waterbird Usage of Wetland Nature Reserves. R. Jaensch and J. Lane, RS 116.

3. Annual assessment of abundance of ducks, swans and coot. J. Lane, RS 117.

4. Assessment of waterbird usage of remote wetlands of probable international importance. J. Lane, RS 118.

5. Assessment of seasonal usage by waterbirds of a number of important, poorly known, wetland sites in south-western Australia. J. Lane, RS 118.

10. Breeding status of Egrets (Egretta spp.) in Western Australia. J. Lane, RS 118A.

11. Development of procedures for monitoring of chironomid (midge) larval numbers of Forrestdale Lake Nature Reserve. J. Lane, RS 114.

13. Ingestion of lead shot by waterbirds. J. Lane, new.

14. Preliminary analysis of opening day bag check (duck shooting season) data. J. Lane, RS 113.

15. Transequatorial migratory wader studies (technical and logistic assistance to RAOU). J. Lane, RS 114.

8. Analysis of Riggert/Fisheries and Wildlife 1960-1975 duck banding data. J. Lane, RS 49.

6. Interactive analysis of results of RAOU Waterbird Survey Project and CALM wetland monitoring project. S. Halse, RS 47.

9. Diet of ducks in fresh and saline wetlands. S. Halse, RS 48, developmental.

7. Conservation status of aquatic invertebrate fauna. S. Halse, RS 48.

12. Herdsman Lake pesticide study, S. Halse, new.

16. Maintenance of Map and index of Western Australia's Wetland Nature Reserves. J. Lane.

Current Non-research Involvements

1. Provision of advice concerning management of duck hunting in W.A. J. Lane, RS 113.

2. Liaison with pro-hunting, non-hunting and anti-hunting associations and individuals concerning management of duck hunting in W.A. J. Lane, RS 113.

3. Provision of scientific advice to government and non government organizations and individuals concerning protection and management of wetlands. J. Lane RS 113 and S. Halse.

4. Participation in various government and non-government committees concerning particular wetland management problems. J. Lane, RS 113 and S. Halse.

5. Involvement in acquisition, management and management planning of certain areas of CALM (wet)land. J. Lane, RS 113 and S. Halse.

6. Membership of CONCOM working group on Treaties relating to Migratory Birds and Wetlands of International Importance. J. Lane.

7. Preparation of Wetland of International Importance nominations. S. Halse, RS 46.

8. Involvement in preparation of Herdsman Lake management plan. S. Halse.