AUSTRALIAN GOVERNMENT COOPERATIVE RESEARCH CENTRES PROGRAM

APPLICATION FOR

PLANT CONSERVATION GENETICS AND GERMPLASM

COOPERATIVE RESEARCH CENTRE

PARTICIPATING INSTITUTIONS
Department of Botany, The University of Western Australia
School of Biology, Curtin University of Technology
Department of Horticultural Science, Murdoch University
Western Australian Wildlife Research Centre, Department of Conservation and Land Management
Western Australian Herbarium, Department of Conservation and Land Management
Kings Park and Botanic Garden
Plantex Australia Pty Ltd

OCTOBER 1990

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PARTICIPATING INSTITUTIONS

DEPARTMENT OF BOTANY, THE UNIVERSITY OF WESTERN AUSTRALIA
SCHOOL OF BIOLOGY, CURTIN UNIVERSITY OF TECHNOLOGY
DEPARTMENT OF HORTICULTURAL SCIENCE, MURDOCH UNIVERSITY
WESTERN AUSTRALIAN WILDLIFE RESEARCH CENTRE, DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT
WESTERN AUSTRALIAN HERBARIUM, DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT
KINGS PARK AND BOTANIC GARDEN
PLANTEX AUSTRALIA PTY LTD

Contact officer for correspondence and enquiries:

Dr S. D. HOPPER
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Department of Conservation and Land Management,
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KEY PERSONNEL

(a) Scientists

J. A. ARMSTRONG Senior Principal Research Scientist and Curator,Western Australian Herbarium, CALM. Plant taxonomy and breeding systems.

Dr J.A. CHAPPILL Lecturer, Department of Botany, The University of Western Australia. Plant systematics, especially phylogenetic analysis.

Dr D. J. COATES Senior Research Scientist, Western Australian Wildlife Research Centre, CALM. Genetic diversity analysis, cytogenetics and breeding system analysis.

Professor B. G. COLLINS Professor of Biology, School of Biology, Curtin University. Plant reproductive biology, pollination biology, disturbance ecology and regulation of seed set.

Professor J. CONSIDINE Professor of Horticultural Science, Murdoch University. Development of new horticultural and floricultural plant varieties.

Dr K. W. DIXON Senior Research Botanist, Kings Park and Botanic Garden. Plant demography, autecology and germplasm storage.

Dr S. D. HOPPER Senior Principal Research Scientist and O.I.C.,Western Australian Wildlife Research Centre, CALM. Genetic diversity analysis, plant taxonomy, demography and reserve management for conservation and restoration.

Dr S. H. JAMES Senior Lecturer, Department of Botany, The University of Western Australia. Genetic diversity analysis, cytogenetics and breeding system analysis.

Dr B. B. LAMONT Senior Lecturer, School of Biology, Curtin University. Plant reproductive biology, disturbance ecology, modelling population dynamics.

Dr N. G. MARCHANT Principal Research Scientist, Western Australian Herbarium, CALM. Plant taxonomy and systematic methods.

Professor J. S. PATE Professor of Botany, Department of Botany, The University of Western Australia. Plant demography and autecology.

(b) Commercial

A.G & I.V. BOWDEN Directors, Plantex Australia Pty Ltd. Development and commercialization of new horticultural and floricultural plant varieties.

III. SUMMARY

The biosphere is the source of our renewable material resources and many of them are poorly managed, as yet unused, or even undiscovered. The loss of biodiversity is an irreversible process of global concern. The Australian flora and fauna face unparalleled rates of extinction, yet the flora, in particular, provides the basis for many industries and the means of restoring degraded lands. Consequently, the conservation of genetic diversity is of immense importance and is featured as one of four fundamental tenets in the World and the Australian Conservation Strategies.

This proposal describes a strategy by which a substantial proportion of the dispersed research capabilities in plant genetics and conservation biology available in Australia and overseas can be integrated and focused onto urgent problems. It seeks to establish a Cooperative Research Centre with the potential to attain world leadership in the management of biodiversity. It will take advantage of the unique resources available in the Australian flora. It will identify, develop and commercialize some notable components, and generate a much enhanced understanding of the genetic diversity of pristine and modified plant population systems. The approach proposed is three fold: (i) to establish a research and educational program of international significance with ample provision to host Visiting Fellows and postgraduate students, to facilitate the exchange of staff and students and to sponsor appropriate conferences and workshops; (ii) to equip and staff a central laboratory with the best available facilities for describing genetic diversity and the systems which modulate it; the laboratory will specialize in the electrophoretic analysis of protein and DNA polymorphisms, cytogenetics, reproductive biology, genetic manipulation and systematics, and will provide resources and skills that can be drawn on by researchers in basic biological sciences, in horticulture, agriculture and forestry, in conservation biology and in environmental rehabilitation; and (iii) to ensure that research results are available to, and implemented by, private industry and the Department of Conservation and Land Management, and other government agencies.

The Centre will focus its research on Australian plants. It will address fundamental questions concerning reproductive mechanisms and the modulation of genetic variation. It will identify commercially useful variants and foster their horticultural and silvicultural development. It will identify biological attributes characterising taxa prone to extinction, and formulate key management initiatives that will minimize extinction rates. It will identify populations of endangered species that should have priority for management, and develop long term germplasm storage, reestablishment and management procedures. The close involvement of the Department of Conservation and Land Management in the Centre provides an outstanding opportunity to test and apply principles in the management of the species-rich Western Australian flora.

The Centre will have a strong commitment to the teaching of senior undergraduate and postgraduate students. Formal and informal links with a select group of national and international laboratories will be fostered to facilitate a substantial exchange program which will serve to provide educational opportunities unique in this hemisphere. The Centre's main laboratory and administration will be at the Department of Botany, The University of Western Australia, with networked facilities at Curtin University, Murdoch University, in various research centres of the Department of Conservation and Land Management, at Kings Park and Botanic Garden, and with Plantex Australia Pty Ltd. Structured in this way, the Centre has international, national and local relevance. It will have the potential to contribute at the highest level in significant research on conservation genetics, in utilizing the rich resources of our flora, and in providing knowledge of consequence in any attempt to redress the global loss of plant biodiversity.

While the Centre will be at least partially self-funding through its consultancy services, contract research and royalties accruing from the development and commercialization of novel plant varieties, its enduring value will come from its significant contribution to knowledge in the areas of genetic diversity and its modulation, the development of superior conservation, restoration and environmental management procedures, and fundamental evolutionary biology.

IV. RESEARCH, EDUCATIONAL AND END-USER STRATEGY

PROPOSED PROGRAM

The loss of biodiversity through extinction of species is of global concern. Of all the major environmental problems facing Earth, this process is irreversible, depriving present and future generations of opportunities to use, study and appreciate many plants and animals. Extinction is merciless; it gives no second chances (see Ledig, attached) and the cost of ignoring biological conservation may be high. For example, previous generations saw no value in leaving perennial native vegetation along margins of drainage lines in the Western Australian wheatbelt. As a result, rising saline water tables now loom as a major hindrance to agricultural production, reversible only by massive and expensive replanting of perennial vegetation. Similarly, the cedar wood industry in New South Wales is gone, due to the clearing of areas such as the Big Scrub. The wild stocks of sandalwood are seriously depleted. A substantial list of wasted resources may be prepared. The destruction of these resources can be halted, and the damage repaired, providing we know enough about those resources and the genetic diversity they contain (see the attached paper for a relevant review). The cost of gathering this information may be large, but the cost of not gathering it will be inestimable. For these reasons, the conservation of genetic diversity is a fundamental tenet of the World and Australian Conservation Strategies.

Yet, the most basic of questions in this area remain to be answered. These include:

i) What are the plant resources available?
ii) Which of these taxa are at risk?
iii) What are the rates of extinction of taxa in the flora?
iv) What biological attributes characterise taxa most prone to extinction?
v) What management initiatives minimise extinction rates?
vi) How is germplasm best stored and cultured for population re-establishment?
vii) How might native plant resources be manipulated most efficiently for commercial development?

This strategic proposal seeks to integrate and accelerate the work of several independent Australian and overseas research groups sharing an interest in conservation biology. An unincorporated research centre within The University of Western Australia will be established. This Cooperative Centre for Plant Conservation Genetics and Germplasm Research will increase knowledge and understanding of native plants (and animals) so that they can be better conserved and utilized. The major requirement in this Proposal is for a substantial increase in the number of research scientists active in fields relevant to conservation biology. Enhanced collaborative research and the joint supervision of postgraduate students and postdoctoral fellows will ensure that the dispersed participating scientists focus on the most important and relevant research questions.

Extinction of species in the Australian flora and fauna is occurring at a rate without parallel on other continental land masses. Eighteen mammal extinctions have occurred this century. More than 100 vascular plants species are presumed extinct, compared with only 20 for Europe, 20 for the U.S.S.R., 39 for South Africa and 90 for the U.S.A.. Recent Australian assessments of threatened species list 500 vertebrates, 400 invertebrates and 3329 vascular plants. Western Australia has 43% of the 3329 plant species listed as threatened, more than any other State on the continent and more than most other countries. Because of the relatively embryonic state of Australian taxonomic knowledge in many plant and invertebrate groups, the above figures may well underestimate the magnitude of the potential losses facing Australia over the next few decades.

The Australian flora is a powerful tourist attraction, and one of the major attractions in Western Australia. In this regard, it is a resource which supports a major set of allied service industries. There is a disproportionately high number of rare plants in the Australian flora, compared with most floras of the world. Many of the rare and endangered Australian native plants have considerable horticultural potential, and could be utilized in the multi-million dollar seed, cut flower and nursery trades. Their rarity alone makes them a highly saleable commodity. Some Australian floricultural companies already have strong international market links in the U.S.A., Europe and Japan, and could sell horticulturally desirable taxa in large numbers. Salt tolerant and industrially useful native plants, such as *Eucalyptus* species, will find a continuing role globally in the restoration of degraded environments, provision of timber, paper pulp and firewood etc. In addition, the chemical and pharmacological resources embedded in the Australian flora are poorly known and essentially untapped. These resources need to be conserved and developed. To do this, they and their environmental interrelationships need to be understood.

A focus on Western Australian plants is intended but the Centre will work on plants and animals from throughout Australia, as appropriate. The magnitude of the threat to the Western Australian flora is in part due to the genetic systems and complex environmental adaptations that characterise it. It has evolved many unusual, elaborate but unstable genetic systems, especially amongst hermaphrodite plants capable of self fertilization. These plants may tolerate high levels of self pollination but impose stringent selection upon the seeds produced, or promote enhanced levels of cross pollination. They often result in highly attractive flowering plants of considerable commercial potential but which exhibit low seed set, or poor quality seed when in cultivation. As well as genetic adaptations, morphological, anatomical, physiological and mycorrhizal adaptations to nutrient-poor and fire-prone habitats are myriad. In addition, many taxa are susceptible to introduced pathogens such as *Phytophthora* while areas of the south-west richest in local endemic species are those favoured for agriculture and therefore subject to population decimation and competition with genetically robust and environmentally tolerant weeds.

The majority of the inimical attributes which characterise the flora, however, are poorly known and therefore poorly understood. They may be of critical importance in cultivation. They have not, and as yet cannot, be taken into account in conservation, environmental management and restoration programs, and they preclude or endanger the horticultural and floricultural commercialization of many forms.

Thus the south-west provides an exceptional and challenging opportunity to investigate and mitigate the detrimental effects of European land-use practices on an ancient and complex flora, and to avail ourselves of its many riches. Without the information that intensive research can generate, we will not be able to manage our biological resources effectively.

Information concerning the reproductive biology and genetic diversity of plant population systems is particularly relevant to both the conservation and development of plant resources. Genetic diversity analysis is also particularly important in taxonomic research, in plant and animal breeding, and in tracing the origins, spread and potential threats of exotic weeds and animal pests. The increasing application of methods for assessing genetic diversity in population systems requires a common set of technological capabilities to be available to a broad spectrum of biologically oriented laboratories. While each laboratory can laboriously generate its own competence, it would be much more efficient if such laboratories had easy access to high quality technical service and advice from a central laboratory.

This proposal seeks to establish a world class laboratory and an international exchange program in which research and postgraduate training on inherited variation and germplasm manipulation is aimed at providing a much enhanced understanding of the genetic architecture of pristine and modified plant population systems. Current resources allocated to such research are too dispersed and inadequate to allow for the major advances in understanding needed if we are to arrest the major losses of biodiversity facing Australia, and the planet, over the next few decades. The Centre will integrate a large section of Australian research in conservation biology and focus the attention of dispersed research groups, especially within Western Australia, on particular problems. It will augment the research capabilities of those groups, and accelerate the resolution of those problems. Many of the principles derived from research at the Centre will have relevance to the management of biological resources similarly under threat both within and outside Australia.

The approach proposed is three-fold:

(i) To establish a research and educational program of international significance.

Ample provision will be made for hosting Visiting Fellows and postgraduate students, as well as for facilitating the exchange of staff and students and the sponsorship of appropriate conferences and workshops. The Centre will host conferences and workshops to facilitate communication among its staff, other scientists, private industry and conservation authorities. The involvement of private industry, Kings Park and Botanic Garden, and the Department of Conservation and Land Management will ensure an integrated approach to fundamental questions concerning the genetics and breeding biology of plants, ensuring relevance to the needs of industry, conservation and germplasm storage.

National and international collaboration with Centre staff, as well as exchange of staff and postgraduate students will be fostered by establishing formal or informal links with the following scientists and their laboratories:

Dr A.H.D. Brown, CSIRO, Division of Plant Industry, Canberra
Dr M.F. Fay, Micropropagation Unit, Royal Botanic Gardens, Kew
Assist. Professor P.L. Fiedler, Dept. of Biology, San Francisco State University, California
Professor J. Hamrick, Department of Botany, University of Georgia, Athens, Ga.
Dr F.T. Ledig, USDA Forest Service, Berkeley, California
Assoc. Professor J.A. McComb, Biological and Environmental Science, Murdoch University.
Dr G. F. Moran, CSIRO, Division of Forestry and Forest Products, Canberra
Professor R. Ornduff, Department of Integrative Biology, University of California, Berkeley
Professor R. Wyatt, Department of Botany, University of Georgia, Athens, Ga.

International recognition of the importance of establishing an Australian Plant Conservation Genetics and Germplasm Cooperative Research Centre is reflected in letters attached to this application. It is clear that establishment of the Centre would have a synergistic effect with overseas institutions, and attract many eminent scientists from other countries to Australia to work on the flora.

The presence of three Visiting Fellows per annum at the Centre will further enhance the educational opportunities offered. The Centre's emphasis on national and international exchange programs will extend the knowledge acquired across the globe to end-users in many countries unable to fund plant conservation genetic and germplasm research. The Centre will place a strong emphasis on attracting and training postgraduate students. Scholarships for 9 postgraduate students will be provided, along with substantial grants for their travel and laboratory costs. In addition the Centre's activities should attract a number of postgraduate students supported by currently available awards. Contributing staff from the Department of Conservation and Land Management, and Kings Park and Botanic Garden, will co-supervise postgraduate students along with University based personnel, and participate in teaching of undergraduates where relevant. A substantial input into new or existing MSc/Diploma courses relevant to plant conservation biology will be made. A postgraduate research and teaching program of this strength in the fields of plant conservation genetics and germplasm studies is currently unavailable anywhere in the world.

(ii) To equip and staff a central laboratory with the best available facilities for describing genetic diversity and the systems which modulate it.

The laboratory will specialize in the electrophoretic analysis of protein and DNA polymorphisms, cytogenetics, reproductive biology, genetic manipulation and systematics, and will provide resources and skills that can be drawn on by researchers in basic biological sciences, in horticulture, agriculture and forestry, and in conservation biology and environmental rehabilitation. The pooled resources of the central laboratory and participating institutions will enable the elucidation of factors influencing recruitment, survival and extinction in plant population systems on a scale simply not possible given current facilities and resources. The long-term storage of germplasm, focussing on endangered Australian organisms, will be the subject of a major research effort. To capitalize on expertise amongst the key scientists, research at the Centre will focus on groups such as *Eucalyptus*, the Proteaceae, Orchidaceae, Myrtaceae, Leguminosae, Stylidiaceae, Haemodoraceae, Rutaceae, Restionaceae and Liliaceae. Thus a mixture of cosmopolitan and/or globally utilized taxa (e.g. orchids, *Eucalyptus*) and uniquely Australian gondwanic taxa (eg. kangaroo paws) will be investigated to ensure international, national and local relevance.

(iii) To ensure that research results are available to private industry and implemented through the operational capabilities of the Department of Conservation and Land Management and other government agencies.

There will be a strong commitment to publish research findings in hosted and attended conferences and workshops, in the formal scientific literature, and in more popular media so that relevant data are available internationally to the widest group of end-users. While its research is likely to generate commercially valuable results in the short term, the enduring value of the Cooperative Research Centre will be its contribution at the highest level to significant research in conservation genetics. In this regard, involvement of the Department of Conservation and Land Management will provide unparalleled opportunities to apply its research results in the development and implementation of recovery and management plans for species, and, thereby, in redressing the global loss of plant biodiversity. Involvement of CALM in the Centre will ensure ready access to an administrative and field management organization with statutory obligations to conserve threatened plants through the Rare Flora provisions of the Wildlife Conservation Act. Consequently, procedures are in place to implement flora conservation research findings efficiently. Wildlife Management Plans aimed at conserving endangered species are presently developed by small working groups that include research scientists, wildlife management biologists, and field operations staff. Centre staff will participate on such planning teams, assist in monitoring, and routinely contribute advice on the implementation of their findings. Early consultation with field management staff will be fostered to ensure that key questions faced by land managers are addressed.

The commercial development of horticulturally and silviculturally desirable endangered species will be facilitated by the joint involvement of horticulturists and foresters at Murdoch and Curtin Universities, CALM and Plantex Australia Pty Ltd. The latter company has a strong committment to the commercial use of Australian native plants for floriculture. With market contacts nationally and internationally, Plantex Australia Pty Ltd's end use of germplasm obtained by the Centre's research has the potential to develop substantial income in the multi-billion dollar global trade in flowers. In addition, the Centre will provide CALM with pertinent information facilitating its statutory obligations to manage commercial wildflower harvesting.

The Centre will welcome requests for advice and technical assistance from other laboratories desirous of introducing genetic diversity analysis and germplasm manipulation into their research and development programs. Technical training and joint research ventures will be encouraged, and on a contract basis where appropriate. This service will be particularly valuable in the development and commercialization of new forms in the horticultural, floricultural and timber industries. An immediate extension of the service may be found in its application to freshwater crayfish (marron) *Cherax tenuimannus* whose concurrent commercial exploitation, recreational fishing and conservation will be possible only given a thorough knowledge of the genetic diversity it contains and how it is modulated.

COOPERATIVE ARRANGEMENTS AND ROLES OF PARTICIPATING INSTITUTIONS

It is intended to establish the main laboratory and Centre administration at the Department of Botany in The University of Western Australia. Substantial new office and laboratory facilities will be required. The Centre would provide a central facility for use by participating institutions in Western Australia, as well as by interested national and international organisations. Visiting Fellows, Postdoctoral Fellows and postgraduate students would be accommodated at this laboratory unless one of the other networked institutions was more appropriate. The central laboratory's role will be mainly in the provision of capability in the analysis of genetic diversity and will maintain a close association with the C.S.I.R.O. Forestry and Forest Products laboratory in Canberra.

Within the Department of Conservation and Land Management, networked laboratories and facilities will include some of those at the Western Australian Wildlife Research Centre, at the Western Australian Herbarium, and, if required, at country research centres and field laboratories in Manjimup, Narrogin, Tutanning, Two Peoples Bay, Perup and Karratha. Kings Park and Botanic Garden will contribute seed storage, glasshouse and tissue culture laboratory facilities, while other specialized laboratory facilities will be available at Curtin and Murdoch Universities and at the Plantex Australia Pty Ltd facility.

Each of the participating institutions will retain its existing research or applications group working in fields relevant to plant conservation biology. The Centre will augment and integrate the research directions of these groups by appropriately allocating Postdoctoral Fellows and resources.

It is intended that a number of new staff will be established, including 12 Postdoctoral Fellowships in subject areas and located, in the first instance, as follows:
- Isozyme diversity analysis, at the central laboratory.
- DNA diversity analysis, at the central laboratory.
- Diversity analysis and the conservation genetics of trees, at the central laboratory and CALM.
- DNA manipulation in plant breeding, at the central laboratory.
- Cytogenetics and breeding systems, at the central laboratory.
- Population demography, at the Wildlife Research Centre, CALM.
- Long-term germplasm storage, at Kings Park and Botanic Garden.
- Systematics - two positions, at the Herbarium, CALM, and Botany Department, UWA.
- Horticultural & floricultural commercialization, at Murdoch University and Plantex Pty Ltd.
- Pollination biology and regulation of seed set, at CALM and Curtin University.
- Population modelling & extinction scenarios, at Curtin University.

One of the Postdoctoral Fellow appointments will be made at a Professorial level to accommodate requirements for a high level of skill in DNA technology. The scientists would require support staff as follows:

- 12 Technical Officers to assist the above scientists, Visiting Fellows and Key Scientists
- Administrative Assistant
- 3 Typist/Clerical Officers

In addition to new staff, the Centre would fund 3 Visiting Fellow positions annually, 9 postgraduate students, and facilitate 6 exchange positions annually with participating national and international institutions.

PERFORMANCE INDICATORS

1. Elucidation of general principles pertaining to the systematics, conservation genetics and germplasm manipulation of endangered plants.
2. Production of taxonomic treatments identifying threatened taxa in morphologically diverse groups.
3. Establishment of techniques for predicting, measuring and monitoring plant extinction rates.
4. Mitigating the threats facing species and enhancing populations so that they are no longer endangered.
5. Effective long-term germplasm storage of significant numbers of taxa.
6. Successful habitat re-establishment of endangered taxa.
7. High quality publications and theses.
8. Appointment of postgraduates and Postdoctoral Fellows to permanent positions in high quality research and teaching establishments.
9. Research results successfully put into practice by CALM and other government and private agencies, including production of Wildlife Management Programs.
10. Development and commercialization of new horticultural, floricultural and silvicultural products.
11. Development of a significant contract research portfolio.

V. MANAGEMENT STRUCTURE

The Centre will be a part of The University of Western Australia and managed by an Executive Director, Dr S. D. Hopper. The Executive Director will be advised by a management committee comprising the key scientists from each of the participating institutions and two independent persons, one a non-participating business administrator and one a scientist. Representation of the Postdoctoral Fellows and the technical staff will also be included. For administrative purposes, the Executive Director would be granted appropriate status by The University of Western Australia, perhaps by secondment. Receipt and disbursement of funds would be through the usual channels of the Botany Department at The University of Western Australia whose management is familiar and experienced with diffuse systems of research funding, such as that associated with The Centre for Water Research. Audit of accounts would be controlled by The University of Western Australia.

Research responsibility would flow from the Executive Director and the management committee to relevant participating scientists who would collaborate with and be responsible for the Postdoctoral Fellows and support staff within their field of expertise (Figure 1). The selection of Visiting Fellows, supervision of postgraduate students, and organisation of the exchange program would likewise follow similar lines of responsibility.

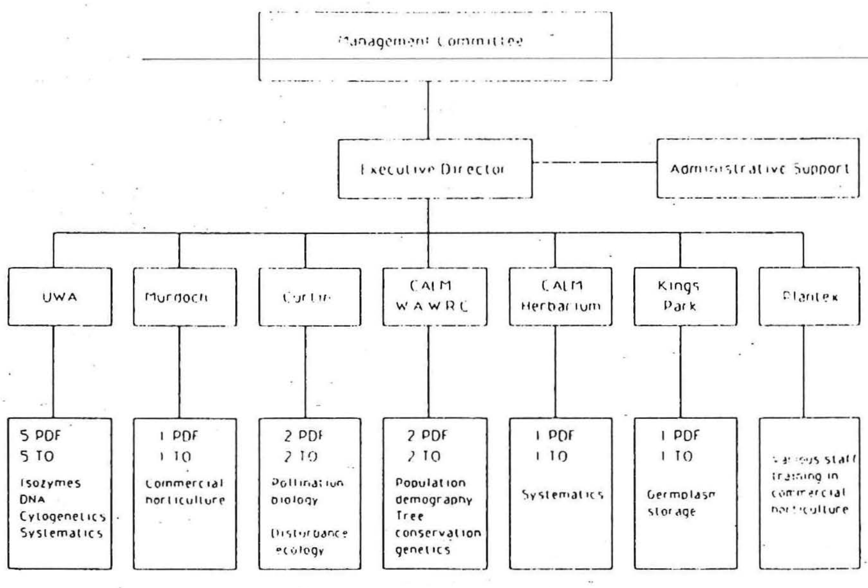

Figure 1. Proposed administrative structure.

The Centre would be largely self-sufficient administratively, with the Administrative Assistant and Typistes responsible to the Executive Director. All staff and students will have ready access to personal computers to disperse word processing and other computing requirements.

CRC PROPOSAL FOR PLANT CONSERVATION GENETICS AND GERMPLASM

INPUT FROM PARTICIPATING INSTITUTIONS	1991 $	1992 $	1993 $	1994 $	1995 $
DEPT. OF CONSERV'N AND LAND MANAGEMENT					
Salaries x3	951624	1046786	1151465	1266612	1393273
External Grants	50000	50000	50000	50000	50000
THE UNIVERSITY OF WESTERN AUSTRALIA					
Salaries x3	371400	408540	449394	494333	543767
External Grants	10000	10000	10000	10000	10000
Success Grant	200000				
KING'S PARK AND BOTANIC GARDEN					
Salaries x3	157416	173158	190473	209521	230473
External Grants	155000	155000	155000	155000	155000
CURTIN UNIVERSITY OF TECHNOLOGY					
Salaries x3	227451	250196	275215	302737	333011
External Grants	100000	100000	100000	100000	100000
MURDOCH UNIVERSITY					
Salaries x3	48720	53592	58951	64846	71331
External Grants	50000	50000	50000	50000	50000
PLANTEX AUSTRALIA PTY LTD					
Salaries x3	40000	44000	48400	53240	58564
Facilities & Training	60000	60000	60000	60000	60000
POTENTIAL EXTERNAL INCOME					
Consultancy and Training	5000	20000	25000	30000	35000
Contract Research	20000	50000	100000	100000	100000
New External Grants		50000	100000	120000	150000
Royalties			10000	50000	100000
TOTAL INSTITUTIONAL CONTRIBUTION	2446611	2521272	2833899	3116289	3440418

EXPENDITURE: CRC GRANT REQUESTS	1991 $	1992 $	1993 $	1994 $	1995 $
CAPITAL WORKS					
New Building/Extension	100000	1100000	800000		
STAFF SALARIES					
Postdoctoral Fellows (12)	209126	376718	495195	546701	546701
Technical Officers (12)	129430	260575	395238	403139	410110
Admin. Assistant	37434	38501	39601	40730	40730
Typiste/Clerical Officer (3)	51178	77560	79144	79144	79144
VISITING FELLOWS					
Airfares, allowances (3)	20000	44000	72600	79860	87846
POSTGRADUATE STUDENTS					
Scholarships (9)	39000	85800	141570	155727	171300
Travel, research allowance (	30000	66000	108900	119790	131769
EXCHANGE PROGRAM					
Airfares, allowances (4)	20000	44000	96800	106480	117128
OPERATING COSTS					
Research team support (12)	80000	176000	290400	319440	351384
Consumables, workshops etc.	30000	65000	100000	110000	121000
Publications	20000	55000	85000	93500	102850
VEHICLES					
6x 4WD, 6x 2WD	80000	80000	80000		
COMPUTERS					
PC's etc (25)	25000	50000	50000		
EQUIPMENT					
Lab. equipment	80100				
EXPENDITURE: CRC GRANT REQUEST	951268	2519154	2834448	2054511	2159962
TOTAL CRC PROJECT COSTS	3397878	5040426	5668347	5170800	5600380

BUDGET SUMMARY

	1991 $ (000)	1992 $ (000)	1993 $ (000)	1994 $ (000)	1995 $ (000)
Total Committed	3 398	5 040	5 668	5 171	5 600
Institutional	2 447	2 521	2 834	3 116	3 440
CRC GRANT REQUEST	951	2 519	2 834	2 055	2 160

The budget has been estimated on the following basis:

Contributions from Participating Institutions

1991:

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT ....total $1 001 624

Salaries (Hopper 100% SPRS L8, Coates 100% SRS L6, Armstrong 40% SPRS L8, Marchant 50% PRS L7, Rye 50% RS L5, Patrick 40% RS L5, Sokolowski 50% STO L5, Brown 50% TO L3, various others as minor participants equivalent to 50% of a Senior Research Scientist L6 and 50% of a Technical Officer L3) x 3 for administrative overheads, operational costs, office and laboratory rental etc..$ 951 624

External grants ....$ 50 000

THE UNIVERSITY OF WESTERN AUSTRALIA.................................total $581 400

Salaries (James 50% SL, Chappill 50%, Pate 10%Prof. , 6 postgraduate students, 2 honours students) x 3 for administrative overheads, operational costs, office and laboratory rental etc...$ 371 400

External grants ....$ 10 000

Success Grant ....$ 200 000

KINGS PARK AND BOTANIC GARDEN..total $ 312 416

Salaries (K. Dixon 50% SRB L6, Bunn 70% L2/4, I.R. Dixon 5% L3) x 3 for administrative overheads, operational costs, office and laboratory rental etc..................................$ 157 416

External grants ....$ 155 000

CURTIN UNIVERSITY OF TECHNOLOGY..total $ 327 415

Salaries (Collins 20% Prof., Lamont 20% Snr L, Tan 20% L, Witkowski 30% Res F,McNee 20% Res Asst, Walton 20% res Asst, Miodeczieski 20% Tecn) x 3 for administrative overheads, operational costs, office and laboratory rental etc..................................$ 227 415

External grants ....$ 100 000

Success Grant ....$ 50 000

MURDOCH UNIVERSITY...total $ 98720

Salaries (Considine 10% Prof, Pop. Geneticist 30% Res F) x 3 for administrative overheads, operational costs, office and laboratory rental etc...$ 48 720

External grants ....$ 50 000

PLANTEX AUSTRALIA PTY LTD..total $ 100 000

Salaries(A. Bowden 10% Co Director, I Bowden Co Director, Technician 100%)......$ 40 000

Facilities (Greenhouse, tissue culture facility) and Training.....................................$ 60 000

* The External grants do not include Commonwealth funded competitive grants.

1992 - 1995:

The salary components rise by 10% per annum.

The External grants component is maintained at a constant level.

The Success Grants, conditional on being awarded a CRC grant, are available only in the first year.

New Expenditure to be funded by CRC Grant

NEW BUILDING OR EXTENSION TO FACILITIES................................total $ 2 000 000

New laboratory and office facilities to accomodate between 15 and 20 staff (Director, Postdoctoral Fellows, Technicians, Visiting Fellows, Postgraduate Students, Administrative Staff) Mainly at UWA but also at Curtin and Murdoch as required.

When fully operational, the Centre will support the following new salaries, allowances and operating costs per annum:

NEW STAFF..total $ 1 043 246

The salary scales given are at the initial appointment rate.

12 Postdoctoral Fellows 11x @ $ 33163,1x Prof. level @ $ 67 812 + 25% administrative overheads ....$ 540 756

12 Technical Officers L2 1st position @ $25886 + 25% administrative overheads ..$ 388 290

Administrative Assistant L3 1st position + 25% admin. overheads ....$ 37 434

3 Typiste/Clerical Officers L1 2nd position+ 25% admin. overheads $76 766

VISITING FELLOWS

airfares, accomodation and research allowances x3...$60 000

POSTGRADUATE STUDENTS

9 scholarships @ 13 000...$ 117 000

9 travel, research grants @ $10000...$ 90 000

EXCHANGE PROGRAM

airfares, accomodation and research allowances for 6 postgraduates or Centre staff per year @ $20 000 each...$ 120 000

OPERATING COSTS

12 teams (Postdoctoral Fellow + Technician) @ $20 000 travel, consumables etc.....$240 000

Consumables, supplementary costs for key scientists, workshops etc..........................$ 100 000

Publications, including Wildlife Management Programs ....$ 100 000

In addition, the Centre will require the following Capital items:

VEHICLES

6 4WD @ $25 000 ....$ 150 000

6 2WD @ $15 000 ....$ 90 000

COMPUTERS

25 personal computers, printers and software @ $5000 each....................................$ 125 000

EQUIPMENT ....total $ 80 100

Dry block $1 500	Cassettes $4 000
Shaking water bath.... $3 200	Hybaid ovens $3 900
Laminar Flow $3 500	P32 lab....$25 000
Incubators................. $ 5 000	Chemicals, consumables ....$ 4 000
Liquid N Dewar ....$ 6 000	Herbarium facilities $20 000

It is anticipated that the Centre will build up its personnel and capital items to full strength over the first three years. In estimating the CRC Grant requirements for the first five years, build-up, salary increments and staff turnover have been anticipated according to the following scheme:

	1991	1992	1993	1994	1995
BUILDING	$100,000	$1,100,000	$800,000		
PDF Appointments	4	6	6	4	4
PDF Terminations		2	2	4	4
TO Appointments	4	6	6	2	2
TO Terminations		2	2	2	2
T/CO Appointments	2	2	1	1	1
T/CO Terminations		1	1	1	1
Vehicles - 4WD	2	2	2		
Vehicles - 2WD	2	2	2		

VII. REFEREES

Australian:

Dr Tony Brown, CSIRO Division of Plant Industry, PO Box 1600, Canberra ACT 2601
Telephone: (06) 246 4911 Fax: (06) 246 5000

Dr Gavin Moran, CSIRO Division of Forestry and Forest Products, PO Box 4008, Canberra ACT 2601
Telephone: (06) 281 8211 Fax: (06) 281 8312

International:

Dr Tom Ledig, U.S.D.A. Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, California 94701 USA
Telephone: Fax:

Dr Michael. F. Fay, Supervisor, Micropropagation Unit, Royal Botanic Gardens, Kew, Richmond, Surrey TW9 3AB England
Telephone: 01-940 1171 Fax: 01-948 1197

AUSTRALIAN GOVERNMENT COOPERATIVE RESEARCH CENTRES PROGRAM

APPLICATION

FOR

PLANT CONSERVATION GENETICS
AND
GERMPLASM

COOPERATIVE RESEARCH CENTRE

APPENDICES

Letters of Support

Curricula vitae

(a) Scientists

(b) Commercial

Relevant Publication

United States Department of Agriculture | Forest Service | Pacific Southwest Forest and Range Experiment Station | 1960 Addison Street P.O. Box 245 Berkeley, CA 94701

Date: October 3, 1990

Dr. Stephen D. Hopper
Western Australian Wildlife Research Centre
Department of Conservation and Land Management
P.O. Box 51
Wanneroo, Western Australia 6065
AUSTRALIA

Dear Steve:

I strongly support your proposal to establish a Cooperative Centre for Plant Conservation Genetics and Germplasm Research. My enthusiasm could not be greater.

The need for such a centre is more critical than any other I can imagine. Extinction is merciless; it gives no second chance. If research on superconductors, as an example, is postponed for a year, the damage is not irreparable; the same experiments can be conducted next year. On the other hand, every year that we postpone research on genetic diversity, more species go extinct, and for those that don't go extinct but merely continue a downward slide, the eventual costs of remediation escalate.

The returns are more substantive than they appear. Tourist dollars are, of course, linked to Australia's unusual plants and animals, and even the most obscure species may yet provide valuable products. But more important is the intrinsic value of native plants and wildlife to Australians. To paraphrase one of our statesmen, Clinton Anderson: A great people conserve their resources, they are not scratching every last nook and cranny for a board of lumber or a grain of wheat. Your biota, and ours, are the canaries in the mine -- when they begin to fade, our societies will shortly follow.

The greatest strength of your proposed centre is its world class scientists: i.e., you, Dave Coates, your cooperators (e.g., Gavin Moran and Tony Brown), and your students. The intimate connection of your centre with land management agencies is another strong point, often missing when research is conducted solely within the confines of academic departments. The active involvement of field managers and research scientists is bound to be synergistic. I imagine also that your centre will improve graduate education in conservation biology by making government scientists even more available to the university community than they are now, although your efforts in that arena are already considerable. Finally, it is important that the centre's work will not stop at research, that you will take an active role in conservation by establishing germplasm collections at the Kings Park and Botanic Garden. Conservation efforts in botanic gardens would benefit, in general, by considering the importance of genetic diversity to their plant collections.

Your Centre will provide an opportunity to link our two institutions; as you know by my last letter, in August the U.S. Forest Service created a new Center for Conservation of Genetic Diversity within the Institute of Forest Genetics. Our laboratory and residence facilities at the Institute could be used by Australian students and scientists working on topics that promise to result in principles of mutual interest.

We do have substantial reasons for improving communication. We have similar concerns because we are both located in Mediterranean climates in areas with extremely high levels of endemism. In addition, Australian eucalypts are economically important to California; their conservation is in our best interests. Furthermore, our Center may provide sites for <u>ex situ</u> conservation of some of your flora as well as testing grounds for research best conducted away from Australia. For example, the chestnut blight fungus and some of our phytophthora root rots (one of which is responsible for dieback of jarrah) have the potential to play havoc with your flora; testing for resistance or susceptibility can identify threats before they occur, and testing here would provide a degree of containment unattainable if similar research were to be conducted in Australia.

In brief, your proposed centre would fill an important role in Australia and would be welcomed on the world stage as well. I support it strongly and look forward to formal linkages and exchanges.

Sincerely,

Tom Ledig

F. Thomas Ledig
Senior Scientist
Institute of Forest Genetics

2502 Plant Sciences
Athens, Georgia 30602

The University of Georgia

College of Arts and Sciences
Department of Botany

TEL (404) 542-3732
FAX (404) 542-1805

October 4, 1990

Dr Stephen D Hopper
Senior Principal Research Scientist
Western Australian Wildlife
Research Center
P.O Box 51
Wanneroo, W.A 6065
AUSTRALIA

Dear Steve,

I have just returned from an international conference in Uppsala, Sweden, on conservation of biodiversity and have read your application for an Australian Plant Conservation Genetic and Germplasm Cooperative Research Centre. I must say that I am impressed! After hearing talk after talk about endangered plants and the myriad threats to their continued existence, I had begun to despair of our chances of acting quickly enough to learn what we need to in order to save them. Your proposed Centre, however, would provide just such a mechanism for discovering the critical parameters and training scientists who can then put sound conservation policies into practice. Australia could quickly become the world leader in this important area.

Your plans for development of the Centre sound eminently reasonable to me. The proposed team of scientists includes a number of world-class botanists, who have made their mark in a range of disciplines relevant to conservation biology: from systematics and cytogenetics to physiological ecology and tissue culture. Individually each of these scientists is excellent in his narrow specialty, but as part of a coordinated team they will form a research force unequalled anywhere in the world. Whereas it is unlikely that all of these researchers would independently focus on conservation of genetic diversity, your proposed Centre would facilitate their banding together to attack this complex, multifaceted problem. I believe this group would have an excellent chance of making rapid progress in this area

I am personally flattered that you have included my name among the list of proposed international collaborators. Certainly my students and I would be delighted to participate as fully as possible. My own research program is moving strongly in the direction of studies of the population genetics and ecology of rare and endangered species, and I certainly have benefited from my continuing collaborations with you, Sid James, and others in Western Australia. The Centre would serve to facilitate and expand the growing international cooperation between research groups in the United States and Australia.

Finally, I recognize the strength of your argument that the proposed Centre is uniquely positioned to put the results of scientific research into immediate practice. I have been impressed in previous visits to Western Australia by the level of cooperation between basic research scientists and governmental agencies like the Department of Conservation and Land Management. This sort of arrangement ensures that the findings of researchers at the new Centre will be put to use as soon as they become available. This close link is absolutely vital in the case of potential loss of biodiversity. The capacity to act speedily is especially critical in Western Australia, where the number of endangered species is exceptionally high and many ecosystems are extremely fragile. It would be a true shame to lose this diversity before we have even begun to scratch the surface in appreciating its horticultural, medicinal, and other economic values.

In short, I endorse your proposal for a Plant Conservation Genetics and Germplasm Cooperative Research Centre with highest enthusiasm. I salute you and the Australian government for your vision in getting a vital, world-class effort in conservation of biodiversity off the ground.

Sincerely,

Robert Wyatt
Professor of Botany

RW/bh

Royal Botanic Gardens, Kew, Richmond, Surrey, TW9 3AB, England

ROYAL BOTANIC GARDENS KEW

Dr S.D. Hopper
Western Australian Wildlife Research Centre
PO Box 51
Wanneroo, W.A. 6065

Dear Dr Hopper

Thank you for your letter of 19/9/90, and the enclosed documents, concerning support for your grant application for a cooperative research centre.

I have now read through the proposal and consider it to be a very interesting document, which, if implemented, will give Western Australia a leading role in the field of plant conservation.

The Royal Botanic Gardens, Kew, has long had a major interest in the conservation of particular endangered floras, our collaborative projects on the floras of St Helena, the Canary Islands and the Mascarenes being examples of the types of work with which we have been involved. We have been successful in propagating many endangered species from such floras, either *in vivo* or *in vitro*. These plants have then been distributed to other botanic gardens in order to ensure their survival at a range of sites, and in a number of cases have been returned to the country of origin. For example, our collaborative work with the Botanic Gardens at Las Palmas, Gran Canaria, has included the successful micropropagation of the endangered endemic *Globularia sarcophylla*, and the return of plants for reintroduction trials.

However, working on the floras of islands remote to the U.K. does present certain problems, in particular with respect to reintroduction of plants into wild locations. This is due to the remoteness of the sites, which makes subsequent management difficult, and the lack of suitable expertise on the islands.

In the light of the above comments, we would be very happy to support the establishment of a research centre looking at the conservation of Western Australian plant genetic resources. The flora in this region represents a significant and irreplaceable element of the world's plant diversity. The fact that the flora has very high levels of endemism and also of species extinction compared to most other parts of the globe makes it even more important that powerful measures to ensure its conservation be instituted as soon as possible.

The concept of bringing together researchers from a range of relevant fields to work on population genetics, propagation, long term germplasm storage, reintroduction and habitat management is eminently sensible and would lead to far quicker progress than would be possible where the various projects were being carried out at different sites. Your publication concerning the conservation program for *Eucalyptus rhodantha* would hopefully become one of many publications of this type.

Telephone 01-940 1171 Fax 01-948 1197 Telex 296694 KEWGAR

In addition, the fact that the species worked on are endemic to the region where the Centre would be situated means that the management of plant reintroduction will be far more straight forward and more likely to be successful. The example of the successful reintroduction of orchid seedlings, produced *in vitro* at Kew, into protected sites in the U.K. supports this statement.

The problems associated with genetic 'bottleneck' situations where populations of endangered species have fallen to critically low numbers and the effects on plant genepools are poorly understood. Preliminary work on the two endemic species of *Trochetiopsis* from St Helena, has shown that one has managed to retain a far higher level of genetic diversity than the other, although both are reduced to critically small populations. Definitive work on the Australian flora in this respect could take on an international significance in providing explanations for similar situations.

The Royal Botanic Gardens, Kew, would hope to maintain a close link with the new research centre. Possible areas of collaboration would include development of techniques for micropropagation and cryopreservation, the latter being a field in which we hope to start work when a source of funding has been located.

We will be holding an international conservation conference in September 1991 entitled 'From Specimen to Habitat Management', examining some of the problems associated with reintroduction of plants to the wild, and would hope that you and your colleagues will be able to participate in this meeting.

In conclusion, I wish you success with your grant proposal and would be willing to act as an international referee if so required.

With my best wishes

Yours sincerely

Michael F Fay

Dr Michael F Fay.

San Francisco State University
1600 Holloway Avenue
San Francisco California 94132

Department of Biology
415/338-1548

1 October 1990

Dr. S.D. Hopper
Western Australian Wildlife Research Centre
Department of Conservation and Management
P.O. Box 51
Wanneroo, Western Australia 6065

RE: Proposal for an Australian Plant Conservation Genetics and Germplasm Cooperative Research Centre

Dear Steve:

I have reviewed carefully your proposal for the establishment of an Australian Plant Conservation Genetics and Germplasm Cooperative Research Centre, and I want to offer my complete support of its immediate funding. There are several extremely persuasive reasons why I believe that your proposal should be funded in the first round of Australian government-funded research centres, and the first of which is that this Centre would be the first of its kind in the world. Thus Australia would clearly emerge as a world leader in rare plant conservation. This is *extremely important*, as you point out in your proposal, in a region (*i.e.*, Western Australia) of extraordinarily high plant species endemism and extinction. Secondly, the proposal will foster the education of all levels of students (*e.g.*, post doctoral, post graduate, *etc.*) in both the field and laboratory. As a professor in primarily a teaching institution, I cannot emphasize enough how important non-classroom education is to our botany students. Such opportunities are now rare in the United States, but represent a crucial component in professional botanical training. As evidence, my own early work with Drs. O.T. Solbrig, R.E. Cook and T.C. Plowman at the Harvard University Herbarium *still* serves me in my research, nearly twenty years hence. This component alone speaks strongly of the proposal. The third reason why I believe the proposal should be funded immediately is that the research that will be produced will have enormous utility to the botanical community world-wide. As a botanist who has devoted the last 10 years of research to understanding the demography of rare plant species, I can assure you that virtually all of the results that you propose to produce from this centre (*e.g.*, taxonomic treatments of endangered taxa, principles of conservation of germplasm of rare species, habitat re-establishment techniques) are desperately needed by the conservation community. Quite simply, your results would have *immediate* relevance and utility to the conservation of rare and endangered plant species worldwide.

As for the formal collaboration with the Centre of myself and my graduate students, I happily and eagerly commit to the Centre as soon as is possible. Presently, I have several students working on the biology of rare plant species in California, and their research ranges from plant systematics to metapopulation dynamics of rare plant species. Personally, I believe you are aware of my long-standing research interests in areas that fit neatly with the proposed Centre -- these being the evolution and systematics of the Proteaceae, and the comparative demography of rare and common congeners. I am eager to combine these interests in collaborative work with you.

If you need any addition information from me regarding this proposal, please don't hesitate to contact me at (415) 338-6270.

Best regards,

Peggy

Peggy L. Fiedler

SEP 28 '90 09:46 DEPT OF ZOOLOGY P.1/1

UNIVERSITY OF CALIFORNIA, BERKELEY

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO SANTA BARBARA • SANTA CRUZ

DEPARTMENT OF INTEGRATIVE BIOLOGY BERKELEY, CALIFORNIA 94720
FAX 415 643 6264

September 27 1990

Dr. S.D. Hopper
Dept of CALM
FAX 09 306 1641

Dear Steve,

Thanks for your recent letter regarding the proposed Centre. I think it is a fine idea; I don't know if you are aware that the Forest Service in Berkeley has a similar, but much less ambitious, scheme. I am not sure when you ask for my support, just how I should give it--a letter to you, or someone else? I'd be happy to help out however I can.

One of the problems that I have seen in this country is the lack of a creative stance on the part of any organization, including the Center for Plant Conservation. The symposium dealing with the genetics of rare species held at St Louis was a step in the right direction, but guidelines for sampling rare species for seed storage struck me as naive. Possibly you saw these when you were here, but they were based on electrophoretic data and I pointed out to CPC that the nature of genetic variation should be taken into consideration. For example, if a species contains autogamous and allogamous races, both should be included in sampling, or if there are edaphic ecotypes, these should be included. They may or may not show up in gels.

I think having a center such as you have in mind would be very useful in influencing opinions about conservation strategies, and would provide model studies in the kind of population biology that should be studied as a basis for understanding the causes of rarity and developing strategies for in situ or ex situ conservation. I do not see any institution or organization in this country taking the lead, so your centre could easily become one of international significance.

I would, of course, be delighted to cooperate in whatever way I can. Three of my four current graduate students are working on genera that include rare taxa, but there are too few published precedents to guide their work. Your centre is really a fine idea, and I wish you success in getting it funded.

Regards,
Bob
R. Ornduff
Professor

The University of Georgia

2502 Plant Sciences
Athens, Georgia 30602

TEL (404) 542-3732
FAX (404) 542-1805

College of Arts and Sciences
Department of Botany

October 11, 1990

Dr. S. D. Hopper
P.O. Box 51
Wanneroo, W.A. 6065
Australia

Dear Steve,

Thank you for the opportunity to review your proposal for an Australian Plant Conservation Genetics and Germplasm Cooperative Research Center. I found the proposal to be well done and am quite excited about the possibility of such a Center. There is little doubt that such a Center is needed, and as you state in your proposal, Western Australia with its large number of endemic species is a logical place for the Center to be located.

I also which to thank you for the opportunity to establish future collaboration between my laboratory and the proposed Center. The idea of an exchange of post doctorals and graduate students is very appealing and I would like to take advantage of it. As you know, much of my current research on tropical trees has direct implications to the conservation of genetic diversity in these species. Since your visit last Spring my lab has received funding from the Nature Conservancy and the U.S. National Park Service to study the levels and distribution of genetic diversity in several endemic plant species. In the future I foresee that my laboratory will become increasingly involved with questions with direct application to conservation biology. Of special interest are the effects of population fragmentation and isolation on genetic diversity and plant breeding systems and the effects of management practices on the genetic structure of plant populations. I was, therefore, quite pleased that concern for management would be one of the tasks undertaken by the proposed Center.

I feel that your students would benefit greatly from the kind of exchange proposed. In addition to my lab and that of Dr. Robert Wyatt's there is a large and active group of population geneticists at the University of Georgia. Of special value to your program would be Dr. John Avise and Dr. Michael Arnold both of whose research is involved with molecular evolution and evolutionary biogeography. Dr. Arnold, although an U.S. citizen, took his degree at the Australian National University with Professor D.D. Shaw.

In conclusion, I would find an interaction between your proposed Center and my laboratory to be a great benefit to my program in plant population genetics. I wish you the best of luck in obtaining the requested funding.

Sincerely,

Jim

James L. Hamrick
Research Professor of
Botany and Genetics

RW/bh

JAMES ANDREW ARMSTRONG - Abbreviated Curriculum Vitae

Born: February 24, 1950, Sydney Australia
Married with two children aged 10 and 6.

Academic qualifications: B.Sc.Agr. 1971, University of Sydney.
Ph.D. (submitted), University of New South Wales.

Current position: Senior principal Research Scientist and Curator Western Australian Herbarium, Western Australian Department of Conservation and Land Management. Appointed February 1989. Responsible for the administration and scientific leadership of 30 permanent research staff and 5 consultant biologists. Responsible for the management of the State Herbarium in Perth, three Regional Herbaria (in Albany, Karratha and Manjimup), 57 Field Herbaria (throughout the State) and for the management of the Dwellingnup Research Centre. Oversees work in the research programs of Flora Collections, Flora Conservation, Flora Information and Plant diseases and responsible for providing expert advice on matters relating to flora, particularly threatened flora, and on plant diseases. Conducts research on the phylogeny, taxonomy, phytochemistry, biogeography and breeding biology of gondwanic plant families, particularly Rutaceae. Represents Western Australia on the Council of Heads of Australian Herbaria and on the CONCOM Working Group on Endangered Flora. Represents Oceania on the CITES Plants Committee, is a Director of the Australian Flora Foundation and a member of the: Western Australian Floriculture Industry Advisory Committee; Australian Academy of Science's Flora of Australia Committee; Australian Flora Foundation Research Committee and the National Forensic Resource Unit. Recently appointed an Expert Examiner by the National Cultural Heritage Committee.

External Grants 1980-90: a total of $175,000 attracted, mainly for plant research, herbarium databasing and the conservation biology of threatened plant taxa. Grants obtained from the Australian National Parks and Wildlife Service, the Australian Flora Foundation, the National Parks and Nature Conservation Authority, the Stade Foundation and the World Wildlife Fund (Australia).

Publications: Editor/coeditor of four stand alone publications; author/coauthor of some 29 botanical papers and 12 published abstracts of papers presented at national and international conferences.

Curriculum Vitae for Dr Jennifer Anne Chappill

Qualifications: B.Sc.(Hons.) (Melbourne 1980)
M.Sc. (Melbourne 1984)
Ph.D. (Melbourne 1988)

Date and Place of Birth: 26 July 1959, Heyfield, Victoria, Australia

Current Position: Lecturer, Department of Botany, University of Western Australia, Nedlands 6009, WA. Appointed July, 1990.

I am responsible for teaching plant diversity and systematics at first, second and third year level and anticipate supervising honours and post-graduate students in coming years. I am also responsible for the running of the UWA herbarium.

My field of research is in legume systematics and I have three projects I am currently working on:

1. Phylogenetic Relationships in the Legumes and Related Families.
2. Taxonomic Revision of *Jacksonia:* (in collaboration with Mr I Telford and Dr M. Crisp, Australian National Botanic Gardens, Canberra)
3. Phylogenetic Significance of Actinorhizal and Rhizobial Nodules in the Angiosperms (in collaboration with Dr J. West of CSIRO Division of Plant Industry, Canberra)

I would bring to the Centre a broad knowledge of systematic methodology. My interests are at all levels of the taxonomic hierarchy from the population to the ordinal level and I am conversent with the numerical methods appropriate for analysing both population level problems (various phenetic methods) and supraspecific problems (cladistic methods).

I have developed links with a number of research institutions worldwide, especially in relation to my legume research and intend to maintain these links in the future. Such major institutions and my primary contacts there are: Harvard University Herbaria where I had a post-doctoral fellowship with Prof. P. Stevens; The Natural History Museum in London where I worked in 1987 with Dr C. Humphries; Royal Botanic Gardens, Kew (Dr R. Polhill); Australian National Botanic Gardens (Dr M. Crisp); and the Australian National Herbarium (Dr J. West).

Refereed Publications:

[1]Chappill, J.A., Ladiges, P.Y. and Boland, D.J. (1986). Variation in *Eucalyptus aromaphloia* Pryor & Willis: A redefinition of geographical and morphological boundaries. *Aust. J. Bot.* 34, 395-412.
[2]Humphries, C.J. and Chappill, J.A. (1988). Systematics as Science: A Response to Cronquist. *Botanical Review.* **54**, 129-144.
Chappill, J.A. (1989). Quantitative characters in phylogenetic analysis. *Cladistics* **5**, 217-234.
[2]Ashton, D.H. and Chappill, J.A. (1989). Secondary succession in post-fire scrub dominated by *Acacia verticillata* (L'Hérit.) Willd. at Wilsons Promontory, Victoria. *Aust. J. Bot.* **37**, 1-18.
[3]Chappill, J.A., Crisp, M.D. and Prober, S. (1990). *Eucalyptus elaeophloia:* a new species from the Nunniong Plateau, Victoria. *Aust. Syst. Bot.* **3**, 275-9.

1. 80 - 90% contribution by JC
2. 50% contribution
3. 60% contribution

DAVID JACK COATES - Abbreviated Curriculum Vitae

Born February 2, 1953, London, U.K.
Married with two children aged 3 and 5.

Academic Qualifications :
B.Sc. (Hons) 1974, University of Western Australia
Ph.D. 1978, University of Western Australia.

Previous Appointments :
Temporary Senior Tutor (Genetics) ,1979, The Australian National University (ANU). Postdoctoral Fellow, 1980 - 1982, Research School of Biological Sciences, ANU. Research Fellow, 1983 - 1985, Research School of Biological Sciences, ANU.

Current Position :
Senior Research Scientist, Western Australian Department of Conservation and Land Management. Program Leader Flora Conservation Research Program. Responsible for 10 permanent staff and 4 consultant botanists at the W.A. Wildlife Research Centre and the W.A. Herbarium. Conducts research in the Flora Conservation and Silviculture research programs, with particular interests in population biology, genetic systems, systematics, population and evolutionary genetics of threatened plants, triggerplants (Stylidaceae), banksias and *Eremaea*.

External Grants 1990-91:
A total of $175 000 attracted for plant conservation and genetic system research from the Australian National Parks & Wildlife Service (Endangered Species Unit), Australian Research Council and private business .

Publications
Author / coauthor of 27 papers in refereed journals and 4 management plans or technical reports in edited conservation literature. key publications relevant to the CRC proposal include:

Coates, D.J. (1988). Genetic diversity and population structure in the rare Chittering grass, *Acacia anomala*. *Australian Journal of Botany* 36: 273-286.
Coates, D.J. and Hnatiuk, R.J. (1990). Systematic and evolutionary inferences from isozyme studies in the genus *Eremaea* (Myrtaceae). In Plant Systematics in the Age of Molecular Biology, eds Ladiges, Brown and Briggs. *Australian Journal of Systematic Botany* 3 : 59-74.
Hopper, S.D. & Coates, D.J. (1990). Conservation of genetic resources in Australia's flora and fauna. *Proceedings of the Ecological Society of Australia* 16 : 567-577.
Sampson, J.F., Hopper, S.D. & Coates, D.J. (1989). *Eucalyptus rhodantha*. Western Australian Wildlife Management Program 4. (CALM, Perth).

Brian Gordon Collins - CV

Born 26th June, 1936, at Werrimul, Victoria.

Married, with one male dependent child (aged 17 years).

<u>Academic Qualifications:</u> B.Sc. (Melb.) (1957) - with honours in Zoology, Phsiology and Botany; M.Sc. (W.A.) (1971) - physiological ecology of small mammals; Ph.D. (Syracuse) (1975) - physiological ecology of birds and small mammals; biology education; Dip. Ed. (Melb.) (1958).

<u>Honours and Awards:</u> Fellow of Australian Institute of Biology; Fellow of Institute of Biology (U.K.); Visiting Research Professor, FitzPatrick Institute of Ornithology, University of Cape Town (1982, 1985), Zoology Department, University of Natal (1987) and Zoology Department, University of Florida (1988).

<u>Current Position:</u> Professor and head, School of Biology, Curtin University of Technology. Responsible for the administration and overall education/scientific leadership of approximately thirty staff within the School of Biology. Academic programs offered by the School range from undergraduate degrees that include general subject areas such as ecology, botany, horticulture and zoology, to more specialized Honours, Masters and Ph.D. research projects. R & D activities of staff and students span areas such as land rehabilitation, conservation biology, physiological ecology, plants breeding, aquatic biology, economic entomology and silviculture. My research involves major programs relating to the pollination ecology and reproductive biology of the Proteaceae, Myrtaceae and Haemodoraceae, conservation biology of endangered plant species, physiological ecology of nectar-feeding birds and mammals, and the influence of habitat fragmentation on animal and plant populations.

<u>Other recent major responsibilities:</u> Immediate Past-President of Australasian Pollination Ecologists; Society; Member of Editorial Board, Australian Journal of Ecology; President of Royal Australasian Ornithologists Union, Chairman of its National Research Committee and Chairman of panel responsible for selection of recipients of D.L. Serventy Medal.

<u>External grants 1980 - 1990:</u> A total of approximately $440,000 has been attracted from private industry and competitive funding agencies such as the Australian Research Council and the Australian National Parks and Wildlife Service.

<u>Publications:</u> My research has generated more than 80 review articles, scientific and educational papers, book chapters and consultancy reports. These have appeared in Australian, African, New Zealand, European and North American publications, in most cases after rigorous peer review. Key publications relevant to the CRC proposal include:

Collins, B.G., Grey, J. and McNee, S. (1990). Foraging and nectar use in nectarivorous bird communities. Studies in Avian Biology 13, 110-121.

Collins, B.G. and Rebelo, A.G. (1987). Pollination biology and breeding systems in the Proteaceae of Australia and southern Africa. Aust. J. Ecol. 12, 387-421.

Collins, B.G. and Spice, J. (1986). Honeyeaters and the pollination biology of *Banksia prionotes* (Proteaceae). Aust. J. Bot. 34, 175-185.

Lamont, B.B., Collins, B.G. and Cowling, R.C. (1984). Reproductive biology of Proteaceae in south-western Australia and southern Africa: a review. Proc. Ecol. Soc. Aust. 14, 213-224.

JOHN ANTHONY CONSIDINE-
abbreviated Curriculum Vitae

Borne 5 January 1943, Melbourne, Victoria
Married with three children aged 20, 18 and 14.

Academic Qualifications: Dip Ag (Longerenong) 1963, BAgSc (Melb) 1965 MAgSc (Adel) 1970, PhD (Melb) 1979.

Current Positions Foundation Professor of Horticultural Science, Murdoch University and a Director of the Horticultural Research and Development Corporation. Appointed 1977/78.

Career History.

Viticultural Research Officer, Victoria 1978-74
Research Fellow in Botany (on secondment) Melb Uni. 1974-78
Research Scientist, Knoxfield, Victoria 1978-80
State Viticultural Research Officer, Victoria 1980
Senior Lecturer in Botany, Univ. of Auckland, 1981-86
Professor of Horticultural Science, Murdoch Univ. 1987-

Awards and Distinctions

1976, Best paper of the year, Amer Soc. Enology and Viticulture
1984, Convention Award, NZ Inst of Horticultural Science

Research Interests

Domestication of the Australian Flora
Physiology and genetics of domestication of wild plant species
Plant growth regulation
Horticultural crop physiology and anatomy
Plant propagation and grafting physiology

Current Research Grants

- Centre for Domestication of Australian Native Plants (Cytogenetics and breeding biology of Verticordia spp, Rural Credits Development Fund, Researve Bank)
- Agronomy and water relations of Boronia spp (HRDC)
- Population genetics and selection of Chamelaucium spp for floriculture (HRDC)
- Water requirements and growth of Geraldton Wax in an arid environment (HRDC)
- Packaging and storage of native cut flowers for export (HRDC)
- The role of the growing environment in the post-harvest storage life of selected Australian cut flower species.(RIRDC)
- Water relations and management of Mangoes and Avocados at Gin Gin, W.A.(National Teaching Co Scheme)

Publications

2 theses,
6 book chapters and conference proceedings,
3 invited reviews and one on **Domestication of the Australian Flora** (Interdisciplinary Science Reviews) in preparation
31 publications in refereed journals,
4 accepted and 2 submitted.

CURRICULUM VITAE

DR KINGSLEY DIXON

BORN: 22 May 1954

NATIONALITY: Australian

ACADEMIC HISTORY: 1975 - Bachelor of Science with First Class Honours, University of Western Australia
19981 - Ph.D., University of Western Australia

RESEARCH ACTIVITY: Development of In Vitro Systems for preservation and propagation of Australian native plants with emphasis on rare and endangered taxa.

Reproductive biology and rehabilitation of Restionaceae, Cyperaceae and Epacridaceae.

Determination of role in microbial and fungal symbionts in growth and development and habitat establishment of Australian plants.

Currently co-supervisor 1 x Ph.D., 1 x M.Sc. and five honour students on projects related to the above.

PUBLICATIONS: Author and co-author of 48 referred publications including five chapters and two books.
Involved in production of information and interpretation literature for the botanic gardens.

PUBLICATIONS RELEVANT TO APPLICATION:

Ramsay, R.R., Sivasithamparam, K. and Dixon, K.W. (1987). Anastomosis groups among Rhizoctonia-like endophytic fungi in south western Australian *Pterostylis* species (Orchidaceae). Lindleyana 2(3): 161-167.

Meney, K.A. and Dixon, K.W. (1989). Phenology, reproductive biology and seed development in four rush and sedge species from Western Australia. Australian Journal of Botany, 36: 711-726.

Wilkinson, K., Dixon, K.W. and Sivasithamparam, K. (1989). Interaction of soil bacteria, mycorrhiza fungi and orchid seed in relation to germination of Australian orchids. The New Phytologist 112/3.

Bunn, E., Dixon, K.W. and Langley, M. (1989). Micro-propagation of *Leucopogon obtectus* Benth. Plant, Cell, Tissue and Organ Culture 19/1: 77-84.

Dixon, K.W., Pate, J.S. and Kuo, J. (1990). The Western Australian Subterranean Orchid *Rhizanthella gardneri* Rogers. Chapter 5 in Orchid Biology, Reviews and Perspectives 5'. J. Arditti, ed. Cornell University Press, Ithaca.

Dixon, K.W. (1990). Seeder/clonal concepts in Western Australian orchids, problems and progress. Proceedings of the First Australian Native Orchid Conference. Australian Native Orchid Society, Wollongong, New South Wales.

Meney, K., Dixon, K.W. and Pate, J.S. (1990). Phenology of growth and resource deployment in *Alexgeorgea nitens* (Nees) Johnson and Briggs (Restionaceae) - a clonal species from south-west Western Australia. Australian Journal of Botany (in press).

Meney, K., Dixon, K.W. and Page, J.S. (1990). Comparative morphology, anatomy, phenology and reproductive biology of *Alexgergea* species (Restionaceae) from south-west Western Australia. Australian Journal of Botany (in press).

STEPHEN DONALD HOPPER - Abbreviated Curriculum Vitae

Born June 18, 1951, Bangalow NSW

Married with three children aged 11, 8, and 5.

Academic qualifications: B.Sc. (Hons) 1st class 1973, University of W.A.
Ph.D. 1978 University of Western Australia

Current position: Senior Principal Research Scientist, Western Australian Department of Conservation and Land Management. Appointed January 1988. Responsible for the administration and scientific leadership of 50 permanent staff and 10 consultant biologists at the W.A. Wildlife Research Centre, Woodvale, and its outstations. Oversees work in the research programs of Biogeography, Fauna Conservation, Fire, Marine Conservation, Research Techniques and Wetlands and Waterbirds. Conducts research in the Flora Conservation, Biogeography and Fire research programs, with specialist expertise in the conservation biology, systematics and evolutionary genetics of eucalypts, orchids, Haemodoraceae, endangered plants, and plants on granite outcrops.

Honours, Awards: - Fulbright Senior Award, March-July 1990

- Miller Visiting Research Professorship, University of California, Berkeley, May-July 1990

External Grants 1980-90: a total of $475 000 attracted, mainly for plant conservation research from competitive Australian Government granting bodies such as the Australian Biological Resources Study, Australian Heritage Commission, and Australian National Parks & Wildlife Service.

Publications: Coauthor of two books, coeditor of a substantial technical review, and author/coauthor of 45 papers in refereed journals and 23 technical papers or management plans in the edited conservation literature. Key publications relevant to the CRC proposal include:

Hopper, S.D. (1979). Biogeographical aspects of speciation in the south west Australian flora. *Annual Review Ecology Systematics* 10: 399-422.

Hopper, S.D., van Leeuwen, S., Brown, A.P. & Patrick, S.J. (1990). *Western Australia's Endangered Flora*. Dept CALM, Perth.

Hopper, S.D., & Coates, D.J. (1990). Conservation of genetic resources in Australia's flora and fauna. *Proceedings of the Ecological Society of Australia* 16: 567-577.

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

CURRICULUM VITAE

Name:	Sidney Herbert JAMES
Date of Birth:	10 July, 1933 — Age: 56 years
Marital Status:	Married with 4 adult children
Degrees:	B Sc University of Sydney 1955 (Botany) M Sc University of Sydney 1958 (Apomixis in the genus *Callistemon*.) Ph D University of Sydney 1963 (Cytological studies in the Lobeliaceae)

Appointments:

1955-1960	Teaching Fellow, Botany Dept., University of Sydney
1961	Senior Tutor Demonstrator, Botany Dept., University of Sydney
1962-1969	Lecturer, Botany Dept., University of Western Australia
1968	Visiting Assistant Professor, Botany Dept, University fo California, Los Angeles (summer term)
1970-	Senior Lecturer, Botany Dept., University of Western Australia

Research Interests: Cytoevolution, biosystematics and speciation studies in components of the Australian flora, with particular reference to the evolution of genetic systems. These studies have led to the concept that genetic systems are largely concerned with the modulation of congenital weaknesses resulting from defective genes. Currently the recipient of an ARC grant of $30 000 for cytoevolutionary research and private industry support totalling $70 000 for a "super marron" fresh water crayfish breeding program.

PhD Supervisions: A total of 10 PhD's supervised in various areas of biosystematics. A majority of these people are now active in conservation genetics.

Significant Publications:

A major series on "The evolution of complex hybridity in *Isotoma petraea*"

I. Heredity 20, 341-353 (1965)
II. Heredity 25, 53-77 (1970)
III. Aust. J. Bot. 18, 223-232 (1970) (with IC Beltran)
IV. Aust. J. Bot. 22, 251-264 (1974) (with IC Beltran)
V. Heredity 51, 653-663 (1983) (with AP Wylie, MS Johnson, SA Cairstairs, and GA Simpson)
VI. Heredity 58, 401-408 (1988) (with P Lavery)
VII. Heredity 64, 289-295 (1990) (with JS Sampson and J Playford)
VIII. Heredity (in press) (with J Playford and JS Sampson)

"Cytoevolutionary patterns, genetic systems and the phylogeography of Australia." in A. Keast, Ed., Ecological biogeography of Australia. Vol 1. (Dr W Junk bv Publishers, The Hague), pp763-782 (1981)

"Chromosome numbers and genetic systems in the triggerplants of Western Australia." Aust. J. Bot. 27,17-25 (1979)

"Postzygotic abortion in the genetic system of *Stylidium* (Angiospermae: Stylidiaceae) J. Heredity (in review) (with AH Burbidge)

Byron Lamont - CV

Qualifications: B.Sc. Agric. (UWA 1966), Ph.D. (UWA 1974), FLS, FI Biol.

Employment: Coordinator of Graduate Studies in Biology/Natural Resources (1988-1990) and Senior Lecturer in Plant Biology (1982-1990), Curtin University; Visiting Scholar at Stanford University 1987; Visiting Lecturer at University of Cape Town 1980.

Awards & Honours: Senior Fullbright Award 1987, Honorary member of International Protea Association, cited in Who's Who in Commonwealth (1st ed.), invited papers to International Botanical Congress, Berlin (1987) etc.

Research Interests: Biology of the Australian sclerophyll flora with major attention to its ecology, environmental physiology and utilisation. Emphasis has been on soil-plant-water relationships, responses to fire and population dynamics. Convenor of the informal Banksia Research Group (1983-1990) with which 30 students, postdoctoral and visiting fellows and technicians have been associated, receiving $508,000 in grants and producing 50 publications, half in international journals.

Grants 1980 - 1990: Over $700,000 for 25 R&D projects, 90% on a competitive basis from the Australia Research Council. Australian National Parks and Wildlife Service, AMC Mineral Sands, Local Government Association, Main Roads Dept., World Wildlife Fund, MERIWA, CALM and 6 others.

Publications: Two monographs, edited two books and one proceedings, 12 invited book chapters, 20 reviews in proceedings, 62 refereed journal papers (mostly international), 18 technical reports, 13 articles, a video script, 26 presented papers and 7 abstract/posters. Key publications: Cowling, R.M., Lamont, B.B. and Enright, N.J. 1990. Fire and management of banksias in southwestern Australia. Proceedings of the Ecological Society of Australia 16: 177-183.

Lamont, B.B., Le Maitre, D., Cowling, R.M. and Enright, N.J. 1991. Canopy seed storage in woody plants. Botanical Review (in press).

Cowling, R.M. and Lamont, B.B. 1986. Population ecology of Western Australian *Banksia* species: implications for the wildflower industry. Acta Horticulture 185: 217-227.

Lamont, B.B., Connell, S.J. and Bergi, S.M. 1991. Population and seed bank dynamics of *Banksia cuneata*: the role of time, fire and moisture. Botanical Gazette (in press).

Lamont, B.B., Enright, N.J. and Bergi, S.M. 1989. Coexistence and competitive exclusion of *Banksia hookeriana* in the presence of congeneric seedlings along a topographic gradient. Oikos 56: 39-42.

CURRICULUM VITAE

Neville Graeme MARCHANT B.Sc.(Hons) Ph.D

Department of Conservation and Land Management,
PO Box 104, COMO, Western Australia 6152

Comprehensive experience in a wide range of botanical disciplines, including twenty-six years research in plant taxonomy; thirty-three years involvement with Herbarium administration and curation and ten years teaching experience in plant biology and taxonomy. Also possessing a wide knowledge of taxonomic and ecologic information on the flora and vegetation of Western Australia.

Undergraduate degree, majoring in Botany, University of Western Australia, 1962; awarded Australian Legacy Scholarship and admitted to Clare College, Cambridge and Department of Botany, Cambridge, UK, as a graduate student, 1966. Awarded Ph.D degree for studies in experimental Taxonomy, 1970.

Level 5 Botanist at Western Australian Herbarium, Perth 1970. Seconded as Lecturer in Botany, University of Western Australia, 1973. Resumed duties as Botanist, Level 5, Western Australian Herbarium, 1974-77; promoted to Botanist Level 6, 1977. Appointed part-time lecturer in Biology, Murdoch University, 1985.

Awarded Churchill Fellowship to study herbaria in Kiev, Moscow and Leningrad, 1985. Study tour of European herbaria, 1985. Promoted to Botanist Level 7, 1986. Published Flora of the Perth Region, volumes 1 and 2, 1987. Appointed Honorary Lecturer in Horticultural Taxonomy, Murdoch University. Seconded to the Kings Park Board to review Park management, development and scientific activities, 1987.

Commissioned by Australian International Development Assistance Bureau funded organisations to survey South East Asian Herbaria, 1988. Appointed Asian Region Adviser to United Nations Educational, Scientific and Cultural Organisation (UNESCO). Appointed Secretary of the Botany-2000 Co-operative Network for the Development of Herbarium Taxonomy in the Asian region.

Forty-six scientific papers, three books and forty popular articles on the flora of Western Australia have been published.

N.G. Marchant

October 1990

CURRICULUM VITAE

NAME: JOHN STEWART PATE FAA, FRS, FLS

ADDRESS: Department of Botany
The University of Western Australia
Nedlands Western Australia 6009

TELEPHONE NUMBER 09 380 2205 (office); 09 386 6070 (home)
FACSIMILE: 09 380 1001 (AUST); 61 9 380 1001 (INT)

DATE AND PLACE 15.1.32. Ilford, Essex, England

NATIONALITY: British/Australian

RESUME: Entrance Scholarship, Queen's University, Belfast. N. Ireland

1953	1st Class Honours Botany.
1954-1956	Assistant Lecturer, Queen's University, Belfast. M. Sc. 1954 Phd. 1956
1957-1960	Lecturer in Botany, University of Sydney.
1960-1965	Lecturer in Botany, Queen's University, Belfast. D.Sc. 1965
1965-1970	Reader in Botany, Queen's University, Belfast.
1970-1973	Personal Chair of Plant Physiology, Queen's University.
1973	Visiting Fellowship, University of Capetown, South Africa.
1973	Professor of Botany, University of Western Australia.
1980	Fellow of Australian Academy of Science.
1985	Fellow of the Royal Society.
1980-82	President, Australian Society of Plant, Physiologists
1983-85	Editorial Board of Australian Society of Plant Physiologists
1987-	Editorial Board of Oecologia
1990	Fellow of the Linnean Society of London.

RELEVANT EXPERIENCE:

Thirty years experience on the biology of native and agriculturally important plant species, in over 200 research publications (research papers, books, solicited reviews and chapters for text books and symposia).

Co-organizer of a number of international symposia on topics including biology of native Australian plants, phloem translocation, N_2 fixation in grain legumes and systematics of Leguminosae.

Participation in University Administration as Head of Department, Academic Council, Planning Committee, Higher Degrees Committee, etc. Plant Sciences Committee, Australian Academy of Science, International Biological Programme on N fixation (UK), Advisory Committee on Legume N_2 Fixation (IAEA), Organizer of International Congresses in 1986 and 1990 on Phloem Translocation.

GENERAL RESEARCH INTERESTS:

Nitrogen metabolism, transport in phloem and xylem, structural and functional aspects of short and long distance transport, m odelling the partitioning of C, N, and H_2O, physiology of grain legumes, adaptations to stress in plants of mediterranean-type ecosystems, anomalous patterns of angiosperm nutrition (parasitism, microbial-assisted nutrient uptake, carnivory), plant growth form, structure:function relationships in fruits.

SEVEN MAJOR PUBLICATIONS;

Pate, J.S. and McComb, A.J. (eds) (1981). **The Biology of Australian Plants.** University of Western Australia Press, Nedlands. 412 pp

Pate, J.S. and Dixon, K.W. (1982). **Tuberous, Cormous and Bulbous Plants.** University of WesternAustralia Press, Nedlands. 268 pp.

Beard, J.S. and Pate, J.S. (eds) (1984). **Kwongan - Plant Life of the Sandplain.** University of Western Australia Press, Nedlands. 284 pp.

Pate, J.S. (1985). Physiology of pea - a comparison with other legumes in terms of economy of carbon and nitrogen in plant functioning. In: **The Pea Crop A Basis for Improvement** (ed P.D. Hebblethwaite, M.C. Heath & T.C.K. Dawkins). Chapter 25, pp. 279-296. Butterworths, Londonl.

Pate, J.S. (1986). Economy of symbiotic nitrogen fixation. In: **On the Economy of Plant Form and Function. Proceedings of Cabot Symposium** - "Evolutionary Constraints on Primary Productivity: Adaptive Strategies of Energy Capture in Plants", 21-25th 1983 (ed. T.J. Givnish). Chapter 10, pp. 299-325. Cambridge University Press, New York.

Pate, J.S. (1986). Xylem-to-phloem transfer - vital component of the nitrogen-partitioning system of nodulated legume. In: **Phloem Transport** (ed. J. lCronshaw, W.J. Lucas & R.T. Giaquinta). pp. 445-462, A.R.Liss Inc., New York.

Pate, J.S. (1989) Legume fruits - the structure:function equation. In: **Advances in Legume Biology.** (ed. C.H. Stirton and J.L. Zarucchi) . pp 399-415, Missouri Bot Gard.

MEMBERSHIP OF LEARNED SOCIETIES

American Society of Plant Physiologists
Australian and New Zealand Association for the Advancement of Science :(President, Botany Section 1983)
Australian Society of Plant Physiologists
(Foundation member 1958; State Representative 1978-80; President 1982-84)
Royal Society of Western Australia (President 1988-89)
Society for Experimental Biology, UK.; (Council member 1967-70)

AGENCIES GRANTING FUNDS 1964-1990 (other than University funding)

Agricultural Research Council (UK)
Alcoa Foundation (USA) and Western Collieries (W. Australia)
Australian Meat Research Committee
Australian Research Grants Scheme (special Program Grant 1984-90)
Department of Conservation and Environment (Perth)
International Atomic Energy Agency (Vienna)
Minerals and Energy Research Institute of Western Australia
Science Research Council (UK)
State Wheat Industry Council
United Nations Development Project
West Australian Wildlife Authority
Wheat Industry Research Council (Australia)
Wool Research and Development Fund
World Wildlife Fund

Plantex Australia Pty. Ltd.

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RESUME

Plantex Australia Pty Ltd

62 Thomas Street
South Lake
Western Australia 6164

COMMENCED

1963
The company commenced operation in 1963 as a plant Nursery supplying the local nursery industry. It has since grown to a large nursery supplying plant material to Western Australian Nurseries, Eastern Australian Nurseries, Overseas Companies as well as supplying plants to the cut flower industry and exporting cut fresh flowers and dried and preserved flowers to many overseas countries. Main export countries include Japan, USA, Europe and the Middle East. The Plantex facility now operates from two premises with 7 hectares of land under intensive use.

STAFF

The company employs fifty staff over all areas of production. As the Company is involved in many areas of expertise each area has its own manager with staff directly responsible to that manager and each manager being responsible to the Managing Director. Communication is vital in all areas of business and this is a very effective form of communication.

RESEARCH AND DEVELOPMENT

The company is dedicated to on going research into various areas of its production. The company operates a commercial Tissue Culture Laboratory that as well as producing 2 million plantlets per annum is also heavily involved in breeding and clonal selection of new and different plant material. Plantex has received Federal Government Funding for salt and drought tolerant research and has now a range of salt tolerant trees available for high saline areas.

The Laboratory is also involved in the breeding of a range of Anigozanthos hybrids (Kangaroo Paw) and these are accepted throughout the world as superior plants. In addition to the Laboratory research the company has an extensive breeding and selection program for many species including Geraldton wax, Salt and drought tolerant plants and reclamation type plants. The research program does not stop when plants are selected but plants are then trialled overseas to test their suitability and further selection then takes place.

Specific examples of plants either selected or bred by the company are the Anigozanthos, one of which was the only Australian Plant selected to represent the Australian Bicentennial Year, Artenema which is being sold overseas and is also an Australian Plant Promotion for 1990 and Kimberley Queen, a fern, that has sold over half a million plants in Australia.

AGENCIES

The company has agencies for very selected nursery product lines such as fertiliser and high quality nursery machinery.

EXPERTISE

Management
The company has an efficient management system that includes production managers, laboratory manager, export manager and dedicated research staff. Mr Adrian Bowden is involved in all areas of export whilst Mrs Irene Bowden handles all financial areas and general company operation.

Tissue Culture
Plantex operates one of the largest laboratories in Australia and is one of the few companies working on hard wooded species.

Plant Production
Plants are supplied to Garden Centres, nurseries and cut flower growers both in Australia and overseas. Plant material is also provided for restoration of salt or drought affected areas and selection and sourcing of new plant material is an ongoing project.

Such plants include trees, shrubs, grasses and similar type plants. The company has an ongoing export program to introduce new material to overseas markets. The Main Roads Department, in Western Australia, awarded the company a tender to produce 230,000 plants for a Freeway Extension and all plants are thriving and growing well.

Flowers
Plantex exports dried and fresh flowers throughout the world. It is one of the leading companies in Australia working in the area of preserved flowers. Most flowers being preserved are Western Australian Native flowers and no other work is being done on these anywhere in the world.

Consultancy
Plantex, through Mr Adrian Bowden, has been involved in consultancy in such areas as Inland Australia, Qatar, India and Kuwait. This consultancy has covered areas such as developing nursery facilities and trialling areas to training overseas personnel in the skills of Tissue Culture. Mr Bowden is also expert in irrigation systems, plant selection and all areas of horticulture.

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CAREER OUTLINE ADRIAN G. BOWDEN

PREVIOUS EMPLOYMENT

1958 - 1960	Wilson & Johns Nursery (A major wholesale nursery)
1960 - 1962	Canning Plant Farm (a large specialist wholesale nursery)
1962 - 1963	Kings Park Botanic Gardens (Main duties - Propagation of Native Material)
1963	Founded Adrian's Nursery
1977	Growing Industries was commenced, as part of the group., main trading being the import of specialised nursery machinery and selected fertilisers.
1982	Plantex Australia Pty Ltd was developed as the export arm of the group.
1987	All companies within the group, being Adrian's Nursery, Plantex Australia Pty Ltd and Growing Industries, were restructured into one company, Plantex Australia Pty Ltd.
1987	April. The Australian Industry Development Corporatio took up a 33.3% equity in the company.

QUALIFICATIONS

Diploma Nursery Practice
Certificate of Municipal and Landscape Gardening
Certificate Garden Maintenance and Design

PROFILE

During the period from 1963 - 1988 the nursery division has been buil from a small wholesale nursery to the present stage of being a major plant producer and exporter.
Staff levels are now fifty (40) including management and middle management staff. The area under intensive nursery production is now seven (7) hectares.

The decision to move into the export market was mainly instigated by Adrian who felt that the local market was unable to expand due to population size.
Initially much time was spent in the Middle East where Adrian was responsible for the setting up of a trial farm, for our products, in conjunction with our Joint Venture Partners, Palms Agro - Production Company.

Adrian has been responsible for the development of breeding and trialling programmes for salt and drought tolerant plants for the Middle East, Timber Trees for India and a selection of indoor plants suitable for the European Market.

Approximately sixty (60) percent of the companies products are entering the export market either as plant material, fresh cut flowers or dried flowers. In 1986 the company entered into the production of plants for cut flower use and consequently the export of such flowers produced by these plants. Whilst the Company does not grow cut flowers itself it sells the plants to other growers on the agreement that when the flowers reach the necessary quality standards then Plantex will purchase the product for sale to overseas markets.

The direction of the companies research and overseas market development is the direct responsibility of Adrian Bowden.
In the case of the overseas markets Adrian travels to all markets at least twice a year to meet with current customers and to seek out potential customers and new market opportunities.
All research and development is being done on a market driven basis rather than a research - production basis.

As Plantex Australia Pty Ltd now has an established name overseas Mr Bowden is often called upon to act as consultant to Government Departments in many countries and is often requested to present papers at Conferences etc.
This consultancy is an important part of the companies long term planning as when selling plant material it is very important to offer before sales advice as well as after sales advice in such areas as fertiliser requirements of the plants, soil type, water requirement etc.
The company offers a total package to its customers.
The company also consults in the areas of Nursery Construction, Tissue Culture Laboratory Design, Irrigation and associated areas.

ASSOCIATION ACTIVITIES

Mr Bowden is a member of the following Associations:
- Nursery Industry Association of Western Australia
- Nursery Industry Association of Australia
- International Plant Propagators' Society
- Wildflower Producers Association

AWARDS

Award of Merit - Australian Nurserymen's Association
Plantex Australia Pty Ltd was awarded an Australian Export Award in 1986
Adrian Bowden, in conjunction with wife Irene, was awarded an Advance Australia Award - for outstanding contribution in the area of Nursery Industry/Export Year 1987

Adrian Bowden has served on many industry committees during his time in the industry including:
President of the Nurserymen's Association of Western Australia for four years.
President of the Australian Nurserymen's Association for one year.
President of the International Plant Propagators' Society for one year.
Mr Bowden has expertise in the areas of growing, harvesting, storing, transporting and marketing of live plants and cut fresh flowers as well as dried flowers.
Research and development both in the breeding of new plant material and the marketing of such material, as well as the development of new markets.
Expertise in the area of plant tissue culture both as a means of research and the production of large quantities of material.
In the area of marketing Mr Bowden is extremely active especially in the development of new and untapped markets.

CURRICULUM VITAE

MR ADRIAN BOWDEN
TECHNICAL PAPERS AND LECTURES PRESENTED

1. INTERNATIONAL PLANT PROPAGATORS JOURNAL
VOLUME 25: PAGE 391
PRESENTED AT TALLAHASSEE - USA EASTERN REGION MEETING 1977
"PROPAGATION OF PHORMIUM TENAX RUBRUM

2. INTERNATIONAL PLANT PROPAGATORS JOURNAL
VOLUME 30: PAGE 623
PRESENTED TO AUSTRALIAN REGION 1980
"TEMPLETONIA AND BANKSIA PRODUCTION

3. 1982 TOURED 6 STATES OF AUSTRALIA PRESENTING A SERIES OF LECTURES ON NURSERY HYGIENE AND PRODUCTION METHODS IN CONJUNCTION WITH PROFESSOR CARL WHITCOMBE AND MR PETER ALBURY FOR 4 WEEKS.
THESE LECTURES WERE PRESENTED TO THE 1600 MEMBER FIRMS OF THE NURSERY INDUSTRY ASSOCIATION OF AUSTRALIA.

4. INTERNATIONAL PLANT PROPAGATORS JOURNAL
VOLUME 33: PAGES 200-202
11TH ANNUAL MEETING IN DARWIN - AUSTRALIA- 1983
"USE OF HERBICIDES IN TUBE STOCK PRODUCTION"

5. INTERNATIONAL PLANT PROPAGATORS JOURNAL
VOLUME 34: PAGES 76-79
12TH ANNUAL MEETING - AUSTRALIAN REGION 1984
"TRANSFERRING TISSUE CULTURE PLANTS TO THE NURSERY ENVIRONMENT.
VOLUME 34: PAGES 99-101
JOINT PAPER WITH MR K. STEVENS
"OUTDOOR PROPAGATION USING HEATED BEDS AND MIST"

6. INTERNATIONAL PLANT PROPGATORS JOURNAL
VOLUME 37: PAGE 138
JOINT AUSTRALIAN AND NEW ZEALAND CONFERENCE - TARONGA - NEW ZEALAND
1987 "APPLICATION OF PHOSPHORUS TO PROTEACEOUS PLANTS"

7. PRESENTED PAPER AT THE SEMINAR BIOTECHNOLOGI TANAMAN - JAKARTA - INDONESIA.
PAPER PRESENTED 12TH DECEMBER 1988
"PROSPECTS AND PROBLEMS OF APPLYING MASS PRODUCTION FROM BIOTECHNOLOGY SYSTEMS TOWARDS AGRO BUSINESS DEVELOPMENT"

8. PRESENTED A SEMINAR AT YAMANAGA - INDIA
PAPER PRESENTED FEBRUARY 1989
"USE OF TISSUE CULTURE AND CLONAL PRODUCTION TO IMPROVE PULP YIELDS IN EUCALYPTUS"
"THE SELECTION AND PRODUCTION OF CLONAL MATERIAL FOR REGENERATION OF SALINE AND DEGRADED SITES, FOR FUEL WOOD AND PULP PRODUCTION"

9. PRESENTED A PAPER AT THE INTERNATIONAL GROWERS CONFERENCE - ODENSE DENMARK.
PAPER PRESENTED SEPTEMBER 8TH 1989
"DEVELOPMENT AND INTRODUCTION OF NEW NATIVE AUSTRALIAN PLANTS TO EUROPE"

10. ACTED AS A CONSULTANT TO DEVELOP A NURSERY ACCREDITATION SCHEME FO THE INDUSTRY IN WESTERN AUSTRALIA TO ADOPT SO AS TO IMPROVE HYGIENE AN QUALITY STANDARDS WITHIN THE INDUSTRY.
THIS SCHEME HAS THE SUPPORT OF THE GOVERNMENT AND IS BEING IMPLEMENTED AS A MEANS OF MINIMISING PLANT DISEASE DISTRIBUTION.

11. PRESENTED A SERIES OF LECTURES IN OKINAWA - JAPAN .
LECTURES PRESENTED NOVEMBER 1989
"THE INTRODUCTION OF CUT FLOWER CROPS WITH COMMERCIAL POTENTIAL AS A BASIS FOR A NEW INDUSTRY WITHIN THE REGION"

12. PRESENTED ANOTHER SERIES OF LECTURES IN OKINAWA - JAPAN.
LECTURES PRESENTED MAY 1990
"THE INTRODUCTION OF CUT FLOWER CROPS WITH COMMERCIAL POTENTIAL AS A BASIS FOR A NEW INDUSTRY WITHIN THE REGION"

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CAREER OUTLINE IRENE V. BOWDEN

PREVIOUS EMPLOYMENT

1960 - 1962	Milne Feeds Pty Ltd Working in their Laboratory testing stock feeds for correct supplement levels.
1962 - 1963	Plaimar Pty Ltd Laboratory testing fruit juices for correct levels and experimenting on new commercial perfumes for manufacture.
1963 - 1966	Department of Agriculture - Western Australia 1963 - 1965 was spent engaged in experimental work on fodder grasses. 1965 - 1966 Supervised main laboratory for germination testing of various commercial fodder crops as well as testing seed for weed infestations.
1966	Joined husband Adrian in the operation of Adrian's Nursery.
1978	The laboratory division, of the company, was commenced. This started as a very small commercial laboratory and now operates as the largest laboratory in Western Australia and one of the largest in Australia.
1987	The restructuring of all the companys under the Adrian's Group into Plantex Australia Pty Ltd which was formally the export arm of the Company.

PROFILE

Involved from the early days of Adrian's Nursery and as such has worked to develop what was a small wholesale nursery into a company that has diversified into tissue culture, importing, exporting as well as consultancy and is a large supplier of wholesale plants to the industry.
As such Irene Bowden has been involved with all facets of the business from propagation of plant material, despatch, sales, tissue culture and office management.

Irene was mainly responsible for the formation of the tissue culture division of the company. This division employs 17 staff full time and produces a wide range of crops including salt tolerant plants, new hybrids of Anigozanthos, some vegetable crops, indoor plants and Australian Native species.

As well as operating the tissue culture division Irene also monitors all sales and is responsible for finance, office management, despatch and general nursery planning.
The office is fully computerised allowing for control of all stock, all financial areas and general word processing.

ASSOCIATION ACTIVITIES

Mrs Bowden is a member of the following Associations:
- Nurserymen's Association of Western Australia
- Australian Nurserymen's Association
- International Plant Propagators' Society
- International Association of Plant Tissue Culture

AWARDS

Plantex Australia Pty Ltd was awarded an Australian Export Award in 1986.
Irene Bowden, in conjunction with husband Adrian, was awarded an Advance Australia Award - for outstanding contribution in the area of Nursery/Export. Year 1987

Irene Bowden has served on many industry committees during her time in the industry including:
Three years as President of the Nurserymen's Association of Western Australia.
One year as Vice President Australian Nurserymen's Association
Two years as President Australian Nurserymen's Association
1987 - 1988
Delegate Floricultural Industries Council of Western Australia
1986 - 1988
Member of the Floricultural Industries Advisory Council (W.A.)
1986 - 1988
Member of the Horticultural Export Development Council (W.A.)
1986 - 1990
Member Australian Horticultural Growers Council
1987 - 1988
Member of the Australian Quarantine Inspection Service Liaison Committee
1987 - 1990
Member of the Australian Shippers Council - Air Freight Committee
1987 - 1988
Vice President International Plant Propagators' Society
1987

President International Plant Propagators' Society
1988
Member Horticultural Policy Council (Federal) Appointed by Mr Kerin
1988 - 1991

Irene Bowden has considerable expertise in all aspects of the nursery and cut flower industry with special expertise in plant tissue culture, administration and industry affairs.

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Conservation of genetic resources in Australia's flora and fauna

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Abstract

Conservation of the genetic resources of the Australian flora and fauna is advocated as wise management aimed at maximizing the options available to future generations for utilization, study and appreciation of the continent's biodiversity. As a natural resource, the flora and fauna already contribute substantially to the national economy through forestry, the pastoral industry, fisheries, tourism, land reclamation, bee keeping, wildflower harvesting and the kangaroo trade. Moreover, the values of natural vegetation to agricultural and urban existence through ecosystem services such as the provision of clean air and pure water, climatic control, soil conservation and soil salinity control are becoming apparent. The potential of the Australian flora and fauna as sources of food and chemicals useful to humans and as a teaching resource has scarcely been realized.

Effective conservation of genetic resources depends upon an adequate data base and a knowledge of the processes that control and sustain inherited variation. For most of Australia's plants and animals, taxonomic descriptions and geographical information will remain the only data base available for conservation initiatives over the next century. It is, therefore, a matter of national priority that taxonomic research and teaching continue at an accelerated rate.

The application of population genetic studies to conservation is a new field. In this chapter, recent genetic information relevant to reserve design, minimum viable population sizes, selection of priority populations for conservation, endangered species management and revegetation is reviewed. Given the pace of ongoing destruction of native vegetation, the search for general principles in gene resource conservation from a limited sample of the Australian flora and fauna is a key scientific challenge facing the next century.

Introduction

Conservation of genetic diversity is a central tenet of the World and Australian Conservation Strategies (Anon. 1984). This reflects widespread recognition that, without a broad base of biodiversity, present and future options for sustained human existence and a reasonable quality of life will be reduced. Plants and animals provide a natural resource of myriad potential for human utilization, study and appreciation.

In Australia, the native flora and fauna already contribute substantially to the national economy through forestry, the pastoral industry, fisheries, tourism, bee keeping, land reclamation, wildflower harvesting and the kangaroo trade. Moreover, natural vegetation facilitates agricultural and urban existence through ecosystem services such as the provision of clean air and pure water, climatic control, soil conservation and soil salinity control (see, for example, papers by van der Moezel & Bell, and by Malcolm in this volume regarding use of salt-tolerant genotypes in several species to reclaim land degraded by rising saline water tables in Western Australia).

The potential of the Australian flora and fauna as sources of food and chemicals useful to humans, and as a teaching resource has scarcely been realized. For example, research at Macquarie University has demonstrated that extracts from the plant genus *Pimelea* inhibit the development of cancers in mice (Howard & Howden 1975).

While the justification for conserving genetic diversity seems clear, the achievement of this aim is not at all certain. Extinction is a process influenced by many possible factors, some genetic and some demographic (see Soulé 1983). Most of these factors are poorly understood. This lack of knowledge presents a major challenge to the nation.

In this chapter, we wish to focus on the contribution that genetic and biosystematic studies can make to the conservation of Australia's flora and fauna during the next century. Such a contribution depends on knowledge in relation to three key questions.

1. What constitutes the Australian flora and fauna?
2. Where do the component taxa occur in the wild?
3. What genetic management is required to maintain sustained reproduction and recruitment?

The Australian flora and fauna

The Australian vascular flora comprises an estimated 25 000+ species, of which about 18 000 had been described by 1980 (George 1981). In addition there are several thousand non-vascular species. The fauna is much larger, consisting of 200 000-300 000 species, of which about 100 000 have been described (Richardson 1984, 1987).

These statistics signal a major problem facing those who wish to conserve this genetic diversity. A taxonomic description provides the minimal data base on which conservation initiatives depend, and such descriptions do not exist at present for a third of the nation's flora and two-thirds of the fauna (particularly invertebrates).

Moreover, the past few decades have witnessed a decline in taxonomic research and teaching in tertiary educational institutions, coupled with a recent decline in job opportunities at major museums and herbaria. Despite major advances in approaches to systematic biology, the subject has waned in popularity with university administrations and government agencies responsible for museums and herbaria.

This process needs to be reversed as a matter of national priority. Australia urgently needs more taxonomists, and tertiary educational institutions, museums and herbaria have key roles to play in this endeavour. It is vital that taxonomic research and teaching continue at an accelerated rate if conservation efforts are to keep pace with activities that involve permanent destruction of native vegetation, fauna, soil and waters.

In this context, it was heartening at this Symposium to hear Professor McComb, in his presidential address to the Ecological Society of Australia, advocate that Australian universities direct more of their research efforts towards solving uniquely Australian environmental problems (McComb 1989).

The taxonomic description and conservation of the continent's flora and fauna fall squarely within the ambit of such a focus for new research.

In groups where patterns of morphological variation are complex or cryptic, traditional taxonomic methods alone will not be sufficient to define the biological units in nature (Paterson & James 1973). Effective conservation efforts here will require population genetic, morphometric, cytogenetic or biosystematic approaches used, for example, by Shaw (1976) in the grasshopper genus *Caledia*, by King (1979) in gekkos of the *Gehyra variegata-punctata* complex, by Coates (1981) in the scale-leaved trigger plants of the *Stylidium caricifolium* species complex, and by Adams *et al.* (1987) to resolve species boundaries in the bat genus *Eptesicus*.

In some cases, resolution of species boundaries within complexes has clear ecological significance relevant to management, e.g. George's (1981) recognition of the fire sensitive reseeder *Banksia littoralis* var. *seminuda* (now regarded as the species *B. seminuda*) as a distinct taxon from the lignotuberous resprouter var. *littoralis*. Ecologists and managers need to be cautious and aware that accepted species names may well conceal unresolved taxa of this kind.

Although an adequate understanding of species boundaries is essential for conservation, in some (perhaps many) cases a knowledge of genetic variation within species is equally important (Lacy 1988). This is especially the case where breeding systems diverge from the typical diploid sexual outbreeding mode seen in many higher vertebrates and perennial plants. Three well-documented Australian examples are the complex translocation heterozygosity associated with inbreeding in the granite rock herb *Isotoma petraea* (James 1965, 1970), the occurrence of triploid parthenogenetic clones and diploid bisexual individuals within the gekko species *Heteronotia binoei* (Moritz 1983), and the evolution of parthenogenesis in the grasshopper *Warramaba virgo* (White 1980).

Natural hybridization is another major process that generates patterns of variation that need to be understood for effective conservation and management. This process has been well documented in such Australian organisms as eucalypts (e.g., Potts & Reid 1985), kangaroo paws (Hopper 1977), frogs (Woodruff 1981) and grasshoppers (Shaw 1981).

Such descriptions of population genetic structure within species and of natural hybridization exist for very few of Australia's plants and animals. Indeed, our knowledge is rudimentary even for the largest and most common members of many of Australia's ecosystems [e.g., Moran & Hopper's (1987) review of data for eucalypts]. This information is essential for intensive species' management aimed at conservation of representative genetic variation in the wild.

Australian geneticists have made seminal contributions to our knowledge of variation and evolution in native plants and animals in the past (e.g., Smith-White 1959; White 1978; James 1981; Barlow 1982), but this field too has waned in favour of a popular interest in molecular genetics in recent years. We can only hope that the urgency and need for conservation genetic studies will inject new life into this field of inquiry. If so, the challenge will be to develop general principles from a well-chosen but limited sample of the fauna and flora (see below).

Australian biogeography and mapping genetic resources

Mapping species

Mapping the continent's flora and fauna in space and through time has proceeded in close association with taxonomic research, but few organisms have been mapped in sufficient detail to provide data adequate for conservation planning and management. This is nowhere more evident than in comparing initial lists of taxa believed to be rare or threatened with current lists (*cf.* Specht *et al.* 1974; Hartley & Leigh 1979; Leigh *et al.* 1981; Briggs & Leigh 1988; Hopper *et al.* 1990).

Nevertheless, biological survey has made considerable progress over the past few decades and has been the foundation on which some recent national parks and nature reserves have been created (Myers *et al.* 1984). The achievement of representativeness in such reserve systems has proceeded through mapping selected components of the flora and fauna, usually dominants in the case of vegetation mapping (e.g., Beard 1981; Sattler 1986). There remains considerable potential for the use of this approach in extending the reserve network over the next century.

At the same time, detailed mapping of selected taxa needs to be pursued to ensure that the reserve system established to achieve representativeness is complemented by additional reserves that protect taxa left out of the larger reserve network. For example, intensive surveys over the past decade have located 1 386 populations of the 238 taxa of flora declared as endangered in Western Australia (Hopper *et al.* 1990). Of these populations, only 381 (28%) occur on existing reserves, with most occurring on freehold land, road verges, etc. Conservation through reserves alone will not ensure that Australia's genetic resources are protected. Land owners from throughout the community at large each have an important contribution to make (Table 1).

Seeking the assistance of interested volunteers in mapping individual species has been successful recently in the compilation of the Atlas of Australian Birds (Blakers *et al.* 1984) and the Banksia Atlas (Taylor & Hopper 1988). Such an approach has considerable merit for well documented, easily surveyed organisms, particularly in view of the size of Australia and the paucity of professional biologists able to conduct extensive field surveys. Industry too is making contributions to the biogeographic data base through requirements for environmental impact assessment (e.g., Worsley Alumina Pty Ltd 1985).

TABLE 1. Land status for populations of declared endangered flora in Western Australia (from Hopper *et al.* 1990).

Land status	No. of populations
National Parks	207
Nature Reserves	174
State Forest	38
Main Road and Shire Road Reserves	302
Private	216
Other	549
Total	1 386

The application of computer-based Geographical Information Systems to biogeographical data has considerable promise in facilitating conservation and management. The integration of satellite technology with conventional cadastral, topographic, climatic, edaphic and biogeographic mapping will yield interactive capabilities of outstanding value to tomorrow's conservation biologists.

Mapping genetic resources within species

Mapping genetic variation within species is an essential requirement to ensure that populations on reserves provide a representative sample of the existing genetic variation. With current technology it is a time-consuming process and therefore few organisms can be mapped in this way.

How to sample genetic variation efficiently remains problematical. Controlled environment studies of polygenic morphological and physiological variation has been customary in forestry and agriculture for many years (e.g., Green 1971; Grant 1975; van der Moezel & Bell this volume; Malcolm this volume). However, these studies are often unsuitable for rapidly measuring and surveying patterns of genetic variation over the geographic range of a species (Lewontin 1974).

Morphometrics. Multivariate morphometric studies (Reyment *et al.* 1984) provide a powerful and efficient approach to resolving patterns of geographical variation, natural hybridization and sibling speciation (e.g., Campbell & Mahon 1974; Hopper 1977; Coates 1981). A genetic basis to such patterns may be reasonably inferred where consistent morphometric differences are seen between populations in sympatry and/or throughout their geographical ranges.

Morphometric studies are less time-consuming per population sampled than biochemical studies and thus enable better sampling of natural populations. However, the underlying genetic basis of morphometric attributes is often polygenic and requires elaborate breeding programmes to be elucidated. Where such knowledge is required, the simpler inheritance of most isozymes offers a preferable field of study (see below).

Over the past decade we have witnessed a transition from the use of morphometric techniques predominantly on large, expensive main-frame computers to ready availability on modestly priced personal computers. This improvement in accessibility, combined with advances in direct measurement by computer data capture, suggest that multivariate morphometric studies will play an increasingly important role in mapping the genetic resources of those Australian species amenable to such analysis.

Chemosystematics. Cryptic variation in morphologically uniform species may be revealed through assays for secondary compounds such as flavonoids or terpenoids. The occurrence of resinous compounds on the leaves and stems of some native plants has proved useful in studies of geographic variation (e.g., Dell 1975). However, as with morphometric attributes, the underlying genetic basis for secondary compounds may be complex and require sophisticated breeding studies to document.

Chromosome markers. Some groups of native plants, reptiles, native rats, marsupials, insects and spiders display geographic variation in chromosome number or structure that has been mapped by cytogeneticists (e.g., James 1965; Shaw 1976; Baverstock *et al.* 1977; Coates & James 1979; King 1979, 1983; White 1980; Briscoe *et al.* 1982; John & King 1983; Moritz 1984; Rowell 1985; Shaw *et al.* 1988). Such variation can be of particular significance in assessing the genetic resources of a species and in adequately conserving and managing that resource.

In some species complexes, chromosome differences may indicate adaptive differences and/or reproductive isolation of varying completeness between populations. Coates and James' (1979) study of chromosome variation in the triggerplant *Stylidium crossocephalum* illustrates this kind of population differentiation (Fig. 1). Such information would need to be considered carefully in any genetic conservation or management strategies, particularly with regard to translocation or re-establishment programmes (James 1982). Clearly, it would be undesirable to mix individuals of one chromosome variant with those of another if the resultant progeny were likely to have reduced viability or fecundity.

Studies documenting chromosome variation within species of lizards (King 1979, 1983; Moritz 1984), native rats (Baverstock *et al.* 1977), rock wallabies (Briscoe *et al.* 1982) and grasshoppers (Shaw 1976) highlight the need for caution in translocation programmes in many groups of fauna as well.

The data from these studies may also provide useful guides to reserve system design. For example, in *Isotoma petraea* (James 1965, 1970), as many as possible of the chromosomally complex heterozygous populations in the south-western part of the range should be conserved to maximize representation of chromosomally marked genetic resources. In contrast, a smaller selection of the bivalent-forming structurally homozygous populations ranging across arid Australia would need to be represented in reserves if chromosomal variation was the primary focus for conservation [a consideration of isozyme variation suggests that many bivalent-forming populations nevertheless should be reserved despite their chromosomal uniformity to protect other types of detectable genetic variation (James *et al.* 1983)].

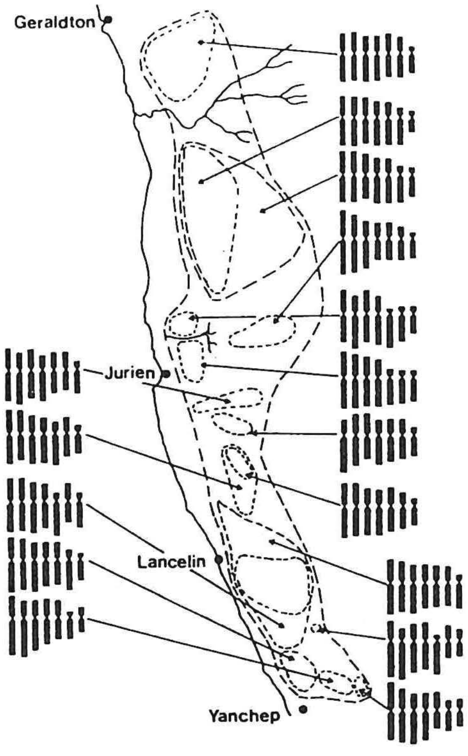

FIG. 1. Distribution in Western Australia of chromosomal variants in the triggerplant *Stylidium crossocephalum* (after Coates & James 1979).

King's (1979, 1983) detailed documentation of chromosomal variation in species complexes of the gekko genus *Gehyra* provides a similar example of the usefulness of cytogenetic studies. It is now clear that dramatically different reserve systems are needed to ensure representativeness of variation in these lizards than would have been predicted on the basis of earlier information.

Isozyme markers. Isozymes currently provide the most efficiently sampled markers for mapping the geographical pattern of genetic variation in wild populations (Lewontin 1974; Brown & Moran 1981; Hamrick 1983). Isozymes, however, provide only a sample of each organism's genetic makeup, so that a lack of isozyme variation in populations need not mean that no genetic variation exists. With this limitation in mind, isozymes nevertheless provide a powerful tool for genetic analysis.

Geographical patterns of genetic variation in populations may be investigated at two levels. The first is to document geographical patterns in genetic differentiation or genetic diversity. These patterns may show a relationship with geographical distance, different biogeographic regions or with marginal versus central areas of a species' distribution. The second level is to investigate associations between geographically varying environmental parameters and genetic variation or specific gene loci.

With regard to correlations between geographic distance and genetic distance, the present evidence is equivocal. Initial indications were that geographic proximity usually is a poor indicator of genetic similarity (Nevo 1978; Levin 1978; Schwaegerle & Schaal 1979; Schaal & Smith 1980; Glover & Barrett 1987). More recently, however, significant positive correlations between geographic and genetic distance were found in several studies (Guries & Ledig 1982; Wendel & Parks 1985), including work on the Western Australian granite rock mallees *Eucalyptus caesia* and *E. crucis* (Moran & Hopper 1983; Sampson *et al.* 1988). These alternative patterns were found within the same species (*Pinus radiata*) in different parts of its distribution by Plessas and Strauss (1986).

Comparisons of levels of genetic variation between geographically marginal populations and central populations have also provided varying results. Theory predicts that marginal populations should exhibit reduced variability but empirical studies indicate that they can be either less, equally or more heterozygous than central populations. Perhaps this is not surprising given the difficulty in distinguishing between what is ecologically marginal and what is just geographically peripheral (Lewontin 1974; Guries & Ledig 1982; Glover & Barrett 1987).

Patterns of isozyme variation in plants are correlated with various life history attributes, such as breeding system, longevity, etc. (Hamrick *et al.* 1979; Loveless & Hamrick 1984). This suggests that it may be possible to derive general principles about genetic variation from a sample of organisms with similar life histories.

Such an approach was investigated by Moran and Hopper (1987) in relation to the conservation of genetic resources in rare and widespread eucalypts. They found that most variation existed within, rather than between, populations in widespread eucalypts. However, the reverse held for *Eucalyptus caesia*, a regionally distributed species occurring in small isolated populations on granite outcrops in the Western Australian wheatbelt (Moran & Hopper 1983). A similar pattern to that in *E. caesia* has been reported recently by Sampson *et al.* (1988) for another granite rock endemic, *E. crucis*.

In some organisms such as marsupials (Baverstock, pers. comm.), isozyme variation is limited within species and provides little data of use to mapping genetic resources. Current studies of mitochondrial DNA variation (Moritz *et al.* 1987) have been successful in documenting genetic differentiation of populations within species of lizards (Moritz & Brown pers. comm.) and fish (Ovenden & White pers. comm). In the future, assaying mitochondrial and other types of DNA may well replace isozyme studies as the most efficient end direct way to sample genetic variation within species (Moritz *et al.* 1987).

Essential genetic management of flora and fauna

Some theoretical considerations

A genetic approach to the management of flora and fauna in the wild is a new field of activity. Much of what we propose below, therefore, is of necessity speculative and needs critical evaluation in future empirical studies.

Firstly, as a fundamental premise, we assume that a primary aim of genetic resource management is the maintenance of genetic diversity.

There is little doubt that the rate of evolution is influenced by the level of genetic variation. Experimental evidence indicates a positive correlation between the amount of heterozygosity and the rate of evolutionary change (Ayala 1965, 1988). Furthermore, a considerable body of knowledge indicates that organisms with high levels of heterozygosity and open recombination systems capable of generating genetic variability are those that constitute evolutionary lineages with the best long-term future (Darlington 1958; James & Hopper 1981).

The selective value of heterozygosity as a fundamental phenomenon in evolution was recognized by Darwin (1859), developed as a concept by Darlington (1958), and empirically explored in Australia at considerable length by James (1981; James & Hopper 1981) and others. The evolution of many unusual breeding systems and cytogenetic attributes may be ascribed to natural selection favouring mechanisms that conserve genetic variation or heterozygosity in the face of enforced inbreeding or harsh environmental circumstances.

If heterozygosity usually is of selective value, it should be possible to demonstrate that heterozygous individuals have higher fitness than homozygous individuals. Such has been the case in many studies (e.g., reviews by Grant 1975; Mitton 1978; Mitton & Grant 1984). An elegant investigation of this hypothesis in a cytogenetically complex situation in *Isotoma petraea* was provided by Beltran and James (1974).

Strong selection for heterozygosity through the life cycle is suggested in many studies of eucalypts and other plant taxa, where heterozygosity in isozyme alleles increases from the seed to the adult stages (e.g., Moran & Bell 1983; Ledig 1986)

Furthermore, individual plants of rare eucalypts that persist in small remnant populations are often highly heterozygous (Moran & Hopper 1987).

On an evolutionary time scale, the high incidence of allopolyploidy and hybrid speciation in plants (Grant 1981) and some animal groups (White 1978) provides additional evidence that selective forces may favour heterozygosity.

To summarise, then, the maintenance of genetic diversity and heterozygosity in natural populations appears to provide the best general strategy for facilitating evolutionary flexibility and persistence for most organisms. However, there are situations where natural selection may favour homozygosity. Such special circumstances would call for different genetic management strategies.

Secondly, the concept of minimum viable population size (MVP) warrants brief discussion because it is a principal issue with regard to both long-term and short-term survival of a species. The concept proposes that there is a minimum effective population size for each organism needed to guarantee a high probability of survival (Soulé 1987).

Understanding the MVP problem is considered to be one of the most important issues in conservation biology (e.g., Lacy 1988). It requires a basic knowledge of the effects of reduction in population size, increased population isolation, inbreeding and the importance of stochastic and deterministic forces in maintaining levels of genetic variation within populations.

Moreover, it is clear that MVP may be influenced by demographic as well as genetic processes (Ewens *et al.* 1987). For example, a single catastrophe may destroy a population irrespective of its genetic makeup, level of inbreeding, etc.

Population genetic theory predicts that large populations should maintain higher levels of genetic variation than small populations because they are less susceptible to loss of variability from stochastic processes. Theory also predicts that the greater the isolation between populations the greater the level of between population variation and that this divergence will be more rapid if the populations are small.

The effects of stochastic processes on genetic variation in populations can be most readily observed when populations are recovering from a bottleneck or new populations are founded by very few individuals. Predictions are a reduction in average heterozygosity and loss of rare alleles although both of these effects depend very much on the size of the bottleneck and the rate of population recovery (see Nei *et al.* 1975).

Although theoretical expectations concerning the effects of population size, bottlenecks and population isolation on levels of genetic variation have been adequately addressed, empirical data on plants and animals remain scarce. A range of situations exist in those cases investigated, perhaps reflecting the diversity of available genetic systems, some of which may conserve heterozygosity, others being neutral, while others favour homozygosity. The eucalypts, for instance, provide contrasting evidence concerning the relationship between population size and levels of genetic variability. In *Eucalyptus pendens*, a localized species with disjunct populations, Moran and Hopper (1987) found no relationship between population size and any single locus diversity measure. For example, the smallest population sampled (North Badgingarra, 27 plants) had higher mean number of alleles per locus, average percentage of polymorphic loci, and observed and expected heterozygosity than one of the largest populations (Coonawarra Downs, 1 000 plants). Similarly in *E. caesia* there was no correlation (Moran & Hopper 1983), whereas in *E. crucis*, a species with a comparable disjunct population structure, Sampson *et al.* (1988) did find a significant correlation between heterozygosity and population size.

Whether small populations can maintain adequate levels of genetic variability depends on the genetic system of the species and the history of the populations. Some species seem to have the capacity to exist in small isolated populations and yet maintain relatively high levels of genetic variability (Moran & Hopper 1987; Coates 1988). It would appear that in these cases selection favouring heterozygosity may be a major factor.

Available evidence suggests that, on genetic criteria, a universally applicable "magic" number of individuals required to constitute a minimum viable population does not exist. Empirical studies of genetic variation and population structure in a diverse range of organisms are needed to ascertain if general guidelines can be established for MVP. In the meantime, we would urge conservation managers to err on the side of caution and to protect populations no matter how small until appropriate genetic and demographic studies can be undertaken.

Genetic management strategies

Where the genetic resources of a species have been adequately documented, a number of management strategies can be implemented to maintain genetic diversity. These strategies include selection of priority populations for conservation, reserve and corridor design, forest tree and fisheries management, and active management of species through propagation, captive breeding and translocation in the wild.

Selection of priority populations for conservation. Managers of wildlife species that are endangered or otherwise in need of special protection are faced often with insufficient resources to look after all known populations. A choice has to be made on the allocation of scarce resources in such circumstances (e.g., for fencing habitat, purchasing habitat, conducting research, etc.). While ecological

and political circumstances often dictate the allocation of management priorities, genetic data deserve consideration from a number of perspectives.

Selection of priority populations for genetic conservation can be based on the level of genetic differentiation between populations, the presence of rare but locally common alleles (Brown 1978), and the level of genetic diversity within each population. If we consider just the level of differentiation between populations, the dendrograms from isozyme data that cluster genetic distance values for population divergence in the three species *Eucalyptus caesia* (Moran & Hopper 1983), karri, *Eucalyptus diversicolor*, (Coates & Sokolowski 1989) and *Banksia cuneata* are particularly informative (Fig. 2).

Eucalyptus caesia is characterized by relatively large genetic distance values between populations, while in comparison both karri and *Banksia cuneata* show much lower levels of interpopulation differentiation.

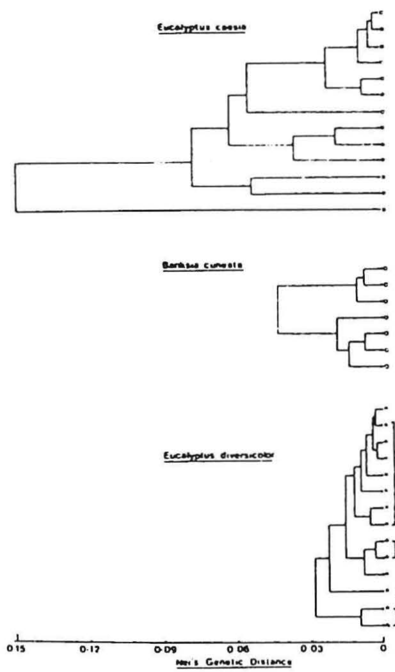

FIG. 2. Dendrograms resulting from cluster analyses based on Nei's genetic distance between 13 populations of *Eucalyptus caesia* subsp. *caesia* (□) and subsp. *magna* (■) (after Moran & Hopper 1983), 13 populations of karri (*E. diversicolor*), and seven populations of *Banksia cuneata*.

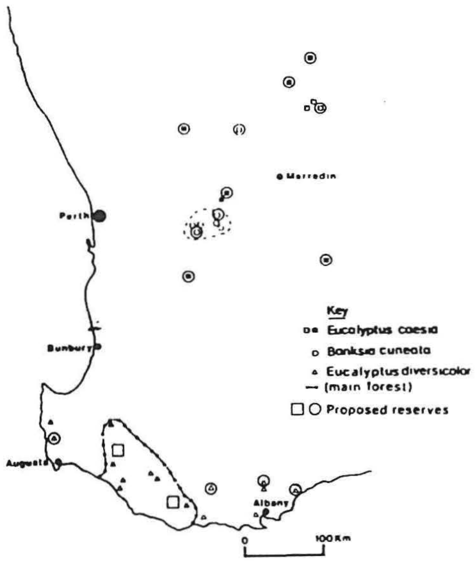

FIG. 3. Distributions and populations used in isozyme studies on *Eucalyptus caesia* subsp. *caesia* (■) and subsp. *magna* (□), karri (*Eucalyptus diversicolor*) and *Banksia cuneata*, and a minimum proposed reserve system for genetic resource conservation in these species. Large reserves are indicated by the open squares.

The dendrograms also indicate that in karri, certain outliers such as the Porongorup populations are noticeably divergent from most other populations while *Banksia cuneata* is characterized by two distinct population groups.

Based on these data, strategies for the conservation of genetic resources in these three species will be quite different (Fig. 3). In *E. caesia* many populations covering its geographic range would need to be protected, while in karri a few large reserves in the main karri belt plus protection of outliers in the Porongorups, Rocky Gully and Leeuwin-Naturaliste block areas would be desirable. In *Banksia cuneata* a minimum of one large population from each of the two population groups would probably ensure adequate protection of genetic resources in this species. Although the information provided in these dendrograms is only a part of the total population data available from isozyme studies it does indicate their value when developing wildlife management programmes.

The work of Johnson and Black (1984) and Johnson (pers. comm.) on genetic resources in marine organisms may be similarly applied to marine conservation programmes.

Reserve and corridor design. Three basic problems concerning reserve design are size, number and spatial arrangement.

There is little doubt that genetic considerations are one of the key concerns in addressing these problems (Soulé & Simberloff 1986). A related concern is the need to determine MVP from a genetic resources point of view. Several factors need to be considered with respect to MVP and reserve design. For instance, the population will need to be sufficiently large to ensure that existing levels of heterozygosity are maintained, and that inbreeding does not reach unacceptable levels. Further, as indicated previously, the long-term survival of a population requires adequate levels of genetic variation, although what these levels should be and what population size is required to maintain these levels are largely unknown for most species. In spite of these difficulties we have already seen that general strategies for reserve design can be obtained from studies on geographic patterns of genetic variation and population genetic structure within both plant and animal species.

The incorporation of corridors in a reserve system has clear advantages, particularly if the aim is to maintain genetic diversity and reduce the possibility of inbreeding by enhancing gene flow and dispersal. Although they may have such benefits, apart from the political and economic difficulties associated with developing a reserve system with corridors, there are other difficulties where corridors could negate the quarantine advantage found in a system of isolated reserves (Soulé & Simberloff 1986).

Where corridors are impractical or do not exist, alternative management strategies are possible to counteract localized extinctions and a lack of gene flow. These strategies may involve translocation of individuals and founding of new populations (see below).

Forest tree and fisheries management. Australian commercial forestry has a strong reliance on wild-growing native hardwoods and so genetic research on wild populations has broken new ground in several key areas. Firstly, provenance trials aimed at establishing the best populations and mother trees for seed for growing at particular locations have been completed on several species (e.g., Green 1971). Secondly, the use of isozymes to investigate mating systems in eucalypts with a view to improving seed orchards was pioneered by A. H. D. Brown and colleagues (Brown *et al.* 1975; Phillips & Brown 1977).

Isozyme surveys of genetic variation in commercially important timber species have proven useful in a number of cases. For example, data on karri, some of which are referred to in the previous sections (Fig. 2), have already indicated priority populations or areas from which seed collections should be made to ensure that any germplasm storage programme will maximize the conservation of genetic resources in this species. These data also show that all major allozyme variants, apart from those in the Rocky Gully population, are adequately represented in conservation reserves and management priority areas. This of course does not necessarily mean that all the genetic variants in karri are adequately reserved. Within the limits of the isozyme technique, however, it is a very useful start.

A knowledge of genetic variation also aids the manager in terms of replanting strategies and in designing seed orchards so as to maximize levels of heterozygosity (Moran pers. comm.).

The application of genetic resource studies to commercial fisheries is a recent development. Pioneering work has been useful in demonstrating the existence of subpopulations or sibling species that may require separate management to maintain sustained yields. For example, Macdonald (1980) showed that the Shark Bay population of the Australian snapper, *Chrysophrys auratus*, had a number of rare alleles not found elsewhere across southern Australia. Further differentiation within the Shark Bay area was shown subsequently by Johnson *et al.* (1986). A second distinctive stock occurred in Spencer Gulf. Depletion of these stocks through overfishing could lead to the loss of significant genetic variation that could not be replaced by recruitment from elsewhere.

By way of contrast, Richardson (1984) found no electrophoretic evidence of population substructuring in the jackass morwong, *Cheilodactylus macropterus*, in south-eastern coastal waters from western Victoria to southern New South Wales and down the east coast of Tasmania. This suggests that heavy local overfishing might be offset by recruitment from elsewhere but Richardson cautioned against management along these lines in view of the limited sampling achieved in his study.

Cultivation, captive breeding and re-establishment or translocation. Intensive genetic management has yet to be carried out on populations of any endangered native Australian plant or animal, although it is an option which may need to be considered in the future if extinction in the wild is to be prevented. This form of management will probably require captive breeding of animals or cultivation of plants followed by their re-introduction or translocation into areas where they were previously known to exist. Alternatively, it may more simply involve translocation of some individuals from one population to another with the aim of enhancing genetic diversity within the recipient population.

Whatever the form of management, it is quite clear that detailed population genetic, breeding system and population ecological studies should be carried out on the species concerned before the programme was initiated. For example, it would be futile to transplant or relocate individuals of species such as *Isotoma petraea*, *Stylidium crossocephalum*,

Caledia captiva or *Heteronotia binoei* without first determining their ability to interbreed and produce viable and fecund offspring. This problem has been addressed by Templeton (1986) in his concept of outbreeding depression.

In the context of this volume, there needs to be some caution in the revegetation of degraded lands if the aim is to re-establish viable breeding populations. In the Western Australian heathlands, for example, remarkable levels of karyotypic and genetic divergence within morphologically uniform widespread species have been documented (e.g., Coates & James 1979; Fig. 1). In such circumstances, it is essential that local seed stocks from as close to the area disturbed as possible be used to revegetate mine sites, road verges, etc. In contrast, species such as karri (Fig. 2) show little genetic differentiation over considerable distances in the main forest and little risk of outbreeding depression would be likely from mixing seed from different geographic sites within the main forest belt. Rather, such management may yield a slight increase in levels of heterozygosity and a more vigorous karri forest.

The difference in likely outcomes of translocation management of species such as *Stylidium crossocephalum* versus karri indicates that a knowledge of population structure, chromosomal and genetic differentiation, and reproductive biology should become an integral part of the expertise of tomorrow's environmental rehabilitation manager.

Philosophical, scientific and economic arguments have been used for and against the intensive management of a species to prevent its extinction in the wild. Some argue that this type of management cannot generally be justified because chances of successful re-introduction are always problematical. Further, they point out that captive breeding or cultivation followed by re-introduction is expensive and that funds going into such programmes are likely to be directed from other programmes which may be more effective in preventing extinction. Although both these points have some merit, the alternative of *ex situ* conservation in botanic gardens or zoological gardens is also plagued by economic difficulties and is likely to be far less efficient in terms of genetic resource conservation. In addition, evolutionary theory predicts that most genetic variation (with the exception of rare variants) can be saved from relatively few individuals if group size is increased rapidly (Nei *et al.* 1975). This suggests that maintaining or restoring adequate levels of genetic variation in a wild population to ensure long-term evolution is a feasible option.

Conclusion

The conservation of genetic resources in Australia's flora and fauna will, of necessity, depend upon the injection of new life in key areas of scientific enquiry. We have highlighted the importance of taxonomic work in defining the biological units which we wish to conserve. We have also noted that a population genetic approach is useful and often essential in resolving complex patterns of variation between and within species, in reserve design for species whose genetic resources are considered important, and in understanding and managing the reproductive biology of such species.

Given the pace of continuing destruction of native vegetation, the search for general principles in gene resource conservation from a limited sample of the Australian flora and fauna is a key scientific challenge facing workers over the next century. The identification of functionally equivalent groups according to their life history, ecology, breeding system and population structure may well enable predictions about genetic resources to be made (e.g., Loveless & Hamrick 1984; Moran & Hopper 1987). We commend this approach to future workers.

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