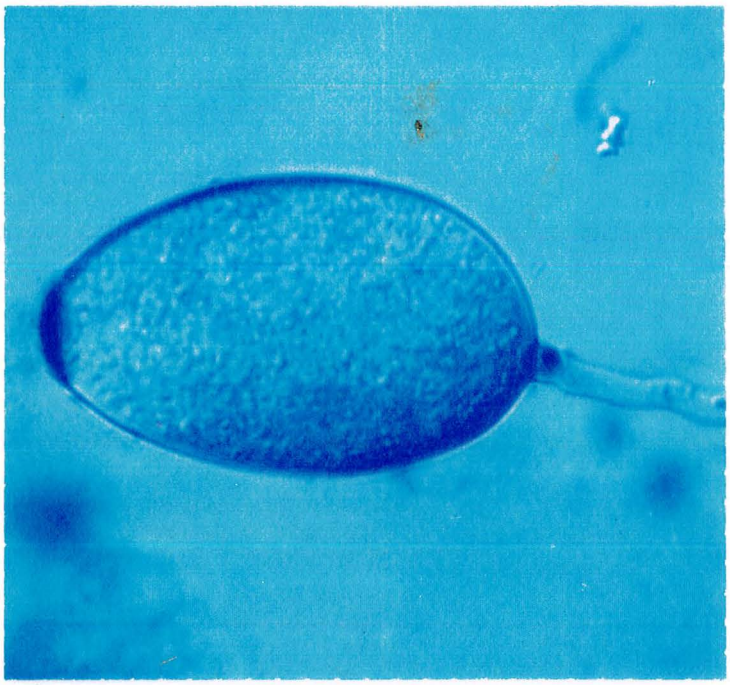

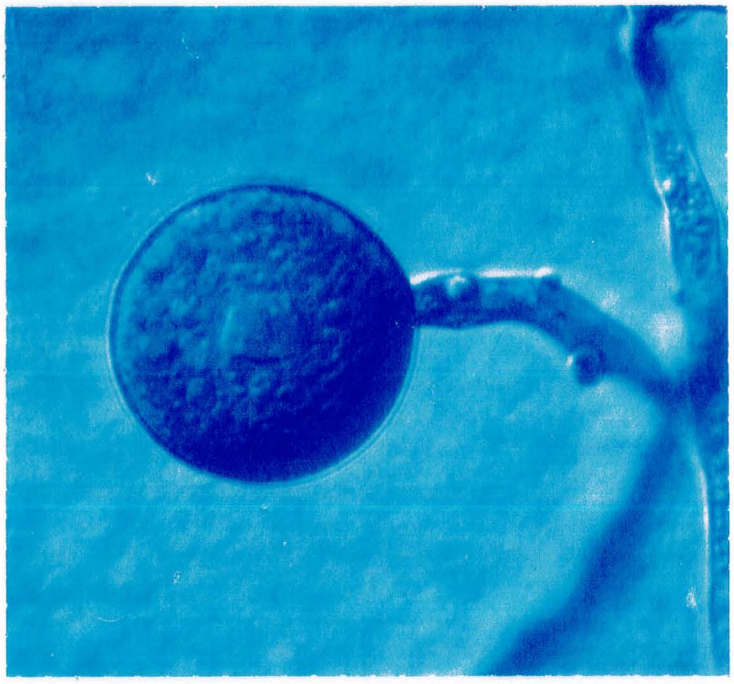

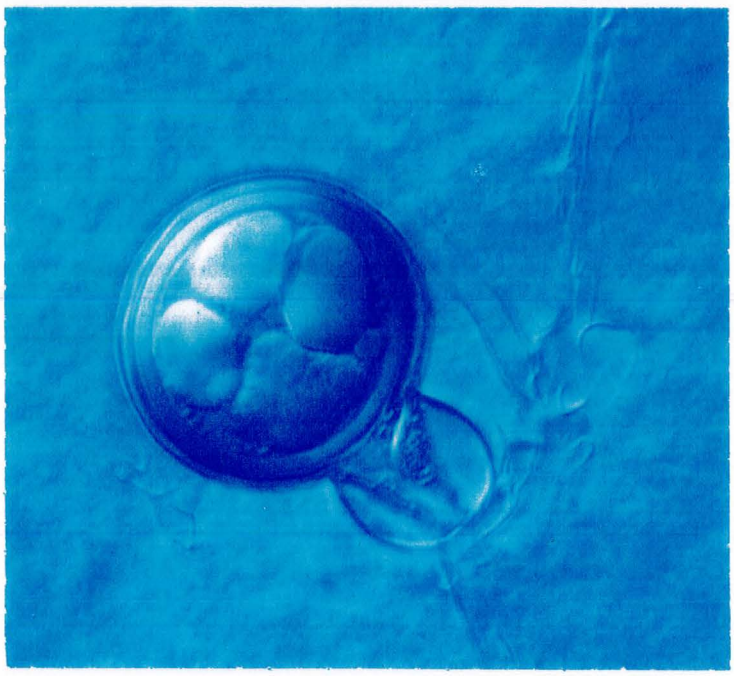

COOPERATIVE RESEARCH CENTRE FOR CONTROL OF PHYTOPHTHORA ROOT DISEASES OF NATIVE VEGETATION

Department of Conservation & Land Management (CALM)

CSIRO Division of Forestry

Murdoch University

University of Melbourne

Australian Nature Conservation Agency

Alcoa of Australia Ltd

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PROPONENTS

COOPERATIVE RESEARCH CENTRE FOR CONTROL OF *PHYTOPHTHORA* ROOT DISEASES OF NATIVE VEGETATION

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Program Leaders

Dr David Coates, CALM
Dr Ian Colquhoun, ALCOA
Dr Ray Wills, CALM
Dr Phil O'Brien, Murdoch University
Dr Bruce Grant, University of Melbourne

PROPOSAL FOR A COOPERATIVE RESEARCH CENTRE FOR CONTROL OF *PHYTOPHTHORA* ROOT DISEASES OF NATIVE VEGETATION

EXECUTIVE SUMMARY

Australia is experiencing the most devastating pandemic disease of native vegetation yet recorded. *Phytophthora* root disease has been listed as one of five processes threatening the biodiversity of the continent, ANCA being required to develop a Threat Abatement Plan by 1998. The CRC will bring together expertise in Western Australia and key research groups from the eastern States to develop means to contain the spread of *Phytophthora* spp. and reduce their impact on native ecosystems, some of which rank globally as unique centres of plant diversity. The Centre will develop conservation and disease control strategies for native heath and shrub communities, rehabilitation of mine sites and adjacent forests and woodlands. These strategies will include land and resource management based on GIS, chemical and biological control of the pathogens and use of resistant species and cultivars of native plants.

Research Unit

Program 1 Disease Management on Natural Lands
Manager Dr David Coates (CALM)
Integrate the most up to-date methods of disease detection, disease control and flora conservation techniques to provide management prescriptions that reduce the impact of disease on native vegetation and conserve endangered communities and taxa at risk from the diseases. Continuously assimilate useful products from other programs into revised prescriptions

- Rapid diagnostics: Dr Phil O'Brien/Murdoch, Dr Adrienne Hardham/ANU.
- Control methodologies and management prescriptions: Dr Brian Shearer/CALM.
- Fungicide application, persistence and efficacy: Dr Brian Shearer/CALM.
- *Ex situ* conservation and gene banking: Dr Kingsley Dixon/Kings Park and Botanic Garden.

Program 2 Disease Management in Mining and Rehabilitation Areas
Manager Dr Ian Colquhoun (ALCOA)
Improve cost-effectiveness of disease control and minimise impacts of *Phytophthora* during mining operations in native plant communities. Rehabilitate mined and other severely disturbed areas affected or at risk from *Phytophthora* .

- Improve cost-effectiveness of mining in disease risk areas: Dr Ian Colquhoun/ALCOA.
- Minimise *Phytophthora* disease associated with mining operations: Dr Ian Colquhoun/ALCOA.
- Minimise *Phytophthora* impacts on rehabilitated sites: Dr Giles Hardy/ALCOA at Murdoch.
- *Phytophthora*-resistant cultivars of trees and shrubs: Dr Jen McComb/Murdoch.
- Marker-aided selection of *P. cinnamomi*-resistant jarrah: Dr Margaret Byrne/CSIRO.

Program 3 Hazard assessment, prediction and decision support tools
Manager Dr Ray Wills (CALM)
Provide a GIS-based decision support system for use in monitoring and controlling the spread of *Phytophthora*-caused disease and the management of highly susceptible taxa.

- Mapping disease distribution through GIS and remote sensing: Dr Ray Wills/CALM.
- Epidemiological modelling of *Phytophthora* disease in landscapes: Dr Ray Wills/CALM.
- Effects of soil microbiological factors on disease epidemiology and impacts: Dr Nick Malajczuk/CSIRO.

Program 4 Molecular Genetics and Biocontrol of *Phytophthora*
Managers Dr Phil O'Brien (Murdoch), Dr Inez Tommerup (CSIRO DF)
Understand host genetic and molecular basis for variation in resistance and susceptibility to *Phytophthora* diseases and develop bio-control methods for *Phytophthora* spp., especially *P. cinnamomi*.

- Molecular genetics of *Phytophthora* spp.: Dr Inez Tommerup/CSIRO.
- Molecular aspects of pathogenicity: Dr Phil O'Brien/Murdoch.
- Mycoviruses as biocontrol agents: Dr Andrew Davidson/Monash.
- Control strategies based on fungal genetics/viruses: Drs O'Brien, Tommerup and Davidson.

Program 5 Biochemistry and Mode of Action of Phosphonate
Manager Dr Bruce Grant, University of Melbourne
Enhance the efficacy of phosphonate as a fungicide for *Phytophthora* spp. in Australian native vegetation through a more complete understanding of its mode of action.

- Mode of action of phosphonate: Dr Bruce Grant/University of Melbourne.
- Uptake and persistence of phosphonate in tpathogens and hosts: Dr Grant/Dr Julie Niere/RMIT.
- Interaction of phosphonate with host defence responses: Dr Ken Gayler/University of Melbourne.

Education and Communication Unit

Coordinators Dr Giles Hardy/Murdoch, Dr Bruce Grant/Melbourne, Dr Steve Hopper/Kings Park and Botanic Garden (KPBG)
There will be a strong community awareness program focused through KPBG. The CRC will also have a major role in education through training at the post-graduate level which will be focussed at Murdoch University and the University of Melbourne. Graduate students will be trained in a wide range of specialist disciplines (co-supervised by CRC research scientists). The Unit will also develop and market through TAFE a prospectus of courses in a range of topics including nursery hygiene, propagation and conservation of native flora, field operations and land management to reduce impacts of *Phytophthora*. These courses will be aimed at employers and agencies with managers and field staff operating in *Phytophthora* disease areas, landcare groups and the concerned public. These courses will draw on the wide range of skills in the CRC, will be tailor-made for client needs and will operate on a user-pays basis.

INTRODUCTION

This proposal addresses an issue not only of national importance but, considering the uniqueness of Australian biota, of global significance. It is a once-only opportunity to capture and focus expertise from all parts of Australia to provide solutions to a catastrophic disease of native vegetation. No one organisation can achieve this alone. Time is not on our side.

Australia is experiencing the most devastating pandemic plant disease of native vegetation yet recorded. Comparisons can be made with chestnut blight which destroyed American chestnut as a major forest species and Dutch elm disease in North America and Europe. Whereas those diseases affect a few genera or a single genus of trees, the death of native vegetation in Australia and especially Western Australia, resulting from *Phytophthora* root disease, is widespread with thousands of species from many genera being decimated and in some instances being driven towards extinction.

The proposal is not a straightforward applied research project; it is a major, attempt to divert research resources of the highest quality into a multifaceted approach to this national and international problem. *Phytophthora cinnamomi* has been recognised as the major disease-causing agent for three decades, but, despite research on many aspects of the etiology and epidemiology of the disease, the pandemic continues. At least two other *Phytophthora* species are also causing damage to vegetation in the south-west of Western Australia. These are *P. megasperma* and *P. citricola*. Although their effects are more cryptic, their presence has increased the difficulty of developing effective management prescriptions.

For many years the disease in the forests of the south west of Western Australia has been known worldwide as jarrah (*Eucalyptus marginata*) dieback, but that name grossly understates its extent as a national problem. In Victoria, tall coastal forests dominated by silvertop ash and stringybark species have been damaged, *E. obliqua* woodlands in central Gippsland and the Brisbane Ranges have suffered dieback, and coastal heath and banksia communities of National Parks, especially Wilson's Promontory, are infested with *P. cinnamomi*. In Tasmania, native species of plants in coastal National Parks are dying of *Phytophthora* root disease, and the fungus has been inadvertently spread into heathlands and rainforest communities of the south-west. Even *Pinus radiata,* which accounts for most of the nation's softwood resource and is crucial to national timber supply strategies, is susceptible to the disease on poorly drained sites. Although the effects of *Phytophthora* disease are most acute on the plant communities of Western Australia, the pathogens also cause severe damage to native plants and horticultural and field crops nationwide.

In the last decade or so, scientists have begun to comprehend the catastrophic effects of *Phytophthora* disease in native plant communities other than forests. The most extreme damage occurs in the south-west of Western Australia where it is estimated that 2000 of the 9000 species of vascular plants are susceptible. Most species in dominant families, including the Proteaceae, Epacridaceae, and Fabaceae die as a result of infection. National icons such as banksias and grass trees are killed by the fungus. Many rare and threatened species are susceptible and the spread of the disease has driven previously-secure species on to the endangered species list. The wide array of dominant species that are killed frequently leads to the collapse of entire communities of plants together with the native fauna that depend on them for food and shelter.

The extraordinary diversity (and endemicity) of vascular plants in south-west Western Australia is globally renowned. There are three nodes of great diversity and all are threatened. Thus, up to 60% of the Stirling Range National Park is infested with *P. cinnamomi* and the disease continues to spread; there are infested sites in both the kwongan of the northern sand-plain in the vicinity of Mt. Lesueur National Park and the Biosphere Reserve, Fitzgerald River National Park. Dr Clive Brasier, one of the most respected international authorities on *Phytophthora* diseases visited Australia in early 1993. He considered that the epidemic in native vegetation of south-west Australia is more severe in its impact than any he has witnessed on other continents, and ranks as an all time great global, ecological disaster.

Responsibility

Much of the remaining native vegetation in southern Australia grows on Crown land that is vested for many purposes in agencies of Federal or State Governments or local authorities. They are responsible for managing and regulating use of areas of natural vegetation which are threatened or infested by *Phytophthora*. Land uses range from defence to forestry, mines, quarries and mineral exploration, water catchment, conservation and recreation. Many affected areas are dissected by transport and communication easements which facilitate the spread of *Phytophthora*.

The Australian public collectively owns and enjoys an immensely rich and unique natural heritage. We value our heritage for its intrinsic worth and for our emotional well-being through enjoyment of natural landscapes and their biota. But we also derive wealth and resources from it. Examples of annual benefits to Western Australia alone are the timber industry (value = $0.75 billion), honey (value = $2.8 million), wildflowers (value = $13.8 million). Tourism depends heavily on the landscape, wildflowers and fauna, particularly (but by no means only) in National Parks. The disease risk places costly obligations on mining companies to operate hygienically. ALCOA, a core participant in this proposal, spends about $0.3 million per year on *Phytophthora*-related research and considerably more on rehabilitation and preventative measures that are necessary because of the disease risk.

Bio-prospecting offers enormous potential for Australia as illustrated by conocurvone, a potential AIDS drug found in some Western Australian species of *Conospermum,* family Proteaceae. This discovery has already led to arrangements that will pay millions of dollars to the nation. Most Proteaceae, including *Conospermum* spp., are highly susceptible to the disease. At least 150 other species have interesting bio-active chemicals but most Australian plants await pharmaceutical exploration.

The unique extent of the threat of *Phytophthora* species to the nation's biodiversity is recognised in the National Strategy for the Conservation of Biological Diversity. Indeed it is the only pathogenic taxon specifically cited. The Commonwealth Endangered Species Protection Act of 1992 lists *Phytophthora* disease as one of one of five "Key Threatening Processes" endangering Australian species and ecological communities. The other four threats are feral animals. The Commonwealth, through ANCA (a core participant in this proposal), is obliged under the Act to prepare a Threat Abatement Plan for *Phytophthora* by 1998. The plan must identify the research and management actions necessary to reduce the threat to an acceptable level. Work on the *Phytophthora* Threat Abatement Plan is scheduled to commence in 1995/96. The work of this CRC will address issues that are central to that Plan. It is noteworthy that two of the other four Key Threatening Processes, namely foxes and rabbits, are already being effectively addressed through the CRC for the Biological Control of Vertebrate Pest Populations, in which ANCA, CSIRO and CALM are also core participants.

This CRC proposal provides a unique opportunity to prevent loss of natural resources and so protect a source of major social and economic wealth. Although *Phytophthora* species form a focus for research in the CRC for Tropical Plant Pathology, the latter serves a different climatic region, crops and agribusiness systems rather than native vegetation, and has a broad brief to provide solutions for diseases of a range of field and horticultural crops and pastures. Discussions with the Director, Professor John Irwin, and his staff have shown that, rather than duplication of objectives, there are many opportunities for collaboration and synergistic support.

We believe that there is a strong case to support a new CRC with the mission:

> **To protect Australia's biological resources from a major threat caused by *Phytophthora* root diseases.**

NEW HOPE FOR CONTROL OF *PHYTOPHTHORA* SPECIES IN NATIVE VEGETATION

Land managers, be they miners or park rangers, need solutions. In the last decade scientists have developed new technologies including new forms of chemical control, molecular biology, new biological control options and computer-based land management systems which offer opportunities to manage or reduce the impact of disease caused by *Phytophthora* species on natural ecosystems. New public and corporate awareness of the consequences of environmental degradation, the need to conserve biodiversity and its potential as a source of wealth for Australia has created a climate for forging a union between the Commonwealth, State and University research organisations, commercial resource managers and government land managers. Just two indications of this awareness among core participants are:

- An initiative by ALCOA, one of the major mining companies in WA, to rehabilitate sites of former mine pits with of their indigenous flora despite the threat of *Phytophthora* disease. This demands new technology. Current costs of rehabilitation average $17000 per ha.

- ANCA has allocated almost $0.5 million per year for five years from its Commonwealth Endangered Species Program budget to *Phytophthora* research and management by CALM in Western Australia. This constitutes approximately 10% of the entire (fauna and flora) National Endangered Species Program budget for 1994/95 ($5.2 million).

New opportunities for disease control to be exploited by the CRC are:

- The discovery of a cheap, effective, systemic fungicide, phosphonate, which may hold the line in protecting native vegetation and could form the basis for disease-free horticulture based on the lucrative market for Australian wildflowers. Its remarkably low phytotoxicity coupled with its long-term efficacy offers great potential for field application. In one experiment banksia trees treated five years ago remain healthy although a *Phytophthora* disease front has passed them by killing all their untreated neighbours. Recent advances in the understanding of its mode of action suggest the potential for important advances in improving its efficacy and in applications technology.

- There have been rapid developments in remote sensing and geographical information systems (GIS) computer hardware and software that integrate spatial information on natural resources. They enable patterns in disease epidemiology to be correlated with physical and biological parameters and facilitate management planning for whole regions including measures designed to reduce the spread and impacts of disease.

- Improved tissue culture technology can be used to clone selected resistant cultivars. This has been achieved with jarrah and resistant clones are now available for rehabilitation in high risk or diseased sites. CSIRO has created a eucalypt genome map which promises the capacity to select *Phytophthora*-resistant individuals by DNA markers.

- Modern molecular genetic technology enables manipulation of the genomes of both the host and pathogen. There are good prospects for commercial benefits from intellectual property rights on resistant clones of otherwise susceptible, commercially valuable species and on biocontrol agents.

- New techniques for germplasm storage (including cryostorage) of Australian plants offer a front-line solution for *ex-situ* conservation of rare and endangered species (including sub-specific genetic variation) threatened by *Phytophthora*.

- The discovery of double stranded RNA (ds RNA) in *Phytophthora* may provide novel biocontrol strategies. These factors, which can be regarded as mycoviruses, offer new opportunities for biocontrol of major pathogens, as their presence often influences the pathogenicity of fungal strains. In some well documented instances (chestnut blight and Dutch elm disease), transmissible elements convert virulent strains to an avirulent phenotype and have provided practical and useful control methods.

- The advent of rapid diagnostic methods based on monoclonal antibodies and DNA probes with specificity at the species and below-species level. Through groups in Canberra (RSBS), Murdoch University and the CRC for Tropical Plant Pathology, Australia is a world leader in this technology for the identification of *Phytophthora*.

No single line of R&D will provide a solution for the problem the very nature of which demands the multifaceted approach outlined in this proposal. The centre of gravity of the CRC will lie in WA at the CALM Como site and at Murdoch University. The requisite technologies, however, span a wide range of disciplinary skills located at a number of institutions across southern Australia. The CRC will focus these efforts on the complex problem of containing the spread and reducing the impact of the *Phytophthora* disease on Australia's natural resources and provide the requisite continuity in funding to convert research outputs into practical solutions.

Where possible, staff of different institutions will collocate. The new WA Centre for Agricultural Biotechnology on the Murdoch Campus presents special opportunities in this regard and an arrangement has been made for a key CSIRO scientist to locate at this facility. CALM and Kings Park and Botanic Garden are currently negotiating a State strategy to store germ plasm of threatened plant taxa; the strategy will include collocation of staff and sharing of research facilities. Field sites offer further opportunities for collaborative research under

different Programs. Several major experimental sites will be developed in the south-west of WA (e.g. the Stirling Range and Two Peoples Bay) and possibly in Tasmania. These sites will be the focus for detailed analysis of vegetation, land forms, disease impacts and control trials. Mine rehabilitation sites will also provide opportunities for a wide range of linked research activities and for the integration of results in management strategies.

COMMERCIAL AND INTELLECTUAL PROPERTY OUTPUTS OF THE CRC

Protection of the biological resources that are threatened by these diseases will be the primary benefit to Australians. This benefit will have economic and aesthetic value to future generations. However, there are clear opportunities for the generation of intellectual property in the areas of computer software, novel fungicide formulations or applications technology, and molecular genetics. The education and communications program will have a strong user-pays component through short courses, training modules and extension activities.

To maximise this potential an essential part of the CRC's initial activity will be to develop and implement a dynamic commercial strategy as a backbone for the Centre's long-term business plan. This will be accomplished with professional advice which is available from CALM's intellectual property and business unit, and CSIRO's Directorate of Corporate Business.

PROGRAMS, PROJECTS AND PARTICIPANTS

The CRC will have two components. **Research and Development** will develop solutions to management problems. **Education and Communication** will transmit the products of R & D to managers, promote community awareness of the issues, educate people and organisations that work in dieback risk areas and train scientists in disciplines that are relevant to plant disease control.

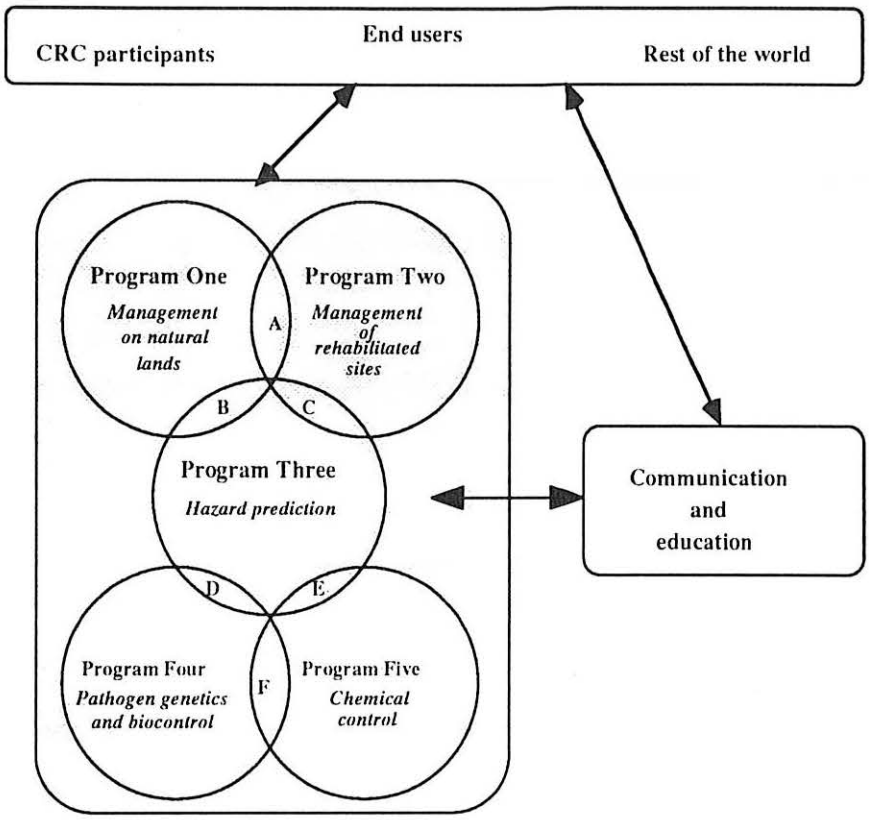
Research and Development: an Integrated Plan (Figure 1)

The plan consists of five programs. Programs 1 and 2 will apply existing technology to reduce disease impacts in natural lands and those areas affected by mining operations. They will also develop to an operational level new solutions from Programs 4 and 5. Program 3 will use remote sensing and state of the art (GIS) technology to characterise sites, to assess disease hazards and to integrate and direct application of control measures on a landscape scale in space and time. The five Programs collectively comprise an integrated plan **to protect Australia's biological resources from the effects of *Phytophthora* root diseases**. We have already drawn attention to technology developed in the last few years that offers new and promising approaches to problems that have taxed scientists in Australia for more than three decades. This CRC will capitalise on achievements of individual research groups by focussing the extraordinary talent that exists within them into one integrated drive for solutions. It will overcome the tyranny of geographical and institutional distance and, most importantly, it will draw together academic researchers and end users. A major focus for the implementation of outcomes will be the Threat Abatement Plan to be compiled by ANCA by 1998.

The fact that CALM, with responsibility for conservation and land management in WA (thus a vitally interested end user) will host the CRC and two of the other five core participants (ANCA and ALCOA) are end users of research outputs ensures that focus on solutions and their rapid availability to managers will be a paramount concern of the CRC.

Although the R&D program is complex, the participants are well known to each other and several scientists already have strong track records of collaboration. We are confident that a highly effective and integrated research effort will be developed.

Figure 1. Integration of the CRC Components the Focus is on Outputs



Legend

A	Application of technology common to both situations.
B	Management planning for protection of natural communities.
C	Operational planning and rehabilitation of sites affected by mining activities.
D	Deployment of novel technologies into the environment.
E	Identification of sites for fungicide application.
F	Interaction of host-pathogen genetics with fungicide activity.

PROGRAM 1 Disease management on natural lands
Manager: Dr David Coates, CALM

Objectives The integration of the most up to-date methods of disease detection, disease control and flora conservation techniques to provide management prescriptions that reduce the impact of disease on native vegetation and conserve endangered communities and taxa at risk from diseases caused by *Phytophthora* spp. This program will continuously assimilate useful products of research in other programs into revised prescriptions.

Expected achievements
- A range of rapid, cost-effective and highly sensitive diagnostic tests for *Phytophthora* species.
- The identification and evaluation of susceptible taxa and communities, and the development of methods for their recovery and regeneration.
- Efficient prescriptions and methods for the safe application of phosphonate and possibly other fungicides.
- The capture in germplasm held *ex situ* of at least 75% of all current genetic variation within taxa critically threatened by *Phytophthora*.
- Prescriptions which provide managers with the means to limit the spread of *Phytophthora*.

Project 1.1 Rapid diagnostics
Key participants: Dr Philip O'Brien, Murdoch University; Dr Adrienne Hardham, ANU; Mr Mike Stukely, CALM

Managers need to be able to obtain identification of pathogens and detect them in soil and plant materials. This project will develop complementary techniques for the rapid identification of *Phytophthora* species. One will be easy-to-use, rapid immunodiagnostic kits for identification to the species level (already developed for *P. cinnamomi*). These kits, suitable for use by inexperienced people, would be effective under a wide range of conditions. Another will identify *Phytophthora* at the species or strain- specific level by characterising their DNA extracted from soil. Thirdly, isozyme techniques will be refined for identifying *Phytophthora* species and strains.

Achievable outcomes

- The rapid identification of a range of *Phytophthora* species. (2 years)
- The identification of *Phytophthora* species from very low levels of inoculum in soil. (3 years)

Project 1.2 Control methods and prescriptions for land and vegetation management
Key participants: Dr Brian Shearer, CALM

Managers need to develop and integrate disease hazard assessment and existing control methods for the conservation and management of native plant communities (particularly rare and endangered taxa). They need to know the susceptibility of plant species and be able to evaluate disease risk at different sites. Hygiene prescriptions for species and communities will be developed along with methods for the regeneration of disease-infested areas and the reintroduction of specific taxa such as rare and threatened species and/or local keystone species.

Achievable Outcomes

- Identification and documentation of species and communities susceptible to *Phytophthora.* (3 years)
- Generic hygiene prescriptions for threatened species and communities. (2 years)
- Regeneration and recovery methods, particularly for rare and endangered species, keystone species and threatened communities. (5 years)

Project 1.3 Fungicide application, persistence and efficacy across host genera and taxa and impact on non-target organisms
Key participants: Dr Brian Shearer, CALM; Dr Bruce Grant, Melbourne University

This project will establish appropriate application methods, particularly aerial spraying and stem injection prescriptions for phosphonate. Persistence and phytotoxicity of phosphonate in plants and the effects of the fungicide on non-target, beneficial micro-organisms will be investigated. Other available chemical control options will be field tested.

Achievable outcomes

- Prescriptions for effective, safe phosphonate application to species and communities. (2-4 years)
- Trial and develop protocols for other fungicides that become available. (ongoing)

Project 1.4 *Ex-situ* conservation and gene banking of flora threatened by disease
Key participants: Dr David Coates, CALM; Dr Kingsley Dixon, KPBG

This project will build a comprehensive germplasm collection of rare and endangered plant taxa, particularly those under threat of extinction by *Phytophthora.* Sampling strategies for capturing genetically representative germplasm collections from each taxon will be developed. Current low-temperature methods are useful for some medium-term germplasm storage but cryostorage techniques will be further refined for long-term gene banking. Where cold or cryostorage

options are not appropriate, techniques will be developed to maintain living collections. Technology developed in WA will be available to other conservation agencies.

Achievable outcomes

- The capture of at least 75% of all genetic variation within taxa critically threatened by *Phytophthora* in WA. (1-5 years)
- Suitable germplasm cryostorage protocols for species threatened by *Phytophthora* and other factors (5 years)
- Living collections of species not amenable to cold or cryo-storage. (1-5 years)

PROGRAM 2 Disease management in mining and rehabilitation areas

Manager: Dr Ian Colquhoun, ALCOA

Objective To minimise impacts of *Phytophthora* during mining operations in native plant communities and to improve the standard of rehabilitation mined and other severely disturbed areas where *Phytophthora* has been present or is a significant risk. To improve cost-effectiveness of these operations.

Expected achievements

- Effective dieback control prescriptions being deployed consistently by all mining operations located in *Phytophthora*-susceptible native communities.
- Capability to rehabilitate mined and other severely disturbed areas, that have been infested with *Phytophthora,* with a high proportion of the original plant species.
- Disease-resistant families and clones of dominant and co-dominant tree and understorey species for planting on rehabilitated sites, as well as with commercial importance in forestry and horticulture.
- Reduced costs and increased effectiveness of disease control measures entailed in mining operations.

Project 2.1 Controlling the spread of *Phytophthora* spp. during mining operations

Key participants: Dr Giles Hardy, Murdoch University; Mr A Petersen, RGC Mineral Sands Ltd

Mining takes place in native communities that are susceptible to *Phytophthora* species. Control measures have been deployed by mining companies to minimise the risk of spreading *Phytophthora* to uninfested areas. These measures are a substantial financial cost to the operations so it is critical to focus on high-risk operations. This project will assess the risk associated with each stage of mining, and ensure that appropriate, cost-effective measures are prescribed.

Achievable outcomes

- Ranking of specific mining operations according to the level of risk of spreading *Phytophthora*. (2 years)
- Quantitative assessment of the effectiveness of dieback control measures for the high risk stages of mining. (3 years)
- Cost-effective methods to minimise the impact of mining on native communities and rehabilitation methods and practicable mining prescriptions in the presence of *Phytophthora*. (7 years)

Project 2.2 Minimising the impact of *Phytophthora* on rehabilitated mined areas

Key participants: Dr Giles Hardy, Murdoch University; Dr Ian Colquhoun, ALCOA

The aim of rehabilitation of mining sites with native vegetation is usually to re-establish a self-sustaining community composed of indigenous plant species. Many of these species are susceptible to *Phytophthora*, the presence of which can prevent achievement of rehabilitation objectives.

Achievable outcomes

- Identification of major etiological factors affecting the survival and sporulation of *Phytophthora* and infection of plants in rehabilitated sites. (4 years)
- Quantification of the effect of *Phytophthora* on the plant species richness of rehabilitated mined areas. (4 years)
- Development and deployment of prescriptions to minimise the impact of *Phytophthora* on native plants in rehabilitated mined areas. (7 years)

Project 2.3 Selection of resistant genotypes of selected host species (clones/families)
Key participants: Mr Mike Stukely, CALM; Dr Jen McComb, Murdoch University; Dr I. Bennett, Edith Cowan University; Dr Ian Colquhoun, ALCOA

Rehabilitation and replanting of mine sites and nearby forest as well as sites in other plant communities affected by *Phytophthora* root disease would be achieved with greater certainty if disease-resistant clones, seed and seedlings were available. Disease-resistant clones of jarrah have been propagated and strategies developed for their deployment. Selection of a wide range of disease-resistant clones of native species would significantly improve species security and greatly benefit the horticultural and cut flower trade.

Achievable outcomes

- Rapid screening methods for resistance (whole plants, plant tissues, callus). (3 years)
- Resistant clones of jarrah for planting on disease-affected sites. (1 year)
- Selection of resistant families of native plant species. (5-7 years)

Project 2.4 Marker-aided selection of jarrah resistant to *P. cinnamomi*
Key participants: Dr Margaret Byrne, CSIRO; Mr Mike Stukely, CALM

CSIRO has produced a linkage map for *E. nitens,* based largely on DNA markers, which can be adapted for *E. marginata* to find markers closely linked to resistance. The map will enable selection of disease-resistant trees for planting in seed orchards, and analysis of inheritance of resistance.

Achievable outcomes

- Determine the feasibility of marker-aided selection of resistant jarrah trees. (2 years)
- Information useful to Program 4 on the inheritance of *Phytophthora* resistance in eucalypts. (3 years)
- Resistant seed and seedlings for sowing or planting on rehabilitation areas. (5 years)
- Selection of 50 genetically unrelated families of *E. marginata* that have high quantified resistance. (2 years)
- Establishment of trial seed orchards of *E. marginata* with high resistance to *Phytophthora* and the development of techniques to promote fruiting. (4 years)

PROGRAM 3 Hazard assessment, prediction and decision support tools

Manager: Dr Ray Wills, CALM

Objective To provide a GIS-based decision support system for use in monitoring and controlling the spread of *Phytophthora*-caused disease and for the management of highly susceptible taxa.

Expected achievements

- A means for managers to assess disease hazard and take measures to minimise impacts
- Development of a user-friendly GIS system to bring together relevant spatial information about *Phytophthora* and allow managers simple access to relevant information.
- A predictive model of the spread of *Phytophthora cinnamomi*, field tested and validated against historic data for a specific region of the south-west of WA.

- Predictions of pathogen behaviour and impacts in different soil/geomorphological units and microbiological environments.

Project 3.1 Mapping distribution of disease using GIS and remote sensing techniques
Key participants: Dr Ray Wills and Mr Graeme Behn CALM; Dr Ian Colquhoun, ALCOA; Dr Derek Milton, University of Western Australia; Dr Simon Cook, CSIRO

The key to management of regions affected by *Phytophthora* root disease is reliable information on the distribution of infested sites, and their relation to the geography, vegetation characteristics and patterns of land use of the area. This project will integrate aerial photography and Landsat imagery into a GIS based on ARC/INFO software, technology using aerial video will also be assessed. Image processing software will be developed to analyse data, and a user interface will be designed to facilitate access to data and computer-generated maps of disease distribution by managers unskilled in the use of ARC/INFO. The result will be a user -friendly system which can be applied to management of existing areas, which will facilitate conservation of vegetation across lands of different tenure and between landscape units, and which will identify areas in need of rehabilitation or restoration.

Achievable outcomes

- An evaluation of the potential of remotely-sensed data for mapping the distribution of disease. (2 years)
- Automation of interpretation of data gathered from aerial photography and satellite imagery. (3 years)
- Development of a user-friendly interface to allow managers simple access to information. (2 years)
- Integration of information into an expert system for management of disease-affected areas. (5 years)

Project 3.2 Disease dynamics modelling and hazard prediction
Key participants: Dr Ray Wills and Dr Bryan Shearer, CALM; Dr Simon Cook and Dr Nick Malajczuk, CSIRO; Dr Ian Colquhoun, ALCOA; Dr Derek Milton, University of WA

Managers need an epidemiological model at the landscape level which will integrate the known biology of the pathogen with landscape attributes to predict disease hazard and severity. In assigning disease hazard values the model will incorporate vegetation types, topography, hydrology, geology, lithological and microbiological parameters, with current knowledge of the role of propagules of *Phytophthora* in survival and spread of the disease. The distribution of road networks and other forms of human access are also key factors in the spread of infestation. Development of the model will assist identification of gaps in knowledge which require further research. The model will facilitate decision-making at two scales: at a catchment scale to predict the patterns of extension of known infections and so assist in deciding where preventative management is needed and at a regional scale to identify where *Phytophthora* infestations are likely to be present, now and in the future.

Achievable outcomes

- A predictive model of the spread of *Phytophthora* infestation for Two Peoples Bay, WA, based on landforms, hydrology, vegetation and access patterns. (2 years)
- Validity testing of the model's predictions based on historical data and extension to other areas (3 years)
- GIS -based decision support system for preventative management of *Phytophthora* root disease. (5 years)

Project 3.3 Microbiological aspects of the epidemiology of *Phytophthora* root disease

Key Participants: Dr Nick Malajczuk, Dr John Scott, Dr Simon Cook, CSIRO

Although climate, site and vegetation characteristics are the principal determinants of disease impacts, soil microorganisms exert a significant influence on survival, sporulation and infection of susceptible hosts by *Phytophthora*. For example some soils suppress *P. cinnamomi*. Although this has usually been attributed to the soil microflora, there has been no attempt to systematically model those features of soils and their microorganisms which contribute to disease suppression. Outputs from the model would be incorporated into **3.2.** In addition, matching of climatic and edaphic factors to the known and predicted distribution of *Phytophthora* root rot diseases may suggest centres of origin of the fungus. This information could be useful in identifying sources of putative biocontrol agents, for example the fungal viruses being sought in project **4.3.**

Achievable outcomes

- Characterisation of several Australian soils known to be suppressive to *P. cinnamomi*. (2 years)
- A model incorporating interactions between *P. cinnamomi*, its hosts and elements of the soil's physical chemical and microbiological environment as a basis for predicting conduciveness or suppressiveness of soil type. Input of information to **3.2.** (2 years)
- Application of GIS to prediction of sites/regions/biocontrol agents suppressive to disease on a national and global basis. Input of information to **4.3.** (3 years)

PROGRAM 4 Molecular genetics and biocontrol of *Phytophthora*

Managers: Dr Philip O'Brien, Murdoch University; Dr Inez Tommerup, CSIRO

Objectives To understand the genetic basis and mechanisms of variation in *Phytophthora*, the molecular basis for variation in host resistance and susceptibility to *Phytophthora* diseases, and to develop bio-control methods especially for *P. cinnamomi*.

Expected achievements:

- Identification of fungal genes linked to pathogenicity, and their mode of interaction with the genome of the host.
- The effects of mycoviruses or other ds RNA elements found in *P. cinnamomi* on fungal growth and pathogenicity and their potential as biocontrol agents.
- Use of mycoviruses or other ds RNA elements as vectors for fungal genes.
- Understanding of the genetic and/or molecular basis for variation in host resistance to *P. cinnamomi*.

Project 4.1 Genetics of *Phytophthora cinnamomi*

Key participant: Dr Inez Tommerup, CSIRO WA

P. cinnamomi shows variation in pathogenicity, growth rates and isoenzyme markers. Molecular markers such as RAPD-PCR and RFLP offer the most efficient way of analysing variability in populations of the fungus, detecting exchange of cytoplasmic and chromosomal markers and relating genotype to pathogenicity and physiological properties.

Achievable outcomes

- Tools for analysis of genetic variability in *P. cinnamomi*. (2 years)
- Changes at the genetic level associated with phenotype variability, e.g. pathogenicity. (5 years)
- Methods for cloning genes associated with disease expression in the host (7 years)

Project 4.2 Molecular aspects of pathogenicity
Key participants: Dr Philip O'Brien, Murdoch University; Dr Ken Gayler, University of Melbourne

The aim of this project is to investigate the mechanisms used by *P. cinnamomi* to overcome the defences of the host and to devise means for blocking them, thereby protecting the host from disease. Several powerful methods are currently available to investigate the nature of these mechanisms and interfere with them including:

- Subtractive hybridisation of DNA libraries from highly virulent and weakly virulent isolates.
- The use of DNA markers to isolate and clone pathogenicity genes.
- Investigation of the role of these genes in pathogenicity by gene disruption experiments.
- Analysis of extracellular enzymes and proteins (elicitins) and determination of their role in pathogenicity.

Achievable outcomes
- First stage identification of DNA sequences controlling the infection process (3 years)
- System for the identification of the role of these sequences in the infection process. (5 years)
- Identification of processes involved in colonisation and disease development in the host. (7 years)

Project 4.3 Fungal viruses
Key participants: Dr Andrew Davidson, Monash University; Dr Ken Old, CSIRO Canberra; Dr Inez Tommerup, CSIRO W.A.

Fungal viruses are found in many species of fungi as double-stranded RNA elements (ds RNA) in the cytoplasm. In some host-pathogen systems they reduce pathogenicity and may even be transmitted with high frequency to virulent strains thereby attenuating virulence. This project will screen Australasian and overseas isolates of *P. cinnamomi* for ds RNA elements, evaluate their effect on virulence and investigate their potential as biocontrol agents.

Achievable outcomes
- Detection of ds RNA which can affect pathogenicity. (2 years)
- An understanding of transmission of ds RNA elements in the population. (5 years)
- Characterisation of the structure and function of dsRNA elements. (7 years)
- Manipulation of mycoviruses to inhibit disease severity in glasshouse experiments. (4 years)

Project 4.4 Physiological and molecular basis of resistance
Key participants: Dr Bruce Grant and Dr Ken Gayler, University of Melbourne; Dr Margaret Byrne, CSIRO Canberra

Infection of plants by the fungus induces expression of plant defence genes. The products of these genes (lignification enzymes, phytoalexins, chitinases, glucosidases) limit the extent of colonisation of the plant. The success or failure of an infection depends on interactions of plant defence genes, the fungal genotype and the environment. Plants of the same species vary in their sensitivity to infection by *P. cinnamomi*. The aim of this project, which will dovetail closely with Projects **2.3**, **2.4** and **4.2**, is to investigate the physiological and molecular differences between sensitive and resistant plant varieties.

Achievable outcomes
- Identification of resistant host genotypes. (2.5 years)
- Identification of resistance mechanisms at the cellular level. (5 years)
- An understanding of factors affecting susceptibility to fungal infection, including host defence gene expression and fungal pathogenicity genes. (7 years)

PROGRAM 5 Biochemistry and mode of action of phosphonate
Manager: Dr Bruce Grant, University of Melbourne

Objective To enhance the efficacy of phosphonate as a fungicide for *Phytophthora* spp. in Australian native vegetation through a more complete understanding of its mode of action. Information may, in the longer term, lead to opportunities for control of other Oomycete pathogens and improved *Phytophthora* disease control in agricultural and horticultural crops.

Expected achievements
- Knowledge of the rate of phosphonate entry to *P. cinnamomi* and the site(s) of phosphonate action under relevant environmental conditions.
- Knowledge of factors controlling the movement of phosphonate within plants, including its loss to the environment.
- Knowledge of the mechanisms by which exposure of *Phytophthora* spp. within host tissues activates defence responses in host plants.
- Development of and, if appropriate, commercialisation of novel phosphonate derivatives with superior activity against *Phytophthora* spp.

Project 5.1 Identification of the site of phosphonate action in *P. cinnamomi*
Key participants: Dr Ken Gayler and Dr Bruce Grant, University of Melbourne; Dr Julie Niere, Royal Melbourne Institute of Technology

Knowledge of the enzyme(s) in the pathogen that are targeted by phosphonate and the effects of phosphonate on the production of potential elicitors of host response are critical to understanding the mode of action of the fungicide and the mechanism by which phosphonate modifies the host defence response. The following lines of research will be followed:

- Measure levels and sub-cellular location of phosphonate in *Phytophthora* spp. isolates and examine effects of phosphonate on phosphorous-containing compounds in the fungus using ^{31}P NMR and mass spectrometry metabolic profiling.
- Purify enzymes associated with pyrophosphate and polyphosphate metabolism (suspected targets of phosphonate activity) and identify phosphonate metabolites in *Phytophthora* spp.
- Characterise effects of phosphonate on the pattern of elicitors and suppressors produced by *Phytophthora* spp.

Achievable outcomes
- Confirmation that *P. cinnamomi, P. citricola* and *P. megasperma* respond to phosphonate in the same manner as other *Phytophthora* species studied to date. (2 years)
- A model of movement of phosphonate into *Phytophthora* spp. (4 years)
- Identification of the enzymes which are targeted by phosphonate and the genes that code for them. (2-5 years)
- Identification of the mechanism by which phosphonate modifies host response to the pathogens. (7 years)

Project 5.2 Dynamics of phosphonate in native host plants
Key participants: Dr Bruce Grant and Dr Ken Gayler, University of Melbourne; Dr Julie Niere Royal Melbourne Institute of Technology; Dr Neil Rothnie, WA Government Chemistry Laboratories; Ms Barbara Komorek, CALM

Knowledge of the behaviour of phosphonate in host plants is critical. We need to know how phosphonate moves, how long it remains in specific sites, whether there are prolonged residual effects and how the host response to *Phytophthora cinnamomi* invasion is modified by phosphonate treatment. This project brings together biochemists, plant physiologists and plant pathologists and uses conventional chemical analysis and novel techniques such as NMR imaging.

Achievable Outcomes

- Knowledge of the gross pattern of phosphonate movement in plants. (3 years)
- Understanding of the spatial and temporal pattern of phosphonate. (7 years)
  accumulation within tissues of native hosts such as *Banksia* spp.
- The identity of potential phytoalexins in a range of native host species. (3-7 years)
- Documentation of the effects of phosphonate, elicitors and suppressors on the (7 years)
  phytoalexin component of plant defence response in susceptible host species.
- Elucidate competition between phosphate and phosphonate in *P. cinnamomi*
  and the effect of environmental parameters on the response to phosphate (4-7 years))
  starvation at the enzyme level in plants.

Project 5.3 Improved delivery of phosphonate and/or phosphonate isosteres to target sites in host plants and *Phytophthora* spp.
Key participants: Dr Julie Niere, Royal Melbourne Institute of Technology; Dr Bruce Grant, University of Melbourne; Dr Neil Rothnie, Chemistry Centre (WA). In co-operation with Ciba Geigy (Aust.) Pty. Ltd.

This project will seek novel compounds based on phosphonate and its isosteres that compete more effectively with phosphonates and phosphate for transport into host or pathogen, thereby being more effective fungicides. If successful it will yield a commercial product as well as a more effective chemical control capability.

Achievable outcomes

- Evaluation of the potential of a range of phosphono-amino acids and peptides (3 years))
  as fungicides for control of *Phytophthora* spp.
- Evaluation of the toxicity of useful compounds to other organisms in the (3-6 years))
  in the natural environment.
- Evaluation of the potential of isosteres of phosphonate as fungicides (4-7 years)
  for control of Phytophthora spp.
- Commercialisation of any novel compounds which pass screening (year 4
  procedures used by Ciba Geigy for evaluating field-effectiveness of onwards)
  of potential fungicides.

EDUCATION AND COMMUNICATION

Manager (To be appointed)
University Coordinators: Dr Giles Hardy, Murdoch University; Dr Bruce Grant, University of Melbourne
Community Activities Coordinator: Dr Steve Hopper*, Kings Park and Botanic Garden

* Although Dr Hopper's time allocation to the CRC is modest, as Director of KPBG and Botanic Garden he will oversee a comprehensive program of public awareness and education run by his staff.

Objective To promote community awareness of the issues, educate people and organisations that work in dieback risk areas and train scientists in disciplines relevant to plant disease control.

This unit will require the appointment of a full-time expert in community communication and tertiary education, including the TAFE system, who also has proven management skills. The CRC will have a major role in education through training at the post-graduate level which will be focussed at Murdoch University but will also take place at the several tertiary nodes especially at the University of Melbourne. Graduate students will benefit from training in a wide range of specialist disciplines. This training will be supplemented by regular workshops organised by the CRC which will place their research in a broader context.

Another key activity will be to develop and market through TAFE (and/or similar organisations) a prospectus of unit courses in a range of topics aimed at employers and agencies whose managers and field staff operate in areas at risk from *Phytophthora*. These courses will draw on the wide range of skills in the CRC, will be tailor-made for user needs and will operate on a user-pays basis. The target audience will be diverse: nursery managers, mining exploration supervisors, road and utility construction supervisors, land management agency staff, catchment and land care groups, and the general public who are interested in conservation of native biota. This series of courses will be offered at several locations in southern Australia, especially where *Phytophthora* problems are acute.

There will be a focus on community awareness and education through Kings Park and Botanic Garden. The Park and Botanic Garden in Perth attracts 600,000 adult Western Australians (average 3 visits per yr = 1.8 million visits) as well as interstate and international visitors. The aims of the CRC will be incorporated into Media Liaison and Strategic Marketing programs being developed for KPBG by consultants.

Activities

- TAFE extension units on *Phytophthora* control, nursery hygiene (leading to accreditation), horticultural techniques, hygenic operation of machinery and natural resource management in the presence of disease (Dr Hardy, Murdoch University).
- Supervision of graduate research projects which will augment the research programs and integrate student education with all aspects of the CRC (supervisors from CRC research staff).
- Summer schools on plant pathology/plant biochemistry and fungicide action (Dr Grant, University of Melbourne).
- Multi-media projects for conveying information on *Phytophthora* diseases.
- Technology transfer to industry through workshops and field days
- Development of Kings Park and Botanic Garden as the public extension arm of the CRC through public awareness lectures and promotions and extension activities (Dr Hopper, KPBG).

Note that the above will combine elements of public awareness/public good with user pays.

PARTICIPANTS

Core participants

CALM The Department of Conservation and Land Management is the Western Australian State Government agency responsible for management of Crown Land reserved for (*inter alia*) National Park, Nature Reserve and State Forest. It is also responsible for State-wide conservation of indigenous fauna and flora. CALM will be the managing agency and a principal end-user.

CSIRO - The Commonwealth Scientific and Industrial Research Organisation. Participating Divisions include Divisions of Forestry, Soils and Entomology.

Murdoch University will be the main WA-based University participating in the CRC. The University has strong links with ALCOA, which currently supports a lecturing position, a research officer and three PhD students engaged on aspects of *Phytophthora* research. The newly-opened State Centre for Agricultural Biotechnology on the Murdoch Campus will house the main activities of Program 4.

University of Melbourne participation through its Department of Biochemistry especially in relation to fungicide biochemistry and biological activity. Dr Bruce Grant, leader of Program 5 is the world authority on the mode of action of phosphonate.

ALCOA is the principal mining company to have supported research on *Phytophthora*-induced disease in native forests and other plant communities in the south-west of Western Australia. In

addition ALCOA has an innovative program of minesite rehabilitation in high risk and infected sites within the jarrah forest and will be a major user of research outcomes

ANCA - The Australian Nature Conservation Agency is the Federal agency responsible for nature conservation at a national level. Through its Endangered Species Program (ESP), ANCA contracts State agencies including CALM to research (and implement actions that will recover) threatened taxa. The ESP includes funding for control of *Phytophthora* diseases in natural vegetation.

Affiliate Members

Participating organisations which will contribute a smaller amount of in-kind or cash to the CRC (not sufficient to merit membership of the Board):
Monash University, University of WA, Australian National University, Royal Melbourne Institute of Technology, Edith Cowan University, Ciba Geigy Australia Ltd, Worsley Alumina Pty. Ltd, RGC Mineral Sands Ltd, Mineral Deposits Pty. Ltd, Westralian Sands Limited, Cable Sands (WA) Pty Ltd, Kings Park and Botanic Garden, and Chemistry Centre (WA).

MANAGEMENT STRUCTURE OF THE CRC (Figure 2)

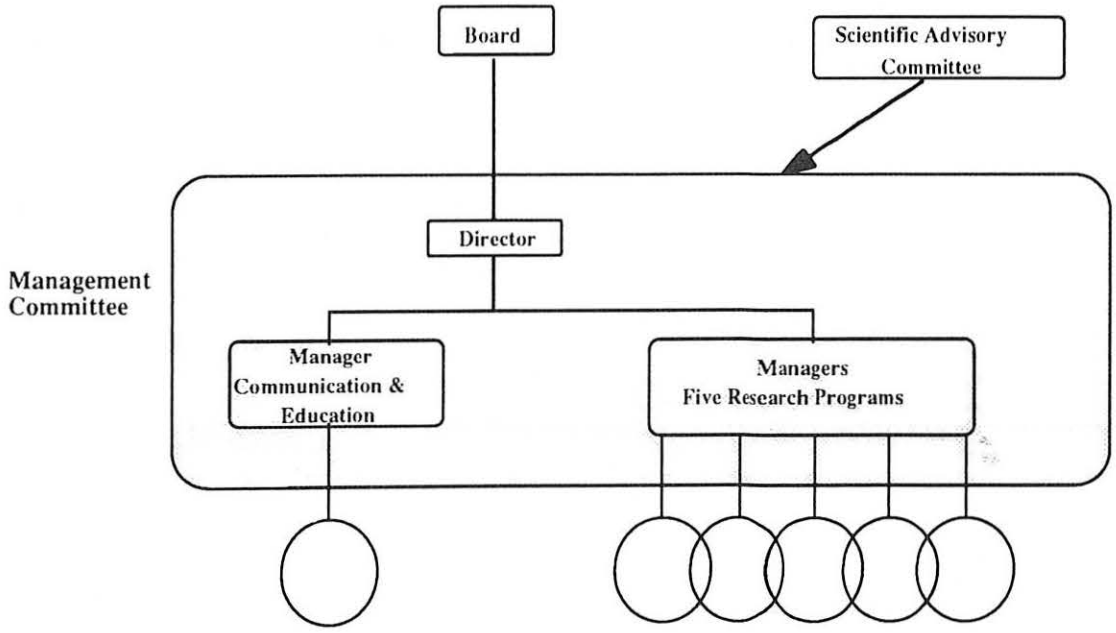
Board of Management

The CRC will be an unincorporated joint venture managed by a Board comprised of one representative nominated by each of the Core Participants and the Director. The function of the Board will be to appoint the Director and to set overall policies, research directions and budgets within the framework of the charter agreed by the CRC and the Commonwealth.

Director

The day-to-day activities and finances of the CRC will be managed by a full-time Director appointed by, and answerable to, the Board. The Director will be supported by an Executive Officer and a Clerical Officer. These will be full-time, new contracted positions funded by the CRC. The appointees will be based in Perth and employed through the administrative structure of CALM.

Figure 2. Administrative Structure of the CRC



Dr Jim Armstrong, Director of Science and Information Division (CALM), will act as interim Director and Dr Ken Old, Assistant Chief Division of Forestry (CSIRO), will act as interim Deputy Director. The appointment of a full-time Director is of highest priority. However, we believe it is unlikely that we can attract people of the highest calibre until we can advertise a real (as opposed to a potential) position. Therefore we have not tried to identify a full-time Director before this CRC proposal is approved.

Selection criteria will include:

- An international reputation for excellence in researching control of disease caused by fungal pathogens, including *Phytophthora* species.
- Experience with disease management in wild host species or natural ecosystems.
- A proven ability to direct and manage a large, diverse research program.
- Management experience in a "multi-campus" or "multi-department" situation.
- A sound knowledge of and commitment to the principals of nature conservation and biological resource management.

Management Committee

A Management Committee will be comprised of the Managers of each of the five Research and Development Programs and the Manager of Education and Communication. It will be chaired by the Director and serviced by the Executive Officer. The Management Committee will meet regularly, probably monthly, using tele-conferencing facilities to bring together members in different locations. The function of the Management Committee will be:

- **Research.** To enhance synergisms between research programs, especially with regard to the translation of research outputs into practical applications.
- **Communication.** To maintain focus on the CRC objectives and to foster the sense of unity and common purpose of the member institutions.
- **Advice.** To advise/assist the Director on all relevant scientific, management and resource issues.
- **Assistance.** To co-ordinate preparation of annual reports, monitor budget management and assist the Director in advising the Board on technical issues.

Scientific Advisers

An external scientific review committee of eminent scientists with relevant experience will be appointed to assist in project/program reviews and provide advice on strategic issues to the Director. Opportunities for interaction with external reviewers and key scientific staff will be provided through an appropriate program of scientific and planning meetings.

EVALUATION STRATEGY OF THE CENTRE

Detailed project proposals which will form the research program of the Centre will be prepared by Project Leaders and submitted to Program Managers and the Director for approval and allocation of resources. Projects will describe objectives and proposed outcomes on a yearly basis, and provide a communication strategy. The proposals will also describe linkages with other parts of the CRC, and clearly provide for the research contributing to practical outcomes and, where appropriate, management options. Research Programs will be reviewed annually by the Director, Program Manager and Scientific Advisers, and their performance assessed against objectives and milestones. The formal Review will be based on procedures currently in place in CSIRO and CALM and will be the basis for renewal of funding and other resources.

PERFORMANCE INDICATORS FOR THE CRC

CRC as a whole

- Recognition of the Centre as the expression of a national effort to provide solutions to the problem of *Phytophthora* disease of native vegetation.
- Evidence of collaboration and synergism within and between Programs.

- Provision and application of a range of effective integrated disease management practices in natural and mining lands.
- Provision of the scientific basis for the development of a National Threat Abatement Plan.
- An increase in public awareness of the impact of land use on disease spread and severity in natural environments, and consequent changes in behaviour patterns.

Program 1
- Hygiene prescriptions limiting damage to threatened species and communities.
- Regeneration and recovery methods for selected threatened species.
- Definition of optimum application methods for phosphonate under a range of field conditions.
- Germplasm storage protocols and prescriptions for threatened species.

Program 2
- Analysis of the risk of spread of *Phytophthora* associated with key mining operations
- Identification of major factors affecting the survival and sporulation of *Phytophthora,* and infection of susceptible plants on rehabilitated minesite areas.
- One or more rapid screening methods for testing resistance of native plants to *Phytophthora*
- Identification of DNA markers closely linked to resistance to *P. cinnamomi.*

Program 3
- An assessment of the potential of remotely sensed data for mapping the distribution of disease
- A model to predict the impact of disease at the regional scale and at the catchment scale
- A computer model of environmental and biotic factors determining the potential distribution of *P. cinnamomi* and its possible geographic origin.
- A user-friendly tool that enables managers to plan operations in the presence of *Phytophthora* and to minimise its impact.

Program 4
- Tools for analysis of genetic variability in *P. cinnamomi.*
- First stage identification of DNA sequences controlling virulence.
- An assessment of the presence of dsRNA (mycoviruses) in isolates of *P. cinnamomi.*
- Identification of mycoviruses in *P. cinnamomi* that influence pathogenicity.

Program 5
- Definition of the site of phosphonate activity on *P. cinnamomi.*
- Understanding of the kinetics of assimilation of phosphonate into plants.
- Delineation of the effects of phosphonate on host responses to infection.

Education and Communication Unit
- MSc and PhD graduates with marketable skills in control of soil-borne disease and management of natural resources in the presence of disease.
- Heightened public awareness of impacts of disease on native plants leading to reduced damage from human activities.
- A series of short courses delivered on a user-pays basis for employees of State agencies and private contractors to encourage and enhance "best practices" and help them comply with disease control regulations.
- Consistent publication of high quality research papers in refereed scientific journals.

Appendix 1

Research staff to be provided by participating organisations

Organisation	Staff	Classification	Proportion of time -%	Program/ project
CALM David	**Dr D. Coates***	PRS	30	1.4
Brian	**Dr B. Shearer**	PRS	65	1.2,1.3,4.4,3.2
Ray	**Dr R.Wills**	RS	60	3.1,3.2.
	Mr G.Behn	RO	100	3.1
	Mr P. Gioia	RS	10	3.1
Mike	**Mr M. Stukely**	RS	60	2.3,2.4.
CSIRO Ken	**Dr K.Old**	SPRS	10	4.3,4.4.
	Mr M.Dudzinski	RS	25	4.3
Inez	**Dr I.Tommerup**	PRS	40	4.1,4.3
Nick	**Dr N.Malajczuk**	SPRS	20	3.2, 3.3
John	**Dr J.Scott**	PRS	10	3.3
	xDr M.Byrne	RS	40	2.4
Simon	**Dr S.Cook**	SRS	20	3.1,3.2, 3.3
	Dr R. Corner	ERS	20	3.2
Bruce — Canada				
Melbourne Univ.	**Dr B.Grant**	Assoc.Prof.	50	5.1,5.2,5.3,5.4
Ken	**Dr K.Gayler**	SL	30	5.3,4.5
	Dr C.Stehmann	RF	100	5.1,5.2,5.3
Murdoch Univ.	**Dr P.O'Brien**	L	30	4.1,4.2
Philip	**Dr J.McComb**	Ass. Prof	20	2.3
Jenny	Mr M.Farbey	RO	100	4.1,4.2
ALCOA Ian (Murdoch.)	**Dr I. Colquhoun**	SRS	70	2.1,2.2,2.3,5.1
Giles	****Dr Giles Hardy**	L	60	2.1,2.2
	Dr I.Kurtboke	RO	80	2.1,2.2
	Mr D.Williams	RO	40	2.3
Adrienne				
ANU, RSBS	**Dr A.Hardham**	SL	10	1.1
Andrew				
Monash Univ.	**Dr A.Davidson**	L	10	4.3
Julie				
RMIT Steve	**Dr J.Niere**	SL	25	5.1,5.2
Kings Park and Botanic Garden	**Dr S.Hopper**	CEO	5	Education and Communication
Kingsley	**Dr K.Dixon**	PRS	10	1.4
Neil				
Chem Centre WA	**Dr Neil Rothnie**	SPRS	15	5.3,5.4
Derek				
UWA Ian	Dr D.Milton	SL	5	3.1,3.2
Edith Cowan Uni	**Dr I. Bennett**	L	20	2.3

*** Key researchers in bold**

**** Salary to be paid by the CRC after 1995-96**

Appendix 2

Proposed Commonwealth Funding

	Year 1 $'000	Year 2 $'000	Year 3 $'000	Year 4 $'000	Year 5 $'000	Year 6 $'000	Year 7 $'000	Total $'000
Salaries (Research Programs)								
Research Scientist (Direct)	25.0	50.0	101.0	103.0	105.1	107.2	109.3	600.6
Post-Doctoral (Direct)	150.3	267.9	234.3	278.3	244.2	249.8	255.4	1,680.2
Technical (Direct)	315.0	355.6	362.7	405.0	299.4	305.4	269.2	2,312.3
PhD students (Direct)	158.6	199.7	232.9	356.5	317.2	314.1	222.7	1,801.7
Salary on-costs @5-30%	125.9	166.8	174.0	199.1	168.6	171.7	161.5	1,167.5
Sub-total	774.8	1,040.0	1,104.9	1,341.8	1,134.4	1,148.1	1,018.2	7,562.2
Salaries (Other)								
Director (Package)	120.0	120.0	120.0	120.0	120.0	120.0	120.0	840.0
Communications Manager	70.0	70.0	70.0	70.0	70.0	70.0	70.0	490.0
Personal Assistant	45.0	45.0	45.0	45.0	45.0	45.0	45.0	315.0
Executive Officer	70.0	70.0	70.0	70.0	70.0	70.0	70.0	490.0
Sub-total	305.0	305.0	305.0	305.0	305.0	305.0	305.0	2,135.0
Total Salaries	1,079.8	1,345.0	1,409.9	1,646.8	1,439.4	1,453.1	1,323.2	9,697.2
Operating (Research Programs)								
Direct operating	303.0	376.0	411.2	474.2	370.0	358.5	332.0	2,624.9
Operating (Other)								
Education Program	100.0	100.0	100.0	100.0	100.0	100.0	100.0	700.0
Central Equipment	100.0	100.0	100.0	100.0	100.0	100.0	100.0	700.0
Rental (Technology Park)	11.5	11.5	11.5	11.5	11.5	11.5	11.5	80.5
Managing Agency costs	250.0	250.0	250.0	250.0	250.0	250.0	250.0	1,750.0
Total Operating	764.5	837.5	872.7	935.7	831.5	820.0	793.5	5,855.4
Capital (Research Programs)								
Direct Capital	291.0	170.0	170.0	125.0	135.0	15.0	0.0	906.0
Total Capital	291.0	170.0	170.0	125.0	135.0	15.0	0.0	906.0
Total Commonwealth Contribution	2,135.3	2,352.5	2,452.6	2,707.5	2,405.9	2,288.1	2,116.7	16,458.6

Appendix 3

Proposed Allocation of Commonwealth Funding to Programs

		Year 1 $'000	Year 2 $'000	Year 3 $'000	Year 4 $'000	Year 5 $'000	Year 6 $'000	Year 7 $'000	Total $'000
Program 1									
Salaries	Research Scientists	25.0	50.0	51.0	52.0	53.1	54.1	55.2	**340.4**
	Post-Doc	0.0	38.0	38.8	39.5	40.3	41.1	42.0	**239.7**
	PhD	0.0	19.0	19.4	38.8	77.5	79.1	80.7	**314.5**
	Technical	105.0	107.1	109.2	146.4	73.6	75.1	76.6	**693.0**
	On-costs	27.3	41.9	42.8	51.9	38.9	39.7	40.5	**283.1**
	Sub-total	157.3	256.0	261.1	328.7	283.5	289.1	294.9	**1,870.6**
Operating		55.0	75.0	75.0	75.0	75.0	75.0	75.0	**505.0**
Capital		0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
	Total	212.3	331.0	336.1	403.7	358.5	364.1	369.9	**2,375.6**
Program 2									
Salaries	Research Scientists	0.0	0.0	50.0	51.0	52.0	53.1	54.1	**260.2**
	Post-Doc	38.0	76.8	38.8	77.5	38.8	39.5	40.3	**349.7**
	PhD	0.0	0.0	19.0	38.4	39.1	39.9	20.6	**157.0**
	Technical	70.0	105.7	107.8	110.0	74.3	75.8	35.0	**578.5**
	On-costs	22.7	38.3	42.2	52.0	36.6	37.4	28.2	**257.4**
	Sub-total	130.7	220.8	257.8	328.9	240.8	245.6	178.2	**1,602.9**
Operating		35.0	70.0	80.0	90.0	55.0	55.0	50.0	**435.0**
Capital		80.0	0.0	0.0	0.0	0.0	0.0	0.0	**80.0**
	Total	245.7	290.8	337.8	418.9	295.8	300.6	228.2	**2,117.9**
Program 3									
Salaries	Research Scientists	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
	Post-Doc	38.0	76.8	78.3	79.9	81.5	83.1	84.7	**522.2**
	PhD	8.5	27.7	38.4	57.8	47.3	38.8	8.7	**227.0**
	Technical	35.0	35.7	36.4	37.1	37.9	38.6	39.4	**260.2**
	On-costs	15.8	25.0	26.0	27.5	27.4	27.5	26.5	**175.7**
	Sub-total	97.3	165.1	179.1	202.2	194.0	188.0	159.3	**1,185.1**
Operating		64.5	83.0	77.0	87.0	70.0	67.0	57.0	**505.5**
Capital		85.0	45.0	30.0	25.0	15.0	15.0	0.0	**215.0**
	Total	246.8	293.1	286.1	314.2	279.0	270.0	216.3	**1,905.6**
Program 4									
Salaries	Research Scientists	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
	Post-Doc	36.3	37.6	39.0	41.0	42.5	44.1	45.6	**286.1**
	PhD	112.1	114.3	116.6	181.3	112.1	114.3	70.0	**820.7**
	Technical	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
	On-costs	15.4	15.9	16.3	20.1	17.1	17.6	15.8	**118.3**
	Sub-total	163.8	167.8	171.9	242.4	171.7	176.0	131.4	**1,225.0**
Operating		113.5	105.0	114.2	157.2	105.0	116.5	105.0	**816.4**
Capital		51.0	25.0	40.0	0.0	20.0	0.0	0.0	**136.0**
	Total	328.3	297.8	326.1	399.6	296.7	292.5	236.4	**2,177.4**
Program 5									
Salaries	Research Scientists	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
	Post-Doc	38.0	38.8	39.5	40.3	41.1	42.0	42.8	**282.5**
	PhD	38.0	38.8	39.5	40.3	41.1	42.0	42.8	**282.5**
	Technical	105.0	107.1	109.2	111.4	113.7	115.9	118.2	**780.6**
	On-costs	44.8	45.7	46.6	47.5	48.5	49.5	50.5	**333.1**
	Sub-total	225.8	230.3	234.9	239.6	244.4	249.3	254.3	**1,678.7**
Operating		35.0	43.0	65.0	65.0	65.0	45.0	45.0	**363.0**
Capital		75.0	100.0	100.0	100.0	100.0	0.0	0.0	**475.0**
	Total	335.8	373.3	399.9	404.6	409.4	294.3	299.3	**2,516.7**
Totals									
Salaries	Research Scientists	25.0	50.0	101.0	103.0	105.1	107.2	109.3	**600.6**
	Post-Doc	150.3	267.9	234.3	278.3	244.2	249.8	255.4	**1,680.2**
	PhD	158.6	199.7	232.9	356.5	317.2	314.1	222.7	**1,801.7**
	Technical	315.0	355.6	362.7	405.0	299.4	305.4	269.2	**2,312.3**
	On-costs	125.9	166.8	174.0	199.1	168.6	171.7	161.5	**1,167.5**
	Sub-total	774.8	1,040.0	1,104.9	1,341.8	1,134.4	1,148.1	1,018.2	**7,562.2**
Operating		303.0	376.0	411.2	474.2	370.0	358.5	332.0	**2,624.9**
Capital		291.0	170.0	170.0	125.0	135.0	15.0	0.0	**906.0**
	Total	1,368.8	1,586.0	1,686.1	1,941.0	1,639.4	1,521.6	1,350.2	**11,093.1**

Appendix 4

Letter of Support

Royal Society of Western Australia

c/o WA Museum
Francis Street
Perth WA 6000

30 June, 1994

The Secretary
Co-operative Research Centres Committee
Department of Prime Minister and Cabinet
3-5 National Circuit
BARTON ACT 2600

Dear Secretary

I writing on behalf of the Council and members of the Royal Society of Western Australia who wish to express their support for the proposal to establish a CRC for control of Phtyphthora diseases. I have viewed the application from the Department of Conservation and Land Management (Western Australia), CSIRO, the Australian Nature Conservation, and their collaborators across Australia. This is a very serious nature conservation issue that is having a major impact on the forests of southern Australia. In addition to scientific concerns about the loss of irreplacable biodiversity due to Phytophthora diseases, the Royal Society is well aware of the impact these diseases are having on industries such as forestry, mining, and tourism.

The Royal Society of Western Australia is a multi-disciplinary scientific organization, and represents a broad cross-section of the scientific community in Western Australia. The current spread of Phytophthora diseases has alarmed scientists in this State greatly, and as a result the Royal Society acted with the Ecological Society of Australia to conduct a Symposium on the issue in April 1994. At the Symposium, attended by 130 of the leading researchers in Western Australia and from other States, there was general approval of the move to establish a CRC to combat these diseases. This was voiced publicly by the Director of the Australian Nature Conservation Agency (Dr Peter Bridgewater) and the Assistant Chief of CSIRO Division of Forestry (Dr Ken Old) at the Symposium.

The solutions to the problems caused by these diseases require a large collaborative research effort. I was pleased to see input from a broad range of organizations across Australia, including representatives of industry who stand to lose financially if nothing is done. The Royal Society of Western Australia strongly supports the application and urges your Committee to fund the research to the maximum extent possible.

Yours sincerely

Wallace A Cowling
President 1993/94
Royal Society of Western Australia

Work address: Department of Agriculture
Baron-Hay Court
South Perth
WA 6151

Tel: 368 3528
Fax: 474 2840

Appendix 5

CVs of Key Scientists

CURRICULUM VITAE: Ian James Bennett

Born: 17 March 1958
Position: Lecturer in Plant Science
Edith Cowan University
Qualifications: BSc (hons) Biological Science, Murdoch University (1980)
Previous Post: Associate Lecturer - Murdoch University (1984 - 91)

Research Interests and Achievements

1. Development of dieback resistance in jarrah. This has involved the selection of resistant plants, micropropagation of resistant clones and glasshouse and field testing for resistance. This work has led to the availability of resistant clones which are being utilised for further breeding and rehabilitation of *Phytopthora* infected areas and mine sites.
2. Insect resistance in jarrah with particular reference to jarrah leafminer. Studies have concentrated on the identification of resistant trees, clonal propagation of such trees and testing clonal trees for resistance. Studies have also involved estimating heritability of insect resistance in jarrah.
3. Salt tolerance in Australian plants for rehabilitation of salt affected areas in agricultural systems and areas affected by mining. This has involved the development of tissue culture techniques for a wide range of plants including eucalypts, acacias, melaleucas, saltbushes, *Eremophila* and casuarinas.

Educational experience

Over 10 years experience in teaching undergraduate courses at Murdoch University and Edith Cowan University. Supervision of honours and postgraduate students.

Publications

13 refereed journal articles and 10 conference papers and book chapters, 1 book. Following are 10 publications since 1986.

a) Bell, D.T., van der Moezel, P.G., Bennett, I.J., McComb, J.A., Wilkins, C.F., Marshall, S.C.B. and Morgan, A.L. (1993). Comparisons of growth of *Eucalyptus camaldulensis* from seeds and tissue culture: root, shoot and leaf morphology of 9-month old plants grown in deep sand and sand over clay. Forest Ecology and Management 57 : 125-139.

b) Bennett, I.J., McComb, J.A. and Bradley, J.S. (1992). Testing the expression of resistance in insect attach: Resistance of jarrah (*Eucalyptus marginata*) to jarrah leafminer (*Perthida glyphopa*). Forest Ecology and Management 48 : 99-105.

c) Bennett, I.J., McComb, J.A. and Tonkin, C.M. (1993). Inoculation of *Eucalyptus marginata* Donn ex Sm. (jarrah) clones with *Phytophthora cinnamomi* Rands in vitro and under glasshouse conditions. Forest Ecology and Management 57 : 115-124.

d) Bennett, I.J., McComb, J.A., Tonkin, C.J. and McDavid, D.A.J. (1992) Effect of cytokinins on multiplication and rooting of Eucalyptus globulus and other Eucalyptus species. In Proceedings of conference on mass production technology for genetically improved fast growing forest tree species in France, AFOCEL, 195-201.

e) Bennett, I.J., McComb, J.A., Tonkin, C.M. and McDavid, D.A.J. (1994). Alternating cytonins in multiplication media stimulates in vitro shoot growth and rooting of *Eucalyptus globulus* Labill. Annals of Botany 73 : in press.

f) Bennett, I.J., Tonkin, C.M.., Wroth, M.M., Davidson, E.M. and McComb, J.A. (1986). A comparison of growth of seedlings and micropropagated *Eucalyptus marginata* (jarrah). I. Early growth to 2 years. Forest Ecology and Management 14 : 1-12.

g) Cahill, D.M., Bennett, U.J. and McComb, J.A. (1992). Resistance of micropropagated *Eucalyptus marginata* to *Phytophthora cinnamomi*. Plant Disease 76 : 630-632.

h) Cahill, D.M., Bennett, I.J. and McComb, J.A. (1993). Mechanisms of resistance to *Phytophthora cinnamomi* in clonal, micropropagated *Eucalyptus marginata. Plant Pathology* 42 : in press.

i) Dell, B. and Bennett, I.J. (1986). The flora of Murdoch University. Murdoch University, Murdoch.

j) McComb, J.A., Bennett, I.J. (19900. A chip of the old block. Landscope 5 : 50-53.

k) McComb, J.A., Bennett, I.J., Van Der Moezel, P.G. and Bell, D.T. (1989). Biotechnology enhances utilisation of Australian woody species for pulp, fuel and land rehabilitation. Australian Journal of Biotechnology 3 : 297-301.

CURRICULUM VITAE: David Jack Coates

Born:	2 February, 1953
Position:	Principal Research Scientist, WA Department of Conservation and Land Management.
Qualifications:	BSc(Hons) Botany, University of Western Australia PhD Botany, University of Western Australia (1979)
Previous Appointments	Senior Tutor, Department of Botany, Australian National University (ANU) (1979). Post Doctoral Fellow, Research School of Biological Sciences, ANU (1980-1983). Research Fellow, Research School of Biological Sciences, ANU (1983-1985).

Research Interests and Experience

1. Population genetics and ecology of rare and endangered, and commercially utilised plant species and the development of management strategies for their *in situ* and *ex situ* conservation. Plant groups covered by previous and current research include *Acacia, Banksia, Eremophila, Eucalyptus, Lambertia, Stylidium* and the Orchidaceae. These studies have lead to the drafting of Recovery Plans for four endangered plants and to the development of various management strategies for the conservation of a range of Western Australian native plant species.
2. The use of isozyme techniques in the identification of pathogenic fungi such as *Cryphonectria cubensis* and in evolutionary and biosystematic studies of taxa in the plant groups *Stylidium* and *Eremaea.*
3. Research into rare and threatened plant germ plasm collection and storage strategies. This includes population genetic, mating system and seed biology studies on taxa such as *Banksia brownii, Banksia cuneata, Lambertia orbifolia* and *Stylidium coroniforme.* Related to this work is my appointment to two working groups responsible for developing both State and Commonwealth strategies for the *ex situ* germ plasm storage of native plant species particularly those listed as rare and threatened.
4. Population cytogenetic and biosystematic studies in the *Caledia captiva* and the *Stylidium caricifolium* species complexes aimed at understanding the significance of hybridisation and genomic restructuring in the evolution of those complexes.
5. Coordination of surveys and conservation status determination of rare and threatened plants and the publication of area based Wildlife Management Programs for rare and threatened flora in Western Australia.

Managerial experience

Program manager (1990-93) for the CALM Flora Conservation Research Program. This included all plant disease research relating to conservation of the Western Australian flora outside the State's timber production areas.

Educational experience

Teaching and research supervision of undergraduate students at ANU (1979). Occasional lecturing and PhD student supervision at ANU (1980-1985). Hons, Msc and PhD student supervision at Curtin University and The University of Western Australia (1986-present)

Membership of learned societies

Royal Society of Western Australia
Society for the Study of Evolution
The Genetics Society of Australia
The Society for Conservation Biology

Publications

35 refereed publications, 18 conference papers, 4 technical reports and 5 popular articles. Following are key publications.

1. Coates, D.J. and James S. (1979) Chromosome variation in (*Stylidium crossocephalum* Stylidiaceae) and the dynamic coadaptation of its lethal system. *Chromosoma* 72, 357-376.

2 Coates, D.J. (1981) Chromosome variation and species relationship in the scale-leaved triggerplants *(Stylidium* section Squamosae). *Aust. J. Bot.* 30, 121-130.

3 Coates, D.J. and Shaw, D.D. (1982) The chromosomal component of reproductive isolation in the grasshopper *Caledia captiva.* I. Meiotic analysis of chiasma distribution patterns in two chromosomal taxa and their F1 hybrids. *Chromosoma* 86, 509-531.

4 Shaw, D.D. Wilkinson, P. and Coates, D.J. (1983) Increased chromosomal mutation rate following hybridisation betweeen two subspecies of grasshoppers. *Science* 220, 1165-1167

5 Coates, D.J. (1988) Genetic diversity and population structure in the rare Chittering grass wattle, *Acacia anomala. Aust. J. Bot*, 36, 273 -286.

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

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

8 Coates, D.J. and Hnatiuk, R.J. (1990). Systematic and evolutionary inferences from isozyme studies in the genus *Eremaea* (Myrtaceae) *Aust. Syst. Bot*, 3, 59-74

9 Davison E. M and Coates D. J.(1991). Identification of *Cryphonectria cubensis* and *Endothia gyrosa* from eucalypts in Western Australia using isozyme analysis. *Aust. Plant. Path.* 20, 157-160

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

11 Coates, D. J. and Sokolowski R. E. S. (1992). The mating system and patterns of genetic variation in *Banksia cuneata* A. S. George (Proteaceae) *Heredity, 69,* 1-20.

CURRICULUM VITAE: Ian Jamieson Colquhoun

Born: 13 June 1954

Position: Senior research scientist
Environmental Department
Alcoa of Australia Ltd

Qualifications: BSc (Hons) Botany, University of Glasgow Scotland, UK (1972-76)
PhD (Botany), University of Western Australia, Perth WA. Thesis title "Eco-physiological studies of two shrub species growing in the Swan Coastal Plain, Perth, Western Australia". (1976-79)

Responsibilities of present appointment
Develops a comprehensive and relevant dieback research programme to ensure that dieback management procedures implemented on the minesites are of the highest practicable standard and are as cost effective as possible.

Ensures that Alcoa-funded external dieback research is relevant to Alcoa's needs, is progressed at an acceptable rate, is efficiently conducted and is well reported.

Contributes to the development of effective dieback control procedures for operations in good quality forest by reporting results of research and monitoring programs and developing better procedures jointly with minesite staff.

Contributes to the development of environmentally sound mine plans in good quality forest regions by evaluating the potential impacts of mining proposals and assisting in the formulation of efficient, low-impact alternatives.

Collaborative Research
Collaborative research projects have taken occurred with Dr D. Bell, Dr J. Considime (University of WA), Dr B. Dell, Assoc Prof J. McComb, Dr J. Hardy (Murdoch University), Dr J. Osborne, Dr D., Fox ·(Curtin University), Dr I. Bennett (Edith Cowen University), Dr E. Greenwood, Dr J. Marshall and Dr R. Gerritse (CSIRO, Division of Water Resources), Dr B. Shearer, Dr G. Stoneman, Dr E. Davison, Mr M. Stukely (Department of Conservation and Land Management).

Contributed or contributing to 5 PhD and 6 University honours projects.

Publications

a) Anon, (1993). Mine Environmental Management Manual. Internal Publication, Alcoa of Australia Limited, Booragoon, WA (IJC was a major contributor to this document).

b) Anon (1994). Environmental Operating Standards/Guidelines for Mining Operations. Internal Publication. Alcoa of Australia Limited, Booragoon, WA (IJC was a major contributor to this document).

c) Anon (1994). Dieback Management Audit Protocol. Internal Publication. Alcoa of Australia Limited, Booragoon, WA. (IJC was a major contributor to this document).

d) Colquhoun, I.J. (1992). Alcoa's Dieback Research Direction. In "Dieback - What is the Future?" (ed. Freeman M.J., Hart R. and Ryall M.). The Northern Southplains Dieback Working Party, Muchea, WA 15-21.

e) Colquhoun, I.J., Baird, G.B., Smith, B.J., Davison, E.M. (1993). Use of Windrow Fires to Eradicate *Phytophthora cinnamomi* from Forest Roads. Poster paper presented to International Plant Pathology Conference, Montreal, Canada.

f) Colquhoun, I.J. and Petersen, A.E. (1994). The impact of plant disease on mining. In "Handbook of the Symposium on Plant Diseases in Ecosystems" (eds. Wills R.T. and Cowling W.A.). Royal Society of Western Australia, Perth WA.

g) Gerritse R.G., Adenay J.A., Baird G., Colquhoun I.J. The reaction of Copper ions and hypochlorite with minesite soils in relation to fungicidal activity. Aust.J.Soil.Res. 30, 723-735.

CURRICULUM VITAE: Simon Ernest Cook

Born: 10 February 1955
Position: Research Scientist
CSIRO Division of Soils
Qualifications: BSc (Hons.) Geography, Swansea, UK (1981)
MSc Soil Science, Reading, England (1982)
PhD Applied Biology, Cambridge, England (1989)
Previous Post: Senior Environmental Consultant, Wardell Armstrong, Newcastle-under-Lyme, England (1989-91)

Research Interests and Achievements:

1 Spatial prediction of soil attributes at catchment scale. Development of a rule-based methodology of soil survey which uses Bayesian inference to produce quantitative estimates of selected soil properties without the requirement for intensive sampling. The method can operate at catchment or regional scale. This updates the conventional soil survey method and is run in Geographical Information Systems (GIS) but on the basis of existing knowledge. The system is currently being developed for adoption by the Western Australian Department of Agriculture.

2 GIS-based land evaluation. This extends the Bayesian methodology for soil survey to the problem of predicting land qualities from incomplete or uncertain data. The method uses a 'weights' of evidence approach to compute the belief in a given land quality as it varies within a given area. The method is being used to predict the distribution of soil *rhizobium* inoculum in N.E Thailand and soil acidification risk in the WA wheatbelt.

3 Remote sensing of soil properties. Review on the potential application of Landsat TM to identify soil variation under agricultural land use. Experimentation using ground and airborne gamma radiometrics to identify soil variation and found airborne radiometrics (in K, Th and U spectra) potentially valuable to identify the distribution of soil materials over the landscape. Results incorporated in rule-based methodology.

4 Soil water modelling. Determined the spatial behaviour of soil physical properties have been found to fluctuate between stochastic and deterministic patterns, and shown that at the scale required for most practical decisions, the stochastic characteristic weakens. Hence geostatistical methods likely to be less efficient than under normal experimental conditions.

5 Minesite rehabilitation. Over 5 years commercial experience in environmental assessment and rehabilitation of minesites, with experience in sand and gravel, opencast coal, brickearth and kaolinite mines.

Educational experience

One years' lecturing and tutorial to undergraduates (University of North London, 1990-91), supervision of postgraduate at University of Western Australia, occasional lecturing at University of Western Australia.

Scholarships, Fellowships

MAFF Scholarship, Reading, England (1981-82).

Publications:

1 Evans, R. and Cook, S.E. (1986) Soil erosion in Britain. SEESOIL 3: 28-59

2 Coppin, N.J., Cook, S.E., Short, J., Eardley, J., Hake, S., Brignall, D. (1993). Landscaping and revegetation of china clay wastes. Department of Environment. HMSO, Eastcote.

3 Cook, S.E., Corner, R.J. Grealish, G. (1993). Application of remote sensing to soil survey. Report to Land and Water Resources Research Development Corporation. Canberra.

4 Cook, S.E., Corner, R.J., Grealish, G. (1994) Application of a knowledge-moderated rule-based system to soil mapping. **7th Australian Remote Sensing Conference,** Melbourne.

5 Cook, S.E. and Coles, N.J. (1994) Spatial variation of selected soil properties in eight catchments within Western Australia. (In review)

6 Cook, S.E., Corner, R.J. Grealish, G. (1994) A new rule-based method of mapping soil variables at catchment scale. (Submitted to Soil Science Society of America Journal).

7 Cook, S.E., Corner, R.J. Grealish, G. (1994) Use of airborne gamma radiometrics in soil survey. (In review)

8 Thies, J. and Cook, S.E. (1994) A Bayesian decision support system to predict the distribution of soil *Rhizobium* in North East Thailand. 1994 Conference Agronomic Society of America. Seattle.

CURRICULUM VITAE: Andrew Duell Davidson

Born: 28th October 1962

Position: Lectuirer, Department of Microbiology
Monash University

Qualifications: BSc (Hons) University of Queensland, 1983
PhD Plant Biochemistry, University of Queensland, 1988

Previous post: Postdoctoral Fellow, Max-Planck-Institute for Plant Breeding Research (Zuechtungsforschung), Cologne, Germany, (1988-91)

Research Interests and Achievements

1. Research interests currently are centered on the molecular biology of RNA viruses, in particular the plant potyviruses. Research projects include: Investigation of the replication cycle of the plant potyvirus, bean yellow mosaic virus; the use of an infectious cDNA clone of dengue virus type 2 to investigate dengue 2 virus replication and pathogenesis; the detection and molecular characterisation of viruses infecting *Phytophthora cinnamomi*. Also associated with a research project characterising a single stranded RNA virus infecting *Agaricus bisporus*.
2. Postdoctoral research was on the molecular biology of barley yellow mosaic and barley mild mosaic viruses. These viruses are of considerable economic importance in Europe and Japan. They are transmitted to barley *via* the soil-borne vector *Polymyxa graminis*. The research was aimed at the development of genetically engineered viral resistant plants using genes derived from the viral pathogens.
3. PhD thesis entitled "Gene expression in *Hordeum vulgare* infected with fungal pathogens". PhD study was aimed at examining patterns of host gene expression in barley in response to infection with *Erysiphe graminis* f.sp. *hordei*. and other fungal pathogens. cDNA clones were isolated corresponding to several mRNAs were used as probes to monitor patterns of gene expression in barley in response to fungal infection.

Educational experience

Currently employed as a Lecturer in Microbiology. Teaching duties include Undergraduate Science and Medical students and research supervision of Undergraduate BSc (Hons) and PhD students.

Scholarships, Fellowships etc

Max Planck Research Fellowship, Germany (1988-1989)
Alexander von Humboldt Fellowship, Germany (1989-1990)

Publications

a) Manners, J.M., Davidson, A.D., and Scott, K.J. (1985). Patterns of post-infectional protein synthesis in barley carrying different genes for resistance to the powdery mildew fungus. Plant Molecular Biology **4,** 275-283.

b) Davidson, A.D., Manners, J.M., Simpson, R.S. and Scott, K.J. (1987). cDNA cloning of mRNAs induced in resistant barley during infection by *Erysiphe graminis* f.sp. *hordei*. Plant Molecular Biology **8,** 77-85.

c) Davidson, A.D., Manners, J.M. Simpson, R.S. and Scott, K.J. (1988). Altered host gene expression in near-isogenic barley conditioned by different genes for resistance during infection by *Erysiphe graminis* f.sp. *hordei*. Physiological and Molecular Plant Pathology **32,** 127-139.

d) Steinbiss, H-H. and Davidson, A.D. (1989). Genetic manipulation of plants: from tools to agronomical applications. Science Progress, Oxford **73,** 147-168.

e) Davidson, A.D., Proels, M., Schell, J., and Steinbiss, H-H. (1991). The nucleotide sequence of RNA 2 of barley yellow mosaic virus. Journal of General Virology **72,** 989-993.

f) Steinbiss, H-H. and Davidson, A.D. (1991). Transient gene expression of chimeric genes in cells and tissues of crops, in Subcellular Biochemistry, Volume 17: Plant Genetic Engineering (B.B. Biswas and J.R. Harris, eds.), pp. 143-166, Plenum Press, New York.

g) Peerenboom, E., Proels, M., Schell, J., Steinbiss, H-H. and Davidson, A.D. (1992). The complete nucleotide sequence of RNA1 of a German isolate of barley yellow mosaic virus and its comparison with a Japanese isolate. Journal of General Virology **73,** 1303-1308.

h) Bendiek, J., Davidson, A.D., Schulze, S.C. Schell, J. and Steinbiss, H-H. (1993). Identification and classification of a resistance breaking strain of barley yellow mosaic virus. Annals of Applied Biology **122,** 481-491.

i) Muradov, A., Petrasovits, L., Davidson, A., and Scott, K.J. (1993). A cDNA clone for a pathogenesis-related protein 1 from Barley. Plant Molecular Biology. **23,** 439-442.

j) Revill, P.A., Davidson, A.D., and Wright, P.J. (1994?). The nucleotide sequence and genome organisation of mushroom bacilliform virus: a single-stranded RNA virus of *Agaricus bisporus* (Lange) Imbach. Virology (accepted for publication).

Curriculum Vitae

Name:	Kingsley Wayne DIXON
Date of Birth:	22 May 1954
University Degrees:	B.Sc(Hons). PhD (Univ of WA)
Present Position:	Assistant Director, Kings Park and Botanic Garden, WA.
Previous Appointments:	Post doctoral fellow, Univ. of WA (1981-2); Research Officer, Univ. of WA (1983).
Other Positions:	Fellow, Australian Orchid Foundation (1988); •Honorary Research Fellow, Department of Horticultural Science, Murdoch University (1989-91); •Scientific exchange to China (Academia Sinica and Australian Academy of Science) (1991); •Adjunct Senior Lecturer, University of Western Australia (Botany Department) (1993-96);
Research Fields:	Native species biology, propagation and conservation particularly application of plant physiology, seed banks, in vitro propagation, smoke germination, genetic screening, mycorrhiza and phytopathology methods. Focus on conservation and restoration of rare and endangered species and communities. and germplasm storage methods and viability testing Successfully supervised three PhD, two MSc and eight Hons programs. Currently supervising 12 PhD, two MSc and one Hons.
Research Funding	$1,300,000 over 18 project areas.
Key Achievements	Executive Officer, Fourth International Botanic Gardens Conservation Congress; Co chair Fourth International Protea Conference; Chairperson, National Working Committee for Germplasm Storage of Rare and Endangered Species; Representative (Oceania), Reintroduction Specialist Group, Species Survival Commission, IUCN.
Total Publications	105 (58 Journal papers, 33 conference papers, newsletters etc, 6 books, 8 book chapters). Further 4 papers are in review.

Selection of recent relevant works:

Meney, K., Nielssen, G. and Dixon, K.W. Seed bank patterns in Restionaceae and Epacridaceae after wildfire in heath (kwongan) in south-western Australia. Journal of Vegetation Science 5. 1994.

von Perger, B.A., Weaver, P. and Dixon, K.W. Genetic diversity and restoration of a recalcitrant clonal sedge (*Tetraria capillaris* Cyperaceae). Biodiversity and Conservation 3. 1994.

Bell, T.L., Pate, J.S. and Dixon, K.W. Response of mycorrhizal seedlings of SW Australian sandplain Epacridaceae to added nitrogen and phosphorus. Journal of Experimental Botany 45. 1994.

Hutton, B.J., Dixon, K.W. and Sivasithamparam, K. . Ericoid endophytes of Western Australian heaths (Epacridaceae). New Phytologist (accepted and in press).1994.

Pate, J.S. , Meney, K.A. and Dixon, K.W Contrasting growth and morphological characteristics of fire-sensitive (obligate seeder) and fire-resistant (resprouter) species of Restionaceae (southern hemisphere restiads) from south-western Western Australia. Australian Journal of Botany 39, 505-25.1991.

Bunn, E. and Dixon, K.W. In vitro propagation of the rare and endangered Corrigin Grevillea, *Grevillea scapigera* A.S. George (Proteaceae). HortScience 27(4), 261-262.1992.

Bunn, E. and Dixon, K.W. Micropropagation of *Stirlingia latifolia* (R.Br.)Steudel (Proteaceae), and improtant horticultural species from Western Australia. HortScience 27(4), 368.1992.

Rossetto, M and Dixon, K.W. and Bunn, E. Aeration: a simple method to control vitrification and improve in vitro culture of rare Australian plants. In Vitro Cellular and Developmental Biology. 28P:192-196.1992.

Rossetto, M and Dixon, K.W. In vitro propagation of Chinese Puzzle (*Caustis dioica* Cyperaceae)- a commercial sedge species from Western Australia. Plant Cell, Tissue and Organ Culture 30, 65-67.1992.

Meney, K.A., Dixon, K.W., Scheltema, M. and Pate, J.S. Occurrence of vesicular-arbuscular mycorrhizal fungi in dryland species of Restionaceae and Cyperaceae from south-west Western Australia. Australian Journal of Botany 41(6):733-37. 1993.

Touchell, D.H. and Dixon, K.W. Cryopreservation for seed banking of Australian species. Annals of Botany. (in press).1993.

Touchell, D.H. and Dixon, K.W. Cryopreservation of seed of Western Australian native species. Biodiversity and Conservation 2(6). 594-602. 1993.

CURRICULUM VITAE: Kenwyn Ronald Gayler

Born:	20 December 1940
Position:	Senior Lecturer Biochemistry Department University of Melbourne
Qualifications:	BAgSC(Hons) Adelaide, (1962) PhD Queensland (1969)
Previous Post:	Research Scientist, David North Plant Research Centre, CSR Ltd (1964-70)

Research Interests and Achievements

My overall research interest has been in the mechanisms by which plant growth and development is regulated and in particular the way plants respond to external challenge. Included in the range of problems which have been examined are the following;

1. Hormonal regulation of sugar cane growth and sugar storage. Emphasis here was on the molecular mechanisms by which the hormones acted. This work included the first successful measurement of plant mRNA half lives and preceded modern molecular biological technology.
2. Nutritional responses of grain legume crops and more recently of cereal grains. The changes in protein composition in response to altered nutrition were analysed in detail and the underlying genes which contribute to changing quality of the harvested seed were isolated, cloned and characterized. Protein responses of unexpected magnitude and selectivity were demonstrated following sulphur deprivation in the grain legume crops, soybean and sweet lupin, highlighting the potential influence of agronomic practice on grain quality. Many of the papers relating to this work which are included in the publication list describe the successful use of the molecular biological and biochemical techniques which will be directly applicable in the proposed analysis of the consequences of invasion of plants by *Phytophthora*.
3. Environmental effects on the malting quality of barley. The theme of crop responses to external influences was extended in a major study on the influence of environmental stress on the malting quality of barley grain. These relatively recent studies in which a potential marker for malting quality in barley grain was identified, again applied protein biochemistry and recombinant DNA technologies in the analysis of the responses of crop development in the field. The potential application of this information in barley breeding is currently under further development.
4. Plant defence genes and their roles in phosphonate dependent control of Phytophthora invasion. Following early work in which the role of mRNA is Phytophthora zoospore germination was investigated, a major program has been set up to investigate the host plant defence-genes and how they respond to Phytophthora invasion. Under particular investigation is the role of elicitin production by Phytophthora and the potential modulating effects of antifungal agents on plant gene responses. This is to be developed further.

Educational experience

Secondary and tertiary undergraduate teaching in Agricultural Biochemistry and in Modern Crop Molecular Biology and supervision of PhD, Masters and BSc Honours students for 20 years. Current supervision of 3 PhD, 1 MSc and 1 BScHons.

Scholarships, Fellowships etc.

British Council Award for Special studes program: Rothamsted Experimental Station, U.K. 1980.

IDP Visiting Adviser to prince of Songkla University, Thailand, 1987.

Publications

Approximately 30 papers in refereed journals. Following are 9 key publications post 1983.

a) Gayler K.R., Boadle, B.G., Snook, M., Johnson, E.D., (1984). Precursors of storage proteins in *Lupinus angustifolius*. Biochem J. 221 : 333-341.

b) Gayler K.R., Sykes, G.E., (1985). Effects of nutritional stress on the storage proteins of soybeans. Plant Physiol.: 78 : 582-585.

c) Johnson, E.D., Knight, J. and Gayler K.R., (1989). Biosynthesis and processing of legumin-like storage proteins in *Lupinus angustifolius* (lupin). Biochem J 232 : 673-679.

d) Gayler K.R., Wachsmann, F., Kolivas, S., Nott, R., Johnson E.D. (1989). Isolation and characterization of protein bodies in Lupinus augustifolius. Plant Physiol 91 : 1425-1431.

e) Penngton, C.J., Iser, J.R., Grant, B.R., Gayler K.R., (1989). Role of RNA and protein synthesis in stimulated germination of zppspores of the pathogenic fungus Phytophthora palmivora. Experimental Mycology 13 : 158-168

f) Gayler K.R., Kolivas, S., Macfarlane, A.J., Lilley, G.G., Baldi, M., Blagrove, R.J., Johnson, E.D. (1990). Biosynthesis, cDNA and amino acid sequences of a precursor of conglutin å, a sulphur-rich protein from Lupinus angustifolius. Plant Mol Biol 15 : 879-893.

g) Howard, K.A., Bedggood, A.G., Gayler K.R., (1992). The role of D-hordein in malting Quality of barley. Proc. U.C. Davis-Pacific Rim food and Agricultural biotechnology Conference, Sacraments, June 1992 : 19.

h) Howard, K.A., Gayler K.R., Eagles, H. Halloran, G.M., (1993). The relationship between D Hordein and Malting Quality. Proc. 6th Aust. Barley Technical Symposium, Laucheston, Tasmania, Sept, 1993. pp 31-34.

i) Kolivas, S., Gayler K.R., (1993). Structure of the cDNA coding for conglutin y, a sulphur-rich protein from *Lupinus angustifolius*. Plant MolBiol 21 : 397-401.

CURRICULUM VITAE: Bruce R. Grant

Date of Birth: April 29, 1936

Position: Reader/Associate Professor Department of Biochemistry, Melbourne University, Parkville, Victoria, 3052

Qualifications: B.Ag.Sci. (University of Queensland), 1958; M.Sc, (Purdue, USA), 1960; PhD. (Purdue, USA), 1962.

Previous Posts: Research Fellow, Dept of Cell Physiology, University of California, Berkeley, (1962-64)
Research Scientist, Senior Research Scientist, CSIRO Division of Fisheries and Oceanography (1964-1969)
Assistant Professor, Department of Biology, Queens University, Ontario, (1969-1972)
Senior Lecturer, Department of Biochemistry, Melbourne University (1972-1985).

Research Interests and Achievements:

1. The study of nitrogen metabolism and the interaction between environmental nitrogen levels photosynthetic rates and net primary productivity in marine ecosystems. In this work I did pioneering work in establishing the hyposaline alga *Dunaliella* as a useful laboratory tool.
2. The study of the metabolic autonomy of chloroplasts in algae, particularly in coenocytes of the genera *Acetabularia* and *Caulerpa*. This work not only clarified some of the views on the integration of chloroplast metabolism in cells, but developed a new understanding the some of the wound responses in these organisms.
3. The investigation of the mechanisms by which zoospores of the Oomycetes, and specifically those from *Phytophthora cinnamomi* and *P. palmivora* undergo differentiation. This work highlighted the importance of divalent cations, particularly Ca^{2+}, in regulating the encystment process. It also showed the importance of plant products such as polygalacturonic acids as triggers of the processes of zoospore differentiation and identified phosphatidic acid generated by a D-type phospholipase as an important second messenger in zoospores.
4. The study of the mechanism of phosphonate action in *Phytophthora* spp. This work included the first quantitative studies of the interaction between phosphate and phosphonate, identification of the major disturbances caused by phosphonate in intermediary metabolism documented and one of the sites of phosphonate action within *Phytophthora* spp. identified. It provided the basis for the current view of the way in which phosphonate treatment gives rise to an altered plant response during *Phytophthora* invasion.

Educational Experience:
In CSIRO I participated in summer schools which trained marine biologists. In universities I have taught and supervised undergraduates and post graduates in both Canada and in Australia. Included in this group were students from Korea, the Netherlands and Germany as well as Australians and Canadians. The 12 PhDs who have obtained PhDs under my supervision since 1972 all hold senior positions in industry, government or universities either in Australia and overseas. I have also organised and conducted short specialist courses to give training in the handling of radioisotopes and given presentations of my scientific work to the general public each year as part of the University of Melbourne's mission to communicate its activities to the general public.

Scholarships, Fellowships etc.
Fulbright Scholar, USA (1958-62), Visiting Research Fellow, AIMS. (Townsville), (1980); Roche Pty Ltd ·Sydney) 1981, Visiting Research Fellow, Oxford U. (1986); Visiting Professor, Drexel University (USA) 1987, NERC Council Fellow Queens University, (1994).

Invitations and participation in International Meetings as Invited Speaker (last 10 years)
1. Australian Biochemical Society, Melbourne 1986
2. Seventh International Congress of Pesticide Chemistry (Hamburg) 1990
3. 10th International Symposium on Modern Fungicides (Reinhardsbrunn) 1992
4. 6th International Congress on Plant Pathology (Montreal, 1993.

Publications
82 Publications in refereed journals, and 60 conference papers and book chapters. The following a selection of key publications since 1984.

a) Grant, B.R. and Byrt, P.N. (1984) Root temperature effects on the growth of Phytophthora cinnamomi in the roots of *Eucalyptus marginata* and Eucalyptus calophylla. Phytopathology74: 179-184.

b) Irving, H.R. and Grant, B.R. (1984) The effect of calcium on Zoospore differentiation in Phytophthora cinnamomi. Journal of General Microbiology 130: 1569-1576.

c) Grant, B.R., Griffith, J.M., Irving, H.R. and Radda, M. (1984) An improved method for the synchronous production of zoospores from Phytophthora palmivora. Experimental Mycology 8: 382-385.

d) Paktits, S., Grant, B.R., and Lawrie, A. (1986) Surface changes in Phytophthora palmivora zoospores following induced differentiation. Protoplasma 135: 119-129.

e) Phillips, D., Grant, B.R. and Weste, G. (1987) Histological changes in the roots of an avocado cultivar Duke 7 infected with Phytophthora cinnamomi.

f) Cahill, D., Legge, N.J., Grant, B.R. and Weste, G. (1989) Cellular and histological changes induced by Phytophthora cinnamomi in a group of plants ranging from fully susceptible to fully resistant. Phytophathology 79: 417-424.

g) Niere, J.O., Griffith, J.M., Grant, B.R. (1990) A 31-P NMR study of the effects of phosphite on the phosphorus metab olism of Phytophthora palmivora J.gen. Microbiol. 136: 147-156.

h) Guest, D.I. & Grant, B.R. (1991) The complex action of phosphonates as antifungal agents. Biol. Rev. 66: 159-187.

i) Griffith, J.M., Davis, A. & Grant, B.R. ·1992) Fungicides to control Oomycetes. In Target sites of Fungicidces, ed W. Koeller, CRC Critical reviews, CRC Press. Booa Raton. Fla. 69-91.

j) Griffith, J.M. Coffey, M.D., Grant, B.R. (1993) Phosphonate inhibition as a function of phosphate concentration. J. General Microbiology, 139: 2109-2116.

CURRICULUM VITAE: **Dr A. R. Hardham**

Address: Plant Cell Biology Group, Research School of Biological Sciences, The Australian National University, Canberra, ACT, 2601

Date of Birth: 12 May 1953

Academic qualifications:

1971-1973	BSc, Monash University, Clayton, Victoria
1974	BScHons I, Department of Botany, ANU. Thesis title: A study of the embryo and developing cotyledons of Pisum sativum,
1975-1978	PhD, Department of Developmental Biology, RSBS, ANU. Thesis title: Microtubules and morphogenesis in Azolla pinnata roots

Previous appointments:

1978-1979	Postdoctoral Fellow, Department of Biological Sciences, Stanford University, Stanford, California, USA
1979-1980	Postdoctoral Fellow, Department of Biology, Carleton University, Ottawa, Canada
1980-1982	Queen Elizabeth Research Fellow, School of Botany, University of Melbourne, Parkville, Victoria
1982-1987	Research Fellow, Department of Developmental Biology, RSBS, ANU
1987-1989	Senior Research Fellow, Plant Cell Biology Group, RSBS, ANU
1989-1992	Fellow, Plant Cell Biology Group, RSBS, ANU

Present appointment:

1992-	Senior Fellow, Plant Cell Biology Group, RSBS, ANU

Academic Awards and Distinctions:

1978	J.G. Crawford Prize, Australian National University
1980	Queen Elizabeth II Research Fellowship
1985	National Research Fellowship (Team Leader)
1988	P.L. Goldacre Award, Australian Society of Plant Physiologists
1988	Australian Research Council Research Fellowship (Team Leader)
1989	Gottschalk Medal, Australian Academy of Science
1992	Distinguished Paper in Phycology Award, Botanical Society of America for: Galway, M.E. and Hardham, A.R. (1991) Immuno-fluorescence localization of microtubules throughout the cell cycle in the green alga Mougeotia (Zygnemataceae). Amer. J. Bot. 78, 451-461

Publications:

60 refereed journal publications and 90 conference presentations. 10 key publications in last 10 years:

26 Hardham, A.R., Suzaki, E. and Perkin, J.L. (1986) Monoclonal antibodies to isolate-, species- and genus-specific components on the surface of zoospores and cysts of the fungus Phytophthora cinnamomi. Can. J. Bot. 64, 311-321

30 Gubler, F. and Hardham, A.R. (1988) Secretion of adhesive material during encystment of Phytophthora cinnamomi zoospores, characterized by immunogold labelling with monoclonal antibodies to components of peripheral vesicles. J. Cell Sci. 90, 225-235

39 Hardham, A.R. and Gubler, F. (1990) Polarity of attachment of zoospores of a root pathogen and pre-alignment of the emerging germ tube. Cell Biol. Int. Rep. 14, 947-956

44 Hardham, A.R., Gubler, F., Duniec, J. and Elliott, J. (1991) A review of methods for the production and use of monoclonal antibodies to study zoosporic plant pathogens. J. Microsc. 162, 305-318

47 Hyde, G.J., Lancelle, S., Hepler, P.K. and Hardham, A.R. (1991) Freeze substitution reveals a new model for sporangial cleavage in Phytophthora, a result with implications for cytokinesis in other eukaryotes. J. Cell Sci. 100, 735-746

49 Hardham, A.R. (1992) Cell biology of pathogenesis. Annu. Rev. Pl. Physiol. Pl. Mol. Biol. 43, 491-526

52 Hyde, G.J. and Hardham, A.R. (1993) Micotubules regulate the generation of polarity in zoospores of Phytophthora cinnamomi. Eur. J. Cell Biol. 62, 75-85

54 Gabor, B.K., O'Gara, E.T. , Philip, B.A., Horan, D.P. and Hardham, A.R. (1993) Monoclonal antibodies specific for Phytophthora cinnamomi and their application in two rapid diagnostic assays. Plant Disease 77, 1189-1197

55 Cahill, D.M. and Hardham, A.R. (1994) Exploitation of zoospore taxis in the development of a novel dipstick immunoassay for the specific detection of Phytophthora cinnamomi. Phytopathology in press

60 Kobayashi, I., Kobayashi, Y. and Hardham, A.R. Dynamic reorganisation of the cytoskeleton in flax cells during rust infection and resistance response. To be submitted to Planta in press

Patent Application:

Hardham, A.R. and Cahill.D.M. (1993) Detection of motile organisms in a sample. International application filed 22 September 1993

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CURRICULUM VITAE

Name: Giles Edward St.John Hardy.

Born: 17/4159

Position Lecturer Plant Pathology School of Environmental Sciences Murdoch University, Perth WA 6150

Qualifications BSc (Hons 1st) Agriculture, University of W. A. (1984) Ph. D. (1989) Agriculture (Plant Pathology), University of Western Australia.

Previous Post Research Scientist, Bunnings Treefarms, Manjimup, W.A. (1989-1991).

Research Interests

1. Biology, ecology and pathology of *Phytophthora* species in native plant communities and the container plant industry.
   Work on *Phytophthora* species in plant production nurseries was a major reason for the implementation of a nursery accreditation scheme in W. Australia.
2. Pathology and taxonomy of fungi causing cankers in native plant species.
3. Biological control of *Phytophthora* species in containers. This work has involved extensive screening of fungi and actinomycetes (other than *Streptomycetes*) for the control of soilborne plant pathogens.
4. Plant-pathogen interactions.
5. Fungal plant pathogens in the horticultural industry.
6. Integrated pest management in pant production nurseries and horticulture.

Educational Experience lecturing in Microbiology and Plant Pathology. The supervision of 9 Honours (3 current), 2 MSc and 4 Ph. D. (Current) students. Seminars and workshop discussions to members of the horticultural industry.

Industry Experience

1. Between 1982-1988 I established a wholesale plant production nursery on 10 acres, south of Perth. This involved supervising the construction of propagation, shade and glasshouses, work buildings, watering and fertilisation systems and stock gardens. The nursery was designed to minimise disease. It employed 4 full time staff and casual labour where necessary. The nursery specialised in ground covers and perennials. Plants were grown from seed, cuttings and tissue culture.

2. From September 1989 to December 1991 I was employed as a Research scientist by Bunnings Tree Farms under a joint CSIRO/Bunnings co-operative agreement. This was to develop a commercially viable ectomycorrhizal program whereby *Eucalyptus globulus* could be inoculated with superior ectomycorrhizal fungi to enhance tree performance in plantations.

   My involvement was a) to help develop a commercially viable and operational ectomycorrhizal inoculation process to produce ectomycorrhizal seedlings in a production nursery, and b) to set up and coordinate field trials on plantations. This project involved the collection, purification and glasshouse screening of ectomycorrhizal fungi.

   Prior to my involvement in the program the establishment of mycorrhizal associations under nursery conditions had been poor. However, after a series of trials with different container media, fungicide and nutrient regimes I helped develop a system whereby it is

possible to get approximately 100% mycorrhizal seedling establishment in a range of Eucalypts. This system can be used to effectively inoculate over 100,000 seed per day.

I also conducted a series of ecological trials to examine competition, persistence and succession of selected isolates under standard plantation conditions.

I was also employed to supervise plantation hygiene and identify any potential disease problems.

3. I am currently funded by Alcoa of Australia Limited, this is looking at the ecology, biology and pathology of *Phytophthora* species (P. *cinnamomi* and P. *citricola*) which influence the effective rehabilitation of mines with native plant species.

Publications.

22 refereed journal publications and 2 conference papers. Following are key publications.

1. Hardy, G. E. St.J. and Sivasithamparam, K. (1988). *Phytophthora* spp. associated with container-grown plants in nurseries in Western Australia. *Plant Disease* 72- 435-437.
2. Hardy, G. E. St.J. and Sivasithamparam, K. (1991). Sporangial responses do not reflect microbial suppression *of Phytophthora drechsleri* in composted Eucalypt bark mix. *Soil Biology and Biochemistry* 23: 756-765.
3. Hardy, G. E. St.J. and Sivasithamparam, K. (1991). The effects of sterile and non-sterile leachates extracted from composted Eucalyptus bark and pine bark media on *Phytophthora* spp. *Soil Biology and Biochemistry* 23: 25-30.
4. Hardy, G. E. St.J. and Sivasithamparam, K. (1991). How container media and matric potential affect the production of sporangial oospores and chlamydospores by three *Phytophthora* spp. *Soil Biology and Biochemistry* 23: 25-30.
5. Hardy, G. E. St.J. and Sivasithamparam K. (1991). Suppression of *Phytophthora* root-rot by a composted Eucalyptus bark mix. *Australian Journal of Botany* 39: 153-159.
6. Hardy, G. E. St.J., and Sivasithamparam, K. 1994. The antagonism of fungi and actinomycetes isolated from composted eucalyptus bark to *Phytophthora drechsleri* in a steamed and non-steamed composted eucalyptus bark-amended container medium. Soil *Biol. and Biochem.* (accepted).
7. Hardy, G. E. St. J., O'Brien, P. A. and Shearer, B. L. (1994). Control options of plant pathogens in native plant communities in south-western Australia. Journal of the Royal Society of Western Australia (Accepted).

CURRICULUM VITAE: Stephen Donald Hopper

Born: 18th June, 1951

Position: Director, Kings Park and Botanic Garden
(Adjunct Professor of Botany, University of Western Australia)
(Adjunct Professor of Environmental Biology, Curtin University of Technology)

Qualifications: B.Sc. (Hons) Botany, UWA (1973)
Ph.D. Botany UWA (1978)

Previous post: Senior Principal Research Scientist and OIC of the Western Australian Wildlife Research Centre, Department of Conservation and Land Management, 1988 - 1992.

Research Interests and Achievements

• Flora conservation, especially rare and endangered species, and plant conservation genetics. Key officer in the establishment of the policy, administration, research and management for Western Australia's State government flora conservation program 1977- 1988. Scientific contributions on the conservation biology, genetics and biogeography of endangered species.

• Granite outcrop flora, its biogeography, ecology and evolution. Population biology of endemic eucalypts has been explored, and comparative biogeographic studies completed on Australian and USA outcrop systems.

• Plant systematics and evolution, especially *Eucalyptus*, Orchidaceae and Haemodoraceae, and the processes of population divergence, speciation and natural hybridization. Some 200 new SW Australian taxa have been identified. Patterns of speciation and natural hybridization have been reviewed with special reference to the SW Australian flora.

• Design and management of conservation reserves. The application of population genetic data to reserve design using gap analysis was pioneered for Australia. Major involvement in the successful creation of Lesueur National Park, in management planning for Fitzgerald River National Park, and in management of Western Australia's most visited conservation reserve, Kings Park.

• Pollination ecology, especially vertebrate pollination. Significant contributions to the quantitative pollination ecology of bird- and mammal-pollinated plants in SW WA and N Qld rainforests.

Educational experience

Supervised, trained and worked with ca. 50 postgraduate consultant botanists and postgraduate students, and one ARC Postdoctoral Fellow, mainly through the Department of Botany, The University of Western Australia. Extensive public speaking, and guest lecturer at UWA and Curtin University of Technology.

Fellowships Awarded

Fulbright Senior Scholar's Award - 1990, USA
Miller Visiting Research Professorship - 1989/90, University of California, Berkeley
CSIRO Visiting Scientist's Award - 1984, Canberra, Division of Forest Research
Australian National University Visiting Fellowship - 1984, Department of Botany

Invitations and participation in International Meetings, as invited speaker

Biodiversity in Managed Landscapes, Sacramento, USA, 1992

Publications

150 publications, including author/coauthor of six books and 68 internationally referreed articles.

Brooker, M.I.H., and Hopper, S.D. (1991). A taxonomic revision of *Eucalyptus wandoo, E. redunca,* and allied species (*E.* series *Levispermae* Maiden - Myrtaceae) in Western Australia. *Nuytsia,* **8** (1): 1-189.

Hopper, S.D. (1979). Biogeographical aspects of speciation in the south west Australian flora. *Annual Review of Ecology and Systematics* **1 0**, 399-422.

Hopper, S.D. (1992). In the Footsteps of Giles *Landscope* **7**(3), 28-34.

Hopper, S.D. (1992). Patterns of diversity at the population and species levels in south-west Australian mediterranean ecosystems. In R.J. Hobbs (ed.). *Biodiversity of Mediterranean Ecosystems in Australia,* pp.27-46. (Surrey Beattey & Sons, Sydney.)

Hopper, S.D. (1993). *Kangaroo Paws and Catspaws: a Natural History and Field Guide.* 144 pp. (Department of Conservation and Land Management, Perth.)

Hopper, S.D., and Coates, D.J. (1990). Conservation of genetic resources in Australia's flora and fauna. In DA Saunders, AJM Hopkins & RA How (eds) *Australian Ecosystems: 200 years of utilization, degradation and restoration. Proceedings of the Ecological Society of Australia* **16**: 567-577.

Hopper, S.D., van Leeuwen, S., Brown, A.P. & Patrick, S.J. (1990). *Western Australia's Endangered Flora.* 140 pp. (Department of Conservation and Land Management, Perth.)

Pate, J.S., and Hopper, S.D. (1993). Rare and common plants in ecosystems, with special reference to the south-west Australian flora. In E.-D. Schultze and H. A. Mooney (eds). *Biodiversity and Ecosystem Function.* pp. 293-325. (Springer Verlag.)

Sampson, J., Hopper, S.D., & James, S.H. (1989). The mating system and population genetic structure in a bird-pollinated mallee, *Eucalyptus rhodantha. Heredity* **6 3**, 383-393.

Taylor, A., and Hopper, S.D. (1991). *The Banksia Atlas.* (reprinted with amendments). Australian Flora and Fauna Series No. **8**. 245 pp. (Bureau of Flora and Fauna, Canberra).

CURRICULUM VITAE: Nicholas Malajczuk

Born:	24th September, 1946
Position:	Senior Principal Research Scientist CSIRO, Division of Forestry
Qualifications:	BSc(Hons) Forestry, Australian National University (1969) PhD Botany, University of Western Australia (1975)
Appointments:	Appointed as Research Scientist, CSIRO, Division of Soils (1973-)

Research Interests and Achievements

1. Biocontrol of *Phytophthora cinnamomi*. During the early part of my career I was involved in an investigation of the microbiological factors in soils and plant roots that might contribute to the biological control of jarrah dieback caused by Phytophthora cinnamomi. Examinations were made of (1) the role of antagonistic bacteria that suppressed disease in the rhizosphere, soil at large and the litter layer and (2) the beneficial effects of mycorrhizal fungi on disease reduction. A combination of light and electron microscopic observations were used to determine the relationships between microorganisms, the pathogen and tree roots. I have published more than 20 articles in scientific journals on this subject. My contributions in this field were recognised by invitations to prepare book chapters and papers, and present papers at international symposia. An invited paper on the microbial antagonism between *Phytophthora* and other micro organisms was presented at an International Symposium on *Phytophthora* in Riverside California, in 1981. This is an authoritative review of international significance and still remains the most comprehensive work on the bio control of P. cinnamomi. I also participated at a Late Blight Conference as one of a select group of scientists invited to assist in determining strategies for control of *Phytophthora infectans* in an international program based in the USA.

2. Biocontrol of *Armillaria luteobubulina*. This research has provided the basis for management of the pathogen in natural and plantation forestry through stump inoculation with select decay macrofungi.

3. Ecology, taxonomy and manipulation of eucalypt ectomycorrhizas. This is pioneering work that has attracted considerable funding from both private and government agencies for development of inoculation technologies for the integration of ectomycorrhizas in modern forest nurseries in Australia. Through ACIAR funding much of these new technologies are now being transferred to forest research programs in China and the Philippines

Educational experience.

Occasional lectures at Murdoch University and University of Western Australia. Supervision of Honours, MSc and PhD students and training of overseas scientific staff associated with ACIAR and AIDAB programs.

Scholarships, Fellowships etc.

CSIRO Postdoctoral Fellow (1978-79)
French Government Senior Scientific Fellow (1986-87)

Invitation and Participation in International Meetings, as invited speaker (last 10 years).

1. Fourth International Congress of Plant Pathology, Melbourne, 1983.
2. Fifth and sixth North American Conference on Mycorrhizas, Bend, Or. and Gainsville, Fl. 1984, 1987.
3. Third International Mycological Congress, Tokyo, 1987.

Publications

108 refereed journal publications and 35 conference papers and book chapters. Edited one book on the Jarrah Forest and one published mycorrhizal conference proceedings. Following are key publications post 1982.

1. MALAJCZUK, N. (1982). 'Microbial antagonism of Phytophthora'. In'Biology, Ecology and Pathology of Phytophthora'. (eds. D.C. Erwin, P.H. Tsao and S. Bartnicki-Garcia) Phytophathol. Soc. America.

2. MALAJCZUK, N., Sanfelieu, C.L. and Hossen, S. (1983). 'Production and survival of P. cinnamomi zoospores in suppressive and conducive soils': Transactions of the British Mycological Society 80(2):305-312.

3. MALAJCZUK, N. and Old, K.M. (1984). Problems and prospects for the control of diseases of eucalypts in rehabilitation programs with particular reference to Phytophthora cinnamomi. In. Proc. Aust. Mining Ind. Council, Kalgoorlie. Ed. D.R. Brooks.

4. Gardner, J.H. and MALAJCZUK, N. (1984). Recolonization of rehabilitated minesites in the Darling Range by mycorrhizal fungi. In. Proc. Aust. Mining Ind. Council, Kalgoorlie. Ed. D.R. Brooks.

5. MALAJCZUK, N., Trappe, J.M., and Molina, R. (1987). Interrelationships among some ectomycorrhizal trees, hypogeous fungi, and small mammals: Western Australia and Northwestern American parallels. Australian Journal of Ecology 12:53-55.

6. MALAJCZUK, N., Dell, B. and Bougher, N.L. (1986). Ectomycorrhiza formation in Eucalyptus III. Superficial ectomycorrhiza initiated by Hysterangium and Cortinarius species. New Phytologist 105:421-428.

7 MALAJCZUK, N. (1988). Interaction between Phytophthora cinnamomi zoospores and microorganisms on non-mycorrhizal and ectomycorrhizal roots of Eucalyptus marginata. Transactions of the British Mycological Society 90:375-382.

8. Dell, B. and MALAJCZUK, N. (1988). Jarrah dieback - A disease caused by Phytophthora cinnamomi. In: The Jarrah Forest. A Complex Mediterranean Ecosystem. Ed. B. Dell, J.Havel and N. Malajczuk. pp. 67-88.

9. Pearce, M.H. and MALAJCZUK, N. (1990b). Inoculation of karri (Eucalyptus diversicolor F. Muell.) thinning stumps with wood decay fungi for control of Armillaria luteobubalina. Mycological Research 94:32-37.

10. MALAJCZUK, N., Lapeyrie, F. and Garbaye, J. (1990). Infectivity of pine and eucalypt isolates of Pisolithus tinctoruis on roots of Eucalyptus urophylla in vitro. New Phytologist 114:627-631.

11. GROVE, T.S., MALAJCZUK, N., Burgess, T., THOMSON, B.D. and Hardy, G. (1991). Growth responses of plantation eucalypts to inoculation with selected ectomycorrhizal fungi. Proceedings of IUFRO Symposium on Intensive Forestry: The Role of Eucalypts, 86-93.

12. GROVE, T.S. and MALAJCZUK, N. (1993). The potential for management of ectomycorrhiza in forestry. Proceedings of the International Symposium on Management of Mycorrhizas in Agriculture, Horticulture and Forestry and Plant and Soil (invited review, in press).

CURRICULUM VITAE: Jennifer McComb

Born: 20 September, 1943
Position: Associate Professor in Plant Biology
Murdoch University
Qualifications: BSc(Hons1) University of Western Australia (1964)
PhD University of Western Australia (1968)

Research Interests and Achievements

1. Improving effectiveness of selection and propagation of jarrah resistant to *Phytophthora cinnamomi*. Propagation and field testing of other woody species with commercial value, eg. *Santalum album*, *Eucalyptus globulus* and salt tolerant *Eucalyptus*. From a total of 82 referred papers and 13 non-refereed ones, some 65 relate to plant tissue culture and the majority of these are on eucalypts.
2. Joint research projects with CALM and ALCOA on selection and testing of dieback resistant jarrah for bauxite mine rehabilitation.

Scholarships, Fellowships etc.

Royal Society Travel Award (1976).

Publications

a) Bennett, I. and McComb, J.A. (1982) Propagation of jarrah (*Eucalyptus marginata*) by organ and tissue culture. Australian Forest Research 12, 121-127.

b) McComb, J.A. and Bennett, I.J. (1986) *Eucalyptus* (eucalypts). In "Biotechnology in Agriculture and Forestry", Bajaj, Y.P.S. Ed. (Springer Verlag: Berlin). I, 340-362.

c) McComb, J., Hinch, J. and Clarke, A. (1987) Expression of field resistance in callus tissue inoculated with *Phytophthora cinnamomi*. Phytopathology 77, 346-351.

d) McComb, J.A., Bennett, I.J., Stukely, M. and Crane, C. (1990) Selection and propagation of jarrah for dieback resistance. A Progress Report. Combined Proceedings of the International Plant Propagation Society 40, 86-90.

e) Cahill, D.M., Bennett, I.J. and McComb, J.A. (1991) Resistance of micropropagated *Eucalyptus marginata* to *Phytophthora cinnamomi*. Plant Dis. 76, 630-632.

f) Cahill, D.M. and McComb, J. (1992) A comparison of changes in phenylalanine ammonia-lyase activity, lignin and phenolic synthesis in e roots of *Eucalyptus calophylla* (field resistant) and *E. marginata* (susceptible) when infected with *Phytophthora cinnamomi*. Physiol. Mol. Pl. Path. 40, 315-332.

g) Bennett, I.J., McComb, J.A. and Tonkin, C.M. (1993) Inoculation of *Eucalyptus marginata* Donn. ex Sin. (jarrah) clones with *Phytophthora cinnamomi* Rands *in vitro* and under glasshouse conditions. Forest Ecology Management 57, 115-124.

h) McComb,. J.A., Bennett, I.J., Cahill, D., Stukley, M. and Crane, C. (1992) Selection, propagation, field and laboratory testing of jarrah (*Eucalyptus marginata*) resistant to dieback (*Phytophthora cinnamomi*). IUFRO/AFOCEL Conference on "Mass Production Technology for Genetically Improved Fast Growing Forest Tree Species Bordeaux, France, September 1992. 2, 451-452

i) Cahill, D.M., Bennett, I.J. and McComb, J.A. (1993) Mechanisms of resistance to *Phytophthora cinnamomi* in clonal micropropagated *Eucalyptus marginata.* Plant Pathology 42, 865-872.

j) McComb, J.A., Stukely, M. and Bennett, I. (1994) Future ecosystems - use of genetic resistance. Journal of the Royal Society of Western Australia (submitted).

CURRICULUM VITAE: Julie Olive Niere

Born: May 15, 1955

Position: Senior Lecturer, Department of Applied Chemistry, RMIT

Qualifications: BSc (Monash University), 1977, PhD (Monash University), 1984.

Other Awards: Diploma of Education (Monash University) 1985
Research Associate, Melbourne University, Department of Biochemistry, Melbourne University 1988 to present.

Other Professional Interests:
Secretary, RACI Division of Medicinal and Agricultural Chemistry

Research Interests and Achievements:
My major research interest lies in the practical and theoretical applications of FT-NMR and in particular the application of the technique to biological systems. My work to date has been in the development of NMR as a tool to study metabolism in fungi, both *in vitro* and *in vivo*. I have used the technique to identify a novel group of polyphosphates in the Oomycetes and to study the site of action of phosphonate in *Phytophthora spp.* including *P. cinnamomi* and in *Fusarium oxysporum*. I am currently extending this work to examine the location and effects of phosphonate in plants and as part of the proposed CRC I will develop the technique to examine the effects of *P. cinnamomi* on the metabolism of roots using *Banksia spp.* and other native species which is a totally unexplored area.

I also have an active program based on the synthesis of novel fungicides based on phosphonate, and the study of their mode of action in Oomycetes, including *P. cinnamomi*. This program has been in operation for only 18 months but has already identified two promising compounds which are being evaluated for patent protection.

Since I am employed by an institution which was a CAE and has only recently begun to generate a research profile, my opportunities for research have been restricted by available time and students.

Invitations and participation in International Meetings as Invited Speaker: (last 10 years)
International Symposium on Cellular and Molecular Biology of Phosphate and Phosphorylated Compounds in Micro-organisms. Woods Hole (USA) 1993.

Publications
6 publications in refereed journals and 11 conference papers and book chapters since 1989. The following are key publications:

a) Hoobin, P., Niere, J.O. and Cathro, K.J. (1989) Stability of quaternary ammonium bromides used in zinc/bromine batteries. Applied Electrochemistry.

b) Griffith, J.M., Smillie, R.H., Niere, J.O. and Grant, B.R. (1989) Effects of phosphate on the toxicity of phosphonate in *Phytophthora palmivora*. Archives of Microbiology 152, 430-436.

c) Niere, J.O., Griffith, J.M. and Grant, B.R. (1990) The effect of phosphonate on phosphorylated metabolites in *Phytophthora palmivora*. Journal of General Microbiology 136, 147-156.

CURRICULUM VITAE: Philip Aiden O'Brien

Position: Lecturer Biotechnology Programme
Murdoch University (1988-present)
University of Melbourne

Qualifications: BSc (Hons) Industrial Microbiology, NUI Dublin (1976)

Previous Post: Research Scientist,
CSIRO Div of Plant Industry, Canberra (Nov 85-Jan 88)
Postdoctoral Research Assistant,
Div of Chemical Biodynamics,
Lawrence Berkeley Laboratory, Berkeley, California (1983-1985)
Postdoctoral Research Fellow
Dept of Molecular Biology
Univ of California, Berkeley. (1981-1983)

Research Interests and Achievements

1. Mechanisms of DNA repair and mutation in bacteria (1977-1983). An investigation of radiation resistance in cyanobacteria established the existence of mechanisms for removal of UV induced lesions from DNA in these organisms. I subsequently developed a system to test the specificity of radiation induced mutation in bacteria by cloning a RNA gene into the single stranded bacteriophage M13.
2. Photosynthetic gene expression in bacteria: (198301985). A variety of molecular mechanisms were used to analyse the expression of these genes.
3. Plant genetic engineering: (1985-1988). Genes for sulphur rich seed storage proteins were isolated from pea plants, modified for expression in leaf tissue and transformed into lucerne and tobacco. The expression of the modified genes in different tissues of the transgenic plants was analysed.
4. Molecular Mechanisms of pathogenesis in *Rhizoctonia solani* (1988-present). This research explores the mechanisms used by the fungus to invade plant tissue and macerate the tissue. Pectic enzymes appear to be important to this process. We are in the process of cloning the pectic enzyme genes. The main aim of this work is to genetically engineer plants for resistance to *R. solani*.
5. Development of DNA diagnostic tests for fungi (1992-present). DNA sequences can be used to identify species of fungi. The DNA is detected after amplification by the polymerase chain reaction (PRC). We have isolated appropriate sequences from Phytophthora cinnamomi, and are investigating the sensitivity of the test.

Educational Experience

Since my appointment as lecturer in 1988 I have developed and have been sole coordinator of two undergraduate courses in Molecular Biology. Molecular Biology I is a second year course with an average enrolment of 45, whilst Molecular Biology II is a third course with an average enrolment of 30. I have also developed workshop courses in Molecular Biology for senior researchers who are not molecular biologists.

Invitations to meetings

1. Australian Society for Microbiology Annual Meeting, Perth 1993
2. Annual Meeting of the malaysian Biochemical Society, Kuala Lumpur, 1993
3. Plant Diseases in Ecosystems Royal Society Symposium, Perth 1994.

Publications

23 refereed publications in scientific journals, 2 Chapters in books and 26 conference presentations. The following are key publications in recent years.

a) Duncan, S., Barton, J.E. and O'Brien, P.A., (1992). analysis of variation in isolates of *Rhizoctonia solani* by rondom amplified polymorphic DNA assay.

b) O'Brien, P.A., (1994). Molecular markers in Australian isolates of Rhizoctonia solani. Mycological Res. (in press).

c) Yang, H.A., Sivasithamparam, K. and O'Brien, P.A., (1993). Mycelial interactions and the potential use of tuft formation in prescreening and characterizing *Rhizoctonia solani* isolates infecting cereals. Aust. J. of Botany 41, 253-262.

d) Yang, H.A., Sivasithamparam, K., Alemohammad, J., Barton, J.E., and O'Brien, P.A., (1994). Association of rhizoctonia strains with bare patch disease of wheat in Western Australia. J. Plant Pathology (in press).

e) Yang, J.A., Zhow, J., Sivasithamparam, K., Tommerup, I.C., Barton, J.E. and O'Brien, P.A., (1994). Genetic variability in pectic enzymes of Rhizoctonia solani isolates causing bare patch disease of cereals. J. of Phytopathol Iin press).

f) Dobrowolski, M. and O'Brien, P.A., (1993). Isolation of a species specific DNA probe for Phytopthora cinnamomi by RAPD-PCR. FEMS Microbiol. Letts. 113 : 43-47.

g) Zarnani, M.R. and O'Brien, P.A., (1993). Different forms of polygalacturonase are synthesized by highly and weakly virulent strains of Thizoctonia solani from wheat roots. Exp. Mycol. (submitted).

h) Tommerup, I.C., Barton, J.E. and O'Brien, P.A., (1994). Reliability of RAOD fingerprinting of three basidiomycete fungi. *Laccaria, Hydnangium,* and *Rhizoctonia.* Mycological Res. (in press).

i) Zamani, M.R. and O'Brien, P.A., (1994). Polygalacturonase as a virulence factor in bare patch strains of Rhizoctonia solani. Plant Pathology (in preparation).

j) Tommerup, I.C., Barton, J.E. and O'Brien, P.A., (1994). Is nonspecific PCR species specific. In Proceedings of the Australian Systematic Botany Society Symposium on Systematics, evolution and Conservation of the Western Australian Flors. Eds: S.D. Hopper, J. Chappill, M. Harvery and N. marchant (in press).

CURRICULUM VITAE: Kenneth Malcolm Old

Born: 17 February, 1938
Position: Assistant Chief
CSIRO Division of Forestry
Qualifications: BSc(Hons) Agriculture, Nottingham England (1961)
PhD Plant Pathology, Minnesota (1964)
Previous post: Lecturer in plant pathology and soil microbiology Dundee University, Scotland (1964-78)

Research Interests and Achievements

1. Pathology of *Phytophthora cinnamomi* on forest trees. Contributions have been made on the etiology of disease, variability of the pathogen with respect to mating type, isozyme markers and pathogenicity to eucalypts.
   The most comprehensive assessment has been made of variability of the fungus across Australia. Differences in pathogenicity of isolates of *P. cinnamomi* have shown the need to incorporate a range of isolates into programmes of selection for resistant host genotypes.
2. Pathology and taxonomy of fungi which cause cankers on eucalypt stems, and the influence of drought and defoliation on disease severity. The first link has been established between infection by these fungi and rural tree decline. *Endothia gyrosa* is one of the more pathogenic of these fungi ,was identified for the first time in Australia, and its widespread presence across southern Australia was shown. Demonstration of the susceptibility of eucalypts in Japan to the severe pathogen, *Cryphonectria parasitica* led to the ban on importation of eucalypt foliage from that country into Australia.
3. Biocontrol of soilborne fungi by mycophagous amoebae. This was pioneer research in the late 1970's and early 80s that established a role for soil amoebae of several genera as biocontrol agents. The review quoted in my publication list was a bench mark of the information in this area in 1986.
4. A study of the susceptibility of the 5 native provenances of *Pinus radiata* to western gall rust showed that one of the island provenances was more resistant than Monterey provenance, but that significant within provenance variation to disease also occurred. This information would be crucial to the development of control strategies in the event of the introduction of this devastating pathogen to Australasia.
5. Research on the consequences of harvesting damage for the development of defect in regrowth eucalypts provided in three reports to the Victorian DCE has been incorporated into post-thinning damage assessments in East Gippsland.

Educational experience

Teaching and research supervision of Undergraduates MSc and PhD students, at Dundee, and some occasional lecturing since at ANU. Supervision and training of overseas post graduates from Japan, China and India.

Scholarships, Fellowships etc.

Fulbright Scholar, USA (1961-64), NATO senior Research Fellow, Holland (1972).
Carnegie Research Fellow, Canada (1975), Visiting Research Fellow, Berkeley, USA. (1979). Japanese Government Visiting Research Specialist, Japan (1986).

Invitations and Participation in International Meetings, as Invited speaker (last 10 years)

1. Fourth International Congress of Plant Pathology, Melbourne, 1983.
2. Third International Mycological Congress, Tokyo, 1983.
3. IUFRO conference on pine stem rusts, Athens, Georgia, USA, 1984.
4. Fifth International Congress of Plant Pathology, Kyoto, 1988.
5. Fourth International Mycological Congress, Regensburg, 1990.

Publications

52 refereed journal publications and 28 conference papers and book chapters, Edited two CSIRO published conference proceedings. Following are 9 key publications post 1983.

a) Old, K.M., Moran, G.F and Bell, J.C. (1983) Isozyme variability among isolates of *Phytophthora cinnamomi* from Australia and Papua New Guinea. Canadian Journal of Botany 62, 2016-2022.

b) Old, K.M., Oros, J. and Malafont, K.W. (1984) Survival of *Phytophthora cinnamomi* in root fragments in Australian forest soils. Transactions of the British Mycological Society. 82, 605-613

c) Old, K.M. and Chakraborty, S. (1986). Mycophagous Soil Amoebae: Their Biology and Significance in the Ecology of Soil-borne Plant Pathogens.Progress in Protistology, I. 163-194.

d) Old, K.M. Murray, D.I.L., Kile, G.A., Simpson, J. and Malafant, K.W.J. (1986). The pathology of fungi isolated from eucalypt cankers in south eastern Australia. Australian Forest Research, 16, 21-36.

e) Old, K.M. Libby, W.J. and Eldridge, K.G. (1986) Genetic variability in susceptibility of *Pinus radiata* to Western Gall rust. Silvae genetica 35, 145-149.

f) Old, K.M. Dudzinski, M.J. and Bell, J.C. (1988). Isozyme variability in field populations of *Phytophthora cinnamomi*, Australian Journal of Botany, 36, 355-360.

g) Old, K.M. and Kobayashi, T. (1988) Eucalypts are susceptible to the Chestnut blight fungus.Australian Journal of Botany, 36, 599-603.

h) Old K.M. Gibbs, Craig, I. Myers, B.J. and Yuan Z.Q. (1990). Effect of drought and defoliation on the susceptibility of eucalypts to cankers caused by*Endothia gyrosa* and *Botryospaeria ribis*. Australian Journal of Botany, 38, 571-581.

i) Dudzinski,M.J.,Old K.M.and Gibbs, R.J. (1993) Pathogenic variability in Australian isolates of *Phytophthora cinnamomi*. Australian Journal of Botany., 41,721-732.

CURRICULUM VITAE: John Kevin SCOTT

Born	23 May 1953
Position:	Principal Research Scientist CSIRO Division of Entomology, Floreat Park, Western Australia (1990- present)
Qualifications:	B.Sc. (Hons.), Zoology, University of Western Australia (1974) Ph.D., Zoology, University of Western Australia, (1981)
Previous posts:	Entomologist (on secondment from Western Australian Department of Agriculture), CSIRO Biological Control Unit, Montpellier, France. (1981-1984) Senior Research Scientist and Officer-in-Charge, Biological Control Unit, CSIRO Division of Entomology, Cape Town, South Africa (1984 -1990)

Research Interests and Achievements

1. Biological control of *Rumex* species. Biological control agents for the important pasture weeds *Rumex* species (docks) were surveyed throughout the western Mediterranean region and species selected for release in Australia. This work has lead to successful control being implemented as shown in recent surveys of *Rumex* in Western Australia.

2. Biological control of weeds of nature conservation areas. Weeds of southern African origin *(Chrysanthemoides* spp., bitou bush and boneseed, and *Myrsiphyllum asparagoides,* bridal creeper) that invade nature conservation areas in Australia were studied for damaging insect fauna in their original habitat. Potential biological control agents selected and assessed for safety have been released. Initial results from the first species released show promising control against bitou bush,

3. Prediction of weediness and weed identification. A new approach was developed to predict which plant species become weeds following introduction into Australia. Clarification of the long standing problem of identification of caltrops in Australia and overseas has been completed using isozyme, cytogenetic and morphological techniques.

4. Biological control of *Emex* species. Initially it was shown that new biological control agents were not likely to come from southern Africa, the region of origin of *Emex australis*. Subsequent work brought to attention a new source in Israel. Current research is assessing the biological control potential of these insects.

5. Development of biological control theory and application. Examples have been developed showing the application of CLIMEX for biological control. Other recent work has included an analysis of biological control for soil pathogens, experiments on interactions between insects and fungi and their field ecology, methods for efficient searches for lost agents or rare organisms and reviews establishing priorities for biological control of weeds of southern African origin.

Publications

35 refereed journal publications, and 28 conference papers and technical publications. Following are 10 recent publications:

a) Adair, R. J. and Scott, J. K. (1991). Distribution, life history, host specificity and suitability of an undescribed *Chrysolina* species (Coleoptera: Chrysomelidae) for the biological control of *Chrysanthemoides monilifera* (Compositae). Bulletin of Entomological Research 81: 235-242.

b) Scott, J. K. and Delfosse, E. S. (1992). Southern African plants naturalised in Australia: a review of weed status and biological control potential. Plant Protection Quarterly 7: 70-80.

c) Scott, J. K. (1992). Biology and climatic requirements of *Perapion antiquum* (Coleoptera: Apionidae) in southern Africa: implications for the biological control of *Emex* species in Australia. Bulletin of Entomological Research 82: 399-406.

d) Scott J. K. and Brown, E. M. (1993). Preliminary observations on the biology and host plants of *Tortrix* sp. (Lepidoptera: Tortricidae), a possible biological control agent of *Chrysanthemoides*. Journal of the Entomological Society of southern Africa 55: 245-253.

e) Shivas, R. G. and Scott, J. K. (1993). Relationship between the stem blight pathogen, *Phomopsis emicis* and the stem-boring weevil, *Perapion antiquum,* two potential biological control agents of *Emex australis*. Annals of applied Biology 122, 617-622.

f) Adair, R. J. and Scott, J. K. (1993). Biology and host specificity of *Ageniosa electoralis* (Coleoptera: Chrysomelidae), a prospective biological control agent for *Chrysanthemoides monilifera* (Asteraceae). Biological Control 3: 191-198.

g) Scott, J. K. and Panetta, F. D. (1993). Predicting the Australian weed status of southern African plants. Journal of Biogeography 20: 87-93

h) Brasier, C. M. and Scott, J. K. (1994). European oak declines and global warming: a theoretical assessment with special reference to the activity of *Phytophthora cinnamomi*. EPPO Bulletin (in press).

i) Scott, J. K. (1994). Classical biological control of plant pathogens. Advances in Plant Pathology (in press).

j) Panetta, F. D. and Scott, J. K. (1994) Weeds and feral animals: management of future threats. In. Conserving biodiversity - threats and solutions. N.S.W. National Parks and Wildlife Service (in press).

CURRICULUM VITAE: Bryan L. Shearer

Born: 6th March, 1945
Position: Principal Research Scientist
Department of Conservation and Land Management
Qualifications: BSc (Agric.) Hons. (1st Class), University of W. Aust (1967)
PhD (Plant Pathology), University of Minnesota (1975)

Research Interests and Achievements

1. Pathology of *Phytophthora cinnamomi* in forest and conservation areas. The research has advanced understanding on expression of impact, host susceptibility to infection, population of dynamics in the soil and development of hazard rating systems. Seasonal quantification of spore survival in the soil has contributed to the development of hygiene prescriptions.
2. Control of *P. cinnamomi* in forest and conservation areas. Demonstrated the efficacy of phosphonate in controlling *P. cinnamomi* infections and developed prescriptions for optimal rates of application in forest and conservation areas. The research has led to the use of phosphonate to protect rare and endangered flora from infection by *P. cinnamomi*.
3. Pathology of *Armillaria luteobubalina* in forest and conservation areas. Quantified the impact of *A. luteobubalina* in jarrah and wandoo forests and in coastal dune vegetation. Demonstrated the importance of *A. luteobubalina* impact on wandoo and coastal dune communities. This research is the first report of *Armillaria* having high impact in coastal dune vegetation.
4. Pathology of canker fungi in forest and conservation areas. Identified the importance of canker fungi in survival of trees in arboreta. Determined the association of canker fungi with extensive mortality of *Banksia coccinea* on the south coast of south-western Australia. The canker on *B. coccinea* is a new species of *Cryptodiaporthe* and the research has led to a ban on picking of the *Banksia* species on crown land.

Educational experience

Invited lectures to undergraduates. Supervision of 6 Honours, 2 Masters and 4 PhD students.

Scholarships, Fellowships etc

Australian Commonwealth Scholarship 1963-1967
W. Harper Research Scholarship 1967
Netherland Government Research Fellowship 1969
Research Assistantship, Univ. of Minnesota, 1970-1975

Publications

41 refereed journal publications, 21 conference abstracts. 1 Research Bulletin and 1 book chapter. Following are 9 key publications post 1983.

a) Shearer, B.I., Tippett, J.T. & Bartle, J.R. 1987. *Botryosphaeria ribis* infection associated with death of *Eucalyptus radiata* in species selection trials. *Plant Disease* 71, 140-145.

b) Shearer, B.L., Shea, S.R. & Deegan, P.M. 1987. Temperature-growth relationships of *Phytophthora cinnamomi* in the secondary phloem of roots of *Banksia grandis* and *Eucalyptus marginata*. *Phytopathology* 77, 661-665.

c) Shearer, B.L. & Shea, S.R. 1987. Variation in seasonal population fluctuations of *Phytophthora cinnamomi* within and between infected *Eucalyptus marginata* sites of south Western Australia. *Forest Ecology Management* 20, 209-230.

d) Shearer, B.L., Michaelsen, B.J. & Somerford, P.J. 1988. The effect of isolate and time of inoculation on the invasion of secondary phloem of *Eucalyptus calophylla*, *E. marginata* and *Banksia grandis* by *Phytophthora* species. *Plant Disease* 72, 121-126.

e) Shearer, B.L. & Tippett, J.T. 1988. Distribution and impact of *Armillaria luteobubalina* in the *Eucalyptus marginata* forest of south Western Australia. *Australian Journal of Botany* 35, 433-445.

f) Shearer, B.L. & Tippett, J.T. 1989. Jarrah Dieback: The dynamics of *Phytophthora cinnamomi* in the jarrah (*Eucalyptus marginata)* forest of south-western Australia. Research Bulletin 3, Department of Conservation and Land Management.

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

h) Shearer, B.L. (1992). The ecological implications of disease in the southern forest of south-western Australia. In: Research on the impact of Forest Management in South-West Western Australia. ed. M. Lewis, CALM Occasional Paper No.2/92. Department of Conservation and Land Management, Como, 99-113.

i) Shearer, B.L. (1994). The major plant pathogens in ecosystems of south-western Australia. *Journal of the Royal Society of Western Australia* (in press).

CURRICULUM VITAE: Michael J.C. Stukely

Born: 1951
Position: Research Scientist, Science & Information Division
Department of Conservation & Land Management (Western Australia)
Qualifications: BSc (Agric.) (Hons1) University of Western Australia 1974

Scholarships and Awards:
Commonwealth Secondary Scholarship 1967-1968
Commonwealth University Scholarship 1969-1973
Commonwealth Postgraduate Research Award 1974-1976

Research Interests and Achievements

Directly relating to CRC Projects 2.3 and 2.4:

1. 1980-1991: Screening and field testing *Pinus radiata* for resistance to *Phytophthora cinnamomi* (with T.B. Butcher, CALM).
2. 1984-present: Screening and field testing *Eucalyptus marginata* (jarrah) for resistance to *P. cinnamomi*.

Directly relating to CRC Project 1.1:

3. 1985-1993: Identification of *Phytophthora* species occurring in native vegetation for CALM's Dieback Disease Detection Service. I was manager of this Service and the new laboratory at Como, 1992-1993.
4. 1994-1995: Supervisor of research project: "Rapid identification of species of *Phytophthora*" (assessing the technique of isozyme analysis as a routine method for identification of *Phytophthora*).

Relating to CRC Project 4.3:

5. My university Honours and postgraduate research (1973-1976_ involved the investigation of a potential biocontrol agent for wheat "takeall" fungus, *Ophiobolus* (now *Gaeumannomyces*) *graminis*.

Publications

a) Stukely, M.J.C. and Crane, C.E. (1994) Genetically based resistance of *Eucalyptus marginata* to *Phytophthora cinnamomi*. Phytopathology 84 (in press).

b) Davison, E.M., Stukely, M.J.C., Crane, C.E. and Tay, F.C.S. (1994) Invasion of phloem and xylem of woody stems and roots of *Eucalyptus marginata* and *Pinus radiata* by *Phytophthora cinnamomi*. Phytopathology 84, 335-340.

c) McComb, J.A., Stukely, M. and Bennett, I. (1994) Future ecosystems: use of genetic resistance. Paper presented by MS at Symposium "Plant Diseases in Ecosystems" (Royal Society of Western Australia/Ecological Society of Australia) Murdoch University 16 April 1994. Journal of the Royal Society of Western Australia (in press).

d) McComb, J.A., Bennett, I.J., Cahill, D., Stukely, M. and Crane, C. (1992) Selection, propagation, field and laboratory testing of jarrah (*Eucalyptus marginata*) resistance to dieback (*Phytophthora cinnamomi*). Proceedings of the IUFRO/AFOCEL Conference "Mass Production Technology for Genetically Improved Fast Growing Forest Tree Species" Bordeaux France, September 1992. 2, 451-452.

e) Bennett, I., Cahill, D., McComb, J., Stukely, M. and Crane, C. (1991) The use of tissue culture in the breeding of *Phytophthora* resistant jarrah (*Eucalyptus marginata*). International Association for Plant Tissue Culture, Australian Branch Meeting, Hobart 1991 (Abstract).

f) Shearer, B., Wills, R. and Stukely, M. (1991) Wildflower killers. Landscope 7(1), 28-34.

CURRICULUM VITAE: Inez C Tommerup

Position: Principal Research Scientist

CSIRO Division of Forestry

Qualifications: BSc Hons I, PhD Genetical and Physiological Plant Pathology 1969, University of Queensland

Previous posts: Research fellow & scientist in plant pathology/fungal genetics, Botany School & Agric. Research Council, Univ. of Cambridge, UK. (1969-75, 87-88); in soil microbiology and plant nutrition, School of Agriculture, University of Western Australia (1975-1987).

Research Interests and Achievements

1. Genetics and pathology of oomycetes, *Phytophthora cinnamomi* and the downy mildew fungi. Research has focussed on classical and currently molecular genetics of fungal variability mechanisms and pathogenicity genes including mating-type, avirulence/virulence genes, asexual and sexual incompatibility mechanisms, and host resistance mechanisms. Results from this work have been used in disease control and breeding resistant crop plants.
2. Genetics of ectomycorrhizal fungi. Ectomycorrhizal fungi increase fertiliser uptake by forest trees and the fungi are a major contributor to forest nutrient recycling. Understanding the breeding mechanisms of ectomycorrhizal fungi and genetics of other life-history traits was the forerunner to defining some species as indicators of disturbance. Such species have potential as new tools for environmental monitoring. The extent of environmental perturbations may be defined by biodiversity changes identified by DNA markers.
3. Novel biotechnological developments for the commercial production of fungal inocula. The concept of producing high quality, uniform hydrogel inocula of fungi using a particular fermentation technology has lead to pilot stage production and utilisation of such inocula for applications in forestry and agriculture has been done with collaborators.
4. Plant-fungal interactions. Plants are continuously interacting with a wide range of microorganisms and this can result in increased plant productivity when the interaction is a mutualistic symbiosis, reduced productivity when the microbe is pathogenic, or no net change when the symbiosis is neutral. A parallel set of interactions can be evoked for soil microbes in relation to other microbes. That both host and pathogen genetics need to be known to define new ways of disease control were concepts presented by invitation to national and international meetings and as invited reviews in 1970-80s.
5. Population biology of soil born plant pathogens and plant beneficial fungi. Understanding life-history strategies of the fungi and fungus-plant-soil interactions in terms of propagule production, survival and capacity to initiate invasion of the host have been used in non-chemical and targeted chemical disease control, and prototypes for management of mycorrhizal fungi in agriculture. Discovery of sexual reproductive stages in two major plant pathogens, *Plasmodiophora brassicae* and *Bremia lactucae,* was a precursor to some of those outcomes.

Educational experience

Research supervision and some teaching of undergraduates and post graduates at Universities of Queensland, Cambridge, Western Australia and Murdoch.

Scholarships, Fellowships etc. Commonwealth Postgraduate Scholarship 1966-69, A Vibert Douglas International Research Fellowship and Jean Gilmore Bursary (1969-70), Univ. Cambridge Fellowship (1971), University of Western Australia Research Fellowship (1975-78), Visiting Professor, Laval University, Quebec, Canada (1981), Maxwell Ralph Jacobs Award (1987).

Invitations and Participation in International Meetings as Invited speaker (last 10 years). Sixth North American Conference on Mycorrhizae, Gainesville, 1984. Seventh North American Congress on Mycorrhizas, Corvallis, 1987. Eight North American Congress on Mycorrhizae, San Diego, 1990. Fourth International Mycological Congress, Regensberg, 1990. Management of Mycorrhiza in Agriculture, Horticulture and Forestry, Perth, 1992. International Symposium on Recent Topics in Genetics, Physiology and Technology of the Basidiomycetes, Chiba Japan, 1992.

Publications 59 referred journal papers, 6 books chapters and 34 major conference papers, editor of 4 volumes of Advances in Plant Pathology (Academic Press Series), editor of Mycorrhiza (Springer-Verlag Journal). Following are 10 key publications related to oomycete and fungal genetics.

1. Maclean, D.J., Sargent, J.A., Tommerup, I.C. and Ingram, D.S. (1974). Hypersensitivity as the primary event in resistance to fungal parasites. Nature 249, 186-7.
2. Maclean, D.J. and Tommerup, I.C. (1979). Histology and physiology of compatibility and incompatibility between lettuce and the downy mildew fungus. *Bremia lactucae* Regel. Physiol. Pl. Path. 14, 291-312.
3. Tommerup, I.C. (1981). Cytology and genetics of downy mildews. In "The Downy Mildews", ed. D.M. Spencer, pp. 121-42. Academic Press: London and New York.
4. Tommerup, I.C. (1988). Genetics of vesicular-arbuscular mycorrhizal fungi. In "Genetics of Pathogenic Fungi" ed. G.S. Sidhu, pp. 81-91. London: Academic Press.
5. Tommerup, I.C. (1988). Nuclear behaviour during conidial ontogeny of *Bremia lactucae* Regel. Mycological Research 92, 61-68.
6. Kuek, K., Tommerup, I.C. and Malajczuk, N. (1992). Hydrogel bead inocula for the production of ectomycorrhizal eucalypts for plantations. Mycological Research 96, 273277.
7. Yang, H.A., Tommerup, I.C., Sivasithamparam, K. and O'Brien, P.A. (1993). Heterokaryon formation with homokaryons derived from protoplasts of *Rhizoctonia solani* anastomosis group eight. Experimental Mycolology 16, 268-278.
8. Tommerup, I.C. and Malajczuk, N. (1993). Genetics and Molecular Genetics of Mycorrhiza. Advances in Plant Pathology 9, 104-134.
9. Martin, F., Tommerup, I.C. and Tagu, G. (1993). Genetics of ectomycorrhizal fungi: progress and prospects. Plant and Soil 159, 159-170.
10. Tommerup, I.C., Barton, J. E. and O'Brien, P.A. (1995). Reliability of RAPD fingerprinting of *Laccaria, Hydnangium* and *Rhizoctonia*. Mycological Research (in press).

g) McComb, J.A., Bennett, I.J., Stukely, M. and Crane, C. (1990) Selection and propagation of jarrah for dieback resistance: a progress report. Combined Proceedings of the International Plant Propagation Society 40, 86-90.

h) Butcher, T.B., Stukely, M.J.C. and Chester, G.W. (1984) Genetic variation in resistance of *Pinus radiata* to *Phytophthora cinnamomi*. Forest Ecology Management 8, 197-220.

i) Chevis, H.W. and Stukely, M.J.C. (1982) Mortalities of young established radiata pine associated with *Phytophthora spp.* in the Donnybrook Sunkland plantations in Western Australia. Australian Forestry 45, 193-200.

j) Stukely, M.J.C., Boughton, T.J. and Chevis, H.W. (1981) Collar-infection in *Pinus radiata* by *Phytophthora cinnamomi* and *Phytophthora cryptogea*. Proceedings of the International Symposium: "*Phytophthora* - its Biology, Ecology and Pathology" University of California Riverside 1987, 71.

k) Sivasithamparam, K., Stukely, M.J.C. and Parker, C.A. (1975) A volatile factor inducing transmissible lysis in *Gaeumannomyces graminis* (Sacc.) Arx and Olivier var. *tritici* Walker. Can. Journal of Microbiology 21, 293-300.

CURRICULUM VITAE: Raymond Thomas Wills

Born: 12 July 1961
Position: Research Scientist
CALM Science & Information Division
Qualifications: BSc(Hons) Mycology, University of Western Australia 1983
PhD Terrestrial Plant Ecology, University of Western Australia 1989

Research Interests and Achievements

1. Until recently, my research was field-based and assessed the ecological impact of plant pathogens on ecosystems in the south of Western Australia, particularly on populations of rare, threatened and poorly known flora. While *Phytophthora cinnamomi* is regarded as the most serious threat to the conservation of both flora and fauna in south-west Australia, other widely distributed pathogens, including other species of *Phytophthora* canker fungi such as *Botryosphaeria ribis* and *Diplodina sp.*, and *Armillaria luteobubulina* have a significant impact on ecosystems of the south-west. Studies examined a range of plant communities and established a Departmental database on the susceptibility of native plant species, particularly rare, threatened and poorly known flora, and keystone species, to plant pathogens. Research also highlighted animal groups sensitive to habitat disturbance by plant pathogens by examining functional groups within plant communities. This information has been written up in a number of scientific and technical publications, and has been used in management plans and to target vulnerable species for seed collection and micropropagation in a project to preserve genetic resources.

2. PhD research investigated the floral resources of the European honeybee in the region of the Beekeepers' Research, a 90,000ha reserve gazetted for the purposes of commercial apiculture and conservation. Vegetation floristics and abundance were assessed at permanent monitoring sites. Flowering phenology of 413 plant species identified from the region was quantified over a 30 month period. Variations in patterns of plant flowering in response to edaphic, pyric, climactic, and other environmental factors were investigated, and all plant species visited by foraging European honeybees were identified. Fire history was derived from aerial photography and LANDSAT satellite imagery and supplemented by ground-truthing and vegetation and geology were mapped using the ARC/INFO Geographic Information System. Data were processed using a variety of mainframe and personal computer databases. The need for an ecological approach to management of apicultural reserves is discussed in my thesis.

3. Teaching general botany and mycological skills, including culture techniques and fungal taxonomy, to undergraduate students.

4. Lectures to Geography and Botany students (University of Western Australia) and to Forest Pathology students (Murdoch University) presented annually since 1990.

5. Western Australian Regional Councillor for the Ecological Society of Australia (1991-1993).

6. Honorary Bulletin Editor for the Ecological Society of Australia (1994).

7. Talks on plant diseases in south-west Australia presented to various community interest groups.

Publications

Three refereed journal publications, two book chapters, 14 conference papers, editor of one Conference Handbook. The following are relevant works:

a) Wills, R.T. (1993) The ecological impact of *Phytophthora cinnamomi* in the Stirling Range National Park, Western Australia. Australian Journal of Ecology 18(2), 145-159.

b) Wills, R.T. and Kinnear, J. (1993) Threats to the biota of the Stirling Range. In: Mountains of Mystery - a Natural History of the Stirling Range (Thomson, C., Hall, G.P. and Friend, G.R. eds) Department of Conservation and Land Management, Como Western Australia, 135-141.

c) Wills, R.T. and Cowling, W.A. (eds) (1994) Handbook of the Symposium on Plant Diseases.