THREAT ABATEMENT PLAN

For

Dieback caused by the root-rot fungus *Phytophthora cinnamomi*

Natural Heritage Trust

Helping Communities Helping Australia

A Commonwealth Government Initiative

Department of the Environment and Heritage

Environment Australia

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Front cover photo: Grass Trees (*Xanthorrhoea australis*) on Flinders Island infected with the Root-rot fungus. (Richard Schahinger, Tasmanian Department of Primary Industries, Water and Environment)

FOREWORD

Australia is renowned for its rich biodiversity. Native vegetation is a rich and fundamental element of our natural heritage.

Unfortunately the depletion and degradation of native vegetation communities threatens the long term health and productive capacity of many Australian landscapes. Factors such as land-clearing, grazing pressures and urban development are the human threats usually associated with declining areas of native vegetation, but another introduced but lesser known threat is the Phytophthora root rot fungus.

Throughout Australia Phytophthora root rot (*Phytophthora cinnamomi)* has had devastating effects on open forests, woodlands and heathlands, spreading as far as the cool temperate rainforests of Tasmania. This pathogenic fungus causes the roots of susceptible plants to rot, in many cases killing the plants. It is believed to have been introduced following European settlement and it now affects hundreds of thousands of hectares of native vegetation. This epidemic has attracted the attention of the global scientific community.

Australia is working hard to address native vegetation decline, including allocating millions of dollars from the $2.5 billion Natural Heritage Trust to programs such as Bushcare, the National Landcare Program and the National Reserve Systems Program. In addition, the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* promotes the recovery of threatened species and ecological communities and helps prevent other species and ecological communities from becoming threatened. Recovery plans and threat abatement plans such as this one are the main mechanisms prescribed in the Act to achieve these aims. Due to its obvious capacity to devastate native vegetation communities, 'Dieback caused by the root-rot fungus *Phytophthora cinnamomi*' was listed as a key threatening process under the Act in 2000. To address this listing, funding has also been provided through the Endangered Species Program for projects that aid in the management of the impact caused by *Phytophthora cinnamomi*.

Although Phytophthora root rot is wide spread in a number of regions in Australia, the level of infestation and its impact on nature conservation values and sustainable forest management varies significantly on both local and regional scales. Along with the difficulty in observing and controlling this microscopic pathogen, this creates a complex problem for management. This plan identifies what management opportunities are available and develops a program for the co-ordinated implementation of action to abate the threat from Phytophthora root rot.

The Threat Abatement Plan has two broad goals: to protect endangered or vulnerable native species and communities from *Phytophthora cinnamomi*; and to prevent further species and communities from becoming endangered by reducing the chance of exposure to the pathogen. These goals will be achieved by implementing currently available management techniques, providing for the development of new techniques and collecting information to improve our understanding of the pathogen and its effects.

For threat abatement plans to be effective their preparation requires the on going involvement and support of many people and organisations. This plan represents the cooperative efforts of Commonwealth, State and Territory agencies responsible for conservation management, beginning with the expert advice from the Threatened Species Scientific Committee, which recommended to the Minister the adoption of the plan.

Although the plan's focus is on actions to reduce the threat posed by Phytophthora root rot to native species and ecological communities, its recommendations will also help land managers limit the effects of Phytophthora root rot on Australia's wildflower and forestry industries.

Roger Beale
Secretary, Department of Environment and Heritage

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Officers of Environment Australia have also contributed to the preparation of the Plan. In particular, Liz Dovey, David Kay, Alex Rankin and Brigitta Wimmer contributed to the first draft Plan that was released for public comment and Robert Moore in the preparation of the final Plan.

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EXECUTIVE SUMMARY

Australia's native vegetation and its dependent biota are threatened by a plant pathogenic fungus called *Phytophthora cinnamomi*. *P. cinnamomi* causes the roots of susceptible plants to rot. It is thought that it was introduced at some time after European settlement; it is now well established in many of the country's higher rainfall areas—areas with a mean annual rainfall greater than 600 millimetres—in a mosaic of infected and uninfected areas. Its effects range from devastating to inconsequential, depending on environmental factors, which vary both within and between regions. The only biomes that appear to be least threatened are the wet-dry tropics and the arid and semi-arid regions. The level of threat and its distribution, however could easily increase if human activities were to alter the site conditions to favour the spread and intensification if the species. The latter activities may include the alteration of the hydrology of an area as this could subsequently foster a rising water table and a subsequent intensification of spread of P. cinnamomi. In addition, *P. cinnamomi* can spread independently or with the assistance of animals or humans.

Detailed information on the nature of *P. cinnamomi* and its history in Australia can be found in the technical report entitled 'A National Overview of *Phytophthora cinnamomi* in Australia: supplementary information to accompany the draft national Threat Abatement Plan' (Podger 1999).

'Dieback caused by the root-rot fungus *Phytophthora cinnamomi*' is listed as a 'key threatening process' in Schedule X to the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999*. When it is determined that having a threat abatement plan is a feasible, effective and efficient way to abate the process a nationally coordinated threat abatement plan must be prepared and implemented to manage the impact of *Phytophthora cinnamomi* on Australian ecosystems.

While eradication is not possible at present, well developed management plans based on current knowledge can assist in restricting the intensification and spread of known infestations and limit spread to new sites.

This Threat Abatement Plan, therefore, has two main goals:

- to protect nationally listed threatened species and ecological communities from *Phytophthora cinnamomi*; and
- to prevent further species and ecological communities from becoming threatened by reducing the chance of exposure to the pathogen.

To abate the threat posed by *P. cinnamomi*, action in four important areas is prescribed:

- Implementation of management programs in specific areas that are a high conservation priority as a result of the species or ecological communities under threat.
- Encourage better understanding through the collection of information that expands our understanding of the ecology and biology of *P. cinnamomi* in Australia, its effects and of methods for managing the pathogen.

- Education of land managers and relevant organisations to increase their knowledge of the effects of *P. cinnamomi* and the role of humans in spreading the pathogen and to ensure skilled and effective participation in management activities.
- Coordination of national, regional and local management activities and administration.

Specific actions in the Plan describe the measures to be used to mitigate the harm caused by the *P. cinnamomi*. The strategy advocated in the Plan involves the use of available methods to restrict the intensification and spread of *P. cinnamomi* in manageable areas that are critical to the conservation of threatened species and ecological communities. In addressing the conservation of species, close links must be established with species recovery plans and with existing State and Territory programs. Action will also be taken to ensure that *P. cinnamomi* does not become established in important 'islands' that are at present free of the pathogen. In addition, there will be a focus on collecting and disseminating information to improve our understanding of *P. cinnamomi* control methods and their effects, particularly in areas that have not been infected for very long.

Implementation of the Plan will allow for consolidation and coordination of the process of managing *P. cinnamomi* impacts on native flora and vegetation. The main priority is to provide support for on-ground control programs that are necessary for the recovery of threatened species and threatened ecological communities. Control programs will have to continue for some time and the costs of this will be considerable. This Plan therefore establishes a framework for allowing the best possible use of resources that are available for managing *P. cinnamomi* infestations.

1 INTRODUCTION

The exotic pathogen *Phytophthora cinnamomi* is thought to have entered Australia with early settlers from Europe. Its patterns of distribution and continuing invasion and its severe impacts in much of southern Australia are characteristic of a pathogen to which much of the flora could not have previously been exposed.

This Threat Abatement Plan has been prepared in order to meet the Commonwealth Government's obligations under the *Environment Protection and Biodiversity Conservation Act 1999* following the listing of 'Dieback caused by the root-rot fungus *Phytophthora cinnamomi*' as a 'key threatening process'. The Act requires the preparation and implementation of a threat abatement plan for nationally coordinated action to mitigate the harm to Australian species, particularly threatened flora and threatened ecological communities, caused by *P. cinnamomi*.

Many fungi are known to cause root-rot disease in Australian flora species, but the introduced *P. cinnamomi* has had the greatest effect and poses the greatest threat. At least 32 species of *Phytophthora* occur in various parts of Australia; 14 of them have been recorded in the wild. Only three species (*P. cinnamomi, P. cryptogea* and *P. megasperma*) are known to cause significant damage in the wild; of these three, *P. cinnamomi* has resulted in more extensive damage in a variety of habitats.

Although *P. cinnamomi* is wide spread in a number of regions in Australia, its impact on nature conservation values and sustainable forest management and the level of infestation varies significantly on both local and regional scales. Along with the difficulty in observing and controlling this microscopic pathogen, this creates a complex problem for management. This plan identifies what management opportunities are available and develops a program for the co-ordinated implementation of action to abate the threat from *P. cinnamomi*.

1.1 The nature of the threat

Serious epidemics of root-rot do not necessarily always follow the arrival of *Phytophthora cinnamomi* in uninfected plant communities. The extent of the *P. cinnamomi* infections are known to extend well beyond the areas which are potentially vulnerable or severely impacted on by the pathogen. The latter reflects the ability of this species to extend into environments where the effects are not immediately apparent.

Major disruption during epidemic disease is not the only expression of disease that could threaten the extinction of populations of vulnerable susceptible plant species. Species that exist in very small populations could be threatened with extinction as a consequence of much less dramatic endemic disease that causes a slow attrition of individuals in natural populations.

A threat of epidemic exists where dominant species of particular plant communities are inherently susceptible to *P. cinnamomi* root-rot and those communities are in areas where environmental conditions favour the pathogen. In such circumstances plants are both susceptible and vulnerable, and both these conditions are necessary if an interaction that is sufficiently destructive to be considered a threatening process is to develop. In fact, the threatening process is the lethal epidemics of the root-rot disease that have followed colonisation of particular native plant communities by the introduced pathogen, *P. cinnamomi*.

Where vulnerability and susceptibility occur together in the presence of the pathogen, among the consequences will usually be the following:

- major disruption of community structure;
- extinction of populations of some flora species;
- a modification of the structure and composition of ecological communities;
- a massive reduction in primary productivity;
- for dependent flora and fauna, habitat loss and degradation.

Further, the vegetation assemblages of resistant species that, with time, recolonise areas affected by this root pathogen are generally less productive, more open overstorey and provide a modified habitat for dependent fauna, flora and heterotrophs.

1.2 The spread of active root-rot disease in Australia

In Australia *Phytophthora cinnamomi* does not usually cause severe damage to undisturbed vegetation in areas that receive a mean annual rainfall of less than 600 millimetres.

The most serious epidemics of root-rot are those that pose identifiable threats of extinction for some rare and threatened species and ecological communities and cause serious disruption and modification of structure and bioproductivity in native communities over extensive areas. Such epidemics are found in three temperate climatic zones south of latitude 30°:

- all elevations in those areas of Mediterranean climate where mean annual rainfall exceeds 600 millimetres—in south-western Australia, South Australia and southern Victoria as far east as Wilsons Promontory;
- the temperate uniform, but erratic, rainfall regimes at low elevations of the coastal plain and foothills between Wilsons Promontory and south of the border area between Victoria and New South Wales; and
- winter-dominant rainfall areas in maritime climates of coastal and sub-montane Tasmania.

A fourth climatic zone that is sometimes affected is the montane region above 800 metres, similar to those parts found in the southern Great Dividing Range and in the Central Highlands of Tasmania. Although localised minor damage has been recorded on grossly disturbed sites, no damage has been reported in essentially intact communities. The *P. cinnamomi* seems unable to survive the winter cold in these areas.

1.3 Current distribution

The areas of native vegetation affected by *P. cinnamomi* exceed many hundreds of thousands of hectares in Western Australia, Victoria and Tasmania and tens of thousands of hectares in South Australia. Historically the pathogen's distribution in Western Australia has been mapped extensively in large sections of the south-west. These mapping exercises have led to a substantial commitment by the managing agencies at a local and regional scale. Various attempts have been made to utilise recent technological methods, such as satellite imagery, however the success of utilising these methods has been restricted by the nature of the impact of *P. cinnamomi* which is often restricted in visual impact. Mapping its distribution elsewhere in Australia, particularly in areas not severely affected, is not practical owing to sampling difficulties and costs. The broad areas of infestation that have been mapped in the past has amounted to millions of hectares and involved hundreds of thousands of kilometres of borders with uninfected communities. The ability to map the infestations is dependent on the availability of skilled professionals and adequate resources to undertake the mapping.

It is also important to note that *P. cinnamomi* is known to occur in coastal Queensland. Although considered to be restricted to the wet coastal forests, many of these areas are designated as conservation reserves or state forests and are managed for recreation and conservation purposes. Visitor access and, therefore, the risk of spread is also considered a problem that will need to be addressed.

1.4 Dispersal mechanisms

Phytophthora cinnamomi disperses independently through very moist but well-aerated soil. Annual rates of spread at the boundaries of existing infection are highly variable, ranging from a few to hundreds of metres downslope depending on the hydrology of substrates. Upslope spread seldom exceeds an average of 1 metre a year (Podger *et al*, 1996).

Among the numerous *P. cinnamomi* vectors, the transport of soil as a result of road building and maintenance, timber harvesting, mineral exploration, the nursery trade and bushwalking is the most important, especially when this is undertaken during the period of the infective southern spring. The success of establishment for new centres of infestation is also dependent on population levels in the soil at the point of pick-up and the quantity transferred. Survival, establishment and further spread are dependent on conditions at the point of delivery; in particular, sufficient moisture for the pathogen and the presence of living host tissue.

1.5 Susceptible species

Appendix B shows a number of flora species many of which are nationally listed as being threatened and which are susceptible to *Phytophthora cinnamomi*. The list is not inclusive it is provided to indicate the range of species that are at risk. The pathogen also affects a large number of native plants that are not currently threatened.

Although no comprehensive, up-to-date list of species known to be severely affected in the wild has been compiled, in 1968 Podger reported for Western Australia of widespread infection in the wild, listing 59 native species from 36 genera in 15 families: one cycad, one conifer, two monocotyledons and 55 dicotyledons. The families from which the pathogen was most frequently isolated are Myrtaceae (seven genera, 11 species), Proteaceae (five genera, 11 species), Fabaceae (six genera, eight species), Epacridaceae (three genera, seven species) and Dilleniaceae (one genus, five species). With the exception of the Dilleniaceae, this reflects the dominance of these families in the woody flora of south-western Australia and their importance as structural components in the affected communities.

More recent studies in Western Australia (Wills, 1993; Wills & Keighery, 1994) have provided further insight into which species are susceptible.

Podger's census and the later studies indicate a remarkable spread of hosts across the span of higher plants, ranging from club mosses, ferns and cycads to conifers, cord rushes, grasses and lilies and extending across the taxonomic spectrum of dicotyledonous families. In all, over 250 species among at least 145 genera in 37 families have been recorded. Zentmyer's 1980 list, which includes records drawn from cultivation and laboratory experimentation, suggests the same taxonomic spread and identifies hosts in some 30 per cent of higher plant families. Together these sources provide unequivocal evidence that *P. cinnamomi* is an aggressive primary pathogen for an extraordinary range of higher plant species, not least in the native flora of Australia.

At best, records of host species suggest only that *P. cinnamomi* is able to parasitise some part of some plants in populations of the listed species. They provide no indication of the extent of invasion or of the severity of the consequences in terms of the health and survival of individual plants, plant populations or species. As a result they are not very useful for predicting the possible fate of a particular species.

Another important issue that needs to be considered here is the distinction between plant species being a host to *P. cinnamomi* and species being fatally affected by *P. cinnamomi.* Many species may become infected with *P. cinnamomi*, but not all species die as a result of infection.

There is a growing body of evidence that the dramatic impact of *P. cinnamomi* infestations on plant communities can result in major declines in some animal species due to the loss of shelter or food sources (Wilson et al, 1994; Laidlaw, 1997). Populations of several regionally rare and nationally threatened fauna species (*Pseudomys fumeus* (endangered), *P. shortridgei* (vulnerable), *Isoodon obesulus* (endangered)) are considered to be at risk because of the impact of *P. cinnamomi* on their habitat.

1.6 Effects on susceptible species and ecological communities

Phytophthora cinnamomi can parasitise a wide range of life stages across the taxonomic spectrum of higher plants, both primitive and recently evolved. It reacts with its hosts in a number of quite distinct ways, ranging from symptomless infection restricted to root tissue (for example, in some grasses) to complete invasion of root and stem storage tissue. With *Blandfordia punicea* and *Xanthorrhoea australis,* the pathogen is also known to infect the apical meristem.

In many high-rainfall areas the biomass of woodland dominated by species of *Banksia* and jarrah forest and on sites of high hazard, basal area (an index of accumulated biomass) can be reduced to a fraction of its pre-infection status. At the other end of the spectrum, *P. cinnamomi* can invade ecological communities and persist beneath them with no discernible impact for many decades.

1.7 Further information

Further information about the nature and effects of the *Phytophthora cinnamomi* pathogen and the dieback disease it causes can be found in a technical report—'A National Overview of *Phytophthora cinnamomi* in Australia: supplementary information to accompany the draft national Threat Abatement Plan'. References to a range of papers on *P. cinnamomi* are also provided at the back of this Plan.

2 DEALING WITH THE PROBLEM

Eradication of *Phytophthora cinnamomi* would be the ideal outcome because once the task is accomplished no further commitment of resources would be required. In order for this to be a viable option a number of issues would need to be achievable:

- The conditions that support the pathogenic capacity of *P. cinnamomi* must be identified and removed.
- There must be no independent or human-assisted spread of the pathogen.
- There must be remediation of all areas that are currently infected.
- All instances of *P. cinnamomi* infection must be able to be identified and mapped at an early stage.
- A discounted benefit–cost analysis must be demonstrated to favour eradication over control.
- There must be an appropriate legal, social and political environment.

2.1 Eradication

There have been several attempts at eradicating *P. cinnamomi* in the wild (Hill, Tippet and Shearer; 1995) in Australia but they were unsuccessful or only partially successful—within a few years severe disease broke out again in the treated areas and at their boundaries.

At present complete removal of *P. cinnamomi*—nationwide or in a local area —is beyond the capacity of available techniques and resources. The pathogen is well established across a very large area and techniques and resources are inadequate even to stem the independent spread of the pathogen.

Podger (1999) reviewed current methods of managing the problems caused by *P. cinnamomi* and concluded that eradication was not feasible at either local or regional scales, necessitating an on going program of management. Two key management strategies were identified, constraining the spread of the pathogen and reducing its impact. He noted that the management actions for constraining further spread of *P. cinnamomi* are different from those used for the minimisation of harm caused to infected areas. A number of other minor management actions have also been used or attempted. The integration of these strategies and the local integration of the available management techniques in an adaptive management approach will maximise the success of *P. cinnamomi* management.

Preventing the introduction of *P. cinnamomi* to areas of high conservation value requires identification of potential routes of invasion, a risk analysis to determine the probability of such an event, and procedures to manage and minimise the risk. There must also be the ability to detect incursions before *P. cinnamomi* has a chance to become established, contingency plans that identify the most suitable control measures, and funding for implementation of the chosen control measures.

2.2 Reducing the pathogen's spread

Spread of the pathogen as a result of human activity can be managed to varying levels of success depending on location and the resources available; spread by natural vectors such as animals adds a number of additional levels of difficulty. Spread resulting from human activity can be reduced by limiting people's access to certain areas (quarantine) and ensuring that when infected areas are entered the potential to transfer infected material to uninfected areas is minimised (hygiene). In the case of animals, it is usually very difficult, and prohibitively expensive, to prevent movement into and out of infected areas.

Quarantine

Some States (such as Western Australia) have legislation that provides for gazettal of 'disease risk areas'. Other States can use the 'place of performance' provision of the Commonwealth *Quarantine Act 1908*, which is used for botanic gardens, research institutes, and the like. Tasmania uses provision within the *Plant Quarantine Act 1997*. Difficulties with these sorts of quarantine measures can arise for social and resource-related reasons:

- opposition to changes in land use/access;
- level of public education required;
- lawlessness and limitations on enforcing quarantine.

Hygiene

To secure hygienic access, a very wide range of human activities must be considered:

Actions

- treatment of water used in fire suppression;
- road-building and -maintenance programs, with the attendant need for demarcation of boundaries between infected and uninfected areas and to clean heavy earth-moving machinery;
- washing down of timber-harvesting equipment on entry to uninfected areas—the availability of hygienic points of entry is often limited by unsuitable topography and drainage;
- use of signs and barriers to exclude access.

Issues

- access to suppress wildfires and for fuel-reduction burning—ploughing firebreaks on private property boundaries is a particularly serious problem;
- denial of access to uninfected areas when wet soils are likely to be picked up from cryptic infections in timber-harvesting coupes and spread further within the coupes—with the consequent need to stockpile produce during drier periods;
- mapping and demarcation in planning access for heavy equipment, to minimise the inadvertent movement of machinery from uninfected areas into infected ones and vice versa;
- access for other activities, eg bush walking, apiarist, drilling, wildflower collecting, etc.

For sound management of hygienic access to uninfected areas, it is necessary to delineate the boundaries between infected and uninfected areas. A number of elements are essential to operational planning:

- recognition of the boundaries between infected and uninfected areas;
- mapping of the boundaries between the two areas as a basis for future access;
- demarcation of the boundaries on the ground, so that machinery operators are forewarned and avoid crossing into infected areas;
- regular inspection to ensure that entry controls are being followed;
- regular testing to ensure that the disease has not spread past the boundaries put in place; and
- assessment that controls put in place have been effective.

In Western Australia boundary definition between infected and uninfected areas is based on identifying characteristic symptoms of the disease. Elsewhere in Australia, with a few localised exceptions (including parts of South Australia), the problems are much greater and in many cases delineation of boundaries is not feasible. In Tasmania, topographic and vegetation variability allows a catchment approach to identifying quarantine areas and applying hygiene. Natural *P. cinnamomi* boundaries between infected and uninfected areas are identified in order to prescribe quarantine areas rather than attempting to monitor actual *P. cinnamomi* boundaries.

2.3 Reducing the pathogen's activity

There are two main ways of reducing *Phytophthora cinnamomi*'s activity: by biological control and by reducing its food base.

Biological control

Application of organic matter and fertilisers has been demonstrated to increase microbial antagonism and energy for root regeneration in infected avocado trees (Pegg & Alcorn 1972). This biological control measure operates by improving the host's ability to regenerate new root systems following feeder root necrosis and to contain the progress of infection within the smaller roots. There is, however, no evidence of a reduction in populations of the pathogen. In fact, evidence suggests that populations of the pathogen are higher beneath healthy trees than beneath untreated diseased trees. In any case, the quantities of organics and fertilisers required for broad-scale management of natural vegetation will probably never be available or affordable.

In the jarrah forests of Western Australia maintenance of naturally accumulated loads of litter, which encourages microbial diversity, has proved to have no effect on the advance of *P. cinnamomi* or on its depredations in the understorey (Podger & Burrows unpub.).

In 1995 at a workshop in Perth, one of the issues explored by experts was the possibility of locating biological agents at the centres of origin of *P. cinnamomi* and transferring those agents to high-impact sites. It was argued, however, that where biological control of soil-

borne plant disease occurred it was more likely that a number of agents were active than that any one of the numerous microbes known to have deleterious effects on *P. cinnamomi* was dominant.

Although the subject warrants further investigation, any proposal to import and spread an exotic biological agent would have to demonstrate that there would be no harmful effects on any of the native flora or fauna, including microbes. The value of such an agent would presumably be limited to modifying the pathogen's activity in areas already infected. It is much more difficult to envisage how biological antagonists specific to *P. cinnamomi* might be deployed ahead of, or at the 'wave-front' of, first invasion.

Other major workshops where biological control issues have been discussed also occurred in 1993, 1994 and in 1997. Experimentation in fostering commensal associations between hosts and particular ectomycorrhizal fungi that provide physical and chemical barriers to infection by *P. cinnamomi* has demonstrated a benefit in pine and eucalyptus. It is, however, difficult to maintain these associations beyond the first year after conjugation in the nursery. There is no Australian evidence for the natural movement of possible agents of biological control from susceptible communities on non-vulnerable sites to their susceptible neighbours on vulnerable sites.

Reducing the food base

It is theoretically possible to reduce the food base available to *P. cinnamomi* by removing dense stands of vulnerable species such as *Banksia grandis* where the management objective is to provide protection for more resistant species (those in which the average level of resistance is at least moderate). Extensive forestry experiments in Western Australia to reduce the stocking of *B. grandis* so as to secure Jarrah's survival provided only short-lived advantage. The benefits of physically removing larger bull Banksia were negated by the rapid growth of numerous small lignotuberous plants that no longer faced competition from the larger plants.

Attempts to use fire to reduce *Banksia* populations have failed because the species is a vigorous resprouter and the intensity of fire required to kill it is too severe to manage safely and leads to the destruction of other desirable values. The same problems are encountered with the fire intensities needed to stimulate mass regeneration of native *Acacia* species producing chemical exudates that are antagonistic to *P. cinnamomi*.

2.4 Altering the physical conditions for the pathogen

Two broad approaches to altering the physical conditions for the pathogen have proved effective in intensive plant culture:

- altering the physical conditions in the soil so that they encourage the host root systems' regenerative capacity;
- reducing the pathogen's pathogenic capacity.

In cultivation, root-rot of pineapple—which in nature is an epiphyte and in cultivation is dependent on soil only for physical support—has been controlled by acidification with

sulphur compounds to a level intolerable to *Phytophthora cinnamomi*. Treatments of this kind are not compatible with conservation of natural systems.

Soil mounding and drainage have proved vital to the establishment of plantations of *Pinus radiata* on poorly drained sites in Western Australia. This approach has also been adopted for re-establishment of Jarrah on *Phytophthora cinnamomi*–infected sites mined for bauxite, but it is obviously incompatible with management of wildlands. Run-off can, however, be engineered to move water quickly in narrow channels away from the areas to be protected.

In Victoria high seedling stocking rates are used when rehabilitating dieback sites, this increases transpiration and reduces the frequency at which soil moisture levels will be suitable for infection. This also provides tissue moisture content that inhibits movement of the pathogen within the plant.

Chemical treatment: phosphite

One treatment that has been found to have some success in controlling *P. cinnamomi* is the use of the chemical, phosphite. There is however sufficient scientific information that indicates that the chemical must be used carefully and that further research is required to fully determine its limitations and optimal methods of being used.

Phosphite has been shown to have a number of useful properties:

- It is effective in inducing resistance when injected or sprayed at low dosages.
- Its effect is much more persistent than is the case with most of the more expensive treatments.
- It appears to have low toxicity for mammals.
- It breaks down rapidly in soil.
- It can be applied as a low-volume aerosol by hand or from low-flying aircraft.

Phosphite has also been shown to have disadvantages, such as:

- it can produce toxic effects if it is used at levels above the tolerances of particular plant species;
- pollen viability and seed germination can be adversely influenced and superficial burning of foliage can occur.

Because species vary greatly in their dosage tolerance, prescriptions for entire communities may not be available. For this reason and because of the cost, the main use of phosphite is likely to be to induce resistance in selected populations of species that are listed as rare or threatened and are already infected.

Phosphite's effects on fauna have not yet been properly assessed, so the chemical should be used with caution in areas where threatened fauna species are known to occur. In addition, phosphite is not an eradicant and the fungus remains in the soil/host plant environment even though symptoms are suppressed. In the case of the latter issue, its use by nurseries should be

carefully monitored, as *P. cinnamomi* could be easily spread when the visible signs of the disease have been masked by the chemical.

2.5 Ex situ conservation of threatened species

The Commonwealth has provided funding for the establishment of a seed bank for ex situ conservation of threatened species and for identification, seed collection and storage of taxa threatened by *Phytophthora cinnamomi*. These measures will greatly expand the options for protection of species that are threatened by *P. cinnamomi*.

2.6 Rehabilitation of damaged sites

Attempts to reforest the 'graveyard' sites in Western Australia, using commercial timbers of exotic origin, have not proved viable. Efforts to improve drainage, using very heavy duty machinery to rip cap rock, have produced disappointing results, unlike its success in restoring native vegetation on bauxite pits.

In spite of this, work on restoring native eucalypt forests in East Gippsland Victoria involving rehabilitation of coastal mixed species forests damaged by *P. cinnamomi* has produced very encouraging results over at least 20 years. In addition, the work by Wills & Keighery (1994), provided information on successful species.

At present attention is being given to what can be done to encourage regeneration of resistant species on severely damaged sites. Consideration should also be given to the potential of taxonomically related and resistant surrogates in repairing structure and protective habitat for native fauna. It is important to explore the rehabilitation issues further, as many ecological processes may be interrupted to such an extent as being a major threat to the sustainability of ecosystems. In Western Australia for example, vertebrate pollination of flowers could be limited or even prevented through the action of *P. cinnamomi* removing key flora species in particular areas.

Selective harvesting systems were responsible for large areas in South and East Gippsland being prone to attack by *P. cinnamomi* through producing changes in species composition, raising of the water table and the presence of host species. This has been countered by the use of high sowing rates that will hopefully promote the selection for resistance from amongst susceptible eucalypt species.

3 FACTORS AFFECTING CONTROL

Five main factors work against successful *Phytophthora cinnamomi* control in Australia: the difficulty of diagnosis; the scale of the problem; mapping constraints; non-human vectors; and the effects of control measures on non-target species.

3.1 The difficulty of diagnosis

There is widespread confusion between the disease and death caused by *Phytophthora cinnamomi* and disease and death resulting from other causes in native vegetation, largely because of the difficulty of diagnosis. This problem is exacerbated by *P. cinnamomi*'s cryptic nature: the organism can be seen only by microscopic examination in laboratories; though it sometimes produces reliable visible symptoms in a number of hosts, in many other hosts it is not reliably detected. This problem may be made worse in the post epidemic period where relatively few susceptible species may be present.

3.2 The scale of the problem

Colonisation of Australian landscapes by *Phytophthora cinnamomi* is almost certainly in its second century. The disease is in the middle stages of its epidemic development and is now established in a mosaic over millions of hectares. As a result, the boundaries between infected areas and those free of infection are hundreds of thousands of kilometres long. Managing these boundaries is a problem that needs to be tackled at both regional and local scales: it is not feasible to deal with them in detail at the national level.

3.3 Social and financial costs of management

Requirements for hygiene may contribute to increased operating costs, such as where machinery operations require a wash down between areas of the same job. That is where road works or forestry operations involve and transect areas that alternate between infected and uninfected.

Quarantine measures can lead to restrictions being placed on public access to areas that include recreational and historic sites, e.g. King George III monument in Tasmania.

3.4 Mapping constraints

Maps that precisely locate the boundaries between areas carrying *Phytophthora cinnamomi* and those free of it would be of great benefit in ensuring hygienic movement, but difficulties associated with sampling, plus the high cost, make such direct mapping impractical in the wild. Field survey for mapping is a year-round process and for most of that time *P. cinnamomi* population levels are very low and difficult to detect. Soil sampling is also very expensive.

Because of these problems, mapping areas of infestation is based on recognising characteristic symptoms of disease. The process relies on combinations of ground inspection, location with

geographic positioning systems, and the use of colour aerial photography at a scale of 1:4500 under the shadow-free conditions afforded by complete high-cloud cover.

Although very large areas of native vegetation in Australia are amenable to such mapping, many areas may have too few indicator plants for interpretation or thickets of resistant shrubs may obscure them. In addition, delineation of the boundary between infected and pathogen-free areas is not always dependably accurate, even where circumstances are very favourable for mapping. Furthermore, boundaries between infected and pathogen-free areas, whether on the ground or on maps, rarely have currency beyond two years of their demarcation.

Extensive work to adapt other techniques of remote sensing—for example, aerial video filming and LANDSAT satellite imagery—has not been successful, mainly because of the loss of precision in averaged images and the costs of navigational correction in aerial video photography.

Irrespective of the problems encountered so far, technological innovation continues to develop at a pace and the issues encountered today will probably be solved tomorrow. Mapping technology is an area that the Threat Abatement Plan Implementation Team should retain a watching brief on.

3.5 Non-human vectors

Even if measures to ensure that inadvertent transport of the pathogen on the part of humans prove successful, the problem of transfer by native and feral animals remains. In the case of feral animals, regional and local plans for action on *P. cinnamomi* should take account of the need for integration with actions related to other threat abatement plans, such as those for the fox, cat, goat and rabbit.

The situation with controlling the movement of native species is possibly more vexed. If it is a matter of protecting a specific population in a restricted locality it may be possible to use a barrier method to prevent ground animals moving into the locality. This method would become increasingly unworkable as the boundary to be protected increases.

However, humans and their many activities will continue to remain the major concern and pose the largest risk to spreading *P. cinnamomi*.

3.6 The effects of control measures on non-target species

Some of the control measures proposed or being tested may have unintended effects on other components of the ecosystems in which the target species occur. There has been no assessment of phosphite's effects on native fauna communities or on other elements of the ecosystem, such as water quality. Phosphite should be used with caution and its effects on non-target elements of the ecosystem should be monitored while more specific studies are being carried out.

4 DEVELOPING A NATIONAL APPROACH TO MANAGEMENT

The epidemic spread and development of disease due to *P. cinnamomi* is a very complex process. There is no clear and universally appropriate action, or even set of actions, for combating it. A combination of methods appropriate to local circumstances is needed. As noted in Chapter 2, however, some of these methods are affordable and effective management components for agriculture but very few are practical and affordable in broad-acre management of problems in native vegetation. It is also important to note that the techniques for mitigating the harm caused by established infection are usually not the same as those designed to prevent further colonisation of native vegetation by the pathogen.

At present it is not possible to accurately estimate current annual expenditure on *P. cinnamomi* control in Australia. Some State and Territory agencies spend considerable sums, but precise details are not available. Landholders and land managers, local government agencies and community groups are also involved in control, but reliable data on the costs of their efforts are scarce.

In recent years the Commonwealth has provided, on average, $400 000 a year for *P. cinnamomi* –control activities such as the following:

- surveys to determine which species and ecological communities are vulnerable to *Phytophthora cinnamomi*;
- detailed habitat and demographic studies of these species;
- establishment of a seed bank for *ex situ* conservation of vulnerable species;
- identification, seed collection and storage of taxa threatened by *P. cinnamomi*;
- analyses of the nature of and threat posed by *P. cinnamomi*;
- analyses of the management options for dealing with the threat posed by *P. cinnamomi*;
- development of GIS-based decision-support tools and databases of taxa that are sensitive to *P. cinnamomi*;
- trial regimes of possible control measures in native plant communities;
- investigation of the use of phosphite to suppress the pathogen's activity and development of an effective phosphite delivery system;
- determining the level to which disease activity must be reduced to allow vulnerable native flora populations to survive;
- investigation of the disease's impact and disease-management techniques in native faunal communities;
- investigation of fungal ecology and population dynamics;
- assessing the effects of the disease on numerous native flora species;
- identification of the main parties with an interest in controlling this problem;
- development of publicity and educational material and programs;
- participation in regional seminars and a national workshop to involve interested parties in preparation of this Threat Abatement Plan.

4.1 Strategies

There will never be sufficient resources to deal with all aspects of disease management. This Threat Abatement Plan is designed to ensure that resources are allocated in such a way as to secure the best outcome for conservation of threatened species and ecological communities.

In 1994 (Barker) a project implemented in Tasmania for susceptible threatened species on funding provided by Environment Australia was recently adopted along similar lines in Western Australia. In Western Australia the project involved the development of guidelines for determining priorities for resource use. Resources are directed to those areas that are most likely to remain free of infection in the longer term. The areas should have the following characteristics:

- They are currently free of infection.
- They are of significance for conservation, either as single-purpose reserves or for other, multiple land uses.
- They are topographically located in such a way that they are unlikely to be entirely colonised by autonomous spread of the pathogen within some definable medium-term time frame.
- There physical location will be amendable to the public to accept restrictions on human access and this is financially affordable.
- They are unlikely to be vulnerable to infection resulting from the presence of other, uncontrollable vectors.

In areas of high conservation value, such as those containing threatened species and ecological communities, a number of States are pursuing an approach that combines direct treatment using protective chemicals, *ex situ* conservation, and the general strategy of vector control.

Such an approach exemplifies the threat abatement approach favoured by this Plan: regional management that focuses on areas where maximum benefit can be derived by reducing the impact of *P. cinnamomi* on a range of species.

Regional control programs are designed to provide protection for a number of at-risk species. But control on this broad scale requires a substantial investment of resources and can be justified only for high-conservation situations, such as threatened species and ecological communities that are known to benefit from control.

On the positive side, regional management can accommodate different experimental control techniques within a broadly comparable area. The controls applied in the jarrah forests near Perth offer a good example of a broad-scale control program that includes an experimental approach. By measuring different control strategies' effectiveness in bringing about the recovery of populations of threatened species, the program will help managers decide on the most suitable ways of protecting other threatened species or areas of high biodiversity. Regional management also provides a mechanism for integrating control measures with other

initiatives aimed at biodiversity conservation, such as Bushcare and other programs funded through the Natural Heritage Trust.

Action to stop the spread of *Phytophthora cinnamomi* into specific areas of high conservation concern—for example, around populations of threatened species and ecological communities—is also integral to this Plan. It will be particularly important in areas that are currently free of the pathogen but are climatically suitable for its establishment and contain species that are vulnerable to it.

Recovery plans for a number of species nominate *P. cinnamomi* as a potential threat (see Appendix B). To ensure that resources are used efficiently and effectively, an experimental approach will be used to determine the significance the pathogen in the decline of those species and the level of control necessary for their recovery.

By approaching local control on an experimental basis, *P. cinnamomi*'s real importance as a threat to these species can be determined. If it proves to be a significant threat, this will justify expanding control activities to other sites where the species in question occurs. Alternatively, if control is shown to be irrelevant to the recovery of the species, efforts can be redirected to techniques that are effective in promoting its recovery.

Given that local eradication of *P. cinnamomi* is impossible, two broad strategies can be used for localised management: sustained management, whereby controls such as hygiene protocols are implemented on a continuing, regular basis; and intermittent management, which seeks to apply measures such as chemical control at critical periods of the year when short-term action can be most effective.

Trying to keep an area free of *P. cinnamomi* in a district where the pathogen is already established is an option only for small areas of high value, such as areas containing threatened species or re-introduction sites. Sustained effort is required to prevent invasion from surrounding infected areas. Such an approach may fail in the long term: the vulnerability of the site to disease development and the potential development of more effective control measures are critical to success.

Buffer zones may be a necessary component of managing small areas, to reduce the likelihood of continual re-infection from surrounding areas. The development of buffer zones requires the participation of the owners of surrounding lands and a clear explanation of the benefits to be obtained by all participants.

4.2 Determining priorities for action

It is obviously important to identify which species, ecological communities and regions will most benefit from coordinated action against *Phytophthora cinnamomi*. A number of recovery plans that have already been developed identify species that are known or thought to be threatened by the pathogen and areas of habitat that are critical for the survival of these species. In terms of national action to abate the threat posed by *P. cinnamomi*, implementation of recovery plans for these species must be accorded the highest priority. If recovery plans are also developed for threatened ecological communities during the life of

this plan they should also be accorded the highest priority. Community groups and landowners should be encouraged to become involved in coordinated control plans for their region.

As recovery plans for more threatened species are finalised and implemented it may be that there will be insufficient resources to fully carry out all the necessary control actions. Areas will then need to be ranked on a nationally consistent basis, to ensure that decisions about funding for control will maximise the potential conservation benefits. An agreed methodology for ranking areas should be developed to cover protecting and facilitating the expansion of existing populations of threatened species and preparing areas for translocation.

The methodology should weight areas according to risk and the possibility of reducing that risk; resources should be allocated to areas where *P. cinnamomi* management is most needed. Priorities for the investment of Commonwealth resources will be determined using four main criteria:

- the degree of threat that infection by *P. cinnamomi* poses to the survival of the threatened species or ecological community;
- the potential of that threatened species or ecological community to recover;
- the number of threatened species likely to benefit from control in that locality;
- the cost-efficiency and potential effectiveness of control measures.

5 GOALS, OBJECTIVES AND ACTIONS

GOALS

This Threat Abatement Plan (the Plan) has two broad goals:

- to protect nationally listed threatened species and ecological communities from *Phytophthora cinnamomi*;
- to prevent further species and ecological communities from becoming threatened by reducing the chance of exposure to the pathogen.

These goals will be achieved by implementing currently available *Phytophthora cinnamomi* management techniques, providing for the development of new techniques, and collecting information to improve our understanding of the pathogen and its effects. A critical performance indicator will be the degree of security achieved for species and ecological communities that are currently or potentially threatened by this pathogen.

OBJECTIVES

There are five primary Objectives for the Plan:

- **Objective 1:** To promote the recovery of nationally listed threatened species and ecological communities that are known or perceived to be threatened by *Phytophthora cinnamomi*.

- **Objective 2:** To limit the spread of *Phytophthora cinnamomi* into areas where it may threaten threatened species and ecological communities or into areas where it may lead to further species or ecological communities becoming threatened.

- **Objective 3:** To improve the effectiveness and efficiency of the management of the *Phytophthora cinnamomi* through appropriate research and monitoring programs.

- **Objective 4:** To inform Commonwealth, State and Territory management agencies, landholders and the public about the Threat Abatement Plan's actions and their outcomes.

- **Objective 5:** To effectively coordinate management activities.

The choice of any strategy for abating the threat posed by *P. cinnamomi* will differ according to the management purpose. If the purpose is to mitigate harm in areas already infected by and vulnerable to the pathogen, currently the choices of abatement are few, the actions may be difficult to undertake, but not impossible and, except in small areas of unique value, the financial cost could be high.

If the objective is to reduce the rate of introduction of uninfected native plant communities that are both susceptible and vulnerable to the disease, a number of more affordable strategies are available. They may not, however, be always or everywhere practicable.

Wherever possible, cost-effective and efficient management measures will be applied through regionally coordinated management partnerships involving landholders, community groups, nursery growers and all levels of government. Management of *P. cinnamomi* should be integrated with other actions relating to the management of other pest species identified as contributing to threatening processes.

To abate the threat posed by *P. cinnamomi*, action in four important areas is prescribed:

- Implementation of management programs in specific areas that are a high conservation priority (Objectives 1 and 2).
- Encourage better understanding through the collection of information that expands our understanding of the ecology and biology of *P. cinnamomi* in Australia, its effects and of methods for managing the pathogen (Objective 3).
- Education of land managers and relevant organisations to increase their knowledge of the effects of *P. cinnamomi* and the role of humans in spreading the pathogen and to ensure skilled and effective participation in management activities (Objective 4).
- Coordination of national, regional and local management activities and administration (Objective 5).

MANAGEMENT OF *Phytophthora cinnamomi*

Objective 1: To promote the recovery of threatened species and ecological communities that are known or perceived to be threatened by *Phytophthora cinnamomi*.

Local Management Plans

Phytophthora cinnamomi is confirmed to be a serious threat to a range of listed threatened and ecological communities. Recovery plans for many of these species and ecological communities nominate management of *P. cinnamomi* as a necessary component of the recovery process. Recovery Plans should identify areas of habitat that are critical to the survival of a species or ecological community and which are affected or potentially affected by *P. cinnamomi*. Implementation of local management plans in areas identified as critical habitat for these species is a priority in this Threat Abatement Plan.

The epidemic of disease due to *P. cinnamomi* is also a perceived threat for a number of other nationally threatened species. Development and implementation of recovery plans for these species should determine the significance of *P. cinnamomi* as a threat to them and the level of management necessary to secure their recovery. Management activities promoted under these recovery plans must be designed to quantify the disease's importance relative to other threats to the species in question. Additionally, decisions about whether species should also be conserved ex situ need to be made.

1. Actions

a. Develop and implement local management initiatives for ecological communities and threatened species where the disease is a known threat. Initiatives might consist of direct treatment with protective chemicals, vector-control strategies, education etc.

b. Develop or implement experimental management programs in areas of critical habitat for species or ecological communities perceived to be threatened by the disease.

c. Determine the seriousness of the threat and the level of management necessary to secure recovery.

d. Based on the Recovery Plan, as adopted under the EPBC Act, identify which species should be conserved *ex situ*. Develop a plan that, as a minimum, indicates the organisation which will take responsibility for this work, how it will be achieved and how the resultant progeny and original material will be used.

e. Develop and use approaches including incentives to promote management on private and leasehold lands that contain or are adjacent to populations of threatened species or ecological communities threatened by *P. cinnamomi*.

Through the Endangered Species Program the Commonwealth will support projects involving local management, especially where they include threatened species and ecological communities affected or potentially affected by *P. cinnamomi*. The funds will assist the development of local partnerships, where appropriate, to integrate management on both public and private lands. Where local management activity confirms that the disease is a serious threat to particular species or ecological communities, this Threat Abatement Plan will promote the expansion and integration of site-specific management plans into regional management plans for the species or ecological communities. It will also promote direct links with other relevant biodiversity conservation initiatives in the region.

Priority-Setting Mechanisms

It is vital that the species, ecological communities and regions that will benefit most from *P. cinnamomi* management activities be identified. Recovery plans specify species and ecological communities at risk and areas of habitat that are critical for their survival. Implementation of these plans must be accorded the highest priority in any national action to abate the threat posed by *P. cinnamomi.*

Available resources will seldom, if ever, be sufficient to fully implement all the management measures recommended in recovery plans. It will become increasingly important to rank areas on a nationally consistent basis, to ensure that decisions about funding for management maximise the potential conservation benefits. An agreed methodology for ranking regions/projects should be developed for protecting and facilitating the expansion of existing populations of threatened species and ecological communities and for preparing areas for translocation.

1. Actions

f. Develop and implement an agreed national methodology for ranking regions/projects for the allocation of resources to protect and facilitate the expansion of existing populations of threatened species and ecological communities. The methodology should include an understanding of the biogeography of susceptible species, ecological communities, critical and high-risk habitats and the disease caused by *P. cinnamomi* to these species and/or ecological communities. IUCN categories will be used as a basis for making decisions. This would lead to the production of a national overview of priority regions that will include mapping and a weighting of these areas/regions in terms of risk and the possibility of reducing that risk.

g. Develop decision-support systems to help land managers decide on locally appropriate management methods and when to apply them to management *P. cinnamomi*.

The *P. cinnamomi* Threat Abatement Plan Implementation Team, as specified in Section 5.4, will take responsibility for implementation of these actions. Environment Australia will work with relevant State authorities so that the available data are collated, analysed and mapped.

Objective 2: To limit the spread of *Phytophthora cinnamomi* into areas where it may threaten threatened species and ecological communities or into areas where it may lead to further species or ecological communities becoming threatened.

It is critical to stop the spread of *Phytophthora cinnamomi* into areas having a high conservation value (i.e. containing threatened species or ecological communities or those species and ecological communities at imminent risk of becoming threatened) that are currently free of *P. cinnamomi*, but are environmentally suitable for the pathogen's establishment.

Preventing the spread of *P. cinnamomi* to areas of high conservation value necessitates identification of potential routes of entry, a risk analysis to determine the probability of such an event, and development of procedures for managing and minimising the risk. It is also important to have procedures that allow for identification of the most appropriate measures for management and specify funding sources to implement those measures.

The main benefit of early detection is to trigger suitable containment procedures to prevent or delay movement of the pathogen into adjacent areas of high conservation value.

2. Actions

a. Identify areas of high conservation value that are environmentally suitable for the establishment of *P. cinnamomi*.

b. Assess the level of risk of *P. cinnamomi* spreading to and infecting plant populations in these areas.

c. Identify potential routes of spread from currently infected areas to the nominated areas having a high conservation value and manage the spread.

d. Limit the vectored dispersal into uninfected areas.

e. Implement a monitoring program to ensure early detection of the pathogen in areas having a high conservation value.

f. Develop and implement procedures for slowing or limiting the spread of *P. cinnamomi* infestation in areas having a high conservation value.

Environment Australia will work with relevant State authorities to develop proposals to carry out these actions.

BETTER UNDERSTANDING AND MORE EFFECTIVE MANAGEMENT

Objective 3: To improve the effectiveness and efficiency of the management of *Phytophthora cinnamomi* through appropriate research and monitoring programs.

Ensuring that field experience and research are used to further improve management programs is an important element of this Plan. It is important to improve our understanding of the disease's effects on a range of native species, particularly those currently listed as threatened, and the effects of any fungicides used on both target and non-target species.

Adaptive management approaches, which experimentally test existing and new management techniques, will be encouraged. By measuring the effectiveness of different management techniques in achieving the recovery of threatened species, we will improve our ability to combat the threat posed by *P. cinnamomi*.

It would be important to facilitate the development of research programs to further improve the effectiveness and efficiency of the pathogen's management.

3. Actions

a. Establish monitoring studies of sufficient duration to determine the:

   (i) long term impact of the pathogen, direct and indirect; and

   (i) effectiveness of management measures in different environments and with different susceptible species.

b. Develop experimental approaches to management including the integration of current management methods and review their effectiveness. In particular:

   (i) encourage the development of new management techniques; and

   (ii) evaluate effectiveness of hygiene procedures under different environmental conditions in order to refine them.

c. Investigate further research directions and priorities and establish a cooperative research program for *P. cinnamomi*.

EDUCATION

Objective 4: To inform Commonwealth, State and Territory management agencies, landholders and the public about the Threat Abatement Plan's actions and outcomes.

Education and Extension

The success of this Threat Abatement Plan is dependent on a high level of cooperation between Commonwealth and State agencies and all those with an interest in the problem. This covers a range of interested parties such as research organisations, landholders, community groups and local government. Educating land managers and community organisations will ensure their skilled participation in management activities and improve their knowledge of the role of human activity in transmitting the pathogen and of the effects of the disease. This is an essential component of the Plan. The Plan is also intended to help with documenting advances in knowledge of techniques for abating the threat. A number of the actions identified require an education and extension effort so that the Plan is effectively implemented.

Improved operator and industry training in management methods is a priority and in particular the use of hygiene and quarantine measures. It is considered important that Codes of Practice, where they do not exist, are developed for high-risk industries. These codes should have a uniform preamble and nationally accepted use of terminology and should be developed in conjunction with relevant State agencies

State agencies should encourage all parties engaging contractors in high-risk activities to ensure appropriate *P. cinnamomi* management practices are adopted.

4. Actions

a. Determine the level of awareness in the community and attitude to *P. cinnamomi* management. Based on the information obtained develop a communication strategy.

b. Prepare and distribute innovative education and extension material to promote understanding of the actions to be taken under this Plan, such as the use of phosphite, and quarantine and hygiene methods. The material should also be designed to increase the community's awareness of species recovery plans and the importance of dieback caused by *P. cinnamomi* as a 'key threatening process'.

c. State agencies to develop guidelines to assist key industries in developing industry specific codes of practice. This is important for high-risk activities in areas having a

high conservation value. Establish partnerships with key industries to assist with this process.

Where possible develop a national code of practice for managing each high risk activity, eg. road and fire trail construction and maintenance, plant propagation, laying pipes, mining, forestry, etc. Where this is not possible, compatible State and Territory codes should be developed.

d. Develop, encourage and facilitate a uniform industry and operator training program for land managers and seek to have it adopted by relevant training institutions. Where necessary the program will also highlight the differences between the operating environment and practices of each industry.

e. Develop and maintain a website available to all users, eg. the public, researchers and managers.

The *P. cinnamomi* Threat Abatement Plan Implementation Team, as specified in Section 5.4, will guide the development and implementation of an education and extension program. Environment Australia will assist with the initial development of a communications strategy and the development of a website.

ADMINISTRATION

Objective 5: To effectively coordinate management activities.

Regional Management Plans

Management at the regional level requires a substantial investment of resources. There are also problems associated with developing and managing management plans that involve large areas of land under differing tenures. Nevertheless, regional plans to manage the pathogen in South Australia, Tasmania and Western Australia have had some success. Such plans are vital to the recovery of a range of threatened species; their continuation, and extension to other States, is a priority for this Threat Abatement Plan.

Regional management plans should provide a strategic overview of the threat posed by *P. cinnamomi* to species and ecological communities that have high conservation value. They should also:

- identify current and proposed local management plans for the region;
- identify where these plans are meeting Objectives 1 and 2;
- outline related research and communication strategies;
- provide guidance for integration of *P. cinnamomi* planning into existing regional and local land management plans; and
- highlight areas that were part of the former range of listed species and ecological communities for later re-introduction.

In some circumstances an important conservation strategy will be to minimise habitat fragmentation and to investigate, in relation to fire, forestry, mining, grazing and other resource uses, options that minimise habitat disturbance.

4. Actions

a. Ensure the continuation and further development of regional management plans for each State and Territory.

b. Support regional organisations, community and industry groups and land management agencies in collaboratively developing and implementing regional management plans.

Through the Endangered Species Program the Commonwealth will make funds available to support the further development of regional management programs. Where possible, management on both public and private lands will be integrated with other regional biodiversity conservation measures through the development of regional partnerships.

National Coordination

The activities and priorities defined by this Plan must be flexible in adapting to change, so that field experience and research results can be applied to further improve the management of the pathogen. Success will only come if all parties that are impacted by this pathogen are involved in the Plan's on going development and continue to cooperate in its implementation. The *P. cinnamomi* Threat Abatement Plan Implementation Team (the Team) will monitor the implementation of the Plan including reviewing the actions and broad priorities for funding, and highlighting gaps. The Team will report annually to the Commonwealth Minister for the Environment.

The development of education and extension material would be assisted by the involvement of the Team, which could also assess the potential for broader application of management methods or approaches developed through local management plans.

Information exchange in relation to *P. cinnamomi* has been largely the domain of research scientists, although there have been numerous conferences and workshops arranged by academic and research institutions. Less formal information exchange between land managers has developed in recent years, encouraged by the collaborative effort to develop this Plan and involving exchange visits for training and technology transfer between a number of States, especially South Australia, Tasmania and Western Australia.

It is important for the Team and Environment Australia to ensure that progress on implementation of the Plan continues and reviews of the implementation process are undertaken regularly during the next five-year period. It is also important that feedback is received from the regional and local areas on how their implementation processes are proceeding.

5. Actions

c. Environment Australia will convene a *P. cinnamomi* Threat Abatement Plan Implementation Team (the Team), that include people with technical and practical experience in *P. cinnamomi* management and research, to advise the Commonwealth Minister for the Environment on implementation of this Plan.

d. To ensure that clear lines of communication are established that promote and manage best practice in on-ground actions, the Team will establish clear link with State-based *P. cinnamomi* Threat Abatement Teams (or their equivalent) and with relevant regional and local bodies which are responsible for management of *P. cinnamomi*.

e. Before the term of the Plan expires an independent review will be commissioned to conduct a comprehensive evaluation of progress made in the Plan's implementation.

f. The Team will develop State of the Environment reporting indicators.

g. In relation to Objective 4, Action 4 b, the Team will oversee the development of a uniform preamble to the guidelines for use by all relevant industries and parties committed to developing codes of practice.

Environment Australia will convene the *P. cinnamomi* Threat Abatement Plan Implementation Team and provide it with secretariat support. The cost of evaluating the implementation of the Threat Abatement Plan will be met from the Endangered Species Program.

Performance Indicators and Milestones

The actions listed under objectives 1 to 5 will be addressed in the following manner:

Stage 1 (Strategic Planning and Priority Setting)

- 1. *P. cinnamomi* Threat Abatement Plan Implementation Team (the Team) will be established within 6 months of the Plans adoption.
- 2. State *P. cinnamomi* Threat Abatement Team equivalents will be established within 3 months of the Team being finalised.
- The Team will review and identify gaps in research and make recommendations on priorities.
- State *P. cinnamomi* Threat Abatement Teams will develop and implement training programs for use in susceptible areas of high conservation value.
- State *P. cinnamomi* Threat Abatement Teams will identify and recommend to the Team possible research priorities.
- The Team will determine the level of community awareness and attitudes towards *P. cinnamomi* management.
- State *P. cinnamomi* Threat Abatement Teams will develop general guidelines that (these may form part of State/Territory land use permit conditions) which lead to the development of codes of practice. It is important that interstate co-operation is achieved in this process.
- States/Territories to develop regional strategic plans, including identification of all key protectable *P. cinnamomi* areas for each State/Territory.
- States and Territories will have identified all threatened species and ecological communities for which *P. cinnamomi* is a major threat, including
  - habitats which are conducive to the development of diseases caused by *P. cinnamomi*.
  - areas of high conservation value where *P. cinnamomi* is a threat.
- Environment Australia to establish a web site for public access to the Plan, including:
  - a glossary of nationally agreed terminology.
  - access to relevant research papers and information on *P. cinnamomi*.
- 3. Agreement reached on prioritising the implementation of the Plan.

- In each State or Territory where *P. cinnamomi* is a problem, there will be public recognition of the importance of reducing the risk of accidentally introducing *P. cinnamomi* into native bushland through contaminated nursery stock used for restoration and revegetation. To manage the risk of spreading *P. cinnamomi* via contaminated nursery stock each State or Territory will have produced guidelines for propagating disease-free plants.

- Establish long-term monitoring on sites which are broadly representative of structural and floristic ecological communities threatened by *P. cinnamomi* to determine impact of *P. cinnamomi*.

Stage 2 (Implementation – on ground actions)

- Research programs in place and national priorities have been set in relation to threatened species and ecological communities.

- States/Territories to finalise development of strategic plans, including mapping location of high-risk sites and areas of high conservation value.

- Engage with researchers in relevant organisations and encourage better collaboration in addressing aspects of the biology of *P. cinnamomi* and control of disease.

- A community education program is developed at State level for the implementation and adoption at regional and local levels. Regional and local levels are able to include additional material that covers specific issues or concerns that are relevant to their area.

- Training programs for operators/managers are developed. A number of high risk industries have a voluntary code of practice in place.

- Increased awareness by land managers and the community of early warning and monitoring systems.

- Development of monitoring programs to be operated at State/Regional level which measure the success of management plans to protect threatened species/ecological communities.

- Development of local management plans addressing the strategic priorities and areas identified in regional plans.

- Hygiene and quarantine procedures to be developed and implemented.

Stage 3 (Indicators reporting on the effectiveness of actions implemented in Stage 2.)

- Evaluate outcomes of projects funded at Stage 1 and 2, including transfer of information to land managers and other researchers.
- Monitor and assess changes in community awareness and attitude.
- Similarly review user groups.
- Implement training programs for operators/managers:
  - monitor and assess number of people trained and which industries.
  - number of high risk industries which have developed and implemented voluntary codes of practice.
- Monitor and assess degree of adoption of codes of practice and reduction in contamination by local councils and similar bodies (these organisations need to be targeted to encourage compliance).
- Impact management plans established and reviewed.
- State and regional monitoring programs will have been implemented.
- Assess whether management measures have been effective
  - learn from successes and failures to revise procedures (ongoing).
- Range of innovative management measures have been tested.
- *P. cinnamomi* indicators are reported in "State of the Environment" report.
- No new listing or upgrading of threat status for species or ecological communities threatened by *P. cinnamomi*.
- majority of high conservation value areas that were free of *P. cinnamomi* at the commencement of the Plan remain free of *P. cinnamomi* (ongoing).

6 EVALUATION AND REVIEW

Section 279 of the *Environment Protection and Biodiversity Conservation Act 1999* provides for a review of the plan at anytime and requires that a threat abatement plan is reviewed at intervals of no longer than 5 years.

> Variation of plans by the Minister
>
> (1) The Minister may, at any time, review a recovery plan or threat abatement plan that has been made or adopted under this Subdivision and consider whether a variation of it is necessary.
>
> (2) Each plan must be reviewed by the Minister at intervals of not longer than 5 years.
>
> (3) If the Minister considers that a variation of a plan is necessary, the Minister may, subject to subsections (4), (5), (6) and (7), vary the plan.
>
> (4) The Minister must not vary a plan, unless the plan, as so varied, continues to meet the requirements of section 270 or 271, as the case requires.
>
> (5) Before varying a plan, the Minister must obtain and consider advice from the Scientific Committee on the content of the variation.
>
> (6) If the Minister has made a plan jointly with, or adopted a plan that has been made by, a State or self-governing Territory, or an agency of a State or self-governing Territory, the Minister must seek the co-operation of that State or Territory, or that agency, with a view to varying the plan.
>
> (7) Sections 275, 276 and 278 apply to the variation of a plan in the same way that those sections apply to the making of a recovery plan or threat abatement plan.

As specified in the actions relating to Objective 5, a *Phytophthora cinnamomi* Threat Abatement Plan Implementation Team will be established to advise on the implementation of the plan. The Team will include people with technical and practical experience in *Phytophthora cinnamomi* management and research. Environment Australia will provide a convenor and act as the secretariat for the Team**.** The Team will monitor achievements of the performance criteria and milestones set out in the plan and provide regular annual reports on progress.

The Act provides for a review of the threat abatement plan at any time at the discretion of the Minister. Environment Australia will recommend to the Minister that a revision of the plan is warranted if evidence is found that a *Phytophthora cinnamomi* control technique recommended in this plan is resulting in adverse impacts on a native species or ecological community such that the species or ecological community is becoming endangered.

Before the end of the five-year life of the plan an independent expert will be commissioned to examine the plan and the supporting technical documents, and the success or otherwise of management actions undertaken. Recommendations from the review will then be used to prepare another threat abatement plan for the next five year phase.

GLOSSARY

Critical habitat	as defined in the EPBC Act
Ecological community	as defined in the EPBC Act
Endangered species	as defined in and listed under the EPBC Act
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth legislation)
High conservation value	Areas that are free of *P. cinnamomi* and contain threatened species or ecological communities or those species and ecological communities at imminent risk of becoming threatened, but have habitats that are environmentally suitable for the pathogen's establishment.
High risk	Activities, eg road construction, that can lead to the spread of *P. cinnamomi* or exacerbate areas already contaminated.
IUCN	International Union Conservation Network.
IUCN categories	as defined in the EPBC Act.
Land Managers	Include, but are not exclusive to field staff of government agencies such as forestry, conservation and parks; local government; and industries such as horticulture and agriculture; property and land owners and lessees.
Local management plan	A Plan that prescribes actions and policies for the protection from, or management of, *P. cinnamomi* within a specific local area. They may be incorporated into existing planning instruments such as Park Management Plans or Recovery Plans or may be a separate Phytophthora control plan.
Threatened species	Refers to a list of threatened native species divided into the following categories as per the EPBC Act: critically endangered; endangered; vulnerable; conservation dependent.
Threatened ecological communities	Refers to a list of threatened ecological communities divided into the following categories as per the EPBC Act: critically endangered; endangered; vulnerable.

Regional management plan	A strategic document that details species and ecological communities that are currently under threat or potentially under threat and the areas and high level actions required to manage those threats.
The Team	The Commonwealth *Phytophthora cinnamomi* Threat Abatement Plan Implementation Team
Vulnerable species	as defined in and listed under the EPBC Act

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APPENDIX A RELEVANT EXTRACTS FROM THE *ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999*

SECT 271
Content of threat abatement plans

(1) A threat abatement plan must provide for the research, management and other actions necessary to reduce the key threatening process concerned to an acceptable level in order to maximise the chances of the long-term survival in nature of native species and ecological communities affected by the process.

(2) In particular, a threat abatement plan must:

(a) state the objectives to be achieved; and

(b) state criteria against which achievement of the objectives is to be measured; and

(c) specify the actions needed to achieve the objectives; and

(d) state the estimated duration and cost of the threat abatement process; and

(e) identify organisations or persons who will be involved in evaluating the performance of the threat abatement plan; and

(f) specify any major ecological matters (other than the species or communities threatened by the key threatening process that is the subject of the plan) that will be affected by the plan's implementation; and

(f) meet prescribed criteria (if any) and contain provisions of a prescribed kind (if any).

(3) In making a threat abatement plan, regard must be had to:

(a) the objects of this Act; and

(b) the most efficient and effective use of the resources that are allocated for the conservation of species and ecological communities; and

(c) minimising any significant adverse social and economic impacts consistently with the principles of ecologically sustainable development; and

(d) meeting Australia's obligations under international agreements between Australia and one or more countries relevant to the species or ecological community threatened by the key threatening process that is the subject of the plan; and

(e) the role and interests of indigenous people in the conservation of Australia's biodiversity.

SECT 274
Scientific Committee to advise on plans

(1) The Minister must obtain and consider the advice of the Scientific Committee on:

(a) the content of recovery and threat abatement plans; and

(b) the times within which, and the order in which, such plans should be made.

(2) In giving advice about a recovery plan, the Scientific Committee must take into account the following matters:

(a) the degree of threat to the survival in nature of the species or ecological community in question;

(b) the potential for the species or community to recover;

(c) the genetic distinctiveness of the species or community;

(d) the importance of the species or community to the ecosystem;

(e) the value to humanity of the species or community;

(f) the efficient and effective use of the resources allocated to the conservation of species and ecological communities.

(3) In giving advice about a threat abatement plan, the Scientific Committee must take into account the following matters:

(a) the degree of threat that the key threatening process in question poses to the survival in nature of species and ecological communities;

(b) the potential of species and ecological communities so threatened to recover;

(c) the efficient and effective use of the resources allocated to the conservation of species and ecological communities.

APPENDIX B
AN EXAMPLE OF THOSE SPECIES OF FLORA WHICH ARE NATIONALLY LISTED AS BEING THREATENED AND WHICH ARE SUSCEPTIBLE TO *PHYTOPHTHORA CINNAMOMI*. THE LIST IS NOT INCLUSIVE, IT IS PROVIDED TO INDICATE THE RANGE OF SPECIES THAT ARE AT RISK.

Western Australia

Species	Priority code	WA Ranking	C'wealth ranking	CALM Region	CALM District	Phytophthora Threat
Adenanthos x cunninghamii	R	EN	V	SC	Al	T
Adenanthos dobagii	R	CR	V*	SC	Al	T
Andersonia axilliflora	R	CR	*	SC	Al	T
Andersonia sp. Two Peoples Bay (G Keighery 8229)	R	EN	E*	SC	Al	T
Banksia brownii	R	EN	E*	SC	Al	T
Banksia cuneata	R	CR	V*	WB	Na	T
Banksia verticillata	R	VU	V	SC,SF	Al,Wl	T
Brachysema papilio ms	R	CR	*	CF	Bu	T
Darwinia collina	R	EN	V	SC	Al	T
Darwinia macrostegia	R	VU	V	SC	Al	T
Darwinia meeboldii	R	VU	V	SC	Al	T
Darwinia oxylepis	R	CR	V*	SC	Al	T
Darwinia sp. Stirling Range (GJ Keighery 5732)	R	VU	V	SC	Al	T
Darwinia squarrose	R	VU	V	SC	Al	T
Darwinia wittwerorum	R	EN	V*	SC	Al	T
Daviesia megacalyx	R	EN	V	SC	Al	T
Daviesia pseudaphylla	R	EN	V*	SC	Al	T
Dryandra anatona	R	EN	*	SC	Al	T
Dryandra montana	R	CR	E	SC	Al	T
Dryandra nivea ssp. Uliginosa	R	EN	*	CF	Bu	T
Dryandra serratuloides ssp. perissa	R	EN	V	MW	Mo	T
Dryandra serratuloides ssp. serratuloides	R	VU	V	MW	Mo,	T
Dryandra squarrosa ssp. argillacea	R	VU	*	CF	Bu	T
Isopogon uncinatus	R	CR	E	SC	Al	T
Lambertia echinata ssp. echinate	R	CR	E	SC	Es	T
Lambertia echinata ssp. occidentalis	R	CR	*	CF	Bu	T
Lambertia fairallii	R	EN	E*	SC	Al	T
Lambertia orbifolia	R	EN	E*	SC,CF	Al,Bu	T
Adenanthos pungens ssp. Effusus	R	CR	E	WB	Kt	T
Adenanthos pungens ssp. Pungens	R	VU	E*	WB,SC	Kt,Al	T
Acacia rhamphophylla ms	R	EN	*	SC	Al	PT
Adenanthos eyrie	R	EN	V	SC	Es	PT
Adenanthos velutinus	R	EN	E*	WB	Kt	PT
Banksia goodii	R	VU	V	SC	Al	PT
Banksia oligantha	R	EN	V	WB	Kt	PT
Boronia revolute	R	EN	V*	WB,SC	Na,Es	PT

Brachysema modestum ms	R	VU	*	CF	Bu	PT
Calytrix breviseta subsp. Breviseta	R	CR	E	SW	Pe	PT
Conospermum densiflorum subsp. unicephalatum	R	EN	*	MW,SW	Pe,Mo	PT
Conospermum undulatum	R	VU	*	SW	Pe	PT
Darwinia acerose	R	EN	V*	MW,SW	Mo	PT
Darwinia apiculate	R	EN	E*	SW		PT
Darwinia ferricola ms	R	EN	E*	CF		PT
Darwinia masonii	R	VU	V	MW	Ge	PT
Darwinia sp. Williamson (GJ Keighery 12717) [aff. apiculata]	R	CR	*	CF	Bu	PT
Drummondita hassellii var. longifolia	R	VU	V	SC	Es	PT
Dryandra aurantia	R	EN	*	SW	Mu	PT
Dryandra ionthocarpa	R	CR	E	SC	Al	PT
Grevillea elongata	R	CR	*	CF	Bu	PT
Grevillea maccutcheonii	R	CR	*	CF	Bu	PT
Grevillea maxwellii	R	CR	*	SC	Al	PT
Hakea megalosperma	R	VU	V	MW	Mo	PT
Kunzea pauciflora	R	VU	*	SC	Al	PT
Leucopogon gnaphalioides	R	CR	*	SC	Al	PT
Persoonia micranthera	R	CR	*	SC	Al	PT
Petrophile latericola ms	R	CR	*	CF	Bu	PT
Sphenotoma drummondii	R	CR	*	SC,SF	Al,Wl	PT
Stylidium galioides	R	VU	V	SC	Al	PT
Symonanthus bancrofti	R	CR	*	WB	Na	PT
Verticordia carinata	R	VU	*	SC	Al	PT
Verticordia crebra	R	VU	V	SC	Al	PT
Verticordia densiflora var. pedunculata	R	EN	*	CF,SF	Bu,Ma	PT
Verticordia fimbrilepis ssp. australis	R	EN	E*	SC,SF	Al,Wl	PT
Verticordia harveyi	R	EN	E	SC	Al	PT
Verticordia helichrysantha	R	VU	V	SC	Al	PT
Verticordia pityrhops	R	EN	*	SC	Al	PT
Verticordia plumosa var. ananeotes	R	CR	E*	CF,(SW)	Bu	PT
Verticordia plumosa var. vassensis	R	EN	*	CF	Bu	PT
Xyris sp. Stirling Range (GJ Keighery 7951)	R	VU	V	SC	Al	PT

T - Known to be threatened	31
PT - Possibly threatened	39

Taxa known to be threatened are - known to be highly susceptible to Phytophthora and occur in areas which are climatically favourable to the pathogen or - are killed in areas where Phytophthora is known to be present and is asociated with death in other species.
Taxa possibly threatened are - thought to be susceptible and occur in areas which are climatically favourable to the pathogen.
Taxa not threatened are - known to be resistant
- found in areas which are not climatically favourable to Phytophthora and the pathogen is not known to occur

South Australia

Species listed under the EPBC Act 1999 that occur in habitats likely to be affected by *Phytophthora cinnamomi*.

Acacia whibleyana
Caladenia argocalla
Caladenia brumalis
Caladenia colorata
Caladenia formosa
Caladenia gladiolata
Caladenia ovata
Caladenia rigida
Caladenia woolcockiorum
Caladenia xantholeuca
Corybas dentatus
Beyeria subtecta
Olearia microdisca
Olearia pannosa ssp. pannosa
Prasophyllum frenchii
Prasophyllum pallidum
Prasophyllum validum
Pterostylis bryophila
Pterostylis cucullata
Pterostylis sp. Hale (R.Bates 21725*)*
Pterostylis tenuissima
Pterostylis uliginosa
Ptilotus beckerianus
Pultenaea trichophylla
Thelymitra epipactoides
Thelymitra matthewsii

New South Wales

Nationally Endangered Species for which *Phytophthora cinnamomi* is a known or perceived threat.

Eucalyptus imlayensis	Imlay mallee
Genoplesium rhyoliticum	Rhyolite midge orchid
Prostanthera askania	Strickland mint-bush
Prostanthera junonis	Somersby mint-bush
Wollemia nobilis	Wollemi Pine

Victoria

Taxa which are considered rare or poorly known in Australia and which are known to be susceptible to *Phytophthora cinnamomi*.

Glycine latrobeana	
Grevillea repens	Creeping grevillea
Grevillea steiglitziana	Brisbane Ranges grevillea
Olearia pannosa ssp. cardiophylla	Velvet daisy-bush
Pultenaea gunnii ssp. Tuberculata	Golden bush-pea
Pultenaea weindorferi	Swamp bush-pea

Tasmania

Lomatia tasmanica

Table 1
Projects funded by the Commonwealth

Application Title	State	Organisation Name	Funding Year	Fund Amt
Phytophthora sp. impact on native flora and fauna	VIC	University of Melbourne	1989/1990	$30,000.00
			TOTAL	**$30,000.00**
Phytophthora cinnamomi public education program	TAS	Dept. of Parks, Wildlife and Wildlife	1991/1992	$30,000.00
			TOTAL	**$30,000.00**
Phytophthora threatened plants research	TAS	Forestry Tasmania	1991/1992	$30,000.00
			1992/1993	$44,170.00
			1993/1994	$25,488.00
			1994/1995	$1,500.00
			TOTAL	**$101,158.00**
Survey for rare & endangered plants in areas secure from P. c.	TAS	Forestry Tasmania	1994/1995	$33,108.00
			1995/1996	$67,008.00
			TOTAL	**$100,116.00**
Phytophthora and Diplodina canker control in WA	WA	Dept. of Conservation and Land Management	1991/1992	$440,000.00
			1992/1993	$460,000.00
			1993/1994	$470,000.00
			1994/1995	$500,000.00
			1995/1996	$500,000.00
			TOTAL	**$2,370,000.00**
Towards cryopreservation of rare and endangered Australian plants	WA	Kings Park and Botanic Garden	1992/1993	$7,500.00
			1993/1994	$15,000.00
			1994/1995	$49,000.00
			TOTAL	**$71,500.00**
Phytophthora and Diplodina canker control in WA, Phase 2	WA	Dept. of Conservation and Land Management	1996/1997	$500,000.00
			TOTAL	**$500,000.00**
Phytophthora in South Australia: effective management	SA	National Parks Foundation of South Australia Inc	1998/1999	$34,000.00
			TOTAL	**$34,000.00**
Conservation of Tasmanian Plant Communities Threatened by P. c.	TAS	Dept. of Primary Industries, Water and Environment	1999/2000	$91,500.00
			TOTAL	**$91,500.00**
Optimising Phosphite Prescriptions for Protection of Threatened Communities from P. c.	WA	Dept. of Conservation and Land Management	2000/2001	$62,400.00
			TOTAL	**$62,400.00**
			GRAND TOTAL	**$3,390,674.00**

Dieback caused by the root-rot fungus *Phytophthora cinnamomi*