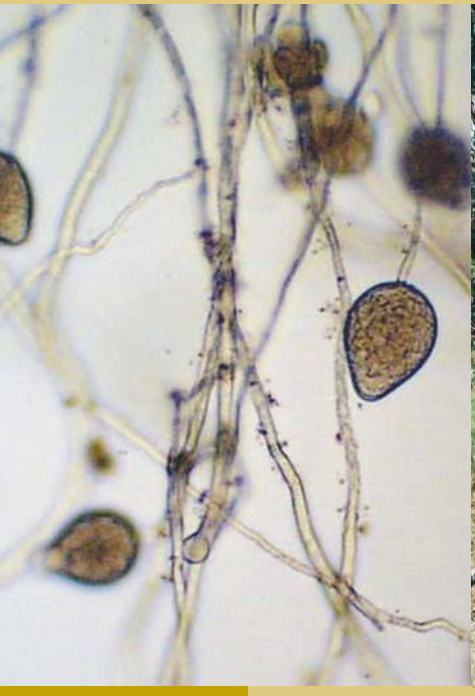
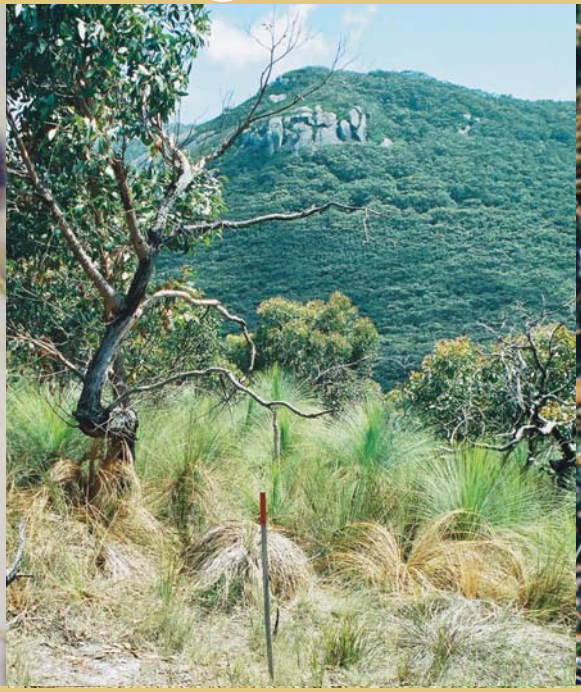
Department of Sustainability and Environment

Victoria's Public Land *Phytophthora cinnamomi* Management Strategy





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Victoria's Public Land *Phytophthora cinnamomi* Management Strategy

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Acknowledgments

The Department of Sustainability and Environment (DSE) acknowledges those field staff and researchers whose efforts have achieved the formal recognition of *Phytophthora cinnamomi* as a national and state threat and contributed the knowledge upon which this Strategy is based (see References).

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Image of *Phytophthora cinnamomi* showing vegetative (hyphae) and reproductive (sporangia) structures. Image courtesy of Ian Smith.

Invasion front of *Phytophthora cinnamomi* in Heathy Woodland at Wilsons Promontory. Photograph courtesy of David Cahill.

The Ground Parrot (*Pezoporus wallicus*), a threatened species that lives in coastal heathlands across Victoria which include many plant species susceptible to *Phytophthora cinnamomi*. Photo: © Len Robinson/Viridans Images

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Minister's foreword

Phytophthora cinnamomi, or Cinnamon Fungus as it was once commonly referred to, is a plant disease that has established itself in Australia, including many regions of Victoria. It attacks native plants through the root system often causing the plant's death and having far reaching consequences for our unique and fragile natural environment.

This pathogen can change the way our ecosystem functions, especially affecting animal species that are dependent on native vegetation.

The impacts of *Phytophthora cinnamomi* have been formally recognised under both State and Federal legislation.

This Strategy contributes to the national effort to combat this disease. The Strategy seeks to explain the scope of the problem and how the Victorian Department of Sustainability and Environment and related agencies can manage this issue.

While the pathogen has established itself in many locations there remain many areas that are uninfected. With investment and effort, there is still much we can do to protect our native flora and fauna.

I encourage all agencies, non-government sectors and the general public to support the implementation of this Strategy and commit the resources necessary to reduce the impacts of *Phytophthora cinnamomi* on our natural environment. Victoria is a unique and wonderful state and we can all work together to keep it that way.

Gavin Jennings MLC
Minister for Environment and Climate Change

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Summary

Phytophthora cinnamomi is an introduced water mould that attacks the root systems of susceptible native plants thereby threatening some plant species, the ecosystems of which they form part and the animals that depend on them.

There is considerable variation in the susceptibility to *Phytophthora cinnamomi* within and between various plant species, and thus plant communities.

The requirement for public land managers to address the threat of *Phytophthora cinnamomi* is provided by both State and National legislation and government policy.

This Strategy sets out the objectives, management principles, priorities, legislation and proposed management approaches for protecting biodiversity from this significant threat.

The pathogen is widely dispersed within Victoria and there is as yet no means of eradicating it in the field, so the primary focus of this Strategy is on protecting important biodiversity and other assets on public land.

The specific objectives of managing *Phytophthora cinnamomi* in Victoria are:

- to protect susceptible biodiversity, with a particular focus on the structure and function of vulnerable ecosystems and threatened species;
- to protect social and economic assets on public land that are at risk;
- to assist in reducing the potential for transmission of the pathogen from public land to other jurisdictions (interstate, industry, community), and;
- to assist agency staff and the wider community to protect their public land by managing this significant threat.

The Strategy sets out 15 actions to achieve these objectives including improved coordination between agencies, integrated planning with a focus on areas at risk, management procedures, communication and community engagement including education and training.

About this Strategy

This Strategy aims to:

- Provide an overview of the threat and management issues relating to the root rot disease *Phytophthora cinnamomi*, leading to improved understanding of the problem;
- Provide a management framework that effectively addresses the risk from *Phytophthora cinnamomi* to biodiversity as well as socio-economic assets on public land;
- Improve consistency and coordination amongst agencies; and,
- Support agencies and the wider community to manage *Phytophthora cinnamomi*.

This Strategy is primarily aimed at public land managers and organisations involved in public land management. Public land managers are required to address this significant issue under both State and National legislation and government policy.

Phytophthora cinnamomi also poses a threat to biodiversity on private land, to the nursery industry, to tourism (through changing visual amenity), to roadside management and other values. While outside the scope of this Strategy, it is anticipated that this wider audience can benefit from its contents by adopting the principles and management actions outlined, and take steps to address the issues identified within.

It is expected that this Strategy will provide a useful template for management of other pathogens, including other species of *Phytophthora*.

The Australian Government's Department of Environment and Water Resources provided the initial funding for development of this Strategy as well as similar plans in other affected regions of Australia.

This Strategy is the final version of the previous 'Draft Strategic Plan for the Management of *Phytophthora cinnamomi* in Victoria' released in 2005.

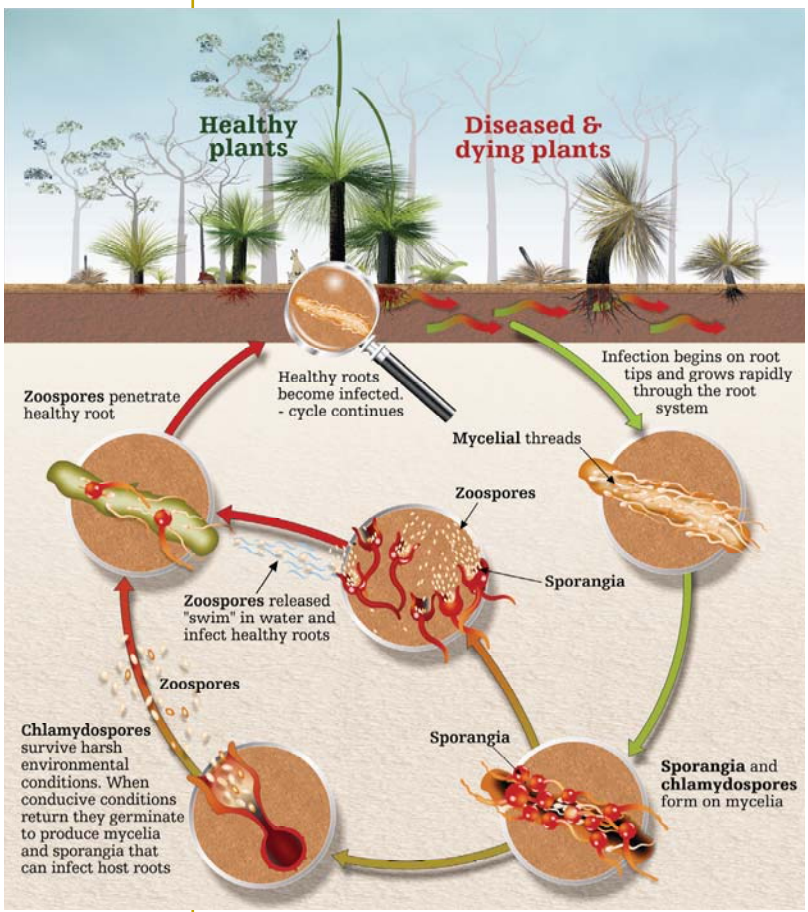
About the pathogen

Introduction

Phytophthora cinnamomi is an introduced water mould, a microscopic organism previously classified as a fungus. The scientific name *Phytophthora* (pronounced fy-TOFF-thor-ah) is derived from the Greek words meaning 'plant destroyer'. The pathogen was identified as the cause of death of cinnamon trees in Sumatra in 1922[1]; hence its former common name 'Cinnamon Fungus'. The genus *Phytophthora* includes a number of serious pathogens including *Phytophthora infestans*, the cause of the potato famine in Ireland in the 1840s.

Based on historical evidence of agricultural impacts in the 1800s, the pathogen is believed to have been brought into Australia by early European settlers, presumably within infected plants[2]. First detected in Australia in 1935, *P. cinnamomi* has since been introduced to many locations across the Australian continent. It has contaminated thousands of hectares in Western Australia, Victoria, Tasmania and South Australia, as well as wet coastal forests in Queensland. Rainfall, temperature and soil characteristics (type and structure) have influenced the geographic distribution of *P. cinnamomi*.

Conditions for growth and reproduction



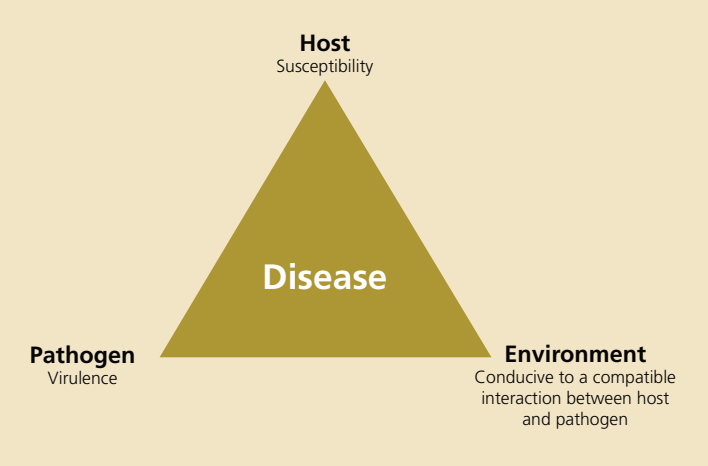
Infection of plants by *P. cinnamomi* is favoured by free water in the soil or ponding on the soil surface. Warm wet soils, especially those with impeded drainage, favour the germination of *P. cinnamomi* chlamydospores (spores that enable the pathogen to survive in an area during harsh environmental conditions). These spores also provide for long distance spread should contaminated soil or dead plant material be moved.

As the roots of the infected plant die, long-lived resistant chlamydospores are produced again. This provides a source for future re-infection of seedlings in the area (Figure 1).

Figure 1: Lifecycle of *Phytophthora cinnamomi*.
Image courtesy of WWF – Australia and the Western Australian Dieback Working Group.

1 Weste, G. (1998)
2 Marks, G.C. and Smith, I.W. (1991)

Figure 2: The disease triangle.



Local and seasonal variations in environmental conditions influence the virulence of *P. cinnamomi*. For instance, if environmental conditions for *P. cinnamomi* are not optimal, despite its presence, it may not be active. The interplay between these factors is often portrayed as the 'disease triangle' (Figure 2).[3]

Soil conditions that affect *P. cinnamomi* include moisture, temperature, structure, chemistry and organic matter content. Soil moisture levels and temperatures significantly influence the activity of *P. cinnamomi*. Temperatures between 15 and 36 degrees Celsius (optimum 24–28°C) and high soil moisture levels (e.g. following rain in spring and summer) favour the production of free swimming spores and increase their potential for infection and spread downhill. On the other hand, high organic matter content provides for increased micro-organisms which may compete with and prey upon *P. cinnamomi*.

Where environmental conditions for infection are favourable to *P. cinnamomi*, its impact is also a function of a plant's susceptibility and the environmental stresses on the host. Plants with damaged roots will naturally succumb more rapidly, especially with greater sun exposure[4].

Mountain Ash (*Eucalyptus regnans*), one of Victoria's more important timber trees, is susceptible to the pathogen. However, the combination of cold winters, dry summers and high organic matter in the soil act to safeguard these plants.

Mode of infection, dieback and epidemics

Chlamydospores germinate to produce sporangia that release motile spores (zoospores). Zoospores are able to locate and attach to root tips after which they give rise to fine filamentous threads (hyphae) that may invade the roots. Plants invaded by the pathogen are said to be hosts.

However, there is variation in the response of hosts to the pathogen. Some hosts may show no obvious symptoms due to the ability to curtail spread of the pathogen within their tissue. Such plants are said to have low susceptibility. In highly susceptible host species *P. cinnamomi* hyphae spread throughout the root system until they girdle the major roots and stems. Death of the plant's vascular tissue[5] impedes the ability to absorb nutrients and water. This leads to symptoms in some larger plants likened to drought stress, called 'dieback', whereby the outermost parts yellow and die first.

The expression of dieback has been mostly limited to Ash species [e.g. Silvertop Ash (*Eucalyptus sieberi*)] and stringybark species of low timber productivity coastal forest in east and south Gippsland. Warm wet summers that favour *P. cinnamomi*, followed by warm dry autumns that water-stress plants, has led to epidemic outbreaks in these forests. These events tend to be cyclic[6].

3 Brown, J.F. and Ogle, H.J. (1997)
4 Wilson et al. (2003)
5 Laidlaw, W.S. and Wilson, B.A. (2003)
6 Tregonning, K.C. and Fagg, P.C. (1985)

Identification

P. cinnamomi can be isolated from soil by placing a soil sample in a container, flooding it with water and adding susceptible plant parts as bait, either partly submerged in the water or floated on the surface. Common baits used in Victoria include pear, cotyledons of Silvertop Ash (*Eucalyptus sieberi*) or roots of Lupins (*Lupinus* spp).

If zoospores of the pathogen are present they will attack the bait resulting in a change in colour of the tissue (cotyledons) or a water-soaked appearance of the pear. The infected material is then plated onto selective agar for identification by either morphological methods or, more recently, by molecular DNA tests. Roots of infected plants may also be directly plated onto selective agars.

The baiting technique is very sensitive to the presence of the pathogen in a soil sample. However, low population levels of the pathogen can result in absence from the sample. To enhance the detection of the pathogen, sampling should be carried out when soil moisture and temperature are at optimal conditions (i.e. following heavy rain in summer). In some cases detection can be enhanced through a wetting and drying cycle between baiting events.

In the field, in vegetation communities where most of the dominant plants are resistant to *P. cinnamomi*, infection is characterised by the loss of minor floral components. This often makes it difficult to define the boundary between contaminated and uncontaminated areas. In communities like heathlands that feature a high proportion of susceptible plants, the visual impact and boundary definition of *P. cinnamomi* is most stark to a casual observer at the time of an outbreak when susceptible flora dies. After the event, should trees survive, the impact is not often evident to the untrained eye because the susceptible understorey plants are replaced with other plants, most commonly sedges.

Field diagnosis is also made difficult as the symptoms of dieback may be caused by other environmental factors or biological agents.

Figure 3: Invasion front of *Phytophthora cinnamomi* in Heathy Woodland at Wilsons Promontory.

Photo: David Cahill

Foreground shows degradation of the heathy woodland. Intact vegetation shown in background.

Dispersal

P. cinnamomi is primarily spread through movement of water, soil and plant material. This may occur through human activities or natural means.

Humans are the main cause of *P. cinnamomi* spread across the landscape. The major pathways of *P. cinnamomi* spread include transfer of infected[7] plants or contaminated soil. A list of human activities at risk of spreading *P. cinnamomi* is included as Appendix 1 (p 29).

The global spread of *P. cinnamomi* has mainly been attributed to the plant trade. *P. cinnamomi* was first detected in Australia in Willow trees (*Salix* spp.), used to make cricket bats, in Melbourne in 1935. In 1965, it was recognised as the cause of dieback of Jarrah trees (*Eucalyptus marginata*) in Western Australia. In 1969, it was identified as the cause of dieback of native forests in East Gippsland[8] and of woodlands in the Brisbane Ranges[9], 75 km west of Melbourne.

Nursery and garden-derived plants infected with *P. cinnamomi* potentially pose a threat to biodiversity through revegetation and landscaping activities in natural settings. Plant nurseries that have inadequate hygiene procedures and some community-based nurseries may unwittingly harbour diseased plants. These plants may not show symptoms either because they are not susceptible or because plant husbandry practices mask the presence of the pathogen. Such practices include temporary suppression with fungicides, temporarily induced plant resistance with other chemicals or provision of additional shade and water to help plants survive.

The commercial use of contaminated soil from gravel pits for road works and other construction may also lead to dispersal.

The unintentional movement of contaminated plants, soil and water also poses a threat. Long distance vectors include unclean vehicles or machinery used for earthmoving (e.g. road construction, mining, pipeline and cable laying, forestry and fire fighting activities[10]). Use of contaminated water for fire fighting and other activities is another potential pathway.

Footwear holding infected soil can also lead to long distance dispersal in association with human movement (e.g. bushwalking) or vehicle movement (e.g. soil deposited in the foot area of vehicle cabins).

Once introduced to an area, *P. cinnamomi* may spread due to human activities such as bushwalking, horse riding, trail bike and other vehicle movement. Illegal harvesting of the foliage of Austral Grass-tree (*Xanthorrhoea australis*) has also contributed to its spread.

The movement of native and domestic animals is also believed to disperse the pathogen. Chlamydospores may be dispersed in minute quantities of soil by animals digging or browsing. There is also a suggestion that *P. cinnamomi* may survive in the gut of some animals if ingested[11].

The potential for successful dispersal is a function of the amount of *P. cinnamomi* in the soil and weather and soil conditions at the location where the soil is dislodged.

7 See definition in glossary

8 Marks et al. (1972)

9 Marks, G.C. and Smith, I.W. (1991)

10 A bulldozer used to put in a firebreak is believed to have introduced the pathogen to one of Victoria's most iconic areas, Wilsons Promontory, in the early 1970's [Bluett et al. (2003)]. Heathland with majestic Austral Grass-trees have been eliminated from roadside patches in key vistas. The pathogen poses increasing on-going management problems as it spreads further.

11 Schahinger et al. (2003)

Spread at a location

Once introduced to an area, *P. cinnamomi* may spread via motile spores (zoospores) travelling through gaps in soil that is very moist and well aerated. Such movement is relatively slow; however zoospore movement may be greatly aided by surface run-off and sub-surface water movement downhill. This can increase the down slope rate of movement from just a few metres to hundreds of metres per year.

P. cinnamomi can also move across slopes and uphill via root-to-root contact between infected and uninfected plants at an average of around one metre per year[12]. The time-scale for such natural spread may therefore range from a few years to many decades in some areas, depending upon the topography, vegetation susceptibility, soil type and climate. *P. cinnamomi* infections typically start from roadsides and tracks where infected soil is dislodged. From here the pathogen fans down gullies with water movement and slowly moves via root-to-root contact across and back up hill slopes.

Values at risk

Effect on flora

There is considerable variation in the susceptibility within and between various plant species and thus plant communities, to *P. cinnamomi*.

Plant species at risk

In general, herbaceous perennials, annuals and geophytes are more resistant to *P. cinnamomi* than woody perennials. The most susceptible plant families are the Proteaceae (*Grevillea* spp., *Hakea* spp. etc.), Fabaceae (peas), Dilleniaceae (*Hibbertia* spp., etc.) and Epacridaceae (heaths)[13].

However, there is variable susceptibility between genera of these families as well as between species of the same genera. Variation in susceptibility has also been observed between and within populations of the same species[14,15].

Plant communities at risk

Many highly susceptible species are structural dominants in the communities in which they occur. Heathlands and coastal forest communities are particularly susceptible to *P. cinnamomi*[16]. Thus infection of susceptible plants can pose a significant threat to ecosystem function in these areas by dramatically altering and reducing the species composition and structural form of the vegetation. This ultimately leads to changes in the faunal assemblage at a site[17].

P. cinnamomi may alter the composition of flora in a landscape from one where plant pollination is dominated by mammals, birds and insects to a landscape that is principally wind pollinated[18].

The overall impact on vegetation varies depending on the percentage and dominance of susceptible plants in a contaminated area and favourable environmental conditions.

12 Podger et al. (1996)
13 Weste, G. and Marks, G.C. (1987)
14 Shearer et al. (2004)
15 Harris et al. (1983)
16 Laidlaw, W.S. and Wilson, B.A. (2003)
17 Wilson et al. (2003)
18 Kennedy J., and Weste, G. (1986)

Plant communities at risk include – flora of dry sclerophyll forests on sandy and lateritic soils; Grampians lowland heath flora, especially *Pultenaea* and some *Xanthorrhoea* species; Brisbane Ranges flora, especially *Pultenaea* species; and sclerophyll communities of the eastern Otways.

Effect on fauna

A range of fauna is affected by *P. cinnamomi*-induced changes to vegetation, including small mammals, reptiles, birds and invertebrates. The extent of faunal effect depends upon the degree of alteration of a species' habitat[19]. Fauna are affected through the loss of shelter (cover, hollows) and food (nectar, pollen, seed and prey, particularly invertebrates) that follow from infection of plants in their habitat. The loss of keystone plants such as Austral Grass-trees (*Xanthorrhoea australis*) appears to have a significant impact on some fauna.

Although research on fauna effects of *P. cinnamomi* is rather limited, indications are that the effect is likely to be greatest on those specialist species that require relatively dense species-rich shrublands and have restricted diets.

A preliminary appraisal[20] has shown that 22 native mammal species, some classified as threatened, have more than 20% of their known distribution in *P. cinnamomi* diseased areas of Victoria.

Threatened mammal species likely to be significantly affected in areas heavily infected by *P. cinnamomi* are the New Holland Mouse (*Pseudomys novaehollandiae*), Smoky Mouse (*Pseudomys fumeus*), Heath Mouse (*Pseudomys shortridgei*), Long-nosed Potoroo (*Potorous tridactylus*), White-footed Dunnart (*Sminthopsis leucopus*) and Southern Brown Bandicoot (*Isoodon obesulus*).

Other threatened fauna likely to be affected includes the Ground Parrot (*Pezoporus wallicus*), Rufous Bristlebird (*Dasyornis broadbenti*), King Quail (*Coturnix chinensis*) and Diamond Python (*Morelia spilota spilota*).

Figure 4: Diamond Python (*Morelia spilota spilota*).

Photo: Ian McCann

Diamond Python is a threatened species dependent upon coastal vegetation that is susceptible to *Phytophthora cinnamomi*.

19 Wilson et al. (1994)
20 Laidlaw, W.S. (1997)

Long-term prognosis

Interpretation of the long-term effects of changes in plant dynamics is difficult given the long time spans associated with regrowth of slow growing species, such as the highly susceptible Austral Grass-tree, and the interplay with climatic changes occurring over several decades. This difficulty is exacerbated by the problem of accurately measuring the activity and amounts of *P. cinnamomi* in the soil.

Ecological studies at Wilsons Promontory[21] and the Brisbane Ranges have noted the return of some susceptible species following an infection event. An interpretation of this occurrence is that regeneration is from soil-stored seed whilst *P. cinnamomi* has effectively been dormant due to exceptionally dry seasons. This is supported by observations of the subsequent death of seedlings and young plants due to a resurgence of activity by *P. cinnamomi* when the weather pattern changes. Others have suggested the return of natural vegetation may be due to selection for resistance.

Long-term forest management research in coastal areas indicates a small percentage of individual trees within susceptible species (genotypes) are resistant to *P. cinnamomi* infection[22].

The percentage of susceptible vegetation observed regenerating in the Brisbane Ranges and at Wilsons Promontory that is resistant is unknown. Whilst the potential for selection and restocking with resistant trees appears to be effective in forest management, it is not known whether this may provide a long-term basis for managing other contaminated areas.

In situations where a serious risk of losing significant flora exists, *ex-situ* conservation may need to be employed.

21 Weste et al. (2004)
22 Marks, G.C., and Smith, I.W. (1991)

Potential geographic range of threat

The pathogen's current range is extensive although patchy, reflecting the influence of a range of factors including temperature, rainfall and soil types. In general, environments considered most conducive to the development of disease are those with temperate climates and rainfall that exceeds 600mm per year. However, the pathogen may thrive in sites with less annual rainfall that are prone to intermittent water logging and, hence, to incorporate most known infected sites, a more conservative 500mm rainfall isohyet has been used to establish risk areas for Victoria[23]. Other soil conditions, including abiotic and biotic factors, also influence the pathogen [see Conditions for growth and reproduction (p 3)].

A preliminary appraisal of the potential range and indicative threat of the pathogen is shown in Figure 5.

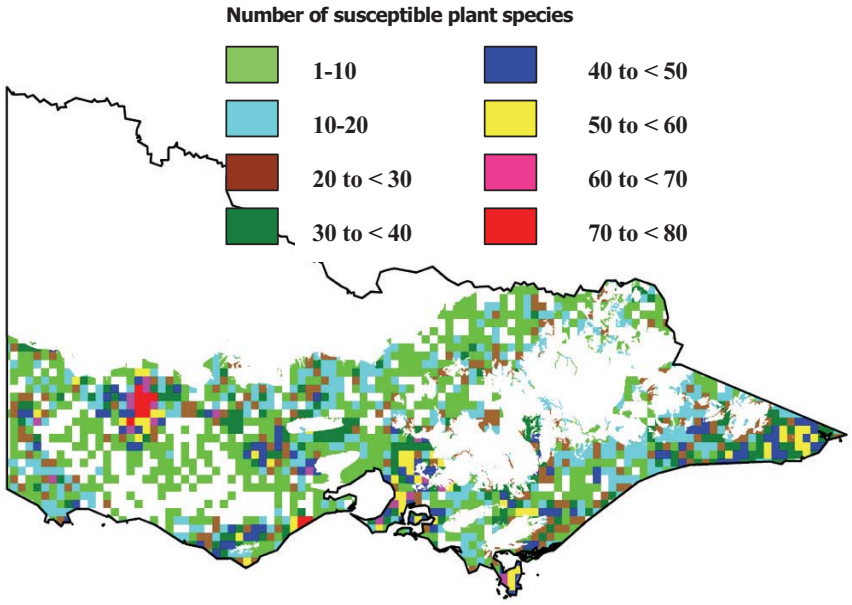


Figure 5: Potential range and indicative threat map for *Phytophthora cinnamomi* across Victoria. [24]

If climate change results in wetter summers and warmer winters, it may lead to a greater virulence of *P. cinnamomi* and potential expansion of its current range. This may create disease outbreaks in more mountainous areas of Victoria that are currently too cool for *P. cinnamomi* to survive or have a significant impact. For example, in the Central Highlands of Victoria the impact may be most noticeable for susceptible species, such as Mountain Ash (*Eucalyptus regnans*) and Shining Gum (*Eucalyptus nitens*), where they grow in flat areas with poor drainage. Climate change may also lead to greater effects in low altitude regions where conditions are currently too dry.

23 Gibson et al. (2002)

24 This map shows the approximate number of susceptible plant species per 5 minute grid cell within the most active range of the pathogen bounded by 500mm isohyets. The map has been compiled from climate and vegetation analysis undertaken by Ballarat University on behalf of Parks Victoria [Gibson et al. (2002)] and modified to reflect areas known to be conducive to the pathogen. It is based upon published research and DSE experience over the last 30 years. It should be noted that this is a generalised map and that some sites within and outside susceptible areas may express or suppress symptoms due to localised topographical features and other soil factors.

Management history

Victoria

Measures to protect State forest in Victoria were put in place in 1970 following the identification of *P. cinnamomi* as the cause of an epidemic outbreak in coastal forest ecosystems. Extensive precautionary hygiene measures were taken to minimise the risk of forestry vehicles transferring the pathogen to more productive forests in higher country[25]. However, application of the precautionary hygiene procedures was halted at higher altitudes after research showed that various site and environmental factors mitigate the pathogen's impact on otherwise susceptible plants [i.e. Mountain Ash (p 4)].

In less productive coastal forest of east and south Gippsland the pathogen was already widespread. Forest management instead shifted its focus to research on the selection for disease resistance amongst susceptible eucalypt species. There have been very real gains made over 30 years to restock sites in dieback affected forests in Victoria following the use of a strategy to exploit the potential that a small percentage of individuals of otherwise susceptible species may be resistant[26]. Sites have been successfully rehabilitated through the strategy of sowing well prepared seedbeds with high numbers of seeds collected from trees endemic to the sites. While the apparent resistance of those that survive is still to be proven, the outcome to date (after 30 years) is that the percentage that survive more than provides for an adequate stocking rate for eucalypts on these previously dieback-affected sites. Interpreting this issue is complicated as the stocking rate is high enough to potentially lower the water table and thus reduce conditions conducive to disease development. Appraising the apparent resistance is the subject of current research.

The Code of Practice for Timber Production[27], which is the key instrument for regulating commercial timber growing and timber harvesting operations, provides for hygiene controls should they be required.

Important work has been undertaken on public land by dedicated researchers[28] and field staff of government agencies. Notable examples are the collaborative efforts by Parks Victoria staff with Melbourne and Deakin University researchers in the Brisbane Ranges National Park and Wilsons Promontory.

Parks Victoria has taken the initiative of undertaking a preliminary review of the actual and potential distribution of *P. cinnamomi* dieback in parks and reserves across the State[29]. This initiative has been followed by renewed efforts to prevent the introduction and spread of the pathogen in numerous parks and reserves.

25 via regulation under the Forests Act 1958
26 Marks and Smith (1991)
27 DSE (2007)
28 Cahill et al. (2002)
29 Gibson et al. (2002)

Interstate approaches

Several states have made substantial efforts to manage *P. cinnamomi*.

In **South Australia** *P. cinnamomi* is a threat to about 20% of the remaining vegetation (about 5% of the State) including the Mount Lofty Ranges, Kangaroo Island, Lower Eyre Peninsula and possibly Lower Southeast of South Australia. Other areas are either too dry or have alkaline soil types. Basic hygiene measures are employed in remaining susceptible areas, whether totally free or partially infected, such as ensuring vehicles, equipment and footwear are clean before entry. Intensive hygiene management is undertaken in more significant areas including quarantine, re-routing of paths and installation of hygiene infrastructure.

Furthermore, maintenance works for sites prone to water logging are restricted to times when soils are dry. *P. cinnamomi* management is supported by information and guidelines. Further work is planned to evaluate the threat from *P. cinnamomi* to threatened biodiversity in infected and un-infected areas within National Parks and Wildlife Reserves to help further prioritise more intensive measures, such as use of chemicals or *ex-situ* conservation.

In **Tasmania** the widespread nature of the pathogen has led to the strategic targeting of significant susceptible areas[30] for intensive management ranging from measures to minimise spread, such as installation of board walks or the application of coarse road metal, to stipulation of strict hygiene procedures. Track closures are a further safeguard. *Ex-situ* conservation of threatened taxa is also undertaken. The use of the fungicide (potassium phosphonate) is also being considered. In less significant areas there is still a requirement for the uptake of hygiene and management measures as specified in Codes of Practice and guidelines specific to various agencies or industries.

In **Western Australia** the pathogen is one of the most significant threats along the state's south coast. Considerable effort is being put into strategic and operational mapping of the pathogen in partnership with regional natural resource management groups. Where hygiene plans exist for significant areas, compliance checks and audits are made of vehicle hygiene upon entry. Specific management guidelines exist for various agencies.

In **Queensland** management of the pathogen is mostly limited to susceptible highland areas in the Wet Tropics World Heritage Area. Here, an ongoing monitoring program of forest health has identified areas for deployment of a range of hygiene initiatives along with education. Efforts in some instances involve re-routing of paths or restricting entry.

In **New South Wales** several areas are intensively managed but the impact overall is still poorly known. A Threat Abatement Plan is in preparation to guide management.

In the **Northern Territory** the pathogen is not perceived to be a significant problem as the environmental conditions are not conducive to the establishment and persistence of *P. cinnamomi* in potentially susceptible native plant communities.

30 Barker et al. (1996)

Management

This section outlines the objectives, principles, legislative requirements, logic and actions for managing *P. cinnamomi* on public land in Victoria.

Management objectives

Given the fact that *P. cinnamomi* is widespread in Victoria, eradication of the pathogen is not practical in the foreseeable future.

Therefore the management approach must aim to protect those values most at risk through measures that protect important sites, maintain ecological processes and the potential for development of natural resistance, and provide protection for species that are potentially threatened.

The specific objectives of managing *Phytophthora cinnamomi* on public land in Victoria are:

- to protect susceptible biodiversity, with a particular focus on the structure and function of vulnerable ecosystems and threatened species;
- to protect social and economic assets on public land that are at risk;
- to assist in reducing the potential for transmission of the pathogen from public land to other jurisdictions (interstate, industry, community), and;
- to assist agency staff and the wider community to protect their public land by managing this significant threat.

This will be achieved through improved coordination between agencies, surveillance, quarantine and hygiene, management prescriptions, education, communication and community engagement.

Management principles

1. **Prevention is better than cure**
   It is much easier to prevent infection than to deal with the effects of infection. Prevention of both the introduction and spread of pathogens is a major priority as it is the most effective means of reducing the impact and cost of management in most instances. Prevention is closely linked to maintaining ecosystem resilience and managing other threats. It underlines the importance of investment in surveillance, quarantine, early detection and rapid response mechanisms.

2. **A precautionary approach should be applied to use of water and soil**
   It should be assumed that soil and water are contaminated with *P. cinnamomi* (and potentially other pathogens) unless it can be shown otherwise.

3. **Programs should endeavour to address the cause and source of infection**
   A causal approach (treating causes and not just symptoms) is a key aim of sound integrated natural resource management. It reduces asset damage, future threat of reinvasion, secondary-threatening processes, and ensures economic and efficient use of resources. Treating causes means understanding the pathways of pathogen introduction (see Appendix 1) and taking action to address these.

4. **Programs should adopt an ecosystems-based approach and support the application of sound ecological management principles**
   The aim here is to maintain ecosystem function by treating the threats and impacts that cause dysfunction in the 'system'. Preventative strategies, such as increasing ecosystem resilience (health), are an approach that guards against future threats. Temporal and spatial scales need to be appropriate to achieve long-term ecological outcomes. Disturbance reduces the ability of ecosystems to resist change by reducing their competitive balance and enabling threatening processes to establish, including invasion by weeds and pests. The general priorities for native vegetation protection is firstly to prevent further losses, enhance the quality of degraded areas, and restore older infected areas through revegetation.

5. **Programs should adopt an asset-based risk management approach**[31]
   Prioritisation should be based on maintaining the viability of key environmental assets and optimising outcomes for asset protection and management. Assets should be ranked according to their significance. Uninfected areas of significant and vulnerable ecosystems, and the species they contain, are the highest priority for greater levels of protection and management. Priority will also be given to species currently or potentially threatened with extinction as a result of *P. cinnamomi*. Where two ecosystems of the same conservation value are being compared, generally intact ecosystems will have priority for management over degraded ecosystems and ecosystems at higher risk will have priority over those at lower risk.

6. **Planning should be collaborative and consistent across tenures**
   Pathogens do not recognise socio-political boundaries, so management planning must be tenure-blind and unaffected by the type of land manager. Preference should be given to co-operative, collaborative and consistent approaches that recognise that a whole-of-catchment or whole-of-ecosystem approach is in most instances the logical way to proceed.

31 See VPMF (2002). Section 3. Pest Management Principles, part 3.6. Pest management must occur within a risk framework.

7. **Pathogen and disease projects must be planned to achieve explicit, demonstrable and measurable ecological management objectives**
   Setting of clear ecological management objectives is vital to planning processes and for monitoring, evaluation and reporting. An ecological management objective describes the desired or expected new condition of the ecosystem as a result of the management applied.

8. **A holistic approach to natural resource management should be applied**[32]
   Approaches should be integrated and consistent within and across businesses and agencies. Relevant frameworks at various scales (catchment, regional, local) need to be applied in an integrated way. The aim is to assimilate natural resource management issues in determining priorities, trade-offs and options for management, maximising success and minimising risk. This includes management of fire, threatened species and habitats and communities, salinity, disaster, natural resource use and extraction (e.g. forestry, fisheries), other conservation objectives and recreation.

9. **Ecologically Sustainable and 'Triple Bottom Line' (TBL) approaches should be used**
   TBL objectives of pathogen management on public land are to:
   Environmental: maintain ecosystem health; maintain the viability of indigenous species and communities; maintain genetic integrity
   Social: maintain human health and well-being; retain culturally significant assets; maintain access for recreational purposes
   Economic: retain economic benefits of ecosystem services; reduce costs of maintaining ecosystem services; prevent impacts on agriculture and other economic activities

10. **Evidence-based decision-making must be a feature of program development, so as to demonstrate that planning and prioritisation is based on sound and up-to-date scientific and technical information including conceptual frameworks**
    This evidence is also useful in determining the appropriate level of investment and to highlight research priorities for the protection of priority environmental assets.

11. **Control programs should be based on an adaptive management approach to ensure continuous development and improvement based on a framework incorporating monitoring, evaluation, feedback and change**
    Adaptive Management (AM) or 'learning by doing' is a technique by which managers evaluate the outcomes of management strategies and use this information to develop more efficient and effective management practices.

32 See VPMF (2002). Section 3. Pest Management Principles, part 3.2. The effective management of pests requires an integrated approach as part of the broader management of land and water resources.

Legislative requirements

The impact of *P. cinnamomi* has been formally recognised under both Federal and State legislation.

National legislation and Threat Abatement Plan

'Dieback caused by the root-rot fungus *Phytophthora cinnamomi*' was listed on 16 July 2000 as a 'key threatening process' under Section 183 of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. Formal recognition under Commonwealth legislation of *P. cinnamomi* as a threat has led to nationally coordinated efforts to curb its impact.

In 2001, the (then) Department of Environment and Heritage (DEH) released the *Threat Abatement Plan for Dieback Caused by the Root-rot Fungus Phytophthora cinnamomi* (the National Plan)[33]. A review of the National Plan has been completed and a revised version is scheduled for release in 2008.

The National Plan provides a framework for implementing actions to reduce the threat of *P. cinnamomi*. The Australian Government is committed to its implementation and working with key stakeholders to ensure its key objectives and actions are achieved.

The Australian Government support has included funding to states and territories to develop their own strategic plans to reduce and manage the spread and impacts of *P. cinnamomi*. Development of Victoria's strategy was subsequently funded under the Australian Government's Endangered Species Program (ID 30831).

Other actions contained in the National Plan include developing national best-practice standards for the management of sites (and species) that are or could be threatened by *P. cinnamomi* and criteria for prioritising areas for management. The Department of Sustainability and Environment and related organisations have actively collaborated on these initiatives.

Victorian legislation

P. cinnamomi has been listed twice as a 'potentially threatening process' under the *Flora and Fauna Guarantee Act 1988* (FFG Act):

- 'Use of *Phytophthora*-infected gravel in construction of roads, bridges and reservoirs' (Final Recommendation 22 May 1991)
- 'The spread of *Phytophthora cinnamomi* from infected sites into parks or reserves, including roadsides, under the control of a state or government authority' (Final Recommendation 5 Feb 2002)

Public authorities must be administered so as to have regard to the FFG Act's conservation and management objectives[34], one of which is to manage potentially threatening processes such as those listed in regard to *P. cinnamomi*.

Agencies may have the power or potential to improve management of the pathogen under provisions in several Acts of Parliament. These include Codes of Practice[35], plant pathogen controls[36], extractive industry controls[37], planning controls[38] and Regional Catchment Strategies[39].

33 Environment Australia (2001)
34 Section 4 (2) of the *Flora Fauna Guarantee Act 1988*
35 *Conservation, Forests and Lands Act 1987*
36 *Plant Health and Plant Products Act 1995*
37 *Extractive Industries Development Act 1995*
38 *Planning and Environment (Planning Schemes) Act 1996*
39 *Catchment and Land Protection Act 1994*

The Code of Practice for Fire Management on Public Land[40] states:

- 1.10.5 Environmental Management Principles
  `The posssible introduction and spread of pest plants and animals, plant diseases, insect pests and biological contaminants to be avoided wherever possible or addressed within appropriate timeframes, by effective machinery hygiene practices;' (para 72, p 7)

- Appendix H Disease, pest plants and animals
  `The Department must follow appropriate guidelines to ensure care is taken to prevent the introduction and/or spread of disease or insect and plant pests during fire suppression (e.g. the transfer of virulent soil pathogens such as *Phytophthora cinnamomi* by machinery and equipment).' (para 599, p 47)

The Code of Practice for Timber Production[41] states:

- 2.3.4 Forest Health (see mandatory actions)
  `Precautions must be taken to avoid the transport of any pest animal, pest plant or pathogen into or from a State forest, or from one place to another within a State forest. Any relevant procedures or guidelines must be followed. Where there is a known risk of introducing pests, pest plants and pathogens to the forest (for example, but not limited to *Armillaria* or *Phytophthora*), precautions must be taken and the risk minimised through appropriate treatment of equipment when moving from known infected areas.' (p 26)

40 DSE (2006)
41 DSE (2007)

Roles and responsibilities

Department of Sustainability and Environment

The Department of Sustainability and Environment (DSE) has policy interpretation and legislative responsibility for managing public land, and coordinates the implementation of the Government's management programs. These programs are delivered through the direct management of public lands (State forests and other Crown lands), via Parks Victoria and through the provision of behavioural change programs.

The Department coordinates fire management on public land, including planned fires (prescribed burns) and management of wildfire.

Parks Victoria

The management of national parks is directed through Parks Victoria (PV), which has a role in managing the pathogen in national parks and areas for the protection of biodiversity and other values.

Department of Primary Industries

The Department of Primary Industries (DPI) is responsible for regulating control of plant pests and diseases of agricultural plants. However, given that *P. cinnamomi* distribution is widespread in agriculture, DPI does not actively control this pathogen. DPI has a role in developing, reviewing and monitoring biosecurity policies, legislation and technical and operational standards for Victoria, in addition to coordinating relevant operational responses.

DPI is also responsible for the regulation of the minerals, extractive, petroleum, pipelines and geothermal industries. DPI has a role in developing policies and operational standards as well as in reviewing, regulating and monitoring to ensure industry compliance with relevant legislation and to meet community expectations. As the use of infected gravel is listed as a potentially threatening process under the FFG Act, DPI will take an active role in assisting DSE to address this issue.

Catchment Management Authorities

Victoria's Catchment Management Authorities (CMAs) are empowered under the *Catchment and Land Protection Act 1994* to develop Regional Catchment Strategies, promote co-operation among land and water managers, advise the Minister (e.g. on priorities, management guidelines, catchment condition), and promote community awareness and understanding of catchment management.

Victorian Pest Management Coordinating Committee

The Victorian Pest Management Coordinating Committee coordinates implementation of the Victorian Pest Management Framework.

Figure 6: Victoria's floral emblem[42], the pink form of Common Heath (*Epacris impressa*).

Photo: Hugh Bramwells.

This species is susceptible to *Phytophthora cinnamomi*, although the degree has not been determined. Much of its heathland habitat is susceptible to *Phytophthora cinnamomi*.

42 http://www.about-australia.com/facts/Victoria/Victoria-flags-emblems

Management actions

In order to meet the aims of this Strategy it will be necessary to:

- Promote collaboration among key stakeholders in public land management to achieve a coordinated approach
- Have a more precise understanding of the location of significant and vulnerable ecosystems and species
- Have a more precise understanding of the distribution of *P. cinnamomi* relative to important asset areas
- Develop site specific surveillance and quarantine procedures and implement them
- Identify the most appropriate site controls and have these included in area management plans, procedures and contracts
- Provide information and training to key stakeholders and the general community

This will be achieved in part through changes to governance arrangements, management systems and through cultural change.

Governance arrangements

Collaboration will help ensure the uptake of appropriate measures within each agency's jurisdiction and thus contribute to consistent and coordinated management effort across the landscape.

DSE will establish a steering committee to ensure implementation of this Strategy. The steering committee will be responsible for oversight of this Strategy and report on progress with its implementation. Committee members will also support the uptake of appropriate management within their organisation and sphere of influence.

Action 1: DSE to ensure implementation of this Strategy through establishing an appropriate Steering Committee.

The steering committee will establish a cross-agency Phytophthora Statewide Working Group (PSWG) to provide technical input to the development of statewide management standards and procedures. The role will include oversight and guidance of the development of regional Phytophthora Management Plans (discussed below) and monitoring of their implementation. Such a body will meet at an appropriate frequency to ensure effective collaboration. It will oversee the activities of Phytophthora Regional Working Groups (PRWG) (see below).

Action 2: Steering Committee to establish a cross-agency Phytophthora Statewide Working Group.

Implementation of actions to reduce the threat of *P. cinnamomi* occurs at the regional level and a coordinating body is required to ensure consistent and efficient implementation across land tenures.

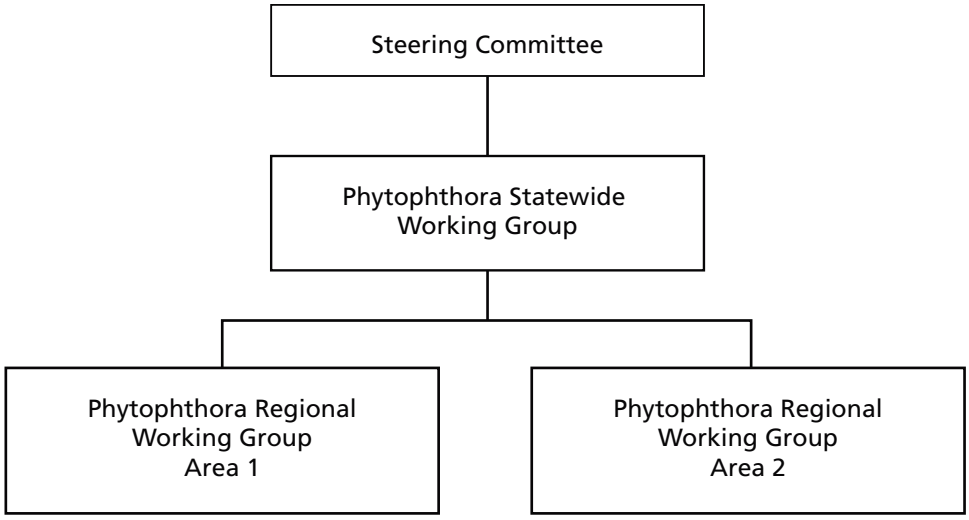
One of the first tasks of the Phytophthora Statewide Working Group will be to recommend to the Steering Committee areas of the State that contain important assets at risk from *Phytophthora* that could be a focus for developing management approaches.

Where appropriate, Phytophthora Regional Working Groups (PRWG) will be established to coordinate efforts across tenures and agencies within a region. In some cases existing coordination groups may be utilised. These groups in future could have a broader biosecurity focus and deal with other pathogens and diseases affecting the environment. Representation would include the major public land management agencies.

Action 3: Phytophthora Statewide Working Group to recommend priority land management units for development of detailed management approaches based on analysis of assets/values and risk.

Action 4: Where appropriate, Steering Committee to establish Phytophthora Regional Working Groups.

Figure 7: Proposed governance arrangements.



Planning and Prevention

In order to enable the detailed planning required to effectively respond to *P. cinnamomi*, this Strategy proposes the development of cross-tenure regional Phytophthora Management Plans (PMP) for public land areas. Information from PMP's would form a component of park and forest management plans and other integrated natural resource management plans for public land.

Understanding the location of significant and susceptible ecosystems and species

Statewide mapping of the potential range and indicative threat of *P. cinnamomi* (Figure 5), is at a coarse scale that is impractical for on-ground management, but useful in guiding broad priority setting. More precise spatial information on the distribution of significant and susceptible species is required in order to facilitate management at the local scale.

Phytophthora Management Plans would include an analysis of the range of values, the level of risk, and the practicality of control, including cost (i.e. a cost/benefit analysis).

Values that should be considered include:

- biodiversity values such as
  - threatened plant communities taking into account the foreseeable impact on floristics and structure
  - threatened plant species based on conservation status and the foreseeable impact in terms of the number of populations affected and their geographic significance
  - threatened fauna based on the impact arising from changes to their habitat
  - potentially threatened biodiversity (taxa and communities whose conservation status may become threatened as a result of *P. cinnamomi*)
- other social and economic assets potentially at risk.

Knowledge of these impacts on biodiversity is limited and support in terms of modelling capability is likely to be required.

Until such time as agencies have the capacity to undertake site appraisals and cost/benefit analyses these should be done by persons with specialist knowledge. In some instances, relying on expert opinion may be necessary as an interim measure.

Action 5: Phytophthora Regional Working Groups to include high resolution maps of the distribution of significant and susceptible ecosystems and species at risk from *Phytophthora cinnamomi* in regional Phytophthora Management Plans.

Understanding the distribution of Phytophthora cinnamomi relative to important asset areas

Mapping the distribution of *P. cinnamomi* requires experience in identifying the signs of infection, knowledge of the biology of *P. cinnamomi* and environmental parameters known to affect its spread and impact, and knowledge of when to undertake soil testing. Generally this task will be completed more efficiently by those people with these specialist skills.

The Australian Government is currently funding research into a cheap effective test for on-site detection that can be completed in short time frames, testing both soil and plant material. In the meantime, work is needed to identify indicator species. Whilst dying Austral Grass-trees are a classic indicator, other plant species need to be used to indicate the presence of *P. cinnamomi* in different types of vegetation.

Mapping should be at a fine scale and concentrated in areas of significant and susceptible ecosystems and species. Maps should indicate confirmed, potential and undetected sites to indicate the relative risk. Modelling the distribution of the pathogen to locate highly susceptible uninvaded sites that need greater protection is being considered now for its usefulness. As an interim measure, it may be appropriate to broadly classify areas based on various grades of susceptibility as well as a combination of factors such as soil type and topography.

Parks Victoria has undertaken a preliminary review of the actual and potential distribution of *P. cinnamomi* dieback in parks and reserves across the State. Parks Victoria has since used this information to identify parks in need of Phytophthora Management Plans.

Action 6: Phytophthora Regional Working Groups to include high resolution maps of the distribution and relative risk of infection by *Phytophthora cinnamomi* in regional Phytophthora Management Plans.

Develop site specific hygiene, surveillance and quarantine procedures and have these included in Phytophthora Management Plans, procedures and contracts

Hygiene, surveillance and quarantine measures are essential to limit the spread of *P. cinnamomi* and to protect significant and susceptible sites.

Phytophthora Management Plans – zonation

Regional Phytophthora Management Plans should identify *P. cinnamomi* management zones based on the significance of the asset and level of risk. Zones should be tiered with highly significant sites at high risk given the highest level of protection. For example:

Zone 1 — Routine Phytophthora Management Zone

The objective is to adopt routine measures to safeguard areas of low to medium biodiversity significance that are susceptible to moderate[43] impact. Routine measures entail active hygiene efforts to clean plant and equipment, vehicles and footwear as necessary. Other measures may entail track or road closures, or scheduling works in relation to weather and infestation status. Measures may also need to be taken to safeguard against importation of contaminated gravel and plant materials.

Zone 2 – Intensive Phytophthora Management Zone

The objective is to adopt both routine measures and intensive efforts to safeguard areas of medium and high value asset significance that are at high risk. Intensive measures include use of physical barriers to protect clean areas, installation of hygiene infrastructure, road and track modification (such as re-routing, addition of passive road and trail hygiene elements as outlined below, or water diversion), monitoring and disease awareness programs and, possibly, chemical intervention.

A program of regular assessment and soil testing should be developed for these important sites.

Until such time as priority areas have been mapped thoroughly active hygiene measures may be required as a default for areas identified as significant and at risk, unless site evaluation indicates that such efforts are not warranted.

Phytophthora Management Plans can be used to indicate the level of management effort that is required in particular zones. For example, they can guide when it is necessary for road making materials to be tested for the pathogen prior to use and where road drainage water diversion measures are warranted.

43 DSE (2004)

Hygiene procedures

Hygiene involves measures to ensure that human activities do not contribute to spread of the pathogen. That is, they are clean. This includes washing or disinfecting all vehicles, equipment and footwear that may be carrying the pathogen and requiring high levels of soil and water testing before use in road making, revegetation and other activities.

Hygiene procedures need to be specified as well as clarification of the sort of apparatus and infrastructure that may be needed to make this an effective and practical activity. The Department of Primary Industries (DPI) 'weed hygiene protocols' may be able to be modified to provide for *P. cinnamomi*.

Apart from aiding active hygiene efforts, consideration is needed of passive design elements along routes (i.e. roads and trails that are designed to dislodge soil from boots or vehicle tyre treads and undercarriages simply by passage along them and hence without deliberate user effort or intent). This is important in situations where parties are unaware of the threat but likely to spread it. The design elements may involve the mode of construction (e.g. cording or crushed rock) or installation of infrastructure (e.g. grids).

As well as focusing on managing inadvertent introduction of the pathogen to significant natural areas, efforts are needed to mitigate the threat from the use of contaminated material. Contaminated material may come in the form of infected plants, growing media or gravel. Contaminated material safeguards need to be developed in association with the DPI and included in regional Phytophthora Management Plans.

Public authorities could apply appropriate contractual safeguards to minimise the threat of supply of contaminated material. Regulatory controls may also be required to help safeguard against the use of contaminated gravel via control over the activities at quarries.

P. cinnamomi is prevalent in the nursery and garden industry[44]. Concern has been raised about poor plant quality as well as the transmission of weeds and pathogens by suppliers to purchasers of stock for on-ground conservation projects[45]. Awareness needs to be raised among purchasers and suppliers of growing media and plant stock used for revegetation of the threat posed by contamination with *P. cinnamomi*. This includes government and non-government agencies undertaking or contracting revegetation activities. Nursery operators and growing media suppliers who take adequate precautions by operating to specified hygiene standards and who do not use plant husbandry practices to mask the presence of the pathogen[46] should be preferred. Supply contracts should stipulate requirements for supply of clean material. Such criteria have not yet been formulated and ideally should be based on those used in the national voluntary accreditation scheme[47].

44 Nursery Paper (2002)

45 Greening Australia (2003)

46 The use of fungicides is a plant-husbandy practice used to suppress the pathogen's impact. Other than fungicides, provision of adequate shading and water is used to prevent stressing plants and thus the expression of disease symptoms.

47 NIASA (2003)

Cooperation is needed from those agencies who fund revegetation activities to manage the threat of *P. cinnamomi*[48] as well as suppliers and persons undertaking the revegetation. Catchment Management Authorities are important groups to engage in preventing the spread of *P. cinnamomi* through revegetation activities. Safeguards should be taken to protect public land from potential contamination from revegetation activities on private land nearby. Suppliers and users need to be motivated to take precautionary measures to prevent introducing the pathogen[49]. Some groups operate independent of industry groups and hence liaising with them poses a challenge.

Surveillance

Surveillance involves observation to detect occurrences of the pathogen at an early stage when control activities are more likely to be effective. Regular visits to potential sites of introduction are needed, as well as follow up monitoring of new works and reporting procedures.

Potential pathways of spread of *Phytophthora* include (see also Appendix 1 for details):

- Earthworks
- Movement of machinery, equipment, vehicles, livestock
- Recreational activities
- Revegetation activities
- Nursery activities
- Fire Management/Emergency Services Activities

Quarantine

Quarantine involves the strict isolation of an area to prevent the spread of a disease. Quarantine measures for *P. cinnamomi* may include limiting the degree of human entry to a location either permanently or seasonally and preventing access by vehicles and machinery. Quarantine may be an appropriate response to detection of a new infestation, particularly where this is in a site of high biodiversity significance.

In addition, for individual projects, there may be a need to validate the risk and to determine management options, likely outcomes and the cost involved (i.e. a cost/benefit analysis).

Integration

To ensure adoption and uptake of an integrated approach, the measures contained in regional Phytophthora Management Plans should be incorporated into integrated natural resource management plans such as park and forest management plans and regional catchment strategies. They also need to be recognised in other management documents such as fire management and operations plans.

48 Regional revegetation activities are funded through the Natural Heritage Trust (NHT), National Action Plan for Salinity and Water Quality (NAP) and the National Landcare and National Bushcare Programs (NLC and NBP).

49 Groups who need to be engaged (i.e. those undertaking revegetation to varying extents) include the CMAs, Greening Australia, Trust for Nature, Tree-Project, Land for Wildlife, Greenfleet, Conservation Volunteers Australia, Field Naturalist Club of Victoria, Bird Observation and Conservation Australia, Birds Australia, Landcare and Coast Care Groups (Regional Landcare Coordinators, local level coordinators and facilitators).

Action 7: Phytophthora Regional Working Groups to develop regional Phytophthora Management Plans for priority areas and ensure these are incorporated into relevant local plans, contracts and specifications.

Action 8: Phytophthora Regional Working Groups to identify *Phytophthora cinnamomi* management zones and associated management procedures in regional Phytophthora Management Plans.

Action 9: The Phytophthora Statewide Working Group to assist with liaison with policy makers in related agencies to ensure adoption of statewide actions detailed in regional Phytophthora Management Plans.

To ensure consistency in approaches, the Phytophthora Statewide Working Group will need to oversee technical standards and provide policy direction.

The accumulated knowledge of these standards should be collated and published as a Guideline to assist future planning.

This will include advice on standards for:

- Determining assets at risk
- Planning guidelines and procedures and designation of management zones
- Best practice on-ground methodologies, (e.g. hygiene standards and protocols, infrastructure, *ex-situ* conservation, site remediation and communication, such as signage)
- Monitoring and evaluation

Action 10: The Phytophthora Statewide Working Group to develop guidelines and procedures for managing the threat of *Phytophthora cinnamomi* on public land in Victoria.

Developing a biosecurity culture

In order to maintain a level of security there will need to be an associated change in the culture within organisations and within the wider community. A statewide Phytophthora Communication and Community Engagement Plan should address the key messages and behaviours and actions to support them. The plan should aim to raise awareness about the pathogen and measures to prevent its effects. The plan should also aim to counter pessimism and misconceptions that have dampened enthusiasm to make a concerted effort to manage the pathogen. These include perceptions that there is no potential to reign in further spread and mitigate site impacts, that even if measures exist the effort isn't warranted because *P. cinnamomi* will inevitably spread across the entire landscape and that management efforts are too late, with some believing that the pathogen has reached all potentially susceptible areas. A key message should be that important assets are still at risk and that effective controls can be implemented.

Past speculation[50] that *P. cinnamomi* may be 'native' to Australia once caused considerable scientific debate. This misconception unfortunately still reverberates within environmental management circles despite overwhelming evidence to the contrary and thus continues to confound its management, often relieving people of a sense of obligation to act. The communication plan should address myths about the pathogen by countering them with factual information.

Attitudes borne of uncertainty both about the pathogen and responsibilities, as well as different imperatives, all in some way hinder acceptance of why there is a need to act.

Recreational users (e.g. trail-bike and horse riders, four-wheel drivers and bush walkers) could be engaged through peak organisations and action encouraged by promoting duty of care principles.

Action 11: The Phytophthora Statewide Working Group to develop a statewide Phytophthora Communication and Community Engagement Plan.

Preparedness

Land managers should make arrangements to prepare for management of *Phytophthora cinnamomi*.

This includes acquiring the appropriate equipment and materials to effectively implement procedures for hygiene, surveillance and quarantine viz:

- Chemical (i.e. potassium phosphonate) and wash-down facilities
- Materials and structures for passive hygiene, road and trail control
- Signage for vehicles or pedestrians
- Barriers for track closures etc.

Further work is needed to standardise the apparatus and infrastructure. These need to build on and integrate with weed hygiene initiatives.

Action 12: Phytophthora Regional Working Groups to determine local preparedness requirements and implement procedures for hygiene, surveillance and quarantine.

Response

Where hygiene and quarantine procedures fail to prevent infestation, and in some already infected communities, a management response may be required to control the pathogen.

Chemical intervention

The most promising agent for controlling *P. cinnamomi* is potassium phosphonate[51], a systemic fungicide thought to also trigger and/or enhance intracellular barrier formation to resist the pathogen's passage through a plant. The effect may last for up to five years. Potassium phosphonate is being applied routinely in high value areas in Western Australia both through tree injections and spraying foliage by hand, and by aircraft. In Victoria, the use of potassium phosphonate is being trialled at places such as Wilsons Promontory, Aireys Inlet[52] and the Brisbane Ranges. At the latter site, potassium phosphonate is being trialled for the protection of Scented Bush-pea, *Pultenaea graveolens*, a threatened native plant species.

50 Shepherd C.J. (1975)

51 Potassium phosphonate is an aqueous solution of mono- and di- potassium phosphonate. The active component of the fungicide is the phosphite ion (PO_3^{3-}) hence the fungicide is also referred to as phosphite.

52 Aerial application has been trialled at Aireys Inlet.

Clarification is needed on the use of potassium phosphonate to control natural spread of *P. cinnamomi*[53].

The use of potassium phosphonate may benefit vegetation downhill of infected sites where water movement will lead to inevitable infestation. It may also be possible to create a vegetative barrier to uphill movement of the pathogen that normally occurs via contact with infected roots.

The optimal concentration of potassium phosphonate needed to induce resistance while not burning foliage varies between vegetation types. Furthermore, potential detrimental effects on non-target plant species and some fauna means that management of *P. cinnamomi* by potassium phosphonate control must be judicious and guided by research and adaptive management.

Figure 8: Aerial spraying of potassium phosphonate to control *Phytophthora cinnamomi* in the Anglesea Heathland.

Photo: David Cahill

Ex-situ conservation

In situations where a serious risk of losing significant flora or fauna exists *ex-situ* conservation may need to be employed, such as germplasm collection, storage and propagation.

Recovery

Remediation of dieback affected forests may offer hope for remediation of other sites. Long-term forest management research into *P. cinnamomi* indicates that some plants in a population of an otherwise susceptible species may be more resistant. A small percentage of susceptible trees planted in research trials survived infection leading to the hope that over time disease resistance may build up in a host population[54].

An active management approach using fire to create ash-beds for sowing of seed has resulted in the successful regeneration of susceptible eucalypts on sites that were badly affected by dieback in the past[55]. All susceptible eucalypt species that were affected in the initial dieback events have regenerated. However, the apparent tolerance may also be a function of the stocking rate which is high enough to potentially lower the water table and thus reduce conditions conducive to disease development [see Management history (p 11)].

While fire may be used as a regenerative tool for some areas, (e.g. enhancing seed set) further research is needed to ensure it is appropriate across all highly susceptible vegetation communities. Information is needed on whether prescribed burns have the potential to actually accelerate spread of *P. cinnamomi* through soil movement by fire management vehicles, surface run-off, soil erosion or enhancing its virulence through increased soil temperatures and moisture.

To prevent extinction of highly susceptible plants, in addition to *ex-situ* conservation and possibly research into resistance, novel approaches to enhance disease resistance may also need to be considered (e.g. genetic engineering).

53 Particularly for the emphasis on interim protection of significant vegetation patches whilst longer-term solutions are explored.
54 Harris et al. (1985)
55 Marks, G.C., and Smith, I.W. (1991), Fagg, P. (1987) and Fagg, P.C. and Marks. G.C. (1987)

Action 13: Phytophthora Steering Committee to support research into the best options for controlling *Phytophthora cinnamomi* at an infected site and for recovery of sites post infection.

Monitoring

Skills are needed for monitoring the pathogen post implementation of management. This includes taking samples for testing as well as recognising the symptoms on indicator species. Simple guidelines to alert staff to the probable occurrence of *P. cinnamomi* may help in this process. An alternative is to engage relevant experts to undertake this activity on a routine basis.

Measuring success and reporting on the strategy

The success of the treatment of any threat should ultimately be measured in terms of the desired outcome. In this case, management aims to protect significant and susceptible ecosystems and species, and social and economic assets at risk.

A task of the Phytophthora Steering Committee will be to determine indicators of success and to set annual performance targets on advice from the Phytophthora Statewide Working Group.

The Phytophthora Steering Committee will initiate a review of this Strategy at the appropriate time, based on its effectiveness and changes in natural resource management.

Action 14: Develop monitoring and reporting methods in association with pilot projects.

Action 15: Phytophthora Steering Committee to set annual targets and performance indicators for this Strategy.

Appendix 1

Human activities at risk of spreading *Phytophthora cinnamomi*[56]

All activities that involve movement of soil, water and plant material (whether deliberately or accidentally) have the potential to cause the spread of *Phytophthora cinnamomi*. Moist soil and plant material readily adhere to machinery, equipment, tyres, tools, hooves, footwear and camping equipment.

Activities at risk of spreading *Phytophthora cinnamomi* include:

Earthworks
- construction and maintenance of roads and trails (including walking, horse riding and mountain bike trails)
- landscaping
- construction and maintenance of firebreaks, powerlines etc.
- forestry operations
- management of drainage

Movement of machinery, equipment, vehicles, livestock
- between sites and along roads and tracks
- logging operations
- forestry operations
- management of powerlines etc.
- pest animal and pest plant management
- off-road vehicles (4WD's, trail bikes etc.)
- movement of livestock

Recreational activities
- bushwalking
- orienteering and associated activities
- bike riding
- horse riding
- motorbike riding
- 4-wheel driving
- camping

Revegetation activities
- plant propagation
- movement of planting stock
- planting-out operations
- movement of machinery, vehicles and equipment

Nursery activities
- plant propagation
- movement of planting stock
- planting-out operations

Fire management / emergency services activities
- construction and maintenance of firebreaks
- fire management and rescue practices
- dispersal of infected water

56 Modified from Phytophthora Technical Group, Phytophthora Management Guidelines, 2006 (2nd Edition), Government of South Australia.

Appendix 2

Summary of actions

Glossary

Adaptive Management	The systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. In its most effective form (Adaptive Experimental Management), it employs management programs that are designed to experimentally compare selected policies or practices, by evaluating alternative hypotheses about the system being managed.
Biodiversity	The variety of life forms: the different plants, animals and micro-organisms, the genes they contain and the ecosystems they form.
Crown land[57]	Land which is, or is deemed to be, unalienated land of the Crown and includes – (a) land of the Crown reserved permanently or temporarily or set aside by or under an Act; and (b) land of the Crown occupied by a person under a lease, licence or other right; (c) land of the Crown managed by a public authority other than the Department of Sustainability and Environment or the Secretary; (d) land of the Crown which is, or is part of, a national park or a park within the meaning of the *National Parks Act 1975*;
Ecosystem	The dynamic interaction between the complex of organisms that make up a community with their non-living environment and each other.[58]
Eradication	Means that a weed has been removed or killed over time and no longer occurs at that site including its propagules[59].
Infected	In this Strategy, the term infected has been used in preference to infested when referring to soil and water. It refers to the state of both living and non-living things as having *P. cinnamomi* present. Technically, inanimate objects such as soil and water that have *P. cinnamomi* present are referred to as being 'infested'.
Public land	All State forest, national park and protected public land as defined by Section 3 of the *Forests Act 1958*, except that managed by the Victorian Plantations Corporation or its successors. All land that is not freehold land. It refers to land owned by the Crown and set aside for public purposes. The term also includes land that is held and managed under delegated arrangements such as Crown Land Reserves managed by Committees of Management.

57 See *Conservation Forests and Lands Act 1987* and *Coastal Management Act 1995*
58 Source: Australian Committee for IUCN (1996)
59 Source: DPI (2005). Weed Alert Rapid Response Plan Victoria

Public land manager

In this Strategy, refers to those who carry the responsibility for the planning, management and monitoring of natural resource management outcomes on public land in Victoria. Key stakeholders in addition to government agencies include corporations and agencies (e.g. utilities including electricity, gas, grain, ports, rail, telecommunications and water) that manage large areas of vested public land for their own or public purposes and that have a duty of care to maintain the land on behalf of the Crown. Vested Crown land is vested for prescribed purposes but remains Crown land. Other land managers include private individuals or small groups that manage public land under licence or agreement on behalf of a public land management agency where that agency is responsible for ensuring appropriate management.

References

Australian Committee for IUCN (1996). *Australian Natural Heritage Charter: Standards and Principles for the Conservation of Places of Natural Heritage Significance*. Australian Heritage Commission, Sydney.

Barker, P.C.J., Wardlaw, T.J. and Brown, M.J. (1996). Selection and design of *Phytophthora* management areas for the conservation of threatened flora in Tasmania. *Biological Conservation* 76*:* 187–19.

Bluett, V., Weste, G. and Cahill, D. (2003). Distribution of disease caused by *Phytophthora cinnamomi* in Wilsons Promontory National Park and potential for further impact. *Australasian Plant Pathology* 32(4): 479–491.

Brown, J.F. and Ogle, H.J. (1997). *In plant pathogens and plant diseases*. Rockvale Publications.

Cahill, D., Harding. C., O'May, J. and Wilson, B. (2002). *Assessment of guidelines of best-practice management of Phytophthora cinnamomi in parks and reserves across Victoria*. Centre for Environmental Management, University of Ballarat.

Commonwealth of Australia (1999). *The National Weeds Strategy. A strategic approach to weed problems of national significance.* Revised Edition. Agriculture and Resource Management Council of Australia and New Zealand, Australian and New Zealand Environment and Conservation Council and Forestry Ministers. Commonwealth of Australia.

DPI (2005). *Weed alert rapid response plan victoria: a surveillance and response plan for potential, new and emerging weeds in Victoria 2004–2005*. Department of Primary Industries, Melbourne.

DSE (2004). *Risk management framework*. Department of Sustainability and Environment, Melbourne.

DSE (2006). *The Code of Practice for Fire Management on Public Land. Revision no.1*. Department of Sustainability and Environment, Melbourne.

DSE (2007). *Code of Practice for Timber Production 2007*. Department of Sustainability and Environment, Melbourne.

Environment Australia (2001). *Threat abatement plan for dieback caused by the root-rot fungus* (*Phytophthora cinnamomi*). Environment Australia, Canberra.

Fagg, P. (1987). Establishment and early growth of indigenous eucalypts sown on forest sites infested with *Phytophthora cinnamomi* in East Gippsland, Australia. *Forest Ecology & Management* 20*:*53–78.

Fagg, P.C. and Marks, G.C. (1987). *Evaluation of tree species for planting on dieback-affected forest sites in East Gippsland. Research Report 324*, Forests Service, Dept of Conservation Forests & Lands, Vic.

Gibson, M., Milne, R., Cahill, D. and Wilson, B. (2002). *Preliminary review of the actual and potential distribution of Phytophthora cinnamomi dieback in parks and reserves across Victoria.* Centre for Environmental Management, University of Ballarat.

Greening Australia (2003). Species, spades and skills. A snapshot of what's missing in regional vegetation management. Notes from presentation given to Environment Australia by Brenton Dickins, National Bushcare Support Manager, Greening Australia.

Harris, J. A., Kassaby, F. Y., Smith, I. W. & Marks, G. C. (1983). Intra-specific variation in resistance to *Phytophthora cinnamomi* in *Eucalyptus regnans*. *Australasian Plant Pathology* 12:20-22.

Harris, J. A., Kassaby, F. Y. & Smith, I. W. (1985). Variation in mortality in families of *Eucalyptus regnans* caused by *Phytophthora cinnamomi*, up to 5 years after planting. *Australian Forest Research* 15:57–65.

Kennedy J., and Weste, G. (1986). Vegetation changes associated with invasion by *Phytophthora cinnamomi* on monitored sites in the Grampians, western Victoria. *Australian Journal of Botany* 34:251–279.

Laidlaw, W.S. (1997). *The effects of Phytophthora cinnamomi on heathland flora and fauna of the Eastern Otways*. PHD thesis, Deakin University.

Laidlaw, W.S. and Wilson, B.A. (2003). Floristic and Structural Characteristics of a Coastal Heathland Exhibiting Symptoms of *Phytophthora cinnamomi* Infestation in the Eastern Otway Ranges, Victoria. *Australian Journal of Botany* 51*:* 283–293.

Marks, G.C. Kassaby, F.Y. and Reynolds, S.T. (1972). Dieback in Mixed Hardwood Forests of Eastern Victoria. *Australian Journal of Botany* 20*:*142–154.

Marks, G.C. and Smith, I.W. (1991). The Cinnamon Fungus in Victorian forests. History, distribution, management and control. *Lands and Forests Bulletin No. 31*, Department of Conservation and Environment, Melbourne.

NIASA (2003). *Nursery industry accreditation scheme, Australia. Best practice management guidelines*. Nursery and Garden Industry Australia. http://www.ngia.com.au

Nursery Paper (2002). Disease awareness in the nursery and garden industry. Nursery and Garden Industry Australia, *The Nursery Papers,* Issue 2002/5.

Podger, F.D., James, S.H. and Mulcahy, M.J. (1996). *Review of dieback in Western Australia*. Report to Minister of Environment.

Schahinger, R., Rudman T., and Wardlaw, T. J. (2003). Conservation of Tasmanian plant species & communities threatened by *Phytophthora cinnamomi*. Strategic regional plan for Tasmania. *Technical Report 03/03*, Nature Conservation Branch. Department of Primary Industries, Water and Environment, Hobart.

Shearer, B.L, Crane, C.E. and Cochrane, A. (2004). Quantification of the susceptibility of the native flora of the South West Botanical Province, Western Australia, to *Phytophthora cinnamomi*. *Australian Journal of Botany* 52*:* 435–443.

Shepherd C.J. (1975). *Phytophthora cinnamomi*; an ancient immigrant to Australia. *Search* 6*:*484–490.

Tregonning, K. C. and Fagg, P.C. (1985). Seasonal rainfall and Eucalyptus dieback epidemics associated with *Phytophthora cinnamomi* in Gippsland, Victoria. *Australian Forest Research* 14*:*219–234.

VPMF (2002). *Victorian pest management. A framework for action*. Department of Sustainability and Environment, Melbourne.

Weste, G. and Marks, G.C. (1987). The biology of *Phytophthora cinnamomi* in Australian forests. *Annual Review of Phytopathology* 25*:* 207–229.

Weste, G. (1998). Dieback at Wilsons Promontory. Is the battle won? *The Victorian Naturalist* 115 (6): 331 –336.

Weste, G., Hewett, M. and Reiter, N. (2004). Dieback threatens endangered native plants. Will they survive? *The Victorian Naturalist* 121 (4)*:* 148 –152.

Wilson, B.A., Newell, G., Laidlaw, W.S., and Friend, G. (1994). Impact of plant diseases on faunal communities. *Journal of the Royal Society of Western Australia* 77*:* 139–143.

Wilson, B.A, Lewis, A. and Aberton, J. (2003). Spatial model for predicting the presence of Cinnamon Fungus (*Phytophthora cinnamomi*) in sclerophyll vegetation communities in south-eastern Australia. *Austral Ecology* 28: 108–115.

Notes

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