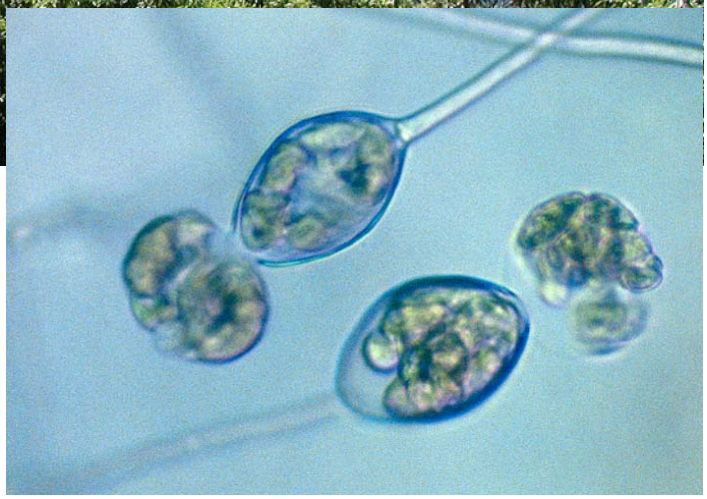

Statement of Intent

1: Infection of native plants by *Phytophthora cinnamomi*

Department of **Environment & Climate Change** NSW

Cover photos:

Sydney Harbour National Park – *Phytophthora cinnamomi* infected areas. DECC.

Phytophthora cinnamomi as it appears under a microscope. R. Pongpisutta, DECC.

Published by:

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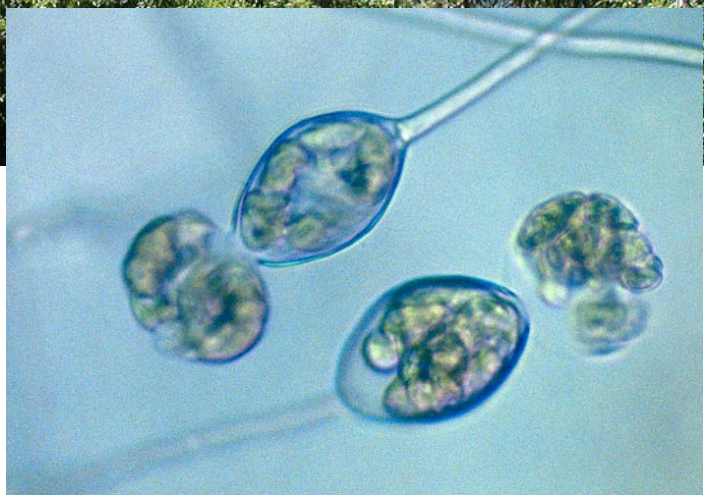
Website: www.environment.nsw.gov.au

ISBN 978 1 74122 759 8
DEC 2008/119

April 2008

An electronic copy of this document is available on the DECC website at www.environment.nsw.gov.au



Statement of Intent

1: Infection of native plants by *Phytophthora cinnamomi*

Department of **Environment & Climate Change** NSW

CONTENTS

1. Introduction

Phytophthora cinnamomi (root-rot fungus, cinnamon fungus) is a microscopic soil-borne plant pathogen that can invade and destroy the root systems of susceptible native and introduced plant species. The resultant disease, Phytophthora root rot, is a major cause of death in trees and shrubs and can devastate Australian native ecosystems and the horticultural, forestry and agricultural industries (Irwin et al. 1995).

Native to south-east Asia, it is generally accepted that *Phytophthora cinnamomi* was introduced to Australia through infested horticultural plants (O'Gara et al. 2005b). It is the most widespread and destructive of the 32 *Phytophthora* species that occur in Australia (Phytophthora Technical Group 2003). Human activities involving the movement of infested soil, water or plant material have led to the spread of *Phytophthora cinnamomi* across the landscape, affecting biodiversity.

Phytophthora cinnamomi has been identified as a threat to a number of threatened species and ecological communities in NSW (NSW Scientific Committee 2002). In December 2002, 'Infection of native plants by *Phytophthora cinnamomi*' was listed as a key threatening process in Schedule 3 of the NSW *Threatened Species Conservation Act 1995* (TSC Act). Comparably, 'Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*)' is listed as a key threatening process under the Australian Government *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Department of Environment and Climate Change (DECC), through the NSW Priorities Action Statement (PAS), has identified various strategies and priority actions relevant to this threat in NSW. A cooperative effort is required to mitigate the impact and manage the threat of *Phytophthora cinnamomi* by engagement with landholders, managers and the public to prevent further spread of the fungus across vulnerable areas in NSW.

This Statement of Intent outlines DECC's approach to implementing a broad program of actions over the next 5 years to manage the threat and minimise the impact of *Phytophthora cinnamomi* on the biodiversity of NSW. Priority initiatives include:

- actions to address gaps in knowledge
- assessment of the risk to flora, faunal habitat and ecological communities
- engagement with key stakeholders to identify and promote cooperative best management across priority areas
- raising of awareness through training, education and communication
- delivery of a coordinated threat abatement program.

Threat abatement actions contained in this Statement are consistent with those presented in the *National Threat Abatement Plan – Disease in Natural Ecosystems caused by Phytophthora cinnamomi*. Several DECC initiatives will be developed and implemented in conjunction with the national approach.

This Statement does not specifically address the direct impacts on the agricultural, forestry and horticultural industries. However, DECC envisages that this Statement will provide opportunities to work in partnership with other government agencies, industry, and land managers, and integrate efforts to tackle this threat into the future.

What is a Threat Abatement Plan?

A NSW Threat Abatement Plan (TAP) is a statutory document that is prepared and approved in accordance with Part 5 of the TSC Act. Threat abatement planning is all about cooperation. DECC is the main body responsible for implementing these plans. However, DECC cannot work in isolation and relies on an integrated and collaborative approach involving other public authorities, organisations and the community to implement the range of activities.

(continued)

Because the plan is a statutory document, Ministers and public authorities are required to take any appropriate action available to them to implement the measures in the plan. Furthermore, they must report to Parliament on the actions taken to implement the measures for which they are responsible, and they must not take actions that are inconsistent with the provisions of the plan.

The NSW Government collaborates with the Australian Government to implement any National TAP prepared under the EPBC Act, and DECC facilitates cooperation across the key government agencies and other stakeholders in NSW.

How does this Statement of Intent differ from a TAP?

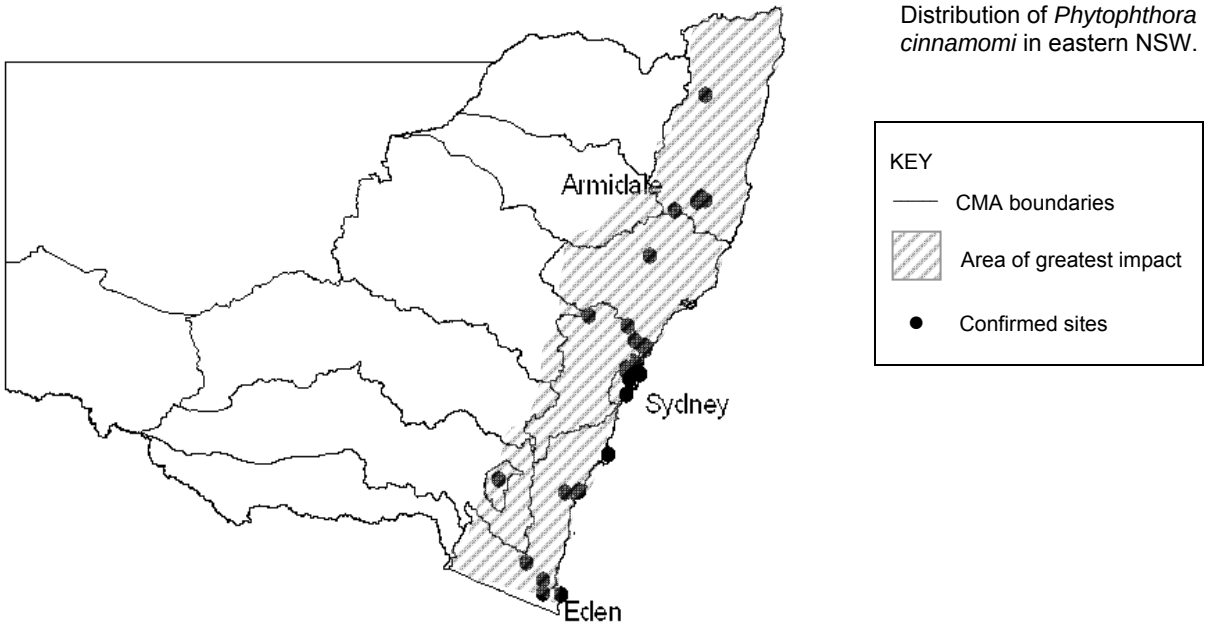
This Statement of Intent presents a strategic framework for a targeted threat abatement program relevant to DECC's area of responsibility. Although not a statutory document, it responds to priority actions identified in a National TAP and the NSW PAS.

2. Distribution

Phytophthora cinnamomi occurs worldwide and affects an enormous number of plant species (Summerell et al. 2005). In Australia, many hundreds of thousands of hectares of native vegetation in Western Australia, Victoria and Tasmania, and tens of thousands of hectares in South Australia, are affected by the pathogen (DEWR 2007). *Phytophthora cinnamomi* is also found in coastal Queensland and eastern NSW, although disease expression in these areas is often more cryptic and the extent of the threat is unknown (DEH 2006).

Rainfall is one key factor influencing the distribution of *Phytophthora cinnamomi*; consequently, disease caused by the pathogen is generally restricted to moister regions (Summerell et al. 2005). It occurs in gullies, depressions, along drainage lines, and in areas of surface seepage on ridge tops (Laidlaw & Wilson 2003).

Other factors that influence disease expression are temperature, geology, soil condition (including pH, fertility, moisture and texture) and the presence of susceptible plant species (O'Gara et al. 2005b).



Distribution of *Phytophthora cinnamomi* in eastern NSW.

Case study – *Phytophthora cinnamomi* across NSW national parks and reserves

In 2001, the discovery of *Phytophthora cinnamomi*-induced dieback in Mt Imlay National Park prompted the NSW National Parks and Wildlife Service (NPWS) and the Botanic Gardens Trust (BGT), now both part of DECC, to conduct a preliminary study of the impact of *Phytophthora cinnamomi* within the NPWS estate. The study concluded that:

- although *Phytophthora cinnamomi* is widespread in eastern NSW, disease expression is rare, either because highly susceptible hosts have already been lost from many communities or there are naturally few, if any, highly susceptible hosts
- *Phytophthora cinnamomi* is not ubiquitous, as there are areas containing known susceptible species from which the pathogen cannot be isolated despite intensive sampling
- *Phytophthora cinnamomi*-induced dieback is having a demonstrable local impact on flora and vegetation in several widely spaced parts of eastern NSW.

Source: McDougall & Summerell 2003

This pathogen does not usually cause severe damage in undisturbed vegetation at sites that receive a mean annual rainfall of less than 600 mm and are north of latitude 30° (O'Gara et al. 2005b). Areas that have a mean annual temperature below 15°C or are on limestone-derived soils are also unlikely to be affected by the pathogen (McDougall 2005).

In NSW, strong evidence of *Phytophthora cinnamomi*-induced dieback has been identified in forest, woodland and heathland vegetation in the Catchment Management Authority (CMA) areas of Hawkesbury–Nepean, Hunter–Central Rivers, Northern Rivers, Southern Rivers and Sydney Metropolitan (McDougall & Summerell 2003; Daniel et al. 2006).

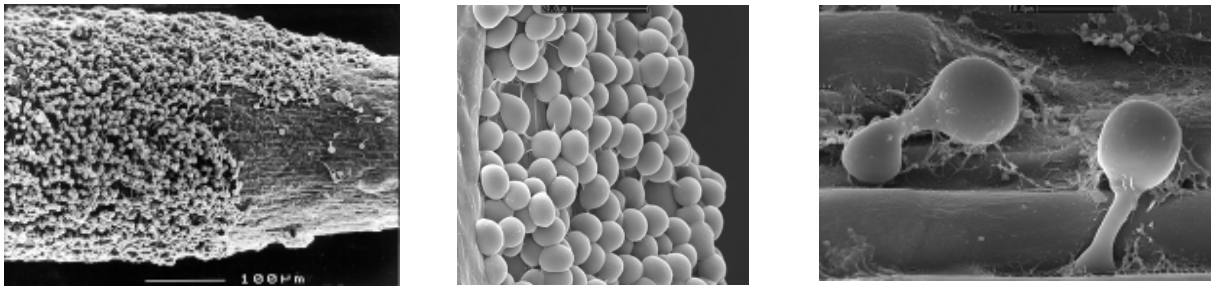
DECC targeted surveys in conservation reserves have confirmed the presence of *Phytophthora cinnamomi* in Barrington Tops, Ben Boyd, Gibraltar Range, Mount Imlay, Mummel Gulf, Murramarang, Oxley Wild Rivers, South East Forests, Sydney Harbour, Royal, Werrikimbe, Lane Cove, Garrigal and Wollemi National Parks (McDougall & Summerell 2003; Daniel et al. 2006; DEC 2006; S. Bullock DEC pers. comm.). With only limited surveys outside these areas the full extent of distribution is unknown.

Climate change in NSW will result in increased frequency of extreme weather events and increased temperatures. In turn, this may alter the range where the pathogen is biologically active and may increase the severity of impact.

3. Biology and ecology of *Phytophthora cinnamomi*

The entire life cycle of *Phytophthora cinnamomi* occurs within soil and plant tissue; the food source of the fungus is the root and stem tissues of living plants (Dieback Working Group 2000). Growth and reproduction are favoured by moist soil conditions and warm temperatures (DSE 2005). The pathogen usually occurs in gullies and depressions, along drainage lines, and in areas of surface seepage on ridgetops (Laidlaw & Wilson 2003).

In its vegetative state, *Phytophthora cinnamomi* develops into colourless threads called mycelia (O'Gara et al. 2005b). Three types of asexual spores are produced by the mycelia: sporangia, zoospores, and chlamydospores. Although all of these spores have the capacity to directly infect plants, the zoospores are thought to be the major propagules of infection (O'Gara et al. 2005b).



Phytophthora spores attached to and infecting roots of susceptible plants.
Reproduced with permission of Prof. A. Hardham, Research School of Biological Sciences, ANU.

Upon maturity, the sporangia release large numbers of motile zoospores into the surrounding soil (DEH 2004).

The zoospores, which are chemically attracted to plant roots, can swim very short distances. They can be dispersed over relatively large distances by surface and sub-surface water flows (Dieback Working Group 2000). Rates of spread of up to 400 metres a year have been recorded down slopes with free water flow (Dawson et al. 1985). Zoospores are also easily transported in contaminated soil and on tools, footwear and vehicles (Summerell et al. 2005).

Chlamydospores are asexual survival structures that are produced when a food source is exhausted (the roots of the infected plant die) or in periods of low temperature or drought.

The mycelium also produces oospores as a result of sexual reproduction (Summerell et al. 2005). Both chlamydospores and oospores can survive for long periods of time in soil and dead plant material, and they will germinate and renew the life cycle when conditions are favourable (DEH 2004). They act as sources for the reinfection of susceptible seedlings at post-disease sites and can be spread long distances through the movement of contaminated soil and dead plant material (DSE 2005).

4. Disease symptoms

Once inside the plant, *Phytophthora* spores develop into mycelia and grow between, and into, the cells of the roots and stems, colonising the vascular tissue and restricting the uptake of water and nutrients.

Susceptible *Xanthorrhoea australis* displaying secondary symptoms.
Photo: R. Daniel, DECC.

Infected *Lambertia formosa* (L); uninfected plant (R).
Photo: R. Amatya-Malla, The University of Sydney.

The primary symptoms of the disease include root and collar rot, caused by the vascular tissue damage, and visual symptoms of wilt, similar to those observed from water stress. Secondary symptoms include the yellowing and drying out of leaves from the tips of the upper branches down, with the eventual death of the host plant. This process is often called *Phytophthora* dieback.

Some plants are capable of restricting the spread of the pathogen farther into the vascular system following its initial infection at the root (Dieback Working Group 2000). Other plants are able to withstand infection by rapidly producing new roots to replace those already infected (Phytophthora Technical Group 2003).

Phytophthora cinnamomi infects a large number of plants, and host species display a range of symptoms (McDougall and Summerell 2002). Highly susceptible plants die rapidly once infected; other plants may take years to develop visual symptoms following infection (Phytophthora Technical Group 2003).

Other factors that could cause similar symptoms leading to plant death include drought, flooding, nutrient deficiency, fire, chemical poisoning or other pest and disease infestation (Summerell et al. 2005).

5. Impacts on biodiversity

The magnitude of impact on biodiversity is conditioned by the interplay between the pathogen and the environment (under favourable local and temporal conditions), together with the susceptibility of the target plant species and its functional role within the ecosystem.

Across Australia

The number of Australian plants species susceptible to *Phytophthora cinnamomi* is unknown but is likely to be many thousands. In south-western Australia alone, Shearer et al. (2003) have estimated, on the basis of the proportions of species for which susceptibility is known, that about 2300 species are susceptible to infection and 800 of these are likely to be highly susceptible. Some Australian plant families appear to be more susceptible to the pathogen than others. Particularly susceptible families include the Proteaceae, Epacridaceae, Fabaceae and Dilleniaceae (Weste 1994). Only a few genera of the Myrtaceae family, including Eucalypts, are consistently highly susceptible (McDougall & Summerell 2002).

Grasses, sedges and geophytes are often more resistant than woody perennials to *Phytophthora cinnamomi* (DSE 2005). As a consequence, infested areas are sometimes characterised by a lower abundance and richness of shrub species and an increased cover and richness of graminoids (Weste 1981, 1986; Laidlaw & Wilson 2003; McDougall & Summerell 2002, 2003). Studies have demonstrated significant impacts on species diversity, where up to 60 per cent of understorey species present before infestation were eliminated (Weste 1974; Dawson et al. 1985; Kennedy & Weste 1986; Wills 1993; Duncan & Keane 1996).

Dieback of *Xanthorrhoea australis* in the understorey of a *Eucalyptus sieberi* forest near Eden, with yellowing foliage (centre) and dead plants (left), and a healthy individual (right).
Photo: K. McDougall, DECC.

Diseased areas are gradually invaded by resistant species, subsequently changing the vegetation structure, species composition and productivity of the ecosystem, with consequential effects on the dependent flora and fauna (Wilson et al. 2003). In Australia, the most destructive disease symptoms have been observed in dry open forests, woodlands and heathlands (Laidlaw & Wilson 2003).

Variation in susceptibility has also been observed within genera. In the genus *Eucalyptus*, gums, boxes and ironbarks are relatively resistant to infection, whereas ashes, stringybarks and peppermints are generally more susceptible (Phytophthora Technical Group 2003). In addition, variations in susceptibility have been observed among different populations of the same taxa, as well as within populations (Harris et al. 1983).

In Victoria, monitoring studies have reported regeneration of many susceptible species in vegetation communities infested up to 30 years ago. Disease still recurs periodically in these areas under favourable conditions (Weste 1997; Weste et al. 1999).

Native animals may be indirectly affected by *Phytophthora cinnamomi* through the loss of shelter (e.g. vegetative cover) and food resources (e.g. nectar, pollen, seed, and prey, particularly invertebrates) in post-disease areas (DSE 2005).

New South Wales impacts

The extent of *Phytophthora cinnamomi* impact within NSW is generally unknown. It does not appear to be causing the dramatic widespread vegetation loss that has been observed in other southern Australian states. However, the pathogen is having a significant local impact on native vegetation in several widely spaced parts of eastern NSW, and these impacts are primarily on understorey species (McDougall & Summerell 2003).

Susceptible threatened plant species listed in the TSC Act include the endangered *Eucalyptus imlayensis* (Imlay mallee) and *Wollemia nobilis* (Wollemi pine) and the vulnerable *Leionema ralstonii* (Ralston's leionema) and *Tasmannia purpurascens* (broad-leaved pepperbush) (O'Gara et al. 2005b; DEC 2006). The NSW floral emblem *Telopea speciosissima* (waratah) is also highly susceptible to the pathogen in cultivation (McDougall & Summerell 2002). A further 78 rare or threatened species are thought to be at risk from the pathogen as a result of their proximity to known infestations or their occurrence in vulnerable habitats (McDougall & Summerell 2002).

Evidence of *Phytophthora cinnamomi*-induced dieback has been identified in the following vegetation classes, as described in Keith (2004):

- montane wet sclerophyll forest
- North Coast wet sclerophyll forests
- northern escarpment dry sclerophyll forest
- southern lowland wet sclerophyll forests
- South Coast sands dry sclerophyll forests
- South Coast heaths
- South-east dry sclerophyll forests
- subalpine woodlands
- Sydney coastal dry sclerophyll forests
- Wallum sand heaths.

Imlay mallee (*Eucalyptus imlayensis*).
Photo: Keith McDougall, DECC.

TSC Act listed endangered ecological communities that contain several species likely to be susceptible to the pathogen include Duffys Forest (Sydney Basin), Eastern Suburbs Banksia scrub, Genowlan Point *Allocasuarina nana* heathland, and low woodland with heathland on indurated sand at Norah Head (McDougall & Summerell 2002).

Changes in vegetation structure caused by *Phytophthora cinnamomi* have been observed in NSW. For example, infested areas of *Eucalyptus sieberi* forest in Mount Imlay National Park are changing from a forest with abundant shrub and *Xanthorrhoea* cover to a forest with an understorey dominated by the herbs *Lomandra confertifolia* and *Tetrarrhena juncea* (McDougall & Summerell 2002). Similarly, there has been a clear structural change in *Phytophthora cinnamomi*-infested sub-alpine vegetation in Barrington Tops National Park, where an understorey previously dominated by dense shrubs has been replaced with one dominated by the grass *Poa sieberiana* (McDougall & Summerell 2003).

The ongoing loss of understorey species in infested *Eucalyptus sieberi* forests on the South Coast will affect two endangered mammal species, the smoky mouse (*Pseudomys fumeus*) and the southern brown bandicoot (*Isoodon obesulus*) (McDougall & Summerell 2002).

The shrubby understorey in non-infested stands of these forests provides cover for these species and potential nesting habitat (specifically, *Xanthorrhoea australis*, the grass tree) for the southern brown bandicoot (McDougall & Summerell 2002). The fleshy fruits and seeds of susceptible flora species in these forests are important components of the smoky mouse's diet (McDougall & Summerell 2002).

Other threatened fauna species that may be indirectly affected by the pathogen include the endangered eastern bristlebird (*Dasyornis brachypterus*), long-footed potoroo (*Potorous longipes*), and Hastings River mouse (*Pseudomys oralis*); and the vulnerable white-footed dunnart (*Sminthopsis leucopus*) and eastern ground parrot (*Pezoporus wallicus wallicus*) (McDougall & Summerell 2002).

Further surveys and species-susceptibility testing are required to identify additional species, populations and ecological communities in NSW that are threatened by *Phytophthora cinnamomi*.

Smoky mouse (*Pseudomys fumeus*).
Photo: Linda Broome, DECC.

Genowlan Point heathland.
Photo: Simon Nally, DECC.

Case study – *Phytophthora* threatens the Wollemi pine

Discovered in 1994 by a NPWS staff member, the Wollemi pine (*Wollemi nobilis*) is one of the rarest plants in the world. It is known to occur only in several stands of fewer than 100 adult plants and about 200 to 300 juveniles and seedlings within a gorge system surrounded by sandstone cliffs within Wollemi National Park.

This species is listed as endangered on Schedule 1 of the NSW TSC Act and as endangered under the Commonwealth EPBC Act. Infection by *Phytophthora cinnamomi* and fire are the biggest threats to the survival of this native plant in the wild.

In 2005, *Phytophthora cinnamomi* was found to be the cause of foliage dieback in three Wollemi pine trees within the Wollemi NP (DEC 2006). It is believed that the pathogen was introduced to the site by an unauthorised visitor (DEC 2005). This discovery triggered the implementation of threat abatement measures at the site, including:

- strengthening of site hygiene protocols
- injecting affected trees with phosphonate
- soil drenching with the fungicide metalaxyl
- conducting experiments on cultivated plants to determine optimum control measures
- implementing a program to monitor the health of infected plants over time (DEC 2006).

These actions now form part of the Commonwealth and NSW Government's *Recovery Plan for Wollemi Pine*, released in 2006. The total cost of implementing the Plan's recovery actions is estimated to reach $1.3 million over the 5-year period to 2011. This will include:

- $200,000 directed to managing the threat of *Phytophthora cinnamomi* in the wild population by controlling the infection and preventing the spread within the critical habitat
- $20,000 to implement the site hygiene protocols and monitor plant health in relation to the effects of *Phytophthora cinnamomi* infection
- up to $190,000 to implement the site access strategy, including increased surveillance of the site (DEC 2006).

Implementation of these actions is a shared responsibility across DECC expert areas of the Parks and Wildlife Group, Scientific Services Division and Botanic Gardens Trust. Funding to support this work is currently being sourced from the royalties received following the commercial release of the plant and recurrent budget allocations.

Recognised as internationally significant for its biodiversity, scientific, social and economic value, this iconic NSW endemic plant can help increase awareness and communicate the real threat associated with *Phytophthora cinnamomi* and impacts on the biodiversity of NSW.

Wollemi pine adult foliage.
Photo: J. Plaza, DECC.

6. What is being done nationally?

Formal recognition of *Phytophthora cinnamomi* as a threat under the Australian Government's EPBC Act prompted a national integrated approach to mitigate this threat. Recently revised, the National TAP provides a strategic framework implementing actions to identify, prioritise and manage the threat of disease in natural ecosystems caused by *Phytophthora cinnamomi*' (DEWR 2007).

Box 1: National report on threat abatement actions in Australia

One of the most significant actions funded under the first National TAP was the development of a best practice model for *Phytophthora cinnamomi* management through the report entitled 'Management of *Phytophthora cinnamomi* for biodiversity conservation in Australia'. The best practice model provides an informed and integrated approach to *Phytophthora cinnamomi* management in Australia, from strategic planning to best practice for on-ground management.

The report is presented in the following four parts:

1. **Part 1 – A Review of Current Management**: A comprehensive review of the threat abatement measures that are being implemented in all affected states, within the context of the best practice model (O'Gara et al. 2005a).
2. **Part 2 – National Best Practice Guidelines**: Building on the review of current management, this document presents the best current practice and processes, in the form of national guidelines for the management of *Phytophthora cinnamomi* in natural ecosystems. They include recommendations on how to apply these best practice models at the strategic/tactical level of management, and recommendations on operational and on-ground management (O'Gara et al. 2005b).
3. **Part 3 – Risk Assessment for Threats to Ecosystems, Species and Communities: a Review:** A review of the various approaches to assessing risk that have been undertaken across Australia to inform the development of a national risk assessment model (Wilson et al. 2005).
4. **Part 4 – Risk Assessment Models for Species, Ecological Communities and Areas:** This report described a set of risk assessment models that were developed to guide investment decisions regarding where *Phytophthora cinnamomi* threat abatement resources in Australia will be most effective. The models use a semi-quantitative scoring system that enables a ranking of biodiversity assets (i.e. flora, fauna habitat, ecological communities and areas) according to the level of risk posed by *Phytophthora cinnamomi* and the perceived ability to manage the risks (CPSM 2005). These models have resulted from preliminary testing with data from all affected States. The revised National TAP adopts the model as a national approach subject to necessary refinements at the State scale.

These reports are available on the Australian Government's Department of the Environment, Water, Heritage and the Arts website. Follow the link at

http://www.environment.gov.au/biodiversity/invasive/publications/p-cinnamomi/index.html

7. What is being done in NSW?

Over the past 5 years, DECC has supported a range of activities to enable us to better understand the nature and impact of *Phytophthora cinnamomi* in NSW. This work, guided by the National TAP, has included surveys to determine distribution and assess impacts, diagnostic testing to identify the presence of the pathogen, on-ground management, and monitoring and research.

A DECC Threat Abatement Working Group for *Phytophthora cinnamomi* was established in 2006 to guide the planning and implementation of a coordinated state-wide threat abatement program for the pathogen. The Group includes DECC expert staff who are leading research into, and managing, this pathogen and its effect within NSW and nationally. The Threat Abatement Working Group represents a combined effort across the various DECC Divisions and Groups, including the Climate Change, Policy and Programs Group, Environment Protection and Regulation Group, Botanic Gardens Trust, Parks and Wildlife Group and Scientific Services Division.

A Phytophthora Disease Coordinator has recently been appointed to a position within the Botanic Gardens Trust to coordinate projects with the Sydney Metropolitan and Hawkesbury–Nepean CMAs. An estimated total of $400,000 (including DECC in-kind contributions and external grants) is being directed to this work in 2007–08. DECC also represents NSW on the National Threat Abatement Plan Reference Group, assists with advice to the Sydney metropolitan local governments, and works in cooperation with the University of Sydney to target research on the nature of this pathogen.

DECC threat abatement work

On-ground mitigation

DECC has started trials involving the application of the chemical phosphonate (also referred to as phosphite) to mitigate the impact of *Phytophthora cinnamomi* on susceptible flora species in Mt Imlay National Park and Wollemi National Park.

Research on the susceptibility of species

DECC and the University of Sydney are undertaking trials to determine the susceptibility of a small number of flora species to infection by the pathogen. Limited trials have also started to determine the effects of phosphonate on a small number of susceptible species (R. Daniel DECC pers. comm.). Monitoring of the field response of canopy trees to phosphonate application is also being undertaken by the managers of infested public lands on the Sydney Harbour foreshore (Jensen 2005).

Surveys and monitoring of impact in eastern NSW

Surveys and monitoring of the impact of *Phytophthora cinnamomi* in DECC's reserve estate are ongoing. This work will help improve our knowledge of the distribution of the pathogen, identify threatened species and communities at risk, and inform identification of priority management areas. Permanently marked floristic quadrats have been established to monitor infested and healthy vegetation in Mount Imlay National Park and South-East Forests National Park (Wilson et al. 2005).

Site controls to protect threatened species

Recovery programs for a number of threatened species and ecological communities listed under the TSC Act include actions to survey the presence of the pathogen, investigate species susceptibility and control site access. These are relevant for the conservation of the smoky mouse (*Pseudomys fumeus*), flora of rocky outcrops in south-eastern NSW, Somersby mintbush (*Prostanthera junonis*) and the Wollemi pine (*Wollemi nobilis*), to name a few.

8. Key challenges and initiatives

This section describes the key challenges and the responding initiatives that DECC will pursue as part of a targeted threat abatement program to tackle 'Infection of native plants by *Phytophthora cinnamomi'.* These actions are grouped under the five main challenges currently faced to effectively control the infection and prevent the spread of this pathogen in NSW. Responsibilities for implementing these actions will be shared across relevant DECC Divisions over the 5-year period from 2007 to 2012. The cost associated with the identified actions will be sourced from DECC in-kind recurrent budgetary allocations, from external grants (e.g. from the Environmental Trust and Natural Heritage Trust) and from the National TAP. The indicative timeframes allocated to each action are identified as either:

- (S) short-term, i.e. 1 to 3 years
- (M) medium-term, i.e. 3 to 5 years
- (L) long-term, i.e. more than 5 years.

Challenge 1 – Understanding the threat

Apart from the significant local impacts in several widely spaced areas along the eastern part of NSW, little is known about the threat *Phytophthora cinnamomi* poses to this State's biodiversity. Early studies were cursory in nature, focusing on the direct impacts on affected trees rather than other impacts on understorey species and fauna. Further investigations are required to identify the elements most at risk from the pathogen. Investigations will be challenged by:

- the lack of easily identifiable disease fronts in NSW
- the lack of indicator species (i.e. widespread species that are reliably susceptible to the pathogen) in NSW
- evidence of impacts being rapidly lost as a consequence of fire and decomposition
- the prohibitive costs associated with collecting and testing soil samples over large areas
- the nature of soil sampling and testing, which can confirm that the pathogen is present, but not that it is absent
- the need to establish field-based susceptibility testing and monitoring of long-term effects
- the large number of flora species that need to be tested for susceptibility
- the potential effects of climate change on the distribution and virulence of the pathogen.

Initiative 1: Assess the risk to flora, fauna habitat, and ecological communities in NSW

Actions

1.1 Develop and apply criteria to identify the areas of NSW where there is a coincidence of environmental conditions conducive to the establishment and persistence of the pathogen (i.e. vulnerable areas) (S)

1.2 Conduct surveys (systematic and targeted) and soil sampling within vulnerable areas to improve knowledge of the distribution of the pathogen (S)

1.3 Test to determine the susceptibility of priority flora species (e.g. threatened, keystone or common overstorey species) that occur in vulnerable areas (S)

1.4 Adapt and apply the national risk assessment models (see Box 1) to assess the level of risk that the pathogen poses to flora, fauna habitat, and ecological communities in vulnerable areas of NSW (S)

1.5 Maintain a database of sites in NSW where the pathogen has been identified, or is suspected of being present (S/M/L)

Challenge 2 – Controlling the spread of the pathogen

There are currently no proven methods to prevent the autonomous spread of *Phytophthora cinnamomi* and controlling spread through natural and/or vectored (by animals and humans) processes can be very difficult and prohibitively expensive (O'Gara et al 2005a). While challenging to manage, efforts should focus on precautionary measures to control spread by humans through means which aim to modify behaviour and activities.

The actions under this initiative seek to facilitate the implementation of on-ground threat abatement in areas where the greatest biodiversity benefits can be secured. DECC adopts the on-ground management objectives to:

- limit the spread of the pathogen; and
- mitigate the impact of the disease in infested areas.

Initiative 2: Identify and promote on-ground management of the pathogen in priority areas

Actions

2.1 Adapt and apply the national risk assessment model across affected areas of NSW to identify priority management areas (S)

2.2 Undertake on-ground management in priority areas of the NPWS estate (S/M/L)

2.3 Encourage land managers to undertake on-ground management in priority areas outside the NPWS estate (S/M/L)

2.4 Obtain permits for broad-scale application of the chemical phosphonate to control the spread of the pathogen (S)

Managing the spread of *Phytophthora cinnamomi* by humans

Humans have the potential to spread *Phytophthora cinnamomi* further and faster than any other vector through the movement of infested soil, water or plant material. Activities such as road construction, timber harvesting, wildflower picking, bushwalking, four-wheel driving, fire break management, revegetation activities and the planting of diseased nursery stock have been implicated in causing the spread of the pathogen (Hardy et al. 2001). Using infected dam water for fire fighting has also been identified as a potential source (DSE 2005).

The National TAP promotes best practice to control the spread of *Phytophthora cinnamomi* across the landscape, with focus on the modification of human behaviour by controlling access to sites and applying strict hygiene protocols (O'Gara et al. 2005a).

Access can be restricted to protect areas not already infested by the pathogen or to isolate infested areas, reducing the risk of the pathogen being dispersed more widely. Management options to restrict access include:

- prohibiting human access (i.e. quarantine) through information and signage
- modifying or reducing access points, roads, tracks and trails through an area
- enforcing restrictions, either permanently or on a seasonal basis, where environmental conditions are conducive to the proliferation and dissemination of the pathogen (O'Gara et al. 2005a).

The national review of management options recognised that quarantining of areas can be difficult to enforce.

Hygiene procedures can minimise the introduction and spread of *Phytophthora cinnamomi* through human activities and domestic animals. Application of hygiene protocols are recommended for anything that can harbour potentially infested soil or plant material, such as large industrial machinery, light vehicles, bicycles, tools, footwear, tent pegs, horses hooves, construction materials, road-building materials, composts, plants and water (O'Gara et al. 2005a).

Application of hygiene protocols to wash down vehicles. Photo: DECC.

Challenge 3 – Identifying effective mitigation measures

There are no known methods for eradicating *Phytophthora cinnamomi* once it is present in a natural ecosystem, and there are limited methods available to control the pathogen at infected sites.

Our knowledge of critical aspects of the science and management of the pathogen is incomplete. The actions under this initiative seek to improve our capacity to identify infested areas and manage these areas effectively. To inform future management decisions, there is an urgent need to monitor the effectiveness and efficiency of containment and impact-mitigation measures.

Initiative 3: Address knowledge gaps that hamper effective and efficient threat abatement

Actions

3.1 Investigate the limitations and optimal methods for the control and eradication of the pathogen (including consideration of off-target impacts) (S/M/L)

3.2 Identify reliable indicator species that will help identify areas where the pathogen is active (S)

3.3 Investigate the impact that climate change is likely to have on the distribution and virulence of the pathogen, and incorporate this knowledge into the national risk assessment model where possible (S)

3.4 Monitor key sites to determine the effectiveness of measures to prevent the spread of the pathogen and suppress its activity in infested areas, and to determine the long-term impact of the pathogen on biodiversity (S/M/L)

3.5 Establish and/or maintain networks with the Australian Government, other State agencies, CMAs, local government and research organisations in relation to the management of the pathogen (S/M/L)

3.6 Develop landscape models that will predict spatial and temporal changes in pathogen distribution and/or disease expression under different development scenarios (S/M/L)

Current mitigation measures

Application of the chemical phosphonate (potassium phosphonate, also referred to as phosphite) can stop the spread of the pathogen in a large number of plant species. Phosphonate can protect normally susceptible plant species or vulnerable vegetation, and it is the most promising control agent identified to date (DSE 2005). It has been applied to infected native vegetation in Western Australia, Victoria and Tasmania, and preliminary trials of its use have begun in NSW's Mt Imlay National Park and on the Wollemi pine (McDougall & Summerell 2002, E. Liew DECC pers. comm.).

Phosphonate is applied to plants as a foliar spray or soil drench, or by stem injection. It stops the spread of the pathogen by triggering a strong and rapid defence response in the host plant (Hardy et al. 2001). However, its effectiveness and persistence varies considerably between species and depending on the season and the rate of application (Hardy et al. 2001). Detrimental impacts resulting from application of phosphonate include phytotoxicity, growth abnormalities and reduced reproductive capacity in some species (Hardy et al. 2001). It has low toxicity to people or animals and a low pollution risk (Dieback Working Group 2000).

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Phosphonate application is time consuming, with labour costs making it an expensive option. However, aerial application is a rapid way to treat entire plant communities, especially where rough terrain would make ground application prohibitively expensive (O'Gara et al. 2005a). Aerial application is also used in areas with many highly susceptible plants, such as the Stirling Ranges in Western Australia. Aerial application is not an option in NSW.

There remains a fine balance between the rate of phosphonate applied, phytotoxicity symptoms and the control of disease caused by *Phytophthora cinnamomi* (Hardy et al. 2001).

Ex-situ conservation measures to mitigate impacts on priority species can be used where control options prove to be unsuccessful or as a contingency measure before the implementation of control options, for example:

- Translocation is an impact mitigation option that is being used increasingly in Western Australia to mitigate the impact of *Phytophthora cinnamomi* (O'Gara et al. 2005a).
- Plant breeding programs targeting threatened species and ecological communities, particularly those threatened by *Phytophthora*, can provide material for research into disease susceptibility and for breeding resistant species for reintroductions at infested sites. Technology is currently being developed in Western Australia.

Application of the chemical phosphonate by injection.
Photo: D. Guest, The University of Sydney

Challenge 4 – Improving awareness and capacity to manage the threat

There is currently a lack of appreciation of the actual and potential impact that this pathogen poses to the biodiversity of NSW amongst stakeholders. This, together with the limited available skill base, presents a significant management challenge.

Several government agencies and industry groups play a key role in their capacity to manage the threat posed by the spread of *Phytophthora cinnamomi*, including those responsible for managing public land and those managing or influencing the management of private land in NSW. Key stakeholders include consent and determining authorities; land managers (including public authorities); field staff and contractors conducting earthworks in or adjacent to natural ecosystems; bushwalkers; horse riders; plant propagators; and bush regenerators.

The actions under this initiative seek to raise awareness of *Phytophthora cinnamomi* among stakeholders and improve their capacity to effectively manage the threat.

Initiative 4: Strengthen training, education and communication

Actions

4.1 With reference to the National Best Practice Guidelines, prepare phytosanitary protocols to guide the application of strategies and practices to reduce the risk of the pathogen being inadvertently spread by human activities into vulnerable areas of NSW (S).

4.2 Prepare and implement a communication strategy that effectively delivers key messages regarding the pathogen through a range of media (including electronic and print media; the Internet; fact sheets and brochures; workshops and seminars; demonstration sites; and interpretive signage), that encourages the adoption of phytosanitary protocols in vulnerable areas across all tenures (S/M).

4.3 Conduct training for land managers and field staff in relation to the identification of disease symptoms and the implementation of phytosanitary protocols (S/M).

4.4 Establish demonstration sites to promote the adoption and effective implementation of the phytosanitary protocols (M/L).

Challenge 5 – Effectively coordinating the threat abatement program

Management of the threat of *Phytophthora cinnamomi* across eastern NSW has the potential to be complicated by the range of organisations that need to be engaged, the complexity of the threat, the extent of management actions, and resource limitations.

A coordinated approach is essential to ensure a timely, cost-effective and efficient delivery of the NSW threat abatement program.

Initiative 5: Provide a framework for the effective and efficient implementation of the threat abatement program

Actions

5.1 Support the *Phytophthora cinnamomi* Threat Abatement Working Group in its role in coordinating the NSW threat abatement program for this pathogen, consistent with this Statement and the National TAP, including responsibility for:

- 5.1.1. Overseeing and monitoring the implementation of actions (as presented in this Statement) (Annual)
- 5.1.2. Evaluating the effectiveness of existing resource effort and DECC's capacity (resource effort to include measures of in-kind contribution of time, staff and re-current funding and external grants) (Annual)
- 5.1.3. Seeking funding support, as required (S/M/L)
- 5.1.4. Initiating opportunities to engage and coordinate actions relevant to the management of *Phytophthora cinnamomi* across key stakeholders (S/M/L)
- 5.1.5. Evaluating the uptake of relevant threat abatement actions, guidelines, protocols and priority assessment procedures across DECC and externally

5.2 Review the overall effectiveness of the threat abatement program for *Phytophthora cinnamomi*, including resource effort and outcomes achieved within 3 years following the approval of this Statement (M)

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5.3 Investigate the social and economic factors associated with the implementation of threat abatement actions (M/L)

5.4 Informed by the above actions (5.1–5.3), evaluate the requirement for preparing a NSW TAP for 'infection of native plants by *Phytophthora cinnamomi*' as a means of formalising NSW Government's commitment to address this threat in NSW (M)

9. Working in partnership

The actions in this Statement of Intent will be implemented by DECC. However, in light of the distribution of *Phytophthora cinnamomi* infection, effective implementation of the actions will require active participation by a range of stakeholders.

DECC will establish partnerships with other government agencies, CMAs, research organisations and industry to integrate efforts to manage this threat in NSW. Funding opportunities will be investigated to support a cooperative approach to make progress in implementing the full range of actions in areas outside DECC responsibility. Key stakeholders will be invited to participate in awareness-raising activities and training to enhance on-ground management requirements.

Case study – Cooperating to abate the threat of *Phytophthora cinnamomi*

DECC is currently working with the Sydney Metropolitan and Hawkesbury–Nepean CMAs to identify the presence of *Phytophthora cinnamomi* throughout these catchment areas. The two separate projects aim to bridge our knowledge gap by gathering data on the extent and spread of the pathogen. This knowledge will aid the development of appropriate management strategies.

Based with the BGT, the projects are being coordinated by a Scientific Officer who is engaging with key stakeholders in these catchments. During 2007–08 the project aims to:

- adapt and apply the national risk assessment model to help identify high-risk species and habitats in the catchment areas. The seedlings of identified target species will then be tested in the greenhouse for susceptibility to the pathogen under controlled environmental conditions.
- survey the catchments (through systematic and targeted surveys) to determine disease risk areas, identifying susceptible species displaying symptoms and collecting and analysing soil samples to confirm the presence of the pathogen.
- map the distribution of *Phytophthora cinnamomi*, building on state-wide data and results to inform on-ground management and monitoring programs across the catchments.
- increase the awareness on the threat of *Phytophthora cinnamomi* through the distribution of education material and the hosting of a series of stakeholder seminars. The seminars will be developed in conjunction with the Australian Network for Plant Conservation.

The stakeholder seminars have begun and have proven a great success, involving various stakeholders including local council staff, nursery operators, bush regenerators, tree surgeon contractors, landcare groups, CMA staff, researchers, DECC rangers and field staff. The seminars are a forum for CMAs and the BGT to engage with interested landholders willing to help identify areas at risk. These landholders are provided with sample kits to help in this

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task. Kits include trowel, sample bags, disinfectant spray, standard data sheets for recording site details (including Global Positioning System points), and information to guide identification and sampling. Soil samples are returned to the BGT for analysis, with results recorded in a database to inform survey and mapping across the catchments.

In 2007–08, a total of $200,000 of Federal and NSW Government funding will be available to enable progress in work within two catchments. This funding will match in-kind contributions from the BGT and other partner organisations (including the respective CMAs, The University of Sydney, Sydney Harbour Federation Trust and local governments).

This work presents a collaborative model for implementing key threat abatement actions across all land tenures, with potential for expanding into other coastal CMAs in the future.

10. Where can I go for further information?

DECC is coordinating the delivery of actions presented in this Statement of Intent through the *Phytophthora cinnamomi* Threat Abatement Working Group.

For further information about the NSW *Phytophthora cinnamomi* threat abatement program or any other related projects contact the Biodiversity and Threatened Species Section, Climate Change, Policy and Programs Group on:

Ph: (02) 9995 5493

Email: info@environment.nsw.gov.au

Useful web sites

- DECC's NSW threatened species information : http://www.environment.nsw.gov.au
- Botanic Gardens Trust's pest and disease diagnostic work and research information: http://www.rbgsyd.nsw.gov.au/plant_info/pests_diseases
- Download a copy of the Botanic Gardens Trust's fact sheet on Phytophthora root rot at http://www.rbgsyd.nsw.gov.au/plant_info/pests_diseases/fact_sheets/phytophthora_root_rot
- Centre for *Phytophthora* Science and Management, with links to current research and best practice management at http://www.cpsm.murdoch.edu.au/

Further information is also available from the Australian Government's Department of the Environment, Water, Heritage and Arts invasive species website at: http://www.environment.gov.au/biodiversity/invasive/index.html

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