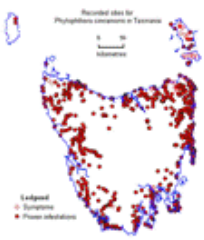

Management of *Phytophthora cinnamomi* for Biodiversity Conservation in Australia

Part 2 - National Best Practice Guidelines

Natural Heritage Trust

Helping Communities Helping Australia

An Australian Government Initiative

MURDOCH UNIVERSITY
PERTH, WESTERN AUSTRALIA

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CPSM
Centre for *Phytophthora* Science and Management

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ABBREVIATIONS

ACT	Australian Capital Territory
Alcoa	Alcoa World Alumina
ARC	Australian Research Council
CALM	The Department of Conservation and Land Management, Western Australia
CPSM	Murdoch University, Centre for Phytophthora Science and Management
CRC PBMDS	Cooperative Research Centre for Plant Based Management of Dryland Salinity
CRC TREM	Cooperative Research Centre for Tropical Rainforest Ecology and Management
CRC TPP	Cooperative Research Centre for Tropical Plant Protection
DCC	Dieback Consultative Council of Western Australia
DEH	Australian Government Department of the Environment & Heritage
DPIWE	Tasmanian Department of Primary Industries, Water and Environment
DWG	Dieback Working Group
EMS	Environmental Management Systems
EPBC Act	Australian Government Environment Protection and Biodiversity Conservation Act, 1999
EPPO	European and Mediterranean Plant Protection Organisation
GIS	Geographic Information Systems
GTSpot	Geo Temporal Species Point Observations Tasmania database, accessible through the Parks and Wildlife GIS Web Server
IUCN	The World Conservation Union
NAPSWQ	National Action Plan for Salinity and Water Quality
NGIA	Nursery & Garden Industry Australia
NIASA	Nursery Industry Accreditation Scheme Australia
NRM	Natural Resource Management
NSW	New South Wales
NT	Northern Territory
NTAP	The National Threat Abatement Plan for Dieback Caused by the Root Rot Fungus *Phytophthora cinnamomi*
NWS	National Weeds Strategy

PCR	Polymerase Chain Reaction
PTG	*Phytophthora* Technical Group of South Australia
SA	South Australia
SA DEH	South Australian Government Department for Environment & Heritage
SCRIPT	South Coast Regional Initiative Planning Team
TPWS	Tasmanian Government Parks and Wildlife Service
WA	Western Australia
WWF	World Wildlife Fund

GLOSSARY

accredited

Official recognition by an authorised body that a person or organisation is capable of undertaking a task, or producing a product according to specific criteria and standards.

best practice

A superior method or innovative practice that contributes to the improved performance of an organisation, usually recognised as "best" by other peer organisations.

biodiversity

The variability among living organisms from all sources (including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part) and includes: (a) diversity within species and between species; and (b) diversity of ecosystems (from EPBC Act, 1999). A contraction of, and synonymous with, the term 'biological diversity'.

consequence

The outcome of an event expressed qualitatively or quantitatively, being loss or injury, disadvantage or gain (from Standards Australia: AS/NZS 4360: 1999).

critically endangered species

Species that have been recognised as critically threatened. The categories of species listed as threatened under the EPBC Act are as follows: a) extinct; b) extinct in the wild; c) critically endangered; d) endangered; e) vulnerable and; f) conservation dependent (from EPBC Act, 1999).

dieback

A symptom of plant disease in which there is a progressive death of shoots, leaves and roots beginning at the tips (American Phytopathological Society online glossary). Commonly used in Australia to describe the symptoms of individual plants, or a general decline in the health and numbers of plants in the landscape as a result of disease caused by pathogens of the genus *Phytophthora*.

ecosystem

A dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit (from EPBC Act, 1999).

endangered species

Species that have been recognised as threatened. A category of threatened species under the EPBC Act: a) extinct; b) extinct in the wild; c) critically endangered; d) endangered; e) vulnerable and; f) conservation dependent (from EPBC Act, 1999).

endemic

Plant or animal species that are native to a particular area and nowhere else.

***ex-situ* conservation**

The conservation of components of biological diversity outside their natural habitats (from Convention on Biological Diversity website).

geographic information systems (GIS)

A package of computer programs specifically designed to collect, store, retrieve, manipulate, analyse and display mapped data.

habitat

The biophysical medium or media: (a) occupied (continuously, periodically or occasionally) by an organism or group of organisms; or (b) once occupied (continuously, periodically or occasionally) by an organism, or group of organisms, and into which organisms of that kind have the potential to be reintroduced (from EPBC Act, 1999).

infected

When an organism has entered, invaded or penetrated and established a parasitic relationship with a host plant (American Phytopathological Society online glossary).

infested

Used of fungi in soil or other substrate in the sense of 'contaminated' (Hawksworth *et al.* 1995).

key threatening process

A process is defined as a key threatening process if it threatens or may threaten the survival, abundance or evolutionary development of a native species or ecological community. A process can be listed as a key threatening process if it could: cause a native species or ecological community to become eligible for adding to a threatened list (other than conservation dependent), or cause an already listed threatened species or threatened ecological community to become more endangered, or if it adversely affects two or more listed threatened species or threatened ecological communities. The assessment of a threatening process as a key threatening process is the first step to addressing the impact of a particular threat under Commonwealth law. Once a threatening process is listed under the EPBC Act a Threat Abatement Plan can be put into place if it is proven to be 'a feasible, effective and efficient way' to abate the threatening process (from DEH website - KTP). *P. cinnamomi* is listed as threatening process to biodiversity in Australia under the EPBC Act, 1999.

likelihood

A qualitative or quantitative description of probability or frequency (Standards Australia, AS/NZS 4360: 1999).

listed

Refer to 'threatened species and communities'.

management plan

Are documents produced by the National or State Government which detail actions that need to be carried in order to manage the natural and cultural values of specific areas, commonly 'protected areas' (e.g. national parks and reserves).

on-ground management

The deployment of physical measures to mitigate the risk of *P. cinnamomi* at specific sites or in a specific area, e.g. the deployment of vehicle wash-down equipment at an infestation boundary to minimise the risk of *P. cinnamomi* being spread from the infested to the uninfested area.

phosphite

An aqueous solution of mono-potassium phosphite and di-potassium phosphite. Also referred to as phosphonate.

recovery plans

The Australian Government Minister for the Environment and Heritage may make or adopt and implement recovery plans for threatened fauna, threatened flora (other than conservation dependent species) and threatened ecological communities listed under the EPBC Act, 1999. Recovery plans set out the research and management actions necessary to stop the decline of, and support the recovery of, listed threatened species or threatened ecological communities. The aim of a recovery plan is to maximise the long term survival in the wild of a threatened species or ecological community (from DEH website – Recovery Plans).

resistant

The power of an organism to overcome, completely or to some degree, the effect of a pathogen or other damaging factor (Hawksworth *et al.* 1995).

risk

The chance of something happening that will have an impact upon objectives. It is measured in terms of consequences and likelihood (Standards Australia, AS/NZS 4360: 1999).

risk assessment

The overall process of risk analysis and risk evaluation (Standard Australia, AS/NZS 4360: 1999) involving probabilities, frequencies, magnitude, and consequences.

stakeholders

Any individual or groups that are affected by regulations for and approaches to the management of *P. cinnamomi* in the environment.

standard

A published document which sets out specifications and procedures designed to ensure that a material, product, method or service is fit for its purpose and consistently performs the way it was intended. (from Standards Australia website).

susceptible

Lacking the inherent ability to resist disease or attack by *P. cinnamomi.* Species which have high mortality in the field.

threat

An indication that serious or irreversible environmental damage may occur (CALM 2004b).

threatened species or communities *(sometimes referred to as 'listed')*

Flora or fauna species or ecological communities that have been recognised as threatened through a legislative process by Commonwealth or State/Territory Governments, in which species are divided into categories according to the level of the threat. The categories of threat vary slightly between States. The categories of species listed as threatened under the EPBC Act are as follows: a) extinct; b) extinct in the wild; c) critically endangered; d) endangered; e) vulnerable and; f) conservation dependent (from EPBC Act, 1999). Listing helps to select and rank the species most in need of practical conservation, which should set in train the processes needed to facilitate de-listing, as the ultimate goal of practical conservation.

uninfested

Areas that are deemed to be free of *P. cinnamomi* by a qualified or suitably experienced person through an assessment of vegetation for indicators of disease (CALM 2004b).

vector

Any biological agent that carries *P. cinnamomi* from one place to another.

vulnerable

Susceptible to physical injury (CALM 2004b)). Also used to formally describe a category of threat to species and ecological communities in Australia (see 'threatened species and communities').

vulnerable zone

Areas where the there is a coincidence of environmental conditions conducive to the establishment and persistence of *P. cinnamomi,* and susceptible native vegetation, so that introduction of the pathogen is likely to result in negative impact due to disease.

1 INTRODUCTION

Disease in natural ecosystems of Australia, caused by the introduced plant pathogen *Phytophthora cinnamomi*, is listed as a key threatening process under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Act requires the Australian Government to prepare and implement a threat abatement plan for nationally coordinated action to mitigate the harm caused by *P. cinnamomi* to Australian species, particularly threatened flora, fauna and ecological communities. The 'National Threat Abatement Plan for Dieback Caused by the Root-Rot Fungus *Phytophthora cinnamomi*' (NTAP) was released in 2001 (Environment Australia, 2001). The NTAP is designed to promote a common understanding of the national threat *P. cinnamomi* poses to biodiversity in Australia.

This project, funded by the Australian Government Department of the Environment and Heritage (DEH), is one of the most significant actions to be implemented from the NTAP to date. The project has two major components:

- review current management approaches and identify benchmarks for best practice
- develop risk assessment criteria and a system for prioritising management of assets that are or could be threatened by *P. cinnamomi.*

The project outputs are presented in a four-part document entitled **Management of *Phytophthora cinnamomi* for Biodiversity Conservation in Australia:**

Part 1 – A Review of Current Management

Part 2 – National Best Practice Guidelines (THIS DOCUMENT)

Part 3 – Risk Assessment for Threats to Ecosystems, Species and Communities: A Review

Part 4 – Risk Assessment Models for Species, Ecological Communities and Areas

The model for best practice management of *P. cinnamomi* for biodiversity conservation, developed in Part 1 - A Review of Current Management, is repeated in this document and the best current practices and processes identified in the review are presented in the context of the model.

These are the first national best practice management guidelines developed in Australia for management of *P. cinnamomi* in natural ecosystems, and consequently recommendations on their use are provided. The management guidelines are divided into two sections: i) addressing best practice at the strategic/tactical level of management; and ii) addressing the operational and on-ground management of *P. cinnamomi*. Critical success factors for management and discussions on the development of appropriate performance indicators are provided.

2 A MODEL FOR BEST PRACTICE MANAGEMENT

The management of *P. cinnamomi* will commonly be undertaken in 'protected areas'. A protected area is defined as '*An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means'* (DEH website – Parks and Reserves, accessed 13/11/05).

As *P. cinnamomi* cannot be eradicated from infested sites and autonomous spread is extremely difficult to control, the only practical management objectives are to minimise the spread to areas that are uninfested, and mitigate impacts where infestations occur. The model of best practice (Figure 2.1) depicts all the elements necessary for the deployment of on-ground measures to achieve the management objectives in protected areas, taking into account the range of stakeholders and land uses that management affects.

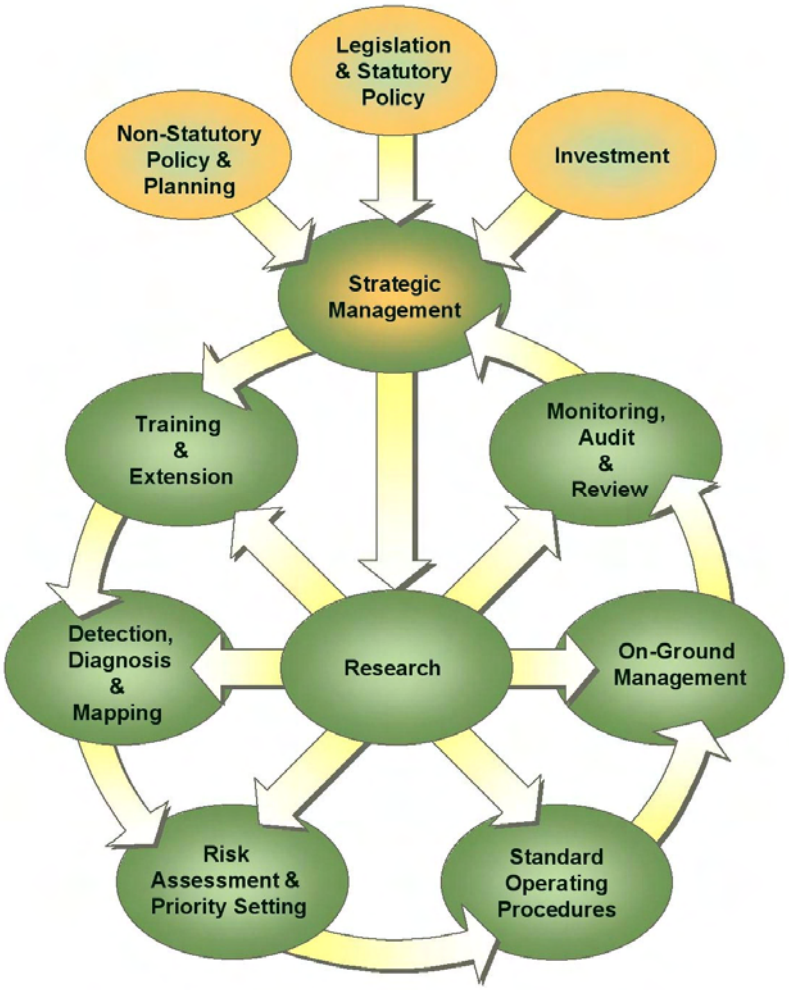


Figure 2.1 A best practice model for the management of *Phytophthora cinnamomi* for biodiversity conservation in natural ecosystems of Australia.

3 RECOMMENDATIONS FOR THE USE OF THE BEST PRACTICE GUIDELINES

Why are these guidelines needed?

National best practice guidelines are needed to facilitate a consistent approach to managing the threat of *P. cinnamomi* across jurisdictions, by providing the current best management procedures, practices and tools in Australia.

Who should use these guidelines?

As *P. cinnamomi* is a management issue primarily in protected areas on public lands it has the potential to affect a wide range of land users and stakeholders. These guidelines are suitable for use by all stakeholders, across all jurisdictions.

However, the primary responsibility for the management of *P. cinnamomi* on public land resides, in the first instance, with government or semi-government land management agencies. Consequently, the guidelines address management of *P. cinnamomi* from the strategic through to the operational and in a level of detail necessary for such agencies.

It is acknowledged that not all stakeholders will want or need this level of detail. Consequently, the information in the guidelines has been presented in discrete sections and appendices to enable stakeholders to readily access the information needed.

How should these guidelines be used?

The potential use of the National Best Practice Guidelines, as indicated by stakeholder consultation, include:

- the NTAP provides a common understanding of the threat *P. cinnamomi* poses in Australia, the National Best Practice Guidelines promotes a common understanding of the best current management of the threat
- review of current management approaches against best practice
- provide new or alternative ideas for management
- development or review of agency, stakeholder or area specific guidelines based on current best practice
- general provision of advice on best practice management
- a resource for training and for raising awareness.

The threat of *P. cinnamomi* varies in scale and magnitude across Australia, and the capacity and resources for management also varies between States and across jurisdictions within affected States. Consequently, appropriate adaptations to the practices and procedures identified will need to be considered.

Review

It is recommended that the National Best Practice Guidelines are reviewed regularly, the mechanisms of review to be considered as part of the 2006 revision of the NTAP.

4 STRATEGIC & TACTICAL BEST PRACTICE MANAGEMENT

In this section the best current practices for management of *P. cinnamomi* in natural ecosystems are presented, in the context of the model for best practice (Figure 1), with examples of best practice from current management of *P. cinnamomi* and other invasive pests in Australia. 'Best practice' was derived subjectively from a review of *P. cinnamomi* management in Australia, where the best current approaches were identified and the gaps in process, practice and knowledge (Part 1 – Review of Current Management). Best practice describes those tools, practices and processes that, when integrated, will lead to more effective and nationally consistent deployment of on-ground *P. cinnamomi* measures.

Where significant gaps were identified in the current management of *P. cinnamomi*, examples of best practices and procedures were sought from other pest management programs. Many were identified from the National Weeds Strategy (NWS) which was launched in June 1997 to address environmental and agricultural weeds of national significance, with an emphasis on the commitment of all governments in cooperation with other stakeholders (Anon 1997). The issue of weed management in Australia has many parallels to the management of *P. cinnamomi*, particularly in the mechanisms of spread. Not surprisingly, the goals and objectives of the NTAP are not dissimilar to those of the NWS.

4.1 Strategic Management

Legislation and Statutory Policy

Best Practice

1. Use of the EPBC Act to protect biodiversity from the threat of *P. cinnamomi*, with a full understanding of the extent of the threat *P. cinnamomi* poses to biodiversity in Australia.
2. Full implementation of the NTAP.
3. Management of *P. cinnamomi* with a full understanding by land managers of the relevant legislation and the interrelatedness of the various statutory provisions.
4. Legislation that is enacted proactively rather than reactively to *prevent* the introduction of *P. cinnamomi*.

Best Practice Examples

The *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act): The mechanism for national protection of Australian biodiversity is the EPBC Act, under which *P. cinnamomi* is listed as a national 'key threatening process'. Any actions that may threaten species and communities that are listed under the Act must be referred to DEH for approval, and such actions may be denied or may be granted with the inclusion of measures for risk mitigation of *P. cinnamomi*. The potential for the Act to protect

biodiversity from *P. cinnamomi* depends on a good understanding of the extent of the threat, which is currently lacking in many areas of Australia.

The National Threat Abatement Plan for Dieback Caused by the Root-Rot Fungus *Phytophthora cinnamomi* (NTAP): It is a requirement that a threat abatement plan is developed for each key threatening process listed under the EPBC Act. The NTAP for *P. cinnamomi* describes how the Commonwealth Government will act to abate the threat of the pathogen in Australia, through the declaration of the Commonwealth's goals, objectives and plans for coordinated actions (Environment Australia, 2001). The Plan is due for review in 2006, although implementation as a Threat Abatement Plan Implementation Team was not appointed to coordinate and oversee actions.

The Australian Government Protected Matters Search Tool: DEH provides a tool designed to assist the general public in gathering information about the national environmental significance of specified areas, and numbers of threatened species and ecological communities present in those areas (DEH website – About Protected Matters Search Tool, accessed 24/11/05). The tool is designed to assist in determining whether a proposed development is likely to affect a matter of national environmental significance, and consequently require referral for assessment and approval under the EPBC Act. This is an excellent tool and would be greatly enhanced with overlays of data on the distribution of key threatening processes such as *P. cinnamomi*.

Queensland *Environmental Protection Act 1994* (Queensland EP Act) and improvements to the *WA Environmental Protection Act 1986* (WA EP Act): Under the Queensland EP Act the Queensland Parks and Wildlife Service has a duty of care to prevent *foreseeable* environmental harm including that caused by threatening processes. Recent revisions to the WA EP Act include a new offence for causing unauthorised environmental harm which carries severe penalties. For the purposes of the WA EP Act the definition of environmental harm includes 'potential detriment or degradation' to enable preventative action to be taken (DoE 2004).

Improving the Understanding and Effectiveness of Weeds Legislation: Many problems with statutory provisions for *P. cinnamomi* management have also been identified in weed management and include: lack of clear and appropriate objectives for weeds legislation; the slowness of implementing legislation for preventing spread of weeds; lack of consistency of legislation within and between States and Territories; and insufficient resources to implement weeds legislation effectively. The NWS produced a Discussion Paper explaining the rationale and mechanisms for government intervention in weed management and compared legislation in each State and Territory. The paper identifies nine core interlinked and achievable principles for effective State/Territory weeds legislation (Weeds Australia website – Newsletter and Papers, accessed 20/09/05). The World Wildlife Fund (WWF) also acknowledges many gaps in weeds legislation and has formulated a '4 Point Plan' to make State and Territory laws more effective (Glaznig 2005). The interrelatedness of legislation across jurisdictions is also vexed area in *P. cinnamomi* management, and a study similar to those conducted for weeds is required to unravel some of the complexities of legislation and ensure best use of regulatory provisions.

Non-statutory Policy and Planning

Best Practice

1. A whole-of-government approach to the management of *P. cinnamomi* in relevant States /Territories, consistent with the objectives of the NTAP.

2. An agreed core set of values and principles that drive *P. cinnamomi* management within key conservation land management agencies which are embodied in a policy, position statement or similar.

3. Corporate level planning, strategy and budget setting capability within key conservation land management agencies to ensure *P. cinnamomi* is managed in accordance with the NTAP and State/Territory objectives and priorities.

4. Organisation-wide standard operating procedures for *P. cinnamomi*.

5. Integration of *P. cinnamomi* management with other functional areas to ensure that the issue is included in general management systems and initiatives.

6. Networking opportunities for personnel involved in *P. cinnamomi* management with those in other agencies and States/Territories to facilitate cross-fertilisation and continuous improvement.

Best Practice Examples

Policy and Planning by CALM in Western Australia: The Department of Conservation and Land Management (CALM) has developed the following integrated processes and practices for management of *P. cinnamomi*:

- a departmental policy statement on *P. cinnamomi* (CALM, 2004a)
- best practice guidelines for the management of *P. cinnamomi* (CALM, 2004b)
- public consultation on the development of the policy and best practice guidelines
- operational guidelines for: general management of *P. cinnamomi* (CALM, 2003); detection, diagnosis and mapping of disease (CALM, 2001); and phosphite application (CALM, 1999a and 1999b)
- training (developed and delivered in-house) for staff and contractors (CALM, 2004c)
- a departmental requirement that detection, diagnosis and mapping on lands managed by CALM or on other lands for purposes that relate to the Department's conservation responsibilities, be undertaken by qualified 'disease interpreters'
- a protocol for the identification of 'protectable areas' and setting management priorities (DCC, 2000)
- support for a full-time position to coordinate the Department's *Phytophthora* management activities.

Policy and Planning by the West Australian State Government: The WA Minister for the Environment appointed the Dieback Consultative Council (DCC) in 1997 to provide specialist advice on issues relating to *P. cinnamomi*. This includes research, management and funding priorities for the State, policy revision and development for CALM and the State, and participation in the NTAP. Key stakeholders from government, industry, research and the community are represented on the Dieback Consultative Council.

The DCC assisted in the development of a State Government initiated Dieback Response Policy Framework, which was launched by the State Minster for the Environment in 2004. Key strategies of the Framework which are currently being implemented include the development of:

- a dieback atlas for WA
- management guidelines for use on all land tenures
- a generic dieback risk assessment methodology
- an action plan specifically to tackle the dieback threat to areas such as the Fitzgerald River National Park
- a whole-of-government policy on dieback management.

Codes of Practice: Codes of Practice are needed for industries and activities that pose a high risk of spreading *P. cinnamomi*. Codes of Practice have been developed for, and in consultation with, the extractive industries of Tasmania and WA. The Tasmanian Quarry Code of Practice provides principles, acceptable standards and suggested measures on all aspects of the extractive process to improve environmental outcomes, including the management of *P. cinnamomi* (DPIWE & DIER, 1999). The Code of Practice developed in WA with the extractive industry, specifically for management of *P. cinnamomi* (DWG, 2004), includes best practice guidelines (DWG, 2005).

A Code of Practice for the management of reserves in Tasmania is designed to promote consistency in the application of management practices by staff of key conservation land management agencies. It provides 'best practice operational standards' for all activities, including plant disease management, which reserve managers are required to adhere to. They must also refer to the Code when assessing applications for lease, permits or exemptions for activities. The Code refers to other relevant codes, key resources and databases to aid in the management of *P. cinnamomi*, which is regarded as one of the primary plant disease problems in Tasmania reserves (TPWS, FT & DPIWE, 2003).

"Cruisin' Without Bruisin'" is a track guide and Code of Practice that was developed for those who undertake recreational vehicle use in parks and reserves of Tasmania. The Code is published on the Tasmanian Parks and Wildlife Service (TPWS) website (TPWS website – 4WD Recreation, accessed 18/02/05), and also available in pamphlet form.

Investment

The Australian Government has invested in the research and management of *P. cinnamomi* through programs such as the Australian Research Council (ARC), the Natural Heritage Trust and National Action Plan for Salinity and Water Quality (NAPSWQ). However, investment is typically *ad hoc* and only a proportion of it is directed to on-ground management. Investment in the States, with the exception perhaps of WA, is either minimal or non-existent. The current lack of information on the economic impacts of degradation caused by *P. cinnamomi* is a major impediment to attracting the investment necessary for research and management. The overall result is uncoordinated, inconsistent and under-resourced management of *P. cinnamomi* nationally, and at the State level.

Best Practice

1. Core national funding to implement the NTAP.

2. Strategic funding of research according to agreed upon national research priorities, and an understanding of the long-term environmental and economic impacts of *P. cinnamomi* in Australia.

3. Suitably qualified and experienced National Coordinator responsible for coordinating and facilitating implementation of the NTAP.

4. Suitably qualified and experienced position(s) in the key conservation and land management agencies in each State/Territory with dedicated responsibilities for coordinating management of *P. cinnamomi* within the agency, and facilitating a coherent and consistent approach to management by other stakeholders.

5. Core State funding to implement on-ground management based on an agreed process of prioritisation and an understanding of the long-term environmental and economic impacts of *P. cinnamomi*.

6. Inclusion of *P. cinnamomi* in relevant to regional Natural Resource Management (NRM) strategic plans, reflection of that in associated investment plans, and collaboration between regional bodies and State Government agencies in managing priority assets threatened by the pathogen.

Best Practice Examples

Economic Analysis of *P. cinnamomi* Impact in WA: The Centre for *Phytophthora* Science and Management (CPSM) in WA commissioned, as part of the State Government Dieback Response Framework, a case study to quantify the benefits of investing in the science and management of *P. cinnamomi* in WA, and conversely the risks of failing to invest or delaying investment (Economic Research Associates 2005). The study clearly indicates in economic terms the significant reduction in the stream of benefits from natural areas over the next 50 years if environmental degradation as a result of *P. cinnamomi* is not reduced immediately.

Economic Analysis of Weed Prevention, Eradication and Containment: A recent economic assessment clearly demonstrated in exact dollar terms the benefits of prevention and early intervention to eradicate weed incursions, compared to the costs and benefits of containing established weeds (Barker 2005). As the effectiveness of current on-ground management measures is currently unknown, Economic assessments of this nature are required for the national threat that *P. cinnamomi* poses.

Coordinators Positions in SA and WA: CALM in WA and the SA Department for Environment and Heritage each support a position responsible for the coordination of *P. cinnamomi* management, or management of diseases in native vegetation. The WA Dieback Working Group (DWG), largely as a result of Natural Heritage Trust funding, also has a full-time coordinator. These positions have been central to recent improvements and innovations in *P. cinnamomi* management in their respective States. They provide advice, services and management tools to a wide range of stakeholders.

Cost-Sharing for Weed Management Between the Australian and State/Territory Governments: Technical criteria developed as part of the NWS are used to determine

the need for cost-sharing arrangements between the Australian and State/Territory Governments in the eradication pest plant incursions (NWSEC 2002; Panetta *et al.* 2002). Similar criteria are needed to ensure funding is available to act quickly and decisively when a *P. cinnamomi* incursion occurs in an area of significant environmental value.

Implementation of the National Weeds Strategy: Investment in pest plants of national significance through the NWS provides a relevant model for investment in *P. cinnamomi* management and, in particular, the implementation of the NTAP. The position of Project Manager, responsible for the implementation of the weeds strategy, was funded under a cost-sharing arrangement between the Australian and State/Territory Governments. From 2000 to 2002 the project received $169,400 per annum for the implementation of the strategy. The success of the NWS has been largely attributed to the extension and liaison of the Project Managers with all stakeholders. This modest investment enabled the completion of over half the strategies, and significant work to be undertaken on the others, in five years (NWSEC 2002).

4.2 Research

Best Practice

1. A Cooperative Research Centre for research into diseases in native ecosystems caused by *Phytophthora* spp.

Best Practice Examples

The Centre for *Phytophthora* Science and Management, Murdoch University (CPSM): The CPSM at Murdoch University in WA, while still in the development phase, provides a model for a strategic approach, with a long-term vision, to the research necessary to improve management of *P. cinnamomi* in natural ecosystems. The CPSM has developed collaborations and linkages with industry, government and non-government organisations within WA, nationally and internationally in the following research programmes: biology; management; conservation, biodiversity and ecosystem restoration; information dissemination and training; disease diagnostics and extension. Although CPSM is exploring a number of investment options, there is currently no core funding and the Centre's research and management activities depend on competitive grants and other *ad hoc* funding sources.

The Cooperative Research Centre (CRC) Program: The Australian Government, Department of Education Science and Training, CRC Program fosters close interaction between scientists, private industry and public sector agencies in long-term collaborative arrangements which support research, development and education activities. Core funding, ranging from $20 to $40 million, is provided to CRCs over seven years (DEST website – CRC, accessed 20/09/05). The CRC for Australian Weed Management (CRC AWM) plays an integral role in the implementation of the NWS (NWSEC 2002) through: conducting research; and providing extension services and technical advice on environmental and agricultural weeds across Australia (Weeds CRC website, accessed 20/09/05).

4.3 Training and Extension

Training

Best Practice

1. Tertiary level (undergraduate and postgraduate) graduates with expertise in the science and management of *Phytophthora* spp. in native ecosystems.
2. Competency-based vocational training appropriate to the duties of all personnel involved in *P. cinnamomi* management within land management agencies.
3. The integration of core *P. cinnamomi* management competencies into organisation-wide training programs within land management agencies.
4. Training to enable effective implementation of codes of practice for high risk activities.

Best Practice Examples

Training by CALM in WA: CALM has developed four competency-based training courses for staff and contractors that are accredited within the organisation and widely recognised in WA: i) management; ii) detection, diagnosis and mapping; iii) field operators course; and iv) phosphite operators course. CALM provides training to staff and contractors on a needs basis in the areas of *P. cinnamomi* management, field operations and phosphite operations, while training in detection, diagnosis and mapping is mandatory for Departmental 'Disease Interpreters'. As well as formal classroom training (4 days), the detection, diagnosis and mapping course has a field experience requirement of up to 3 months before a trainee is considered qualified. All training is based on and consistent with the Department's standard operating procedures.

Training by Alcoa World Alumina Australia (Alcoa) in WA: Alcoa delivers training in *P. cinnamomi* management to staff via a computer-based Learning Management System, part of the company's overall Environmental Management System. The training modules were developed specifically for the WA mining operations by the company's Senior Environmental Consultant. The training covers biology and ecology of the pathogen, procedures for management during all mining operations and a self-test process. Re-testing is undertaken every two years. Field-based personnel receive similar training/refreshers in a classroom setting which is triggered at appropriate intervals by the Senior Environmental Officer at the mine.

National Training Competencies in Vertebrate Pest and Weed Management: The National Conservation and Land Management (CLM) Training Package (RTCA website – CLM Training Package RTDO2, accessed 22/11/05) was endorsed in 2002 and provides a formal mechanism to develop practical vocational skills in conservation and land management. It includes sectors on vertebrate pest management and weed management that provide accredited training for a wide range of responsibilities (Hart 2005; NWSEC 2002). Following a review of university weed management courses in Australia, the CRC AWM has developed a range of training resources which meets the objectives of the NWS and which are available free of charge on the CRC AWM website (CRC AWM website – Education and Training Resources, accessed 23/11/05; NWSEC 2002). The training competencies in weed management are predicted to have the greatest single impact of all the NWS action, as they will form the basis of consistent training across the nation, encourage professional standards for weed officers, and enable job mobility and promotional standards to be developed (NWSEC 2002).

Extension

Best Practice

1. Extension programs and materials with nationally consistent terminology, and advice consistent with the policies and procedures of leading State conservation and land management agencies

Best Practice Examples

Communications Strategy in WA: A comprehensive communications strategy for WA was developed in late 2004, and is in the early stages of implementation. Although the Strategy has been developed under the auspices of the DCC, the WA Dieback Working Group (DWG) is the main driver of the Strategy. The three key goals of the Communications Strategy are: i) increased awareness of *P. cinnamomi* so that it becomes a major environmental priority for the people of WA; ii) identification of key stakeholders groups and ideal behaviours for each group; and iii) simple messages and the identification of appropriate communication methods to evoke the necessary changes in behaviour.

Extension Activities of the WA DWG: The WA DWG was formed in 1996 by Perth metropolitan area Local Government authorities, community groups and State Government land management agencies concerned with the management of *P. cinnamomi*. Funding for the activities of the Group has come primarily from the Natural Heritage Trust. Prior to the formation of the WA DWG there was very little information filtering through to Local Government authorities, industry and the community in regards to the *P. cinnamomi* management procedures developed by CALM and mining companies in the State. The WA DWG provides the tools necessary to manage *P. cinnamomi* including: disease occurrence maps and dieback management plans for specific areas; providing training in dieback management procedures; conducting information and field days; developing guidelines for key stakeholders (DWG 2000; DWG 2005; Dunne 2005) and facilitating the uptake of management by Local Government and industry, particularly the extractive industry. Many of these tools have been made available on the WA DWG website (DWG website, accessed 22/11/05).

Extension Material in SA: A range of excellent extension material has been developed in SA and is available as either hardcopy, or electronically on the SA Government Department for Environment and Heritage (SA DEH) website (SA DEH website – Biodiversity/Plants & Animals, accessed 22/11/05). The fact sheets target what are considered high-risk activities such as bushwalking (SA DEH 2003b), horse riding (SA DEH 2002) and plant propagation (SA DEH 2003c). The horse riding fact sheet was produced in collaboration with the Horse Federation of South Australia. More detailed booklets have also been produced for *P. cinnamomi* specifically (SA DEH 2004a) and other forms of dieback (SA DEH 2004b). All the material produced provides a clear and consistent message about the risks, the potential impacts of the pathogen, and methods to reduce the risk of introducing the pathogen to uninfested areas. The guidelines provide useful information on the known extent of the threat in SA, known susceptible species and contact details for further information. The text is liberally illustrated with clear diagrams and high quality photographs, and all are available in electronic format, free, from the SA Government Department for Environment and Heritage website.

4.4 Detection, Diagnosis and Mapping

Best Practice

1. Systematic method for determining and mapping the distribution of *P. cinnamomi* in the landscape to facilitate the deployment of on-ground management measures.
2. National standard for the collection and handling of tissue, soil and water samples for *Phytophthora* spp. analysis.
3. Rapid, reliable, inexpensive and nationally standard methods for analysis of tissue, soil and water samples for the presence of *Phytophthora* spp.
4. Single database in each State with information on the distribution of *P. cinnamomi* and other *Phytophthora* spp. on public lands, using nationally agreed standards of recording and storing data.

Best Practice Examples

Disease 'Interpretation' Processes of CALM in WA: A systematic process for the detection, diagnosis, demarcation and mapping of *P. cinnamomi* has been developed by CALM in WA. CALM policy states that detection and diagnosis of disease caused by *P. cinnamomi* on lands for which CALM has conservation responsibilities must be undertaken by personnel who have undergone internally accredited training. Detection is based on the identification of visible symptoms of disease in over 40 species of plant in WA that are reliably susceptible to *P. cinnamomi* (indicator species), and confirmation of its presence through laboratory analysis of soil and plant tissues (CALM 2001). Initial interpretation is done wherever possible from aerial colour photographs followed by confirmation by on-ground survey. The physical demarcation of infestation boundaries has been standardised and all staff and contractors are trained to recognise the cues as triggers for particular management procedures.

Diagnostic Kit for *Phytophthora* spp. developed by CRC TPP: A DNA-based *Phytophthora* identification kit was developed by the CRC for Tropical Plant Protection and released in 2004 for use in laboratories licensed for polymerase chain reaction (PCR). It can detect and identify 26 different *Phytophthora* species from plant material (CRC TPP website - IDENTIKIT, accessed 21/01/05).

Diagnostic Protocol for *P. cinnamomi* by the European and Mediterranean Plant Protection Organisation (EPPO): The EPPO is an intergovernmental organisation responsible for cooperation in plant protection in the European and Mediterranean region (EPPO website, accessed 20/05/05). The EPPO has produced a standard that describes in detail, diagnostic protocols for *P. cinnamomi* including examination of symptoms, isolation, identification of the pathogen through morphological characteristics, immunological and molecular methods, and reporting (OEPP/EPPO 2004).

Data Management Protocols in Tasmania, WA and SA: In Tasmania, the Department of Primary Industries, Water and Environment (DPIWE) manages a database called GTSpot to which the States leading land managers (DPIWE, Tasmanian Parks and Wildlife Service and Forestry Tasmania) contribute data relating to *P. cinnamomi*. The information is readily accessible in electronic format to government, industry and the private sector, and can be interrogated for specific information for plotting or the creation of models. Pathogen isolation records are based on spot sampling of soil by Forestry Tasmania since 1972. Symptom distribution data consists of polygons assessed visually by trained observers. The database also contains maps of areas susceptible to *P. cinnamomi*, and *P.*

cinnamomi management areas in Tasmania. State-wide mapping units within the Tasmanian floristic database, TASVEG, have been categorised on the basis of perceived susceptibility to *P. cinnamomi*, as either: reliably highly susceptible; reliably not susceptible or having low susceptibility; or having variable susceptibility (Rudman 2004; Schahinger *et al.* 2003; DPIWE website – GTSpot User Guide accessed 03/03/05).

4.5 Risk Assessment and Priority Setting

Although Standards Australia (AS/NZS 4360: 1999) describes risk as being a measure of consequences and likelihood, the term is used variably in *P. cinnamomi* management and often describes only the probability of an event such as pathogen transmission and/or impact. A range of processes is described below that have been developed in Australia, using indicators of consequence and/or likelihood, to assist in planning or in setting priorities for the management of *P. cinnamomi*. The range of methods reflects the variable environmental, political, financial and social contexts in which *P. cinnamomi* must be managed, as well as differences in the amount and quality of data available on the threat. All processes acknowledge to some degree that the scarce resources available for *P. cinnamomi* management must be targeted where the need is greatest and the potential for success is highest.

Best Practice

1. Criteria for determining priorities for *P. cinnamomi* management within each State/Territory.
2. Resources for the management of *P. cinnamomi* directed to environmental assets of the highest priority, and where the potential for successful management is greatest.

Best Practice Examples

Processes to Identify Threatened Species and Ecological Communities for Protection

Risk Assessment Process developed through NTAP for *P. cinnamomi*: In the current project a generic process was developed, suitable for national adoption, for assessing the risk of *P. cinnamomi* to threatened species, ecological communities and areas, and ranking them as the basis for setting management priorities (Part 4 – Risk Assessment Models for Species, Ecological Communities and Areas). The models identify the source of risk, the likelihood of occurrence and the magnitude of the consequences. The models are semi-quantitative (i.e. qualitative criteria are assigned scores) and therefore produce indicative assessments. The models are based on current scientific knowledge. However, where significant knowledge or data gaps exist, expert opinion will be required. The risk assessment process developed is viewed as iterative, and improvements and reviews should be undertaken as new data and knowledge becomes available.

Identification of '*P. cinnamomi* Management Areas' in Tasmania: The Tasmanian process of setting management priorities, identified 67 '*P. cinnamomi* Management Areas' based on the presence of viable numbers of rare and susceptible plant species and communities and the capacity to provide long-term protection against infection by *P. cinnamomi* (Barker *et al.* 1996; Schahinger *et al*., 2003). Priorities for management included 12 species listed in the Commonwealth Government's EPBC Act. However, also

targeted were areas which contain species that are listed under the Tasmanian *Threatened Species Protection Act 1995*, and plant communities perceived to be reliably highly susceptible according to the Tasmanian floristic database TASVEG (Schahinger *et al*., 2003).

CALM Protocol for Identification of 'Protectable Areas': 'Protectable areas' are defined as uninfested areas, occurring in the vulnerable zone, that have good prospects of remaining uninfected over the next 2-3 decades. The highest priority for management is afforded to areas with very high conservation values at risk e.g. listed species, communities and habitats.

Processes to Identify Significant Disease-Free Areas for Protection

Regional Scale Project in WA: A regional scale project, funded under the Commonwealth Government Natural Heritage Trust–Regional Competitive Component, is currently being undertaken in WA by the South Coast Regional Initiative and Planning Team (SCRIPT) Natural Resource Management Region in WA. The primary goal is to protect, in the long term and regardless of land tenure, the biodiversity of areas assessed as significant, valued by the community and at risk from dieback caused by *P. cinnamomi*. The process initially involves the identification of significant disease-free areas, followed by an assessment of those areas for risks of *P. cinnamomi* introduction, and the manageability of those risks. Community input is being sought in the nomination of areas for assessment. Ultimately, management plans will be developed for specific areas identified as having regional and community significance.

Vulnerability Mapping

These maps are important management tools and may be produced at a strategic or operational scale. The probability of *P. cinnamomi* being introduced and/or becoming established in a defined area is mapped according to environmental parameters and vector activity.

The Potential Distribution and Impact of *P. cinnamomi* in Victoria: A strategic level map was developed for Parks Victoria showing the potential distribution and impact of *P. cinnamomi* in the State. The risk map was constructed with geographic information systems (GIS) overlays of: topographic and climatic parameters suitable for the pathogen; known distribution of the pathogen; distribution of susceptible species; and the distribution and density of roads and tracks as a surrogate for the probability of pathogen transmission (Gibson *et al.* 2002). The 'risk classification system' has been incorporated as a layer in the Parks Victoria electronic Environmental Management System (Parks Victoria 2004).

Correlation Between Disease and Site Characteristics in the Wet Tropics World Heritage Area: As *P. cinnamomi* is uniformly distributed in the soils of the Wet Tropics World Heritage Area, but disease associated with *P. cinnamomi* is not, a project was undertaken to determine if outbreaks of disease are associated with particular site characteristics. Patches of canopy disturbance observed from aerial photographs were transferred onto topographic maps, digitised and overlain with environmental attributes recorded in GIS and data derived from multi-spectral aerial imagery. This analysis showed that areas of disease were correlated with acid-igneous geology, flat areas where drainage is impeded, notophyll dominant vegetation and elevations of 750 m and greater (Gadek *et al.* 2001; S. Worboys *pers. comm.*).

The Shire of Mundaring, WA: As mapping the distribution of *P. cinnamomi* is beyond the resources of the Shire of Mundaring, road reserves are assigned a 'risk category' based on an assessment of the integrity and health of the vegetation by a qualified ecologist (for example, vegetation in excellent condition would be considered a 'high' risk of becoming infected with *P. cinnamomi*). In the Shire's GIS database the risk category for an area is combined with relevant site factors to produce a *P. cinnamomi* 'risk rating' which appears on operational scale maps and triggers the deployment of appropriate management tactics (McCarthy 2005).

Decision Rules

Decision rules have been developed to assist in management planning by identifying vulnerable areas, and applying criteria by which on-ground management options are deployed.

Tasmania: the management system in Tasmania recommends management measures according to the likelihood of *P. cinnamomi* being introduced to vulnerable uninfested areas. The likelihood of an introduction is considered high if: i) public access to the area is unlimited; or ii) low if access is restricted (Rudman 2004).

South Australia: 'Risk' ratings are assigned to areas in SA according to the disease status of the site and the likelihood of *P. cinnamomi* spread from it, or the potential for the pathogen introduction and establishment. In contrast to other affected States, infestations in SA are largely localised. Consequently, 'High Risk Zones' are those confirmed or suspected to be infested and for which strict *P. cinnamomi* management guidelines apply to ensure the pathogen is contained (PTG 2003).

4.6 Standard Operating Procedures

Best Practice

1. Clear operational instructions that are consistent with the policies and statutory requirements of the agency, that are readily available to staff and are regularly updated.

Best Practice Examples

A number of guidelines for *P. cinnamomi* management have been developed around Australia for a range of audiences and applications. The application or audience is self-evident from most of the titles listed below, although where this is not the case the application is briefly described:

- **Assessment of Guidelines for Best Practice Management of *Phytophthora cinnamomi* in Parks and Reserves across Victoria (Cahill *et al.*, 2002):** Parks Victoria has indicated that given the date of this document, some of the guidelines may be out-of-date.
- **Best Practice Guidelines for the Management of *Phytophthora cinnamomi* (CALM 2004b):** The purpose of the best practice guidelines is to provide the staff of CALM in WA with a clear and concise statement of the best practice methods and standards for managing the threat posed by *P. cinnamomi*. The guidelines are also designed to be adapted by other land management organisations and proponents of activities in vulnerable areas.

- **Guidelines for reducing the spread of *Phytophthora cinnamomi* during earth moving operations (Smith, 2002).**
- **Interim *Phytophthora cinnamomi* Management Guidelines (Rudman, 2004):** This document is recommended for planners, land managers and contractors across the different sectors of the community and tenures. It provides the planning framework, assessment tools and recommended prescriptions necessary for a standard approach to management of *P. cinnamomi* in Tasmania.
- **Management of *Phytophthora* Dieback in Extractive Industries (DWG, 2005)**
- **Managing Phytophthora Dieback: Guidelines for Local Government (DWG, 2000)**
- **Managing Phytophthora Dieback in Bushland: A Guide for Landholders and Community Conservation Groups (Dunne, 2005)**
- **Nursery Industry Accreditation Scheme, Australia. Best Management Practice Guidelines (NIASA, 2003):** Available for purchase at the Nursery and Garden Industry website, http://www.ngia.com.au/accreditation/niasa.asp
- ***Phytophthora cinnamomi* and disease caused by it. Volume 1 – Management Guidelines (CALM, 2003):** Primarily a guide for the staff of CALM in WA, on Departmental legislative responsibilities, policy and procedures in relation to the management of *P. cinnamomi* on CALM estate. However, it is freely available from the CALM website and therefore provides guidance to any interested party on the best current management practices.
- ***Phytophthora cinnamomi* and disease caused by it. Volume 2 - Interpreter's Guidelines for Detection, Diagnosis and Mapping (CALM 2001):** Not currently available electronically. Contact CALM on (08) 9334 0333 for further information.
- ***Phytophthora cinnamomi* and disease caused by it. Volume 3 - Phosphite Operations Guidelines (CALM, 1999a)**
- ***Phytophthora:* Fire Response Team Handbook, Kangaroo Island (SA DEH, 2003a)**
- ***Phytophthora cinnamomi* causing dieback in plants (SA DEH, 2004a)**
- ***Phytophthora* Management Guidelines (PTG, 2003):** These Guidelines were developed by the cross-agency Phytophthora Technical Group of SA. They have stated that the aims of the Guidelines are to provide a framework for the management of *Phytophthora*, by Government and non-government organisations, landholders, community groups and individuals in order to achieve the best outcomes in *P. cinnamomi* management.
- **Rainforest Dieback: Risks Associated with Roads and Walking Tracks (Worboys and Gadek, 2004)**

4.7 On-Ground Management

Best Practice

1. The strategic deployment of on-ground management that is adequately resourced, underpinned by the latest scientific knowledge, undertaken by appropriately trained and briefed personnel in accordance with the standard operating procedures, with the support of all stakeholders, and monitored for compliance and effectiveness.

Please refer to the following section 'Operational or On-ground Best Practice Management' for comprehensive guidelines on the on-ground management options and their deployment.

4.8 Monitoring, Audit and Review

Monitoring

Monitoring can be undertaken to determine the long-term ecological impacts of disease caused by *P. cinnamomi*, or the rate of pathogen spread in the landscape either in response to environmental variables or management measures. Monitoring pathogen spread to determine the effectiveness of management requires knowledge of compliance to the procedures and prescriptions, and consequently is considered under 'audit and review'.

Best Practice

1. A nationally coordinated and strategic program of monitoring to determine the rate of spread and the long-term ecological impact of *P. cinnamomi* in a range of environments, using standardised techniques, and where possible utilising sites for which data already exists.

Best Practice Examples

Long-term monitoring of impact and spread: A number of monitoring sites have been established in WA, Tasmania and NSW in the 1990s or early 2000s for monitoring the impacts and spread of *P. cinnamomi* and/or the effectiveness of phosphite. Some sites in WA and Tasmania, established by Dr Frank Podger in the 1960/1970s have been re-surveyed. The long-term impact of *P. cinnamomi* in Victoria has been studied by Dr Gretna Weste, who has recently retired from a long and dedicated career in *P. cinnamomi* research. Dr Weste monitored the degradation of infested areas of the Grampians, Brisbane Ranges and Wilsons Promontory from 1970 to 1985, and then the gradual regeneration of those areas to the year 2000 with a corresponding reduction of pathogen levels in the soil (AAS website – Interview with Dr Gretna Weste, accessed 12/12/05). It is critical that monitoring continues at these established sites, and that research on the mechanisms of regeneration.

Audit and Review

Best Practice

1. Mechanisms within key land management agencies to monitor compliance to, and effectiveness of policies and standard operating procedures in a review and adaptive management framework.

Best Practice Examples

Environmental Management System (EMS) of Alcoa in WA: Alcoa undertakes annual internal audits for operational performance and procedural compliance in *P. cinnamomi* management. The accredited EMS (AS/NZS ISO 14001:1996) adopted by Alcoa is audited by an independent auditing contractor every 4 years, and in recent years has been extended to *P. cinnamomi* management procedures. Alcoa has integrated the audit of *P. cinnamomi* management procedures with the broader environmental audit which is more efficient, but also ensures that management of the pathogen is considered central to the Company's environmental policy rather than a 'side issue' (I Colquhoun, *pers. comm.*). The auditors assign a rating to performance, make recommendations and list actions for improvement. Each action is assigned to a responsible individual to complete, and a tracking system ensures that it is acted upon (I Colquhoun, *pers. comm.*).

Monitoring of management effectiveness by Alcoa in WA: Other than the studies by Alcoa in bauxite mines of WA (Colquhoun and Hardy 2000), there has been very little done in Australia on the effectiveness of management.

5 OPERATIONAL OR ON-GROUND BEST PRACTICE MANAGEMENT

In this section, options for on-ground management, aimed at limiting the spread and mitigating the impact of *P. cinnamomi* in natural ecosystems, have been compiled from current practices around Australia (Table 5.1 to 5.7). *P. cinnamomi* can be readily moved from one location to another in infested soil, plant material or water. Humans have the potential to spread the pathogen further and faster than any other vector or process. Appendix 1 provides background information on the biology and epidemiology of *P. cinnamomi*.

The main objectives of on-ground management are to:

1. prevent the spread of *P. cinnamomi* to uninfested sites; and
2. mitigate the impact of *P. cinnamomi* at infested sites.

As humans are the most significant vector of *P. cinnamomi*, managing spread commonly involves the modification of human behaviours and activities. The management options are presented in Tables 5.1 to 5.7 according to a range of human activities that vary in the potential for soil disturbance, and thus risk of spreading the pathogen in the landscape. The table format allows only a brief description of each option but further information is available in Appendix 2.

Table 5.1 Ecosystem and biodiversity conservation

Table 5.2 Research, survey, rehabilitation and conservation activities

Table 5.3 Recreational land use

Table 5.4 Construction and maintenance of road/tracks and other infrastructure

Table 5.5 Fire control and emergency rescue operations

Table 5.6 Low impact commercial activities (e.g. apiculture, flower and seed collecting)

Table 5.7 High impact commercial activities (e.g. mining, extractive industries, forestry, establishment and maintenance of utilities).

While an approach in which there is an integration of management options is much more likely to be successful, it will not be practical or possible to deploy all of the management options listed for a particular activity or site. The risk of introducing or spreading *P. cinnamomi* at a particular site for a particular activity will need to be assessed, and the tables consulted to determine which combination of the options will best reduce those risks. Socio/political considerations and available resources are also likely to influence the choice of management options.

A decision flow diagram (Figure 5.1) is provided as a guide to the appropriate application of the management options, based on the suitability of the site for the persistence and establishment of *P. cinnamomi*, and according to the disease status of the site.

When the disease status of a site is unknown

The decision flow chart (Figure 5.1) terminates with the determination of disease status of the site, with three possible options: infested, uninfested or disease status unknown. If the disease status of the site is unknown the literature, and other databases should first be consulted. Key literature and/or the custodians of such data are listed below for each State. Please note: this is not an exhaustive list and other sources such as NRM agencies, local scientists or community groups may also possess such information.

Western Australia

- The Department of Conservation and Land Management, Forest Management Branch http://www.calm.wa.gov.au/index.html
- The Dieback Working Group http://www.dwg.org.au/index.cfm

Tasmania

- Department of Primary Industries, Water and Environment - GTSpot Database: http://www.gisparks.tas.gov.au/explorer/GTSpotUserGuide/UserGuide.html

Victoria

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

South Australia

- Department for Environment and Heritage http://www.environment.sa.gov.au

Far North Queensland

- Gadek PA, Gillieson D, Edwards W, Landsberg J, Pryce J (2001) Rainforest Dieback Mapping and Assessment in the Wet Tropics World Heritage Area. Schools of Tropical Biology, Tropical Environmental Studies, Geography and the Rainforest CRC. James Cook University, Cairns.

If this information is unavailable or is incomplete a survey will need to be undertaken. Current methods of detection, diagnosis and mapping have been reviewed in Part 1 – A Review of Current Management.

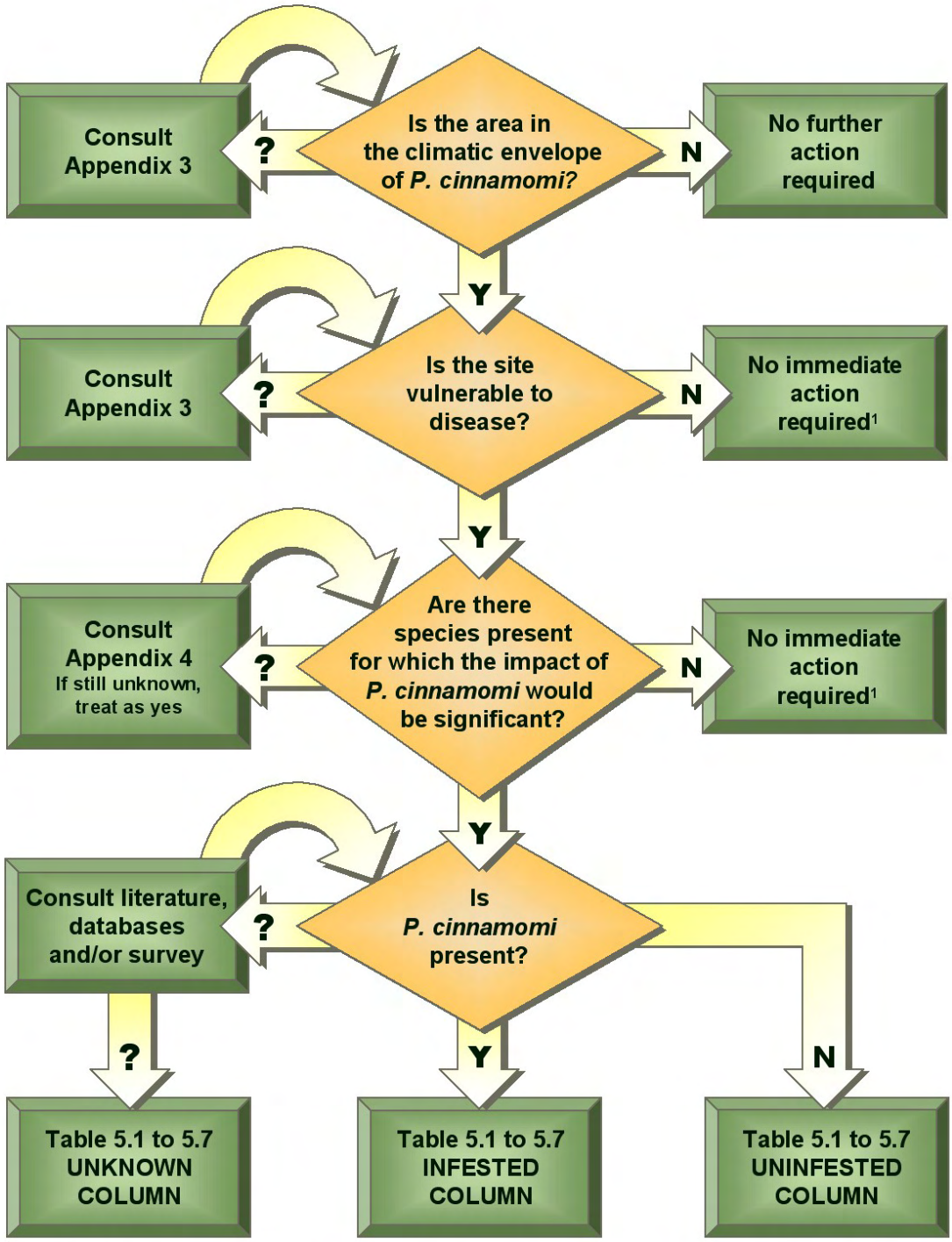
However, surveys may fail to establish the disease status of a site for many reasons including: a failure to detect *P. cinnamomi* from soil and/or tissue samples coupled with cryptic disease expression, poor knowledge of susceptible species in the area, the absence of susceptible species from the site, and/or the masking of disease symptoms by other factors such as recent fire or drought. If the disease status of the site cannot be determined after a survey, the 'unknown' column of the table should be consulted.

The 'precautionary principle' must be applied where the disease status is unknown, particularly when there are significant values at risk at, or nearby the site. The precautionary principle describes the avoidance of an action that has some potential for major or irreversible negative consequences. Consequently, the management options for

sites where the disease status is unknown includes management options for sites that are infested and uninfested, making management of these sites more onerous.

Management options for infested sites

The difference between the management options for infested and uninfested sites in Tables 5.1 to 5.7, are admittedly subtle. This is the result of management options marked with a '**ǂ**', which denote additional recommendations for management of infested areas in SA, where *P. cinnamomi* has been mapped as discrete areas within largely uninfested areas. In SA, management to contain the pathogen within discrete areas is given a high priority, and this approach would be highly recommended wherever a similar pattern of pathogen distribution occurs.



[1] Although no immediate action is required, there is a responsibility, statutory in WA & Vic, not to spread the pathogen to uninfested areas that may contain susceptible species.

Follow links to Appendix 3 and Appendix 4

Figure 5.1 A decision flow chart to determine the need for management of *P. cinnamomi* and the appropriate management options, based on the disease status of the site, to be deployed

Table 5.1 Management Options for Ecosystem and Biodiversity Conservation.

Note: + in a cell indicates options appropriate for the activity and the disease status of the site. ‡ denotes additional options when the objective of managing the infested site is containment of *P. cinnamomi*.

Ecosystem and Biodiversity Conservation page 1/2	Disease status of land in relation to *Phytophthora cinnamomi*		
	Uninfested	Infested	Unknown
PLANNING			
identify susceptible plant species and communities that are listed as 'threatened' under the *Australian Government Environment Protection and Biodiversity Conservation Act 1999*, relevant State legislation, those that may not be listed but fulfil IUCN criteria as 'threatened', or those with the potential to become threatened in the near future	+	+	+
set management priorities by undertaking a risk assessment for threatened or near threatened species, communities or areas that are susceptible to disease	+	+	+
COMMUNICATION			
educate staff, contractors and volunteers on the threat of *P. cinnamomi*, management objectives, procedures and prescriptions	+	+	+
where appropriate consult with traditional owners prior to implementing management controls	+	+	+
EX-SITU CONSERVATION			
conserve critically endangered species *ex-situ*	+	+	+
PHOSPHITE			
treat threatened plant species or communities with phosphite	+	+	+
ACCESS			
restrict human access permanently	+	‡	+
restrict human access temporarily (e.g. during wet weather)	+	‡	+
restrict access to ranging livestock and other animals	+	‡	+

Ecosystem and Biodiversity Conservation page 2/2	Disease status of land in relation to *Phytophthora cinnamomi*		
	Uninfested	Infested	Unknown
WATER, DRAINAGE AND EFFLUENT			
manage drainage so that water is not discharged into uninfested areas, or is directed to the lowest point in the landscape		+	+
install or improve drainage sumps that; are constructed to prevent animal and human access to the contents, allow evaporation, and will contain a 1 in 10 year rainfall event	+	+	+
maintain drains and sumps regularly and dispose of contents ensuring infested material is disposed of hygienically	+	+	+

Table 5.2 Management Options for Research, Survey, Site Restoration and Community Conservation Activities.

Note: + in a cell indicates options appropriate for the activity and the disease status of the site. ‡ denotes additional options when the objective of managing the infested site is containment of *P. cinnamomi*.

Research, Survey, Site Restoration and Community Conservation Activities page 1/3	Disease status of land in relation to *Phytophthora cinnamomi*		
	Uninfested	Infested	Unknown
PLANNING			
assess all operations for the likelihood of introducing or spreading *P. cinnamomi*, modify operations and apply hygiene to reduce the risks	+	‡	+
schedule activity for periods with the highest likelihood of dry soil conditions	+	‡	+
schedule activity in uninfested areas before moving to infested	+	‡	+
implement appropriate disease monitoring programs for new outbreaks of disease, spread of existing infestations and effectiveness of disease management procedures and prescriptions	+	+	+
COMMUNICATION			
educate staff, contractors and volunteers on the threat of *P. cinnamomi*, management objectives, procedures and prescriptions	+	+	+
where appropriate consult with traditional owners prior to implementing management controls	+	+	+
define clear roles and responsibilities for staff and contractors in *P. cinnamomi* management procedures and prescriptions	+	+	+
supervise staff, contractors and volunteers to ensure compliance with *P. cinnamomi* management procedures and prescriptions	+	+	+
write specific *P. cinnamomi* management procedures and prescriptions into contracts and licence agreements, and monitor compliance	+	+	+
inform all land users and neighbouring landholders of the disease status of the area, management objectives and procedures and prescriptions	+	+	+

Research, Survey, Site Restoration and Community Conservation Activities page 2/3	Disease status of land in relation to *Phytophthora cinnamomi*		
	Uninfested	Infested	Unknown
ACCESS			
restrict human access permanently	+	‡	+
restrict human access temporarily (e.g. during wet weather)	+	‡	+
restrict access to ranging livestock and other animals	+	‡	+
minimise the number of entry points	+	+	+
control unauthorised access	+	+	+
HYGIENE			
plan for hygienic practices if working across infection boundaries is unavoidable	+	+	+
maintain natural barriers to *P. cinnamomi*	+		+
avoid watercourses or sites prone to flooding or ponding	+	‡	+
minimise activities that cause soil disturbance (for example mow, slash or spray weeds rather than plough them under)	+	‡	+
avoid the importation of basic raw material, but if unavoidable use disease-free or low-risk construction materials	+	‡	+
restrict movement of vehicles and pedestrians to formed roads and tracks	+	‡	+
vehicles, equipment, materials and footwear, clean on entry	+		+
vehicles, equipment, materials and footwear, clean on exit when moving to uninfested areas		+	+
construct hygiene station at border with uninfested area		+	+
employ a 'barrier system' if working across infestation boundaries is unavoidable	+	+	+
avoid the introduction of plants for revegetation. As an alternative, consider direct seeding or regeneration of vegetation by fire	+		+

Research, Survey, Site Restoration and Community Conservation Activities page 3/3	Disease status of land in relation to *Phytophthora cinnamomi*		
	Uninfested	Infested	Unknown
if the introduction of plants is unavoidable, obtain them from a nursery accredited by NIASA	+		+
if the introduction of plants is unavoidable, obtain plants resistant to disease caused by *P. cinnamomi* from a nursery accredited by NIASA		+	
WATER, DRAINAGE AND EFFLUENT			
minimise the amount of water used on the site	+	‡	+
use water from mains or deep bore for all activities (ensure no contamination with organic matter), or sterilise/disinfect water before use	+		+
manage drainage so that water is not discharged into uninfested areas, or is directed to the lowest point in the landscape		+	+
install or improve drainage sumps that; are constructed to prevent animal and human access to the contents, allow evaporation, and will contain a 1 in 10 year rainfall event	+	+	+
maintain drains and sumps regularly and dispose of contents ensuring infested material is disposed of hygienically	+	+	+

Table 5.3 Management Options for Recreational Land Use.

Note: + in a cell indicates options appropriate for the activity and the disease status of the site. ‡ denotes additional options when the objective of managing the infested site is containment of *P. cinnamomi*.

Recreational Land Use page 1/1	Disease status of land in relation to *Phytophthora cinnamomi*		
	Uninfested	Infested	Unknown
COMMUNICATION			
educate land users on the threat of *P. cinnamomi*, management objectives, procedures and prescriptions	+	+	+
where appropriate consult with traditional owners prior to implementing management controls	+	+	+
educate local tourist operators and equipment hire companies on the threat of *P. cinnamomi*, management objectives and the promotion of responsible recreation by their customers	+	+	+
ACCESS			
permanently restrict public access where threatened or potentially threatened species or communities have been identified	+	+	+
restrict movement of traffic from infested to uninfested areas	+	‡	+
restrict human access temporarily (e.g. during wet weather)	+	‡	+
HYGIENE			
promote hygiene on entry	+		+
restrict movement of vehicles and pedestrians to formed roads and tracks	+	‡	+
promote minimal soil disturbance	+	‡	+
promote the avoidance of watercourses or sites prone to flooding or ponding	+	‡	+
promote hygiene on exit when moving to uninfested areas		+	+
construct hygiene station at border with uninfested areas and erect clear information and instructions for use		+	+
provide adequate parking and turn-around points for vehicles on hard, well drained surfaces that do not impinge or drain into surrounding vegetation	+	‡	+

Table 5.4 Management Options for Construction and Maintenance of Roads/Tracks and other Infrastructure.

Note: + in a cell indicates options appropriate for the activity and the disease status of the site. ‡ denotes additional options when the objective of managing the infested site is containment of *P. cinnamomi*.

Construction and Maintenance of Roads/Tracks and other Infrastructure page 1/3	**Disease status of land in relation to *Phytophthora cinnamomi***		
	Uninfested	**Infested**	**Unknown**
PLANNING			
assess all operations for the likelihood of introducing or spreading *P. cinnamomi*, modify operations and apply hygiene to reduce the risks	+	+	+
schedule activity for periods with the highest likelihood of dry soil conditions	+	‡	+
schedule activity in uninfested areas before moving to infested	+	‡	+
plan operation to maintain natural barriers to *P. cinnamomi*	+		+
COMMUNICATION			
educate staff, contractors and volunteers on the threat of *P. cinnamomi*, management objectives, procedures and prescriptions	+	+	+
where appropriate consult with traditional owners prior to implementing management controls	+	+	+
define clear roles and responsibilities for staff and contractors in *P. cinnamomi* management procedures and prescriptions			
supervise staff, contractors and volunteers to ensure compliance with *P. cinnamomi* management procedures and prescriptions			
write specific *P. cinnamomi* management procedures and prescriptions into contracts and licence agreements, and monitor compliance			
ACCESS			
use existing roads and tracks wherever feasible, before constructing new ones	+	+	+
plan new or re-route existing roads/tracks so that they do not traverse infection boundaries or occur on ridges that form boundaries between infested and uninfested areas	+	+	+
plan new or re-route existing tracks to avoid watercourses, or sites prone to flooding or ponding	+	‡	+
Construction and Maintenance of Roads/Tracks and other Infrastructure page 2/3	**Disease status of land in relation to *Phytophthora cinnamomi***		

	Uninfested	Infested	Unknown
plan new or re-route existing tracks that are hard and well-drained with no water ponding	+	‡	+
plan new or re-route existing tracks so they do not pass above susceptible and/or threatened communities	+		+
plan new or re-route existing tracks so that they pass through areas of non-susceptible vegetation	+		+
HYGIENE	+	+	+
plan for hygienic practices if working across infection boundaries is unavoidable	+	+	+
minimise activities that cause soil disturbance	+	‡	+
grade from upslope to down slope	+		+
do not grade wider than existing road/track or wider than prescribed	+		+
angle grader blade to avoid carrying soil/gravel long distances	+	+	+
avoid watercourses or sites prone to flooding or ponding	+	‡	+
avoid the importation of basic raw material, but if unavoidable use disease-free or low-risk construction materials	+	‡	+
plan for hygienic earth-movement and stock-piling of soil and other basic raw materials on site	+		+
control unauthorised access to work site	+	+	+
restrict movement of vehicles and pedestrians to formed roads and tracks	+	‡	+
vehicles, equipment, materials and footwear, are to be clean on entry	+		+
vehicles, equipment, materials and footwear, are to be clean on exit when moving to uninfested areas		+	+
provide parking and turn-around points for vehicles and machinery on hard, well drained surfaces	+	‡	+
construct hygiene station at border with uninfested areas		+	+
employ a 'barrier system' if working across infestation boundaries is unavoidable	+	+	+

Construction and Maintenance of Roads/Tracks and other Infrastructure page 3/3	Disease status of land in relation to *Phytophthora cinnamomi*		
	Uninfested	Infested	Unknown
WATER, DRAINAGE AND EFFLUENT			
minimise the amount of water used on the site	+	‡	+
construct wooden walkways over areas prone to ponding or mud	+	‡	+
use water from mains or deep bore for all activities (ensure no contamination with organic matter), or sterilise/disinfect water before use	+		+
manage drainage so that water is not discharged into uninfested areas, or is directed to the lowest point in the landscape		+	+
install or improve drainage sumps that; are constructed to prevent animal and human access to the contents, allow evaporation, and will contain a 1 in 10 year rainfall event	+	+	+
when cleaning drains direct spoil onto surface such as paved roads where it can be removed and transported to a designated disposal site	+	+	+

Table 5.5 Management Options for Fire Management and Emergency Rescue Operations.

While the priorities of life and property in the management of any emergency situation are recognised, the consideration of P. cinnamomi during *preparations and planning for emergency events has the potential to reduce the risk of pathogen spread and impact.*

Note: + in a cell indicates options appropriate for the activity and the disease status of the site. ‡ denotes additional options when the objective of managing the infested site is containment of *P. cinnamomi*.

Fire Management and Emergency Rescue Operations page 1/2	**Disease status of land in relation to *Phytophthora cinnamomi***		
	Uninfested	**Infested**	**Unknown**
PLANNING			
identify areas at high risk from *P. cinnamomi* and avoid these whenever possible during planning for prescribed burns, wildfires and emergency rescue operations	+	+	+
assess all emergency preparedness activities for the likelihood of introducing or spreading *P. cinnamomi*, and modify operations and apply hygiene to reduce the risks	+	+	+
plan for hygienic aircraft access during wildfire response	+		+
wherever possible schedule emergency preparedness activities for periods with the highest likelihood of dry soil conditions	+	‡	+
COMMUNICATION			
educate staff, contractors and volunteers on the threat of *P. cinnamomi*, management objectives, procedures and prescriptions	+	+	+
define clear roles and responsibilities for staff and contractors in *P. cinnamomi* management procedures and prescriptions	+	+	+
supervise staff contractors and volunteers to ensure compliance with *P. cinnamomi* management procedures and prescriptions	+	+	+
write specific *P. cinnamomi* management procedures and prescriptions into contracts and licence agreements, and monitor compliance	+	+	+
ACCESS			
use existing roads and tracks wherever feasible before constructing new ones. If new roads/tracks are necessary refer to Table 5.4 for prescriptions.	+	+	+

Fire Management and Emergency Rescue Operations page 2/2	Disease status of land in relation to *Phytophthora cinnamomi*		
	Uninfested	Infested	Unknown
HYGIENE			
wherever possible schedule emergency preparedness activities in uninfested areas before moving to infested	+	‡	+
wherever possible minimise activities that cause soil disturbance	+	‡	+
wherever possible grade from upslope to down slope	+		+
do not grade wider than existing road/track or wider than prescribed	+		+
angle grader blade to avoid carrying soil/gravel long distances	+	+	+
wherever possible maintain natural barriers to *P. cinnamomi*	+		+
avoid watercourses or sites prone to flooding or ponding during activities	+	‡	+
avoid the importation of basic raw material, but if unavoidable use disease-free or low-risk construction materials	+	‡	+
wherever possible restrict movement of vehicles and pedestrians to formed roads and tracks	+	‡	+
maintain aircraft, vehicles and equipment in clean condition for emergency deployment	+	+	+
vehicles, equipment, materials and footwear, clean on entry	+		+
wherever possible vehicles, equipment, materials and footwear, clean on exit when moving to uninfested areas		+	+
provide parking and turn-around points for vehicles and machinery on hard, well drained surfaces	+	‡	+
wherever possible construct hygiene station at border with uninfested areas		+	+
employ a 'barrier system' if working across infestation boundaries is unavoidable	+	+	+
WATER, DRAINAGE AND EFFLUENT			
use water from mains or deep bore for all non-emergency activities (ensure no contamination with organic matter), or sterilise/disinfect water before use	+		+

Table 5.6 Low Risk Commercial Activities (e.g. Apiculture, Flower and Seed Collecting)

Note: + in a cell indicates options appropriate for the activity and the disease status of the site. ‡ denotes additional options when the objective of managing the infested site is containment of *P. cinnamomi*.

Low Risk Commercial Activities page 1/2	Disease status of land in relation to *Phytophthora cinnamomi*		
	Uninfested	Infested	Unknown
PLANNING			
assess all operations for the likelihood of introducing or spreading *P. cinnamomi*, modify operations & apply hygiene to reduce the risks	+	+	+
schedule activity for periods with the highest likelihood of dry soil conditions	+	‡	+
schedule activity in uninfested areas before moving to infested	+	‡	+
COMMUNICATION			
educate staff, contractors & volunteers on the threat of *P. cinnamomi*, management objectives, procedures & prescriptions	+	+	+
where appropriate consult with traditional owners prior to implementing management controls	+	+	+
define clear roles & responsibilities for staff & contractors in *P. cinnamomi* management procedures & prescriptions	+	+	+
supervise staff, contractors & volunteers to ensure compliance with *P. cinnamomi* management procedures & prescriptions	+	+	+
write specific *P. cinnamomi* management procedures & prescriptions into contracts & licence agreements, & monitor compliance	+	+	+
HYGIENE			
plan for hygienic practices if working across infection boundaries is unavoidable	+	+	+
minimise activities that cause soil disturbance	+	‡	+
avoid watercourses or sites prone to flooding or ponding	+	‡	+

Low Risk Commercial Activities page 2/2	Disease status of land in relation to *Phytophthora cinnamomi*		
	Uninfested	Infested	Unknown
avoid the importation of basic raw material, but if unavoidable use disease-free or low-risk construction materials	+	‡	+
restrict movement of vehicles and pedestrians to formed roads and tracks	+	‡	+
vehicles, equipment, materials and footwear, clean on entry	+		+
vehicles, equipment, materials and footwear, clean on exit when moving to uninfested area		+	+

Table 5.7 High Risk Commercial Activities (e.g. Mining, Extractive Industries, Forestry, Establishment and Maintenance of Utilities)

Note: + in a cell indicates options appropriate for the activity and the disease status of the site. ‡ denotes additional options when the objective of managing the infested site is containment of *P. cinnamomi*.

High Risk Commercial Activities page 1/3	Disease status of land in relation to *Phytophthora cinnamomi*		
	Uninfested	Infested	Unknown
PLANNING			
assess all operations for the likelihood of introducing or spreading *P. cinnamomi*, modify operations and apply hygiene to reduce the risks	+	+	+
schedule activity for periods with the highest likelihood of dry soil conditions	+	‡	+
schedule activity in uninfested areas before moving to infested	+	‡	+
implement appropriate disease monitoring programs for new outbreaks of disease, spread of existing infestations and effectiveness of disease management procedures and prescriptions	+	‡	+
COMMUNICATION			
educate staff and contractors on the threat of *P. cinnamomi*, management objectives, procedures and prescriptions	+	+	+
where appropriate consult with traditional owners prior to implementing management controls	+	+	+
define clear roles and responsibilities for staff and contractors in *P. cinnamomi* management procedures and prescriptions	+	+	+
supervise staff and contractors to ensure compliance with *P. cinnamomi* management procedures and prescriptions	+	+	+
write specific *P. cinnamomi* management procedures and prescriptions into contracts and licence agreements, and monitor compliance	+	+	+
ACCESS			
use existing roads and tracks wherever feasible before constructing new ones. If new roads/tracks are necessary refer to Table 5.4 for prescriptions.	+	+	+

High Risk Commercial Activities page 2/3	Disease status of land in relation to *Phytophthora cinnamomi*		
	Uninfested	Infested	Unknown
plan new or re-route existing roads/tracks so that they do not traverse infection boundaries or occur on ridges that form boundaries between infested and uninfested areas	+	+	+
plan new or re-route existing tracks to avoid watercourses, or sites prone to flooding or ponding	+	‡	+
plan new or re-route existing tracks that are hard and well-drained with no water ponding	+	‡	+
plan new or re-route existing tracks so they do not pass above susceptible and/or threatened communities	+		+
plan new or re-route existing tracks so that they pass through areas of non-susceptible vegetation	+		+
minimise number of entry points	+	+	+
control unauthorised access to site	+	+	+
HYGIENE			
plan for hygienic practices if working across infection boundaries is unavoidable	+	+	+
minimise activities that cause soil disturbance	+	‡	+
grade from upslope to down slope	+		+
do not grade wider than existing road/track or wider than prescribed	+		+
angle grader blade to avoid carrying soil/gravel long distances	+	+	+
maintain natural barriers to *P. cinnamomi*	+		+
avoid watercourses or sites prone to flooding or ponding	+	‡	+
avoid the importation of basic raw material, but if unavoidable use disease-free or low-risk construction materials	+	‡	+
plan for hygienic earth-movement and stock-piling of soil and other basic raw materials on site	+		+
restrict movement of vehicles and pedestrians to formed roads and tracks	+	‡	+

High Risk Commercial Activities page 3/3	Disease status of land in relation to *Phytophthora cinnamomi*		
	Uninfested	Infested	Unknown
vehicles, equipment, materials and footwear, clean on entry	+		+
vehicles, equipment, materials and footwear, clean on exit when moving to uninfested areas		+	+
provide parking and turn-around points for vehicles and machinery on hard, well drained surfaces	+	‡	+
construct hygiene station at border with uninfested areas		+	+
employ a 'barrier system' if working across infestation boundaries is unavoidable	+	+	+
avoid the introduction of plants for revegetation. As an alternative, consider direct seeding or regeneration of vegetation by fire	+		+
if the introduction of plants is unavoidable, obtain them from a nursery accredited by NIASA	+		+
if the introduction of plants is unavoidable, obtain plants resistant to disease caused by *P. cinnamomi* from a nursery accredited by NIASA		+	
WATER, DRAINAGE AND EFFLUENT			
minimise the amount of water used on the site	+	‡	+
use water from mains or deep bore for all activities (ensure no contamination with organic matter), or sterilise/disinfect water before use	+		+
manage drainage so that water is not discharged into uninfested areas, or is directed to the lowest point in the landscape		+	+
install or improve drainage sumps that; are constructed to prevent animal and human access to the contents, allow evaporation, and will contain a 1 in 10 year rainfall event	+	+	+
maintain drains and sumps regularly and dispose of contents ensuring infested material is disposed of hygienically	+	+	+

6 CRITICAL SUCCESS FACTORS & PERFORMANCE INDICATORS

P. cinnamomi cannot be eradicated from infested sites and autonomous spread is extremely difficult to control, therefore the only practical management objectives are to minimise the spread to currently uninfested areas and mitigate impacts where infestations occur. As humans are the most significant vectors of *P. cinnamomi*, efforts to minimise further spread focus on modifying human behaviours and activities. Section 5 of this document describes how human activities can be modified to reduce the risk of *P. cinnamomi* transmission.

To prevent the introduction of *P. cinnamomi* to an uninfested area of public land requires the consistent deployment of on-ground management measures by all land-users. Section 4 of this document identifies best practice at the strategic and tactical levels of management in processes, procedures and tools necessary for successful and consistent deployment of on-ground management. Not all the points of best practice identified in section 4 will be applicable in every jurisdiction, as the magnitude and relative importance of the issue varies between States and regions.

For the purposes of this document, therefore, 'critical success factors' have been defined as minimum elements necessary, in all jurisdictions affected by *P. cinnamomi*, for successful deployment of on-ground management:

- a policy framework that recognises the threat of *P. cinnamomi* in decision making
- knowledge of the distribution of *P. cinnamomi* and the extent of the threat it poses to environmental values
- stakeholders, informed of the threat of *P. cinnamomi* and its implications and supportive of active management
- priorities for management of the threat and mechanisms to address those priorities.

Performance indicators

According to the NTAP the objective of *P. cinnamomi* management is to mitigate the impact on biodiversity (Environment Australia, 2001). The effectiveness of current management is unknown, primarily because of inadequate monitoring. However, if long-term progress towards achieving the management objective is to be assessed some indicator(s) of performance is required.

Performance indicators are simple measures that enable trends in the condition of the environment to be tracked over time without having to capture the full complexity of the system (ANZECC-SOERT, 2000). Some attempts have been made to identify performance indicators for the outcomes of *P. cinnamomi* management. The NTAP suggests the following indicators for reporting on the effectiveness of the Plan:

- no new listing or upgrading of threat status for species or ecological communities threatened by *P. cinnamomi*

- majority of high conservation value areas that were free from *P. cinnamomi* at the commencement of the Plan remain free.

A key performance indicator for the success of the WA Forest Management Plan in maintaining ecosystem health and vitality is 'the effectiveness of dieback hygiene' measured as 'the number of sampled areas uninfested with *P. cinnamomi* that remain uninfested following an operation with an approved hygiene management plan' (Conservation Commission WA, 2003).

In Tasmania the 'area adversely impacted by *P. cinnamomi*' is an indicator for the sustainable management of natural resources (Tasmania Together 2002 website - Current Goals and Benchmarks, accessed 16/12/05).

Each of these indicators has distinct weaknesses. The NTAP indicator of '*no new listing or upgrading of threat status for species or ecological communities threatened by* P. cinnamomi', for example, is immediately hampered by inadequate knowledge of the extent of the threat *P. cinnamomi* poses to native taxa generally, and more specifically to currently listed species and communities.

The development of outcome-based performance indicators in biodiversity management is inherently difficult, as acknowledged by ANZECC who developed core indicators for State of the Environment reporting (ANZECC, SOERT, 2000). ANZECC cites incomplete data sets, data inconsistencies across jurisdictions and/or lack of robust measurement techniques as impediments to the development of appropriate and meaningful environmental indicators. While performance indicators on national progress in the protection of biodiversity from *P. cinnamomi* are needed, careful thought and consultation is required on what provides meaningful measures across jurisdictions.

Until such time as sufficient and consistent data becomes available to measure management outcomes, output-based performance indicators, or to use the terminology of State of the Environment Reporting 'response indicators' (ANZECC, SOERT, 2000) could be developed. Performance indicators based on the critical success factors identified above, would at least provide consistent information across jurisdictions on the implementation of the key elements of management, which is information appropriate for State of Environment reporting. Key stakeholders should be consulted as part of the 2006 review of the NTAP on the potential for the development of such indicators.

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