Flora Technical Note No. 8:

Management of *Phytophthora cinnamomi* in production forest

FPA
FOREST PRACTICES AUTHORITY

The *Flora Technical Note Series* provides information for Forest Practices Officers on flora management in production forests. These technical notes are advisory guidelines and should be read in conjunction with the requirements of the Tasmanian F*orest Practices Code.*

Technical notes can be accessed on the Forest Practices Authority's website: www.fpa.tas.gov.au

1. Introduction

Flora values in many forest and scrub communities can be adversely affected by the introduction of disease and exotic plants. Section D3.1 of the *Forest Practices Code* gives guidelines to reduce the risk of weeds and disease being introduced through forestry operations. Other information is given in the *Forest Botany Manual*. Quarrying, roading and road use are generally of more concern than logging and regeneration activities.

Phytophthora cinnamomi (often called root rot fungus or cinnamon fungus) is an introduced pathogen that attacks the roots of many Australian plant species, including over 130 Tasmanian species. Species vary greatly in their response to *Phytophthora*. Some species (e.g. several eucalypt species) only show signs of disease in periods of drought or other stress, while others (e.g. banksias, grasstrees) die rapidly and entire populations can be destroyed. *Phytophthora cinnamomi* has its greatest impact in Western Australia, Victoria and Tasmania and is the only pathogen listed as a 'threatening process' on the Commonwealth *Environment Protection and Biodiversity Conservation (EPBC) Act.*

Over 20 species of *Phytophthora* occur in Australia, but only *Phytophthora cinnamomi* poses a threat to Tasmania's native vegetation. For convenience, all references to *Phytophthora* in this technical note refer to *Phytophthora cinnamomi*.

Plant species associated with open vegetation in moist, lowland environments – such as dry sclerophyll forest, scrub, heath and moorland – are most at risk from *Phytophthora*. This includes many of Tasmania's threatened flora species (these are indicated in the Regional Modules of the *Forest Botany Manual*), and habitat for threatened fauna species such as the New Holland mouse (*Pseudomys novaehollandiae*). *Phytophthora* infection can change the structure and composition of vegetation, and reduce plant species diversity and resources (e.g. nectar, pollen and shelter) with resultant flow-on effects to fauna. Forest communities that are highly susceptible to *Phytophthora* are indicated in Section 2 (community tables) of the manual's *Regional modules*.

Phytophthora has been introduced to many areas by spores carried on vehicles and machinery, but other sources include the boots of wandering people and the feet of native or exotic animals. It is impossible to eradicate once established and can spread rapidly in surface run-off and groundwater percolation. The risk of spreading *Phytophthora* can be reduced by machinery hygiene, use of *Phytophthora*-free material in road construction, and attention to infrastructure planning.

Over sixty *Phytophthora* management areas, containing species or communities that are particularly susceptible to the pathogen, have been delineated – mainly on public land in lowland areas of the state. Locations of *Phytophthora* management areas are given in databases that Forest Practices Officers (FPOs) preparing forest practices plans (FPPs) must use to complete the FPP *Biodiversity evaluation sheet,* including the webmap available on the FPA Biodiversity Values Database (BVD) (http://www.fpa.tas.gov.au/fpa_services/planning_assistance/advisory_planning_tools/Biodiversity_values_database).

This technical note provides information that will allow FPOs to develop prescriptions to reduce the risk of spreading *Phytophthora* as a result of forestry operations. In some circumstances, if hygiene guidelines in Section 6 of the technical note are followed, there is no need for FPOs to contact the FPA for specialist advice. In other situations, liaison with the FPA specialists is

necessary (e.g. if threatened species occur within operational areas). However, information in this technical note will still be useful to FPOs when they develop prescriptions for the FPP area.

2. Biology of *Phytophthora cinnamomi*

Phytophthora has a complex life cycle that allows it to survive unfavourable periods and rapidly disseminate and infect host plants when conditions are more favourable. Its life cycle is shown in Figure 1.

Phytophthora living within infected roots produces sporangia when soils are sufficiently moist and warm (above about 15°C). The sporangia are flask-shaped organs, which rupture to release motile zoospores that swim through water films surrounding soil particles or are transported in water bodies. Zoospores are the primary way that *Phytophthora* infects host plants. Chemicals produced by the plant roots attract the swimming zoospores.

Once zoospores attach to the host roots (mainly near the root tips), they encyst and then produce germ tubes that penetrate the walls of the host root cells. *Phytophthora* exists as mycelium (fungal threads) within the host roots – these spread through the roots and occasionally into the stem. Disease is caused when enzymes produced by the mycelium destroy the cells of the host, which is visible as a dark discolouration in affected tissue.

While *Phytophthora* is well adapted to parasitise living host tissue, it is poorly adapted to survive in dead plant tissue. During unfavourable conditions (e.g. absence of suitable living hosts to infect, or unsuitable soil conditions to allow dispersal), *Phytophthora* can produce thick-walled spores (chlamydospores) which persist for extended periods (usually <1 year but up to 6 years). When conditions are more favourable, they germinate to produce a sporangia and the cycle continues.

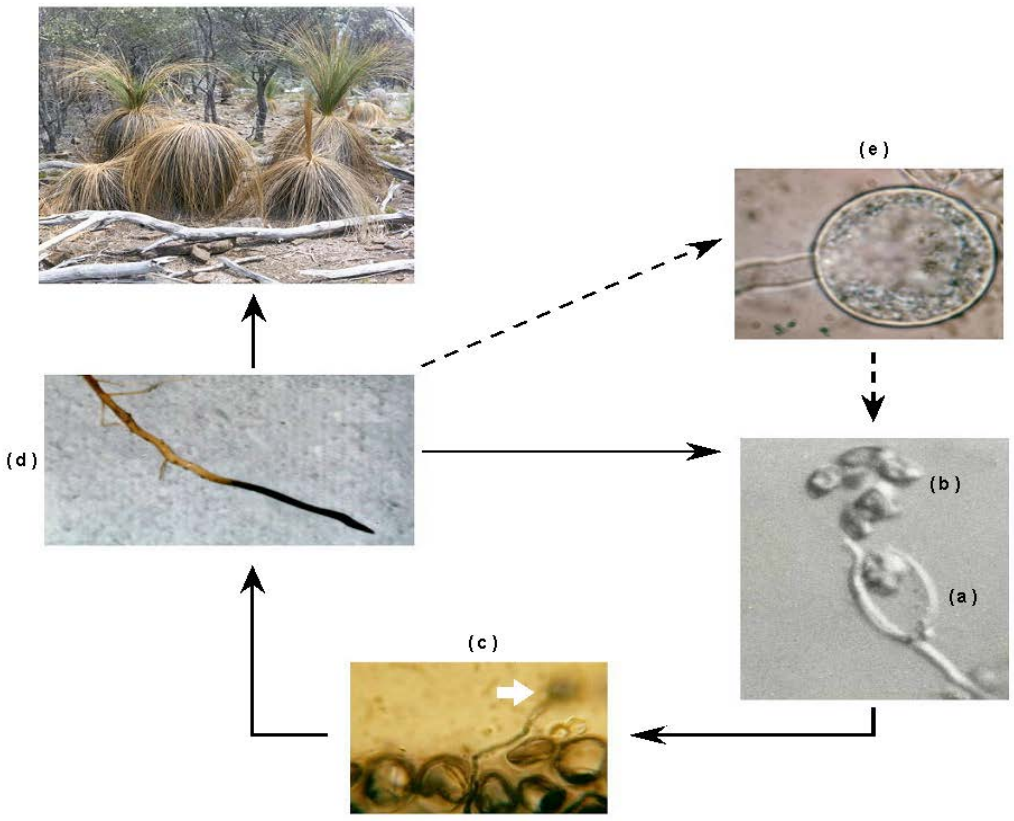

Figure 1. Life cycle of *Phytophthora*: sporangia (a) releasing zoospores (b) that encyst on roots (c) and produce a germ tube that grows into the root and then spreads as mycelium, releasing enzymes that kill the root cells resulting in darkly discoloured lesions (d) and eventual mortality in susceptible plants. Under favourable conditions the cycle continues with the production of sporangia from mycelium growing in infected roots. When conditions are unfavourable, thick-walled chlamydospores (e) are produced within infected tissues and lie dormant until favourable conditions return, at which time they germinate to produce a sporangia and continue the cycle.

3. Distribution of *Phytophthora cinnamomi* in Tasmania

The first report of *Phytophthora* in Tasmania was in 1956, when it was isolated from a suburban garden in Hobart. Its significance as a threat to native plants was not recognised, and measures to slow its spread were not introduced until nearly two decades later. By then, *Phytophthora* was established in many areas of Tasmania and is now widely distributed throughout the state (Figure 2). More detailed maps (e.g. from CONSERVE database) indicate the distribution of known locations at a finer scale.

Outbreaks of *Phytophthora* enlarge naturally within localised areas by water transport, root-to-root infection and animal digging. However, it is human activities that are primarily responsible for introducing the pathogen into new areas that are distant from the source of the original infection. The present distribution of *Phytophthora* within Tasmania has been strongly influenced by transport of infested soil and gravel or infected plant material to start new disease foci. Consequently the distribution is closely associated with roads, mineral exploration routes and walking tracks.

Local spread is strongly governed by the direction of water movement. A *Phytophthora* infection can move rapidly downhill and along roadside drains. *Phytophthora* spreads much more slowly uphill by growing from plant to plant through root infections. The density of susceptible host plants therefore affects uphill and across-slope movement of the pathogen. The greater the density of host plants the easier it is for *Phytophthora* to move from plant to plant.

Phytophthora is widespread in lowland areas of Tasmania, across all land tenures. However, disease will not develop when soils are too cold or too dry. For these reasons, *Phytophthora* is not a threat to susceptible plant species that grow at altitudes higher than about 700 metres or where annual rainfall is less than about 600 mm (e.g. Midlands and Derwent Valley). Furthermore, disease is unlikely to develop beneath a dense canopy of vegetation because shading cools the soils to below the optimum temperature for the pathogen. A continuous canopy of vegetation taller than about 2 metres is sufficient to suppress disease. Hence *Phytophthora* is not considered a threat to susceptible plant species growing in wet sclerophyll forests, rainforests (except disturbed rainforests on infertile soils) and scrub (e.g. tea-tree scrub).

Many small catchments containing susceptible vegetation are still free of *Phytophthora*, because Tasmania's dissected topography provides natural barriers that can limit the spread of the disease.

Figure 2. Distribution of *Phytophthora cinnamomi* in Tasmania (as at July 2012) based on point locations of field symptoms that have been confirmed by laboratory testing. Field observations suggest a much wider distribution in local areas with favourable vegetation and conditions.

NOTE: This distribution map represents more than 35 years of records and does not necessarily indicate how active *Phytophthora* is currently within an area. Active *Phytophthora* root rot produces characteristic field symptoms. Areas with active root rot will have high soil populations of the pathogen. Transporting soil or plants from such areas carries a high risk of spreading *Phytophthora*.

4. Recognising field symptoms of active *Phytophthora* root rot

The mix and pattern of diseased and healthy plants provides clues to the likely presence or absence of *Phytophthora* in an area. Most species that are susceptible to *Phytophthora* produce striking symptoms (death, dieback, leaf yellowing) following infection.

Table 1 lists susceptible and resistant species for Tasmania's main vegetation types. Some species (e.g. *Banksia marginata*, *Boronia* species) are better indicators in some vegetation types than others – where possible, it is best to use a suite of indicator species. Images of many of the species are on the plant species gallery on the FPA website.

***Phytophthora* is probably present if:**

- **susceptible species show symptoms of disease and**
- **resistant species remain healthy.**

***Phytophthora* is probably absent if:**

- **susceptible species are uniformly healthy.**

Another cause of vegetation decline (e.g. drought or waterlogging) is probably responsible if:

- both susceptible and resistant species are showing signs of disease, **or**
- susceptible and resistant species are affected inconsistently.

Any suspected infections of *Phytophthora* in areas not already known to be infected (see *Phytophthora* map in the Conserve Database) should be confirmed by laboratory testing.

Photo 1. A disturbed drainage line with extensive death of *Sprengelia incarnata* (susceptible) surrounded by healthy teatree and sedges (resistant). This is strong evidence of a *Phytophthora* infestation.

Photo 2. A dead *Banksia marginata* surrounded by other susceptible species (*Hibbertia*) that are all healthy on this rocky slope suggests drought rather than *Phytophthora*.

Photo 3. A healthy population of the highly susceptible grasstree (*Xanthorrhoea australis*) is good evidence that *Phytophthora* is not present at this site.

Table 1: Species that are good indicators of *Phytophthora* occurrence in Tasmanian native vegetation. Occurrence of species in different vegetation types is indicated by shading.

SUSCEPTIBLE SPECIES	VEGETATION TYPE				
	Sedgeland	Heath	Dry sclerophyll forest	Rainforest / Wet euc. forest	Disturbed rainforest
Agastachys odorata White waratah	+				+
Amperea xiphoclada Broom spurge		+	+		
Anopterus glandulosus Native laurel				+	+
Aotus ericoides Golden pea		+	+		
Astroloma humifusum Native cranberry		+	+		
Baeckea leptocaulis Slender heathmyrtle	+				
Banksia marginata Silver banksia	+	(+)	(+)		+
Blandfordia punicea Christmas Bells	+	+	+		+
Boronia species Boronia	+	(+)	(+)		
Cenarrhenes nitida Native plum	+			+	+
Cyathodes species Cheeseberry		+	+	+	+
Dillwynia glaberrima Parrotpea	+	+	+		
Epacris species Heath	+	+	+	+	+
Hibbertia species Guineaflower	+	+	+		
Leptocophylla species Pinkberry		+	+	+	+
Leptospermum glaucescens Smoky teatree	+		+		+
Leucopogon species Beardheath		+	+		
Melaleuca squamea Swamp paperbark	+	+	+		
Monotoca glauca Goldeywood		+	+	+	+
Monotoca species Broomheath		+	+	+	+
Nematolepis squamea Lancewood, satinwood				+	
Oxylobium species Shaggypea		+	+	+	+
Pultenaea species Bushpea	+	+	+	+	
Richea pandanifolia Pandani					+
Richea species Candleheath, scoparia	+	+		+	+
Sprengelia incarnata Pink swampheath	+	+			
Stylidium graminifolium *Common triggerplant*	+	+	+		

SUSCEPTIBLE SPECIES (continued)	VEGETATION TYPE				
	Sedgeland	**Heath**	**Dry sclerophyll forest**	**Rainforest / Wet euc. forest**	**Disturbed rainforest**
Tasmannia lanceolata Mountain pepper			+	+	+
Tetratheca species Pinkbells	+	+	+		
Xanthorrhoea species Grasstree		+	+		

RESISTANT SPECIES	VEGETATION TYPE				
	Sedgeland	**Heath**	**Dry sclerophyll forest**	**Rainforest / Wet euc. forest**	**Disturbed rainforest**
Acacia species Wattle		+	+	+	+
Baloskion (Restio) species Cordrush	+			+	+
Baumea species Twig rush	+				
Bedfordia species Blanketleaf, blanketbush			+	+	
Calorophus elongatus Long roperush				+	+
Cassinia aculeata Dollybush			+	+	
Comesperma species Milkwort	+	+	+		
Coprosma species Native currant			+	+	+
Empodisma minus Spreading roperush	+	+	+		+
Exocarpos cupressiformis Native cherry			+	+	
Gahnia grandis Cutting grass			+	+	+
Gymnoschoenus sphaero–cephalus Buttongrass	+				
Lepidosperma species Swordsedge	+	+	+	+	
Leptocarpus tenax Slender twine rush	+	+			
Leptospermum scoparium Teatree, manuka	+	+	+	+	+
Lomandra longifolia Sagg, matrush		+	+		
Melaleuca squarrosa Scented paperbark	+	+	+	+	+
Olearia species Daisybush			+	+	+
Pimelea species Riceflower	+	+	+	+	+
Pomaderris species Dogwood			+	+	
Spyridium species Dustymiller		+	+		
Zieria arborescens Stinkwood			+	+	+

Table 2: **Forest communities that have been identified in the *Regional modules* of the *Forest Botany Manual* as being highly susceptible to *Phytophthora*.**

Priorities for conservation under the RFA are: Y* – threatened community; Y – other priority community; Yog – oldgrowth component of community has priority; N – non-priority community.

Regions which contain the community in a highly susceptible form are indicated: BL – Ben Lomond; CH – Central Highlands; DNT – D'Entrecasteaux; FR – Freycinet; MDL – Midlands; WN – Woolnorth; WSW – West-Southwest. Other abbreviations are given in the *Forest Botany Manual*.

Floristic community code and name		Qualification	RFA code	RFA priority	Region where community is highly susceptible to *Phytophthora*
DRY-gOV	Grassy *E. ovata* forest/woodland		OV	Y*	BL DNT FR WN WSW
DRY-gTEN	Grassy *E. tenuiramis* forest/woodland	Substrate mudstone or sandstone	TI	Y*	BL DNT FR MDL
DRY-hAM	Heathy *E. amygdalina* forest	Substrate sand or alluvium (coastal and subcoastal areas) or granite	AC	N	BL DNT FR MDL WN WSW
		Substrate sandstone, mudstone or Mathinna series	AS	Y*	BL DNT FR MDL WN WSW
DRY-hGLOB	Heathy *E. globulus* forest	Mainly coastal environments	G	Y*	BL DNT FR MDL WN WSW
		King Island	KG	Y*	WN
DRY-hNIT	Heathy *E. nitida* forest		N	N	DNT WN WSW
DRY-hOB	Heathy *E. obliqua* forest		O	N	BL DNT FR WN WSW
DRY-hOV	Heathy *E. ovata* forest/woodland		OV	Y*	BL CH DNT FR WN WSW
DRY-hPAUC	Heathy *E. pauciflora* forest		PS	N	BL
DRY-hSIEB	Heathy *E. sieberi* forest		SG	Yog	BL FR
DRY-hTEN	Heathy *E. tenuiramis* forest	Substrate granite	TG	N	BL FR
		Substrate sandstone, mudstone or Mathinna series	TI	Y*	BL DNT FR MDL
DRY-hVIM	Heathy *E. viminalis* forest	King Island	KG	Y*	WN
		Substrate sand	G	Y*	BL DNT FR MDL WN WSW
		Substrate granite	AC	N	BL FR
DRY-sdAM and DRY-scAM	Sedgy *E. amygdalina* forest/woodland Scrubby *E. amygdalina* forest/woodland	Substrate sand or alluvium in (sub)coastal areas or granite or Precambrian beds	AC	N	BL DNT FR MDL WN WSW
		Substrate sandstone, mudstone or Mathinna series	AS	Y*	BL DNT FR MDL WN WSW

Floristic community code and name		Qualification	RFA code	RFA priority	Region where community is highly susceptible to *Phytophthora*
DRY-sdNIT and DRY-scNIT	Sedgy *E. nitida* forest/woodland Scrubby *E. nitida* forest/woodland		N	N	DNT WN WSW
DRY-sdOV and DRY-scOV	Sedgy *E. ovata* forest/woodland Scrubby *E. ovata* forest/woodland		OV	Y*	BL DNT FR MDL WN WSW
DRY-sdROD and DRY-scROD	Sedgy *E. rodwayi* forest/woodland Scrubby *E. rodwayi* forest/woodland		RO	Y	BL FR WN
DRY-shAM	Shrubby *E. amygdalina* forest	Understorey with similar amount of wet and dry sclerophyll shrubs and *E. obliqua* or *E. viminalis* subdominant or codominant	DSC	Yog	BL
		Not DSC and substrate sand or granite	AC	N	BL FR WN WSW
		Not DSC and substrate sandstone, mudstone or Mathinna series	AS	Y*	BL DNT FR WN WSW
DRY-shGLOB	Shrubby *E. globulus* forest	Substrate sand or granite in coastal areas	G	Y*	BL DNT FR MDL WSW
		King Island	KG	Y*	WN
DRY-shNIT	Shrubby *E. nitida* forest		N	N	DNT WN WSW
DRY-shOV	Shrubby *E. ovata* forest		OV	Y*	BL DNT FR WN WSW
DRY-shSIEB	Shrubby *E. sieberi* forest	Substrate sand or granite	SG	Yog	BL FR
		Other substrates	SO	Yog	BL FR
DRY-shTEN	Shrubby *E. tenuiramis* forest	Substrate granite	TG	N	BL FR
		Substrate sandstone, mudstone or Mathinna series	TI	Y	BL DNT FR
DRY-shVIM	Shrubby *E. viminalis* forest	Not DSC and substrate coastal sand	G	Y*	BL DNT FR MDL WN WSW
		Not DSC and substrate granite or (sub)coastal gravels	AC	N	BL FR WN WSW
		King Island	KG	Y*	WN

Note: On some sites, some of these communities can be dominated by species that are not *Phytophthora*-susceptible (e.g. sedges, bracken, manuka). Such sites may not need standard hygiene prescriptions – but should be referred to FPA for confirmation of this.

5. When should *Phytophthora* hygiene measures be considered?

The objective of *Phytophthora* management through forest practices planning is to reduce the risk of further disease impacts, particularly in areas that contain susceptible species or communities of high conservation significance. The *Forest Botany Manual*, the *Biodiversity evaluation sheet* and the *Threatened Fauna Adviser* indicate that *Phytophthora* hygiene measures must be considered in the following circumstances:

1. **Presence of highly susceptible forest and non-forest communities**

   Forest communities that are highly susceptible to *Phytophthora* have been identified in the *Forest Botany Manual* (Section 2 of each Regional Module). They include threatened (i.e. rare, endangered and vulnerable) communities and non-threatened communities. Many non-forest communities are also at risk from *Phytophthora*. The FPP evaluation process requires that all native non-forest vegetation is referred to the FPA for specialist advice. Such advice will indicate whether prescriptions are needed to cater for *Phytophthora*.

2. **Priority species**

   Species that are listed under the Tasmanian *Threatened Species Protection Act 1995* or the EPBC Act, or species that are otherwise of bioregional significance, are listed in Section 3 of each Regional Module. Species known to be susceptible to *Phytophthora* are indicated. FPA specialist advice will include *Phytophthora* hygiene measures, if appropriate.

3. **New Holland mouse habitat**

   Potential habitat for the New Holland mouse is heathlands (mainly dry heathlands but also where dry heathlands form a mosaic with other heathland, moorland and scrub complexes), heathy woodlands (i.e. eucalypt canopy cover 5-20%), *Allocasuarina*-dominated forests on sandy substrates (not dolerite or basalt), and vegetated sand dunes. Key indicator plants include (but are not restricted to) *Aotus ericoides, Lepidosperma concavum*, *Hypolaena fastigata* and *Xanthorrhoea* spp. These vegetation communities and some of the indicator species are at risk from *Phytophthora.* The *Threatened Fauna Adviser* recommends *Phytophthora* hygiene measures, where appropriate, for operations within potential habitat.

4. **Sites of significance**

   Some environments listed as sites of potential significance for flora (Section 4 of each *Regional module*) contain communities or species that are susceptible to *Phytophthora*. This includes any sites containing populations of grasstree (*Xanthorrhoea* species), which are highly susceptible to *Phytophthora* and include two threatened species (*Xanthorrhoea bracteata* and *X. arenaria*). FPA specialist advice will include *Phytophthora* hygiene measures, if appropriate.

5. ***Phytophthora* Management Areas (MDC on Permanent Timber Production Zone land (PTPZL))**

   Phytophthora management areas comprise areas (mainly catchments on PTPZL) identified for their ability to impede the spread of *Phytophthora* to important populations of susceptible threatened species, or communities with a high proportion of susceptible elements. They have been mapped as Special Management Zones (*Phytophthora* Management Areas) on Sustainable Timber Tasmania's MDC system, are shown on the Conserve Database and on the FPA Biodiversity Values Database webmap.

Most forestry operations in the above situations should incorporate **standard hygiene measures** (see next section) into the FPP, to reduce the risk of introducing *Phytophthora* or facilitating its spread. However, the attributes of the site and operation will also dictate the hygiene measures required. For example:

- Hygiene measures may not be needed if non-susceptible species dominate the understorey.
- Pre-operational hygiene prescriptions will provide little benefit if the area is already widely infected with Phytophthora (although post-operational hygiene measures may need to be incorporated into the FPP, to reduce the risk of spores being carried onto another site).

Details of the site and operation should be included on the FPP *Biodiversity evaluation sheet*. FPOs should also include draft prescriptions on the *Biodiversity evaluation sheet*.

An FPO must contact the FPA for specialist advice if:

- **the *Biodiversity evaluation sheet* indicates that advice is needed because of the presence of priority communities, species or sites, or other flora-related reasons; *or***

- **the site contains a highly susceptible non-threatened forest community *and*:**
  - **the standard hygiene measures cannot be followed; *or***
  - **the FPO does not think standard hygiene measures are warranted.**

An FPO does not need to contact the FPA for specialist advice if:

- **the site contains a highly susceptible non-threatened forest community *and*:**
  - **the standard hygiene measures can be followed; *or***
  - **the site is over 700 m altitude (a.s.l.).**

6. Standard *Phytophthora* hygiene measures

The following standard hygiene measures will be incorporated into most FPPs for operations (including the construction of fire-breaks) being conducted in any area containing *Phytophthora*-susceptible vegetation, as outlined in the previous section.

Additional measures to reduce the risk of accidentally introducing *Phytophthora* may be required by the Forest Practices Authority for operations within particularly sensitive areas. Such measures will be recommended by FPA Biodiversity Program staff on a case-by-case basis. They will be mainly restricted to sites containing threatened species or communities susceptible to *Phytophthora*.

Phytophthora hygiene measures may have other benefits (e.g. reducing spread of weed species).

Location of roads and tracks

- Survey route for presence of *Phytophthora* and record location of any symptoms of infection.
- Minimise roading through *Phytophthora*-susceptible communities or sites rich in *Phytophthora*-susceptible species, and locate roads below such areas if possible.
- Avoid crossing from *Phytophthora*-infected areas into *Phytophthora*-free areas. If such sites are in close proximity, keep within infected areas and infected catchments if possible.
- Limit the potential infection area by minimising the length of roading and locating roads low in the landscape. Avoid locating roads along ridges that form boundaries between infected and uninfected areas.
- Develop access strategies to control unauthorised access (e.g. boom gates, permanent barriers after completion of operation).

Construction of roads and tracks

- Plan to conduct operations during periods when soils are likely to be dry.
- Program works to commence in disease-free areas and progress into diseased areas.
- Do not allow machines to cross from *Phytophthora*-infected areas into disease-free areas without a washdown.
- Crushed rock and gravel imported for road construction within the FPP area must be sourced from a quarry that is currently certified as being *Phytophthora*-free. District offices of Sustainable Timber Tasmania maintain a register of PTPZL quarries that are certified as *Phytophthora*-free.
- Use local gravel wherever possible (e.g. same micro-catchment).
- Source water for construction locally and don't import from an infected to an uninfected area.
- Minimise the area of disturbance (e.g. restrict width of road verge).
- Construct roads and firebreaks to shed water and dry quickly.
- Where possible, construct drains so that water is directed towards non-susceptible vegetation types (e.g. wet sclerophyll forest).
- All roads, landings and primary snig tracks that are constructed in the FPP area must be monitored for symptoms of *Phytophthora*. Monitoring must be done during autumn after one full growing season (September–February) has elapsed since completion of the operation.

Maintenance of roads and tracks

- Crushed rock and gravel used for road maintenance within the FPP area must be sourced from a quarry that is currently certified as being *Phytophthora*-free. District offices of Sustainable Timber Tasmania maintain a register of PTPZL quarries that are certified as *Phytophthora*-free.
- Work wherever possible from uninfected areas to infected areas.
- Do as much maintenance as possible in dry weather.
- Clean out table drains when soil is dry and dump spoil locally. Don't move spoil from infected areas in uninfected catchments.
- Clean machinery before leaving *Phytophthora*-infected areas.

Machinery washdown

- All earthmoving machinery (e.g. dozers, excavators, loaders) and forest harvesting machinery (e.g. skidders, forwarders and excavators) must be washed down prior to entering the FPP area.
- The washdown should follow the procedures detailed in the *Washdown guidelines* (Department of Primary Industries, Water and Environment 2004). Washdown should be done either at the point of departure from the previous operation, or at a designated washdown facility with a well-drained hard surface. The photographs below demonstrate a well-conducted washdown of a dozer.
- An FPO or suitably accredited supervisor should inspect machinery for cleanliness prior to entering the FPP area:
  - If the machinery meets the standards of cleanliness outlined in the *Washdown guidelines,* the FPO or supervisor can authorise the entry of machinery into the FPP area. The minimum standard is: *No clods of dirt or loose soil should be present after washdown*. Smeared soil stains and soil firmly lodged in difficult-to-access areas are acceptable.
  - If the machinery does not meet the minimum standard of cleanliness, the FPO or supervisor must direct that it be moved to a suitable site away from the FPP area for further cleaning.
- Remember that any earthmoving machinery used in operational areas that contain active *Phytophthora* will probably accumulate contaminated soil. The FPP should specify a thorough washdown of machinery before it is moved to a new site. This will reduce the risk of the machinery spreading the pathogen after leaving the operational area.

Chipping off compacted soil from tracks with a crowbar.

A high pressure water spray removes general accumulation of soil. Note how tracks have been lifted off the ground.

At the completion of washing the dozer was lowered onto rubber tyres in preparation for loading onto a float.

7. Maintaining quarries free of *Phytophthora*

Quarries that can provide *Phytophthora*-free gravel are a valuable resource. They are particularly valuable when they are situated near regions that have a concentration of plant communities likely to require hygiene prescriptions.

Good management practices can maintain the *Phytophthora*-free status of clean quarries. Many of these are illustrated in the photos below.

Quarry and borrow pit management

Movement of infected gravel, sand and soil has been implicated in the spread of *Phytophthora* throughout Australia. Maintenance of *Phytophthora* free quarries and pits is essential to avoid spreading the fungus. Relevant points are provided below.

- Quarries used for road construction and maintenance on PTPZL can only be certified as *Phytophthora*-free if they have undergone an annual or biennial (dependent on risk) on-site inspections by qualified personnel.
- Hard rock quarries are lower risk for *Phytophthora* than weathered rock quarries where soil and organic matter are often mixed with the quarried material.
- Borrow pits or quarries that use topsoil or superficial gravel deposits can harbour *Phytophthora*. Their status should be determined by looking for field symptoms of disease in reliable indicator species that are regenerating in disturbed areas in and around the pit.
- Reduce risk of infection from surrounding areas by constructing and maintaining effective drains to ensure that water draining those areas is diverted away from the quarry.
- Maintain good drainage in the quarry to prevent mud building up in working areas.
- Stockpile topsoil from the quarry (particularly hard rock quarries) away from the active quarry area and ensure any drainage from the stockpile is diverted away from the active quarry area.
- Earthmoving machinery (loaders, excavators or dozers) should be free of any adhering soil before entering the quarry (see machinery *Washdown guidelines*). Avoid frequent transport of such machinery into and out of the quarry.
- Trucks carting quarry material should not be allowed to accumulate large clods of soil – this can be avoided by establishing good drainage during road construction prior to surfacing.
- Road access into the quarry should be well-drained and kept free of potholes to prevent puddles forming.
- Install gates to restrict access into clean quarries in strategically important areas.

Hard rock quarries are lower risk for *Phytophthora* than weathered rock quarries where soil and organic matter are often mixed with the quarried material.

Borrow pits or quarries that use topsoil or superficial gravel deposits can harbour *Phytophthora*. Their status can be determined by looking for field symptoms of disease in reliable indicator species that are regenerating in disturbed areas around and in the pit.

Avoid possible infection by constructing and maintaining effective drains which ensure that water is diverted away from the active quarry area.

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Road access into the quarry should be well-drained and kept free of potholes to prevent puddles forming.

Install gates to restrict access into clean quarries in strategically important areas.

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Publication details

This technical note has been prepared by Tim Wardlaw, Fred Duncan and Mark Wapstra. It should be cited as:

Forest Practices Authority 2019, 'Management of *Phytophthora cinnamomi* in production forest', *Flora Technical Note No. 8,* Forest Practices Authority, Hobart.

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Document Summary Information

Document name	**Flora Technical Note No.8: Management of *Phytophthora cinnamomi* in production forests**
Version	2.4
RM record	D19/206934
Owner	Biodiversity Section Staff
Author(s)	Biodiversity Section Staff
Release date	August 2019
Release Approved by	Biodiversity Manager
Release status	For publication on the FPA webpage and other external distribution

Version Control

Version	Date	Author(s)	Summary of changes
2	Nov 2009	Biodiversity Section Staff	Document previously available on FPA website revised. Previous revisions pre-date document control.
2.1	Feb 2011	Nina Roberts	Note: the wording of this document is identical to that approved by the FPA Biodiversity Manager in early 2010, except for the addition of document control information.
2.2	June 2012	Anne Chuter	Added section to link to New Holland mouse habitat in the BVD and the importance of managing PC in NHM potential habitat. Map updated.
2.3	March 2016	Amy Koch	Add reference to the BVD webmap as place where planners can view where the PC management zones are.
2.4	August 2019	Kirsty Kay	Updated text relating to hard rock quarries, and photo, minor change to NHM habitat description, and other minor edits.