A Guide to the Tasmanian Distribution of *Phytophthora cinnamomi* and its Effects on Native Vegetation

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Abstract

Phytophthora cinnamomi *is a soil and root-inhabiting, microscopic fungus which has caused considerable damage to Tasmanian native plants in heathlands. In forest communities damage is usually restricted to understorey plants and occasionally seedlings of canopy species. The fungus is widely distributed in Tasmania as a mosaic of infected areas among more extensive areas of uninfected vegetation but is not known in the coldest or driest regions. This introduced pathogen is continually increasing its range by natural spread within the soil and with the assistance of earth-moving activity. A map of its known distribution in the State and a list of 136 Tasmanian native plants which have been recorded as its hosts are presented. Guidelines for the recognition of infested areas are given.*

Introduction

Phytophthora cinnamomi Rands is a plant-pathogenic, soil-borne fungus which is most active in warm, wet soils. It is almost certainly native to South-east Asia (Crandall and Gravatt 1967), and has caused serious problems of plant disease in many parts of the world (Zentmyer 1980). With the discovery that this fungus was the cause of an epidemic of severe dieback in the jarrah forests of Western Australia (Podger 1972), there was considerable concern that *P.cinnamomi* might also pose a threat to the health of other Australian forests.

In 1972 the Forestry Commission initiated a program of research in which CSIRO collaborated. This research has reached the stage where the distribution of the fungus, and its effects on various native plant communities are well known. The research has established that *P.cinnamomi* does not seriously threaten wood production from Tasmanian forests, but that it poses significant problems for the conservation of many species in heathlands and in the understorey of dry sclerophyll communities.

In this paper we present a map of the Tasmanian distribution of *P.cinnamomi,* a list of the State's native plant species which have been recorded as hosts, and a set of guidelines for recognition of its presence in the field.

Distribution Map

Fig. 1 shows the location (recorded to the nearest 0.1 km) of places for which a validated record exists of the presence of *P.cinnamomi*. The fungus has been isolated directly from stem and root tissues of native plants or by baiting from soil beneath native vegetation by the methods described in Podger and Brown (1989). It indicates the locations of samples, among more than 5,000 tested, which yielded *P.cinnamomi.*

Many tests of samples taken from beneath healthy vegetation produced no evidence of the presence of the fungus. Such negative results cannot, as a matter of course, be taken as proof of the absence of *P.cinnamomi*. The level of affordable sampling, in such a wide-scale survey as this, is a miniscule part of the potential habitat available to the fungus. We cannot have therefore a high degree of

Fig. 1. Distribution of records of isolation of Phytophthora cinnamomi *in native vegetation in Tasmania.*

confidence that failure to isolate from any single sample (typically a kilogram of soil or less), indicates that the fungus is absent from an area. We can have however, a greater degree of confidence that the fungus was not present at the time of sampling where we have tested a larger number of samples and where we also have coincident evidence that: 1) other samples taken nearby from beneath diseased vegetation of the same type, on similar soils have yielded the fungus and 2) it was readily recovered following the addition of a small quantity of *P.cinnamomi* to the negative samples.

This evidence and frequent observation of the spread of disease symptoms along fronts from sources of infection due to both inadvertent and experimental inoculation leads us to conclude that *P.cinnamomi* is increasing its range in a complex mosaic of infected patches within a steadily decreasing area which is free of the pathogen.

Several large areas have no record of infection, notably the central highlands and the central and south midlands. A supplementary program of sampling in parts of these regions has produced no evidence of the presence of the fungus. Climatic analyses indicate that these areas are respectively too cold and too dry for disease-causing activity by the fungus (Podger *et al.* 1990).

There are other significant areas considered to be climatically suited to *P.cinnamomi* for which there is no record of the fungus. (Podger *et al.* 1990). The absence of record may be due to a lack of opportunity for infection or to the low level of sampling in these areas. They should be regarded as worthy of special attention and subject to intensive survey prior to commencement of developmental works: In the event that surveys show the areas to be free of infection a program of strict hygiene should be considered.

Effects on Native Vegetation

Although isolation of *P.cinnamomi* from surface-sterilized tissues of plants is required for listing a species in the 136 species host record for Tasmania (Table 1) it does not constitute proof that *P.cinnamomi* is the cause of associated disease. Rigorous proof of the causal role of *P.cinnamomi* has been demonstrated with plants grown in the glasshouse and/or inoculation experiments in natural field populations (see, for example, Podger 1989, Podger and Brown 1989).

The host range of *P.cinnamomi* among native species in Tasmania (Table 1) is extremely varied, not only in the taxonomic diversity and range of life-forms affected but also in the range of stature and maturity of plants attacked. It has been recovered from ferns and lilies, from seedlings of rainforest species and eucalypts, from old mallee-like rootstocks in heaths and burned rainforest, and from grass trees more than 100 years old.

The extent to which *P.cinnamomi* damages plants is highly variable. At one extreme, it massively invades and completely destroys all plants of the lilies *Blandfordia punicea* and *Xanthorrhoea australis* as they are encountered during the spread of the fungus through heathlands at Rocky Cape National Park. At the other extreme, it may infect soft tissues in the zone of elongation of a few roots in seedling plants such as *Eucalyptus globulus*, but spread no further and cause no apparent malfunction in the host. The eucalypts, with notable exceptions such as *E.amygdalina*, *E.obliqua*, and *E.sieberi* are usually field resistant. Most eucalypts on the host list represent records of restricted damage demonstrated on seedlings in greenhouse experiments. Adult eucalypts are usually resistant with the exception of some small patches of *E.amygdalina*, *E.sieberi* and *E.obliqua* on microsites particularly favourable for fungal attack (Wardlaw and Palzer 1988). Between the extremes of complete susceptibility and a high degree of resistance there is great variety of response; in some species a very large proportion of local populations is severely damaged; conversely there are others in which a very small proportion of the population is affected.

Table 1. Tasmanian native plant species from which Phytophthora cinnamomi *has been isolated. Taxonomic nomenclature follows Buchanan* et al.*(1989). Previously unpublished host records are indicated "N". Most prior records of isolation from surface-sterilised host tissues are given in Zentmyer (1980). The more recent are in Hinch and Weste (1979), Kleijunas (1979), Podger (1989), Podger and Brown (1989), and Weste and Cahill (1982). Species from which* P.cinnamomi *has been isolated from plants growing naturally in the wild in Tasmania are indicated by "T". Species which have been recorded as hosts elsewhere, but for which there is no report of isolation from naturally occurring plants in Tasmania are indicated "O". Those for which there is proof of pathogenicity in experiments with a Tasmanian provenance of a species in the glasshouse or in field populations are indicated (G) and (F) respectively.*

Host Taxa	Record	Pathogenicity Test
BLECHNACEAE		
Blechnum wattsii		T
LYCOPODIACEAE		
Lycopodium deuterodensum	O	
PODOCARPACEAE		
Phyllocladus aspleniifolius	T	G,F
Podocarpus lawrencii	O	
TAXODIACEAE		
Athrotaxis selaginoides	T	G
CYPERACEAE		
Gahnia grandis	T	
Gymnoschoenus sphaerocephalus	N,T	
Lepidosperma concavum	N,T	
IRIDACEAE		
Diplarrena moraea	T	
Patersonia fragilis	N,T	
LILIACEAE		
Blandfordia punicea	T	F
Dianella tasmanica	T	F
RESTIONACEAE		
Restio monocephalus	O	G
ASTERACEAE		
Cassinia aculeata	T	
CASUARINACEAE		
Allocasuarina monilifera	N,T	F
CUNONIACEAE		
Anodopetalum biglandulosum	T	G,F
Bauera rubioides	T	G,F
DILLENIACEAE		
Hibbertia acicularis	N,T	
H.empetrifolia	N,T	
H.procumbens	N,T	F
H.prostrata	N,T	
H.riparia	N,T	
H.sericea	N,T	
EPACRIDACEAE		
Acrotriche serrulata	T	
Astroloma humifusum	T	
A.pinifolium	N,T	
Cyathodes juniperina	T	G,F
C.glauca	T	
Epacris corymbiflora	T	G,F
E.gunnii	T	
E.impressa	T	G,F
E.lanuginosa	N,T	
E.obtusifolia	N,T	F
Leucopogon australis	T	
L.collinus	N,T	F
L.ericoides	T	
L.virgatus	T	
Lissanthe strigosa	O	
Monotoca elliptica	N,T	
M.glauca	T	F
M.submutica	T	F
Prionotes cerinthoides	T	
Richea milliganii		G
R.pandanifolia	T	G,F
Sprengelia incarnata	T	G,F
Styphelia adscendens	O	
Trochocarpa disticha	T	
T.gunnii	T	
ERICACEAE		
Gaultheria hispida	T	G
ESCALLONIACEAE		
Anopterus glandulosus	T	G
EUCRYPHIACEAE		
Eucryphia lucida	T	G,F
E.milliganii	T	G
EUPHORBIACEAE		
Amperea xiphoclada	N,T	
Ricinocarpus pinifolius	N,T	
FABACEAE		
Acacia genistifolia	O	
A.melanoxylon	O	
A.mucronata	T	
A.myrtifolia	N,T	
A.suaveolens	N,T	
A.ulicifolia	O	
A.verticillata	T	
Aotus ericoides	T	
Bossiaea cinerea	T	
B.prostrata	O	
Daviesia latifolia	T	
D.ulicifolia	T	
Dillwynia glaberrima	T	
D.sericea	T	
Gompholobium huegelii	T	
Hovea heterophylla	O	
H.longifolia	O	
Kennedia prostrata	O	
Oxylobium arborescens	N,T	
O.ellipticum	T	
Phyllota diffusa	N,T	F
Platylobium obtusangulatum	T	
Pultenaea daphnoides var *obcordata*	T	
P.gunnii	N,T	
P.humilis	O	
P.juniperina	N,T	
P.stricta	T	
P.pedunculata	O	

Host Taxa	Record	Pathogenicity Test
FAGACEAE		
Nothofagus gunnii	O	G
N.cunninghamii	T	G
HALORAGACEAE		
Gonocarpus tetragyna	T	
G.teucrioides	T	
LABIATAE		
Prostanthera lasianthos	O	
LOGANIACEAE		
Mitrasacme sp.	N	G
M.pilosa	N,T	
MONIMIACEAE		
Atherosperma moschatum	T	G
MYRTACEAE		
Baeckea leptocaulis	T	G,F
Calytrix tetragona	N,T	
Eucalyptus amygdalina	T	
E.coccifera	O	
E.cordata	O	
E.delegatensis	T	
E.globulus	O	G
E.nitida	T	
E.obliqua	T	G
E.ovata	O	
E.pauciflora	O	
E.pulchella	O	
E.regnans	O	G
E.sieberi	T	G,F
E.tenuiramis	O	
E.viminalis	O	
Leptospermum glaucescens	T	
L.scoparium	T	
Melaleuca gibbosa	T	
M.squamea	T	G,F
M.squarrosa	T	
PROTEACEAE		
Agastachys odorata	T	G,F
Banksia marginata	T	G,F
B.serrata	T	
Cenarrhenes nitida	T	G,F
Hakea nodosa	O	
H.sericea	T	
Isopogon ceratophyllus	O	
Orites diversifolia	O	G
Persoonia gunnii	T	
P.juniperina	T	
Telopea truncata	T	G
RUTACEAE		
Boronia citriodora	N,T	
B.parviflora	T	G,F
B.pilosa	T	G,F
Correa reflexa	T	
Eriostemon virgatus	N,T	
Phebalium squameum	T	G,F
STYLIDIACEAE		
Stylidium graminifolium	T	G,F
TREMANDRACEAE		
Tetratheca ciliata	O	
T.labillardierii	N,T	
T.pilosa	N,T	F
T.procumbens	N,T	
UMBELLIFERAE		
Actinotus bellidioides	N	G
WINTERACEAE		
Tasmannia lanceolata	T	G, F
XANTHORRHOEACEAE		
Xanthorrhoea australis	T	F

The same is true of the effect of *P.cinnamomi* at plant community level. Severe damage is usually restricted to heathlands (Podger and Brown unpublished, Podger and Palzer unpublished) and to the understorey of sclerophyllous woodlands and forests (Forestry Commission, Tasmania 1978; Palzer 1985). Only very occasionally has damage been observed in the overstorey of forest communities (Wardlaw and Palzer 1988). In heaths and heathy forest communities the effects of *P.cinnamomi* generally are long-lasting and may well be permanent. Damage to rainforest and wet-sclerophyll communities appears to be restricted to disturbed sites alongside roads and on recently burned areas. In such places soil temperatures reach levels suitable for fungal attack but are seldom attained beneath undisturbed communities. In these latter circumstances it is possible that the effects of infection are largely transient and susceptible species may recolonise once soil temperatures are depressed under a developing canopy of resistant species (Podger and Brown 1989).

Guidelines for Field Recognition of Infection

P.cinnamomi is now established very widely and is continually extending on an enormous and scattered perimeter; no map of its distribution will ever be up to date. Responsible land managers will need, therefore, to develop the capacity to make on-site judgements about the need (and practicality) to adjust works programs so that further spread of the fungus is minimised. Recognition of the presence of *P.cinnamomi* is a first step. The following guidelines should assist.

Table 2. List of species which have high proportions of highly susceptible or highly resistant elements in field populations.

Susceptible species		Resistant species	
1.	*Agastachys odorata*	32.	*Richea pandanifolia*
2.	*Allocasuarina monilifera*	33.	*Sprengelia incarnata*
3.	*Amperea xiphoclada*	34.	*Stylidium graminifolium*
4.	*Anopterus glandulosus*	35.	*Tasmannia lanceolata*
5.	*Aotus ericoides*	36.	*Tetratheca spp.*
6.	*Astroloma humifusum*	37.	*Xanthorrhoea australis*
7.	*Baeckea leptocaulis*	38.	*Acacia spp.*
8.	*Banksia marginata*	39.	*Allocasuarina littoralis*
9.	*Bauera rubioides*	40.	*A.stricta*
10.	*Blandfordia punicea*	41.	*Baumea spp.*
11.	*Boronia spp.*	42.	*Bedfordia spp.*
12.	*Cenarrhenes nitida*	43.	*Calorophopus elongatus*
13.	*Cyathodes glauca*	44.	*Cassinia aculeata*
14.	*C.juniperina*	45.	*Comesperma spp.*
15.	*Dillwynia glaberrima*	46.	*Coprosma spp.*
16.	*Epacris corymbiflora*	47.	*Empodisma minus*
17.	*E.impressa*	48.	*Exocarpos cupressiformis*
18.	*E.lanuginosa*	49.	*Gahnia grandis*
19.	*Gaultheria hispida*	50.	*Gymnoschoenus sphaerocephalus*
20.	*Hibbertia spp.*	51.	*Lepidosperma spp.*
21.	*Leptospermum glaucescens*	52.	*Leptocarpus tenax*
22.	*Leucopogon collinus*	53.	*Leptospermum scoparium*
23.	*L.ericoides*	54.	*Lomandra spp.*
24.	*Melaleuca squamea*	55.	*Melaleuca squarrosa*
25.	*Monotoca glauca*	56.	*Olearia spp.*
26.	*M.submutica*	57.	*Pimelea spp.*
27.	*Oxylobium spp.*	58.	*Pomaderris apetala*
28.	*Persoonia gunnii*	59.	*Restio spp.*
29.	*Phebalium squameum*	60.	*Spyridium spp.*
30.	*Phyllota diffusa*	61.	*Zieria arborescens*
31.	*Pultenaea spp.*		

1. Look for signs of disease in those places where the fungus is most likely to express itself. Usually the presence of *P.cinnamomi* is most obviously expressed in heathlands and in buttongrass plains. In areas with taller cover, search on recently disturbed areas (burns or logging coupes and along road-verges); pay particular attention to places exposed to soil warming e.g. north facing aspects. In drier forests concentrate on sites which gain water e.g. downslope of culverts.

2. Where *P.cinnamomi* is present it is usual to find a mix of diseased and healthy plants. Most species listed as susceptible produce striking symptoms of discoloration; most of these have been proved to be susceptible in pathogenicity tests (Table 1). A few species for which we have not yet proved pathogenicity are included in a list of good indicators of *Phytophthora* because they consistently exhibit strong symptoms in areas of known infection, but remain healthy in nearby disease-free

stands. The field inoculation experiments have also provided reliable information on the status of resistance of a number of species not listed in the host record (Table 2).

Look for species listed as good indicators for the vegetation type with which you are concerned. A list of highly susceptible and highly resistant species for each of five major vegetation classes is given in Table 3.

3. If the presence of *P.cinnamomi* is suspected, check that the susceptible species are in various stages of decline (some healthy, some dying and some dead). *P.cinnamomi* takes some time to produce strong symptoms and rarely attacks all plants in a patch simultaneously. If plants are all at the same stage of damage and resistant species also are affected there is probably some other cause for the deaths such as drought or waterlogging.

4. Remember that there are unlikely to be obvious symptoms where the fungus has been established for a considerable time. In such situations the majority of highly susceptible indicators will have been killed. Diagnosis is especially difficult where the remains of dead plants have been removed by fire. If you are still in doubt move slowly uphill or along the road searching for stronger symptoms at the boundaries of active invasion.

5. If you recognise the above suite of symptoms and signs in any area shown blank on Fig. 1, or any other circumstance which seems unusual or potentially important, please notify a forest pathologist.

Table 3. List of reliable indicator species (either susceptible or resistant to P.cinnamomi*) in each of five broad vegetation classes (see Table 2 for codes to species identities).*

Community	Susceptible	Resistant
Sedgeland	*1,7,8,9,10,11,12,16 20,24,33,34,36*	*41,47,50,51,52,53 55,57,59*
Heath	*2,3,5,6,7,8,9,10,11 15,17,18,20,22,23,24 27,30,31,33,34,36,37*	*38,39,45,51,52,53,55 57,60*
Open forest and scrub	*2,3,5,6,8,9,11,13,14,15 17,18,20,21,22,23,24 26,27,31,34,35,36,37*	*38,39,40,42,44,45 46,48,49,51,53,54, 55,56,57,60,*
Tall open forest	*4,13,14,19,25,26,27 29,31,35*	*38,42,43,44,46,48,49 51,53,55,56,57,58,59,61*
Disturbed rainforest	*1,4,8,9,10,12,13,,19 21,25,26,27,32,35*	*38,43,46,47,49,53 55,56,57,59,*

References

Buchanan, A.M, McGeary-Brown, A. and Orchard, A.E. (1989) *A Census of the Vascular Plants of Tasmania*. Tasmanian Herbarium Occasional Paper No. 2.

Crandall, B.S. and Gravatt, G.F. (1967) The distribution of *Phytophthora cinnamomi*. *Ceiba* **13** : 43-53.

Forestry Commission, Tasmania (1978) *Phytophthora cinnamomi* root rot. Forest Pests and Diseases Leaflet No. 6. Forestry Commission, Hobart.

Hinch, J.M. and Weste,G. (1979) Behaviour of *Phytophthora cinnamomi* zoospores on roots of Australian forest species. *Aust. J. Bot.* 27 : 679-691.

Kleijunas, J.T. (1979) Effects of *Phytophthora cinnamomi* on some endemic and exotic plant species in Hawaii in relation to soil type. *Plant Disease Reporter* 63 : 602-606.

Palzer, C. (1985) Diseases and fungi. Working Paper No. 9 Environmental Impact Statement on Tasmanian Woodchip Exports Beyond 1988. Forestry Commission, Hobart.

Podger, F.D. (1972) *Phytophthora cinnamomi*, a cause of lethal disease in indigenous plant communities in Western Australia. *Phytopathology* 62 : 972-981.

Podger, F.D. (1989) Comparative pathogenicity of fourteen Australian isolates of *Phytophthora cinnamomi* determined on transplants of Tasmanian temperate heathland. *Aust. J. Bot.* 37:491-500.

Podger, F.D. and Brown, M.J. (1989). Vegetation damage caused by *Phytophthora cinnamomi* on disturbed sites in temperate rainforest in Western Tasmania. *Aust. J. Bot.* 37 : 443-480.

Podger, F.D., Mummery, D.C., Palzer, C. and Brown, M.J. (1990) Bioclimatic analysis of the distribution of damage to native plants caused by *Phytophthora cinnamomi* in Tasmania. *Aust. J. Ecol.* (in press).

Wardlaw, T.J. and Palzer, C. (1988) Regeneration of *Eucalyptus* species in an eastern Tasmanian coastal forest in the presence of *Phytophthora cinnamomi*. *Aust. J. Bot.* 36 : 205-215.

Weste, G. and Cahill, D. (1982) Changes in root tissue associated with infection by *Phytophthora cinnamomi*. *Phytopathologische Zeitschrift*. *103* : 97-108.

Zentmyer,G.A. (1980) *Phytophthora cinnamomi* and the diseases it causes. American Phytopathological Society Monograph 10 : 1-96.