FOREST DISEASE SURVEY OF BANKSIA WOODLAND ON LOWLANDS AND RECOMMENDATIONS FOR HYGIENE MANAGEMENT AND DISEASE CONTROL

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GLOSSARY

Autonomous disease spread
The natural movement of infective motile spores in saturated soils and growth of mycelium between connecting root systems.

Cryptic infestation
The situation in which a host plant is infected with a pathogen but there are no secondary symptoms.

Dieback
In Western Australia, the term is specifically used to describe the disease in native vegetation caused by the *Phytophthora cinnamomi* fungus. The term is also generally used to describe any progressive deterioration of tree crowns.

Disease
The decline in plant health as a result of the presence of a pathogen and environmental conditions favourable to the pathogen.

Hyphae
Threadlike strands or filaments that constitute the body (mycelium) of a fungus.

Impact
The effect of disease on plant health.

Infested
Areas of vegetation displaying secondary symptoms consistent with *Phytophthora cinnamomi* infection.

Keystone species
A plant species in an ecosystem that provides conditions pivotal for the survival of other flora and fauna.

Mycelium
A mass of fungal hyphae forming the body of a fungus.

Non-susceptible species
Plant species that do not display secondary symptoms of *Phytophthora cinnamomi* infection when exposed to the pathogen. They may display primary symptoms of infection including the death and discolouration of root tissue and lesion development.

Phytophthora
A genus of microscopic fungi responsible for widespread damage in native vegetation of Western Australia.

Phytophthora susceptible species
Plant species that will develop secondary symptoms of *Phytophthora cinnamomi* infection when exposed to the pathogen. Secondary symptoms include crown decline and death of the host.

Pathogen
A pathogen is any agent causing disease.

Vectored pathogen spread
The spread of infective propergules through the inadvertent movement of infested soil or vegetative material. Agents include vehicles, machinery, animals and walkers.

Vegetation associations
A group of similar plants that grow in a uniform environment that contains one or more dominant species.

Uninfested
Areas of vegetation free of secondary symptoms, indicating an absence of *Phytophthora cinnamomi*.

Zoospore
A motile spore approximately 0.01 mm in diameter produced within a sporangium.

1. BACKGROUND

The plant disease known in Western Australia as "dieback" or "Jarrah dieback" is caused by an introduced, microscopic, soil-borne fungus of the genus *Phytophthora*. The most destructive and widespread species is *Phytophthora cinnamomi* Rands, which has caused irreversible decline of susceptible species from Eneabba in the north to Cape Arid on the south coast (Shearer & Tippett, 1989).

The *Phytophthora cinnamomi* fungus is highly invasive and will infect the roots of a large range of plant species. The primary symptom of infection is the death and discolouration of root tissue. The secondary symptoms are crown decline and/or the death of the infected plant. Plant species that are partially resistant and do not develop secondary symptoms are classified as "non-susceptible" hosts, and species that develop secondary symptoms are regarded as "susceptible" hosts. There are few native plant species that have been found to be completely resistant to dieback and able to inhibit fungal growth at the point of entry.

Phytophthora cinnamomi mycelial strands spread through the root system of an infected plant and, under certain environmental conditions, develop sporangia. The sporangia release zoospores into the soil where they spread through water movement and, to a lesser degree, through self-propulsion. People and animals can also spread the spores through the movement of infected soil or plant material.

Dieback has been inadvertently spread throughout the coastal sand plains and infested many areas. The impact that dieback will have in native vegetation communities is determined by a complex interaction between the host species, the *Phytophthora* fungus and environmental factors. The banksia woodlands of the coastal plain are especially at risk as they contain many susceptible species.

Until recently, the only method of dieback control was to implement hygiene measures designed to minimise vectored spread. There was no effective method of controlling autonomous spread within infested areas, or protecting susceptible plant communities in high conservation value areas. Several trials undertaken by the Department of Conservation and Land Management have shown that foliar spraying and stem injection of phosphorous acid gives excellent control of *Phytophthora cinnamomi* in a range of susceptible hosts. In a report to the Western Australian Minister for the Environment, phosphorous acid treatment is identified as an effective measure for the protection of threatened flora (Podger, James & Mulcahy, 1996).

2. INTRODUCTION

This survey was requested by The Lowlands Conservation Association, to determine the disease status of the native vegetation adjacent to the private property access road from Lowlands Road to the farm residence. The results and subsequent recommendations will be considered in the formulation of disease management strategies for native vegetation on the property.

An initial field inspection was made on 14 December 1999 in conjunction with providing a quotation for formal field assessment. Field assessment was commenced and completed on 22 February 2000. The method of disease assessment was the systematic examination of vegetation for symptoms of *Phytophthora cinnamomi* infection, supported by soil and root sampling for laboratory analysis. This report contains the results of the survey including the susceptibility of the vegetation associations to infestation, disease distribution, disease expression, disease impact, discussion of the issues relevant to management, and the subsequent management recommendations.

3. METHOD OF DISEASE SURVEY

The initial field inspection indicated a continuous disease front to the north of and approximately parallel to the access road. This area was assessed for the presence of *Phytophthora cinnamomi* by traversing the vegetated areas and examining the susceptible native plant species for secondary symptoms of fungal infection. Secondary symptoms include dead and dying leaves, crown decline and death. Disease fronts were demarcated with dayglow orange flagging tape, with the knots towards the infestation.

It is not possible to conclusively identify *Phytophthora* in the field as the fungus is microscopic during all stages of its life cycle. A sample of soil and root material was taken from susceptible plants displaying secondary symptoms of *Phytophthora* infection was collected for laboratory analysis. The sample site was demarcated in the field with dayglow orange flagging tape and an aluminium identification tag.

The sample was processed by Dr. Elaine Davison of Curtin Consultancy Services. The soil material was flooded with distilled water containing 10 *Eucalyptus sieberi* cotyledons that had been surface sterilised with 70 % ethanol solution. Cotyledons that changed colour from green to beige were examined for sporangia then plated on agar selective for *Phytophthora*. After seven days, all remaining cotyledons were plated on selective agar. Plant tissue was surface sterilised with 70% ethanol solution and cut into small strips before being plated onto selective agar. Plated material was left for one week then examined for the development of fungi. Identification of *Phytophthora* species was determined by the structure, size and development of sporangia and hyphae.

4. SUSCEPTIBILITY OF VEGETATION TO *PHYTOPHTHORA CINNAMOMI*

The flora communities within the survey area were classified into three vegetation associations based on the presence of one or more dominant species. The distribution of the vegetation associations has been determined by soil characteristics, drainage features, and modification through agricultural practices. The distribution, composition and susceptibility to *Phytophthora cinnamomi* of the three vegetation associations is described below.

Banksia woodland
The vegetation composition is an overstorey of *Eucalyptus marginata* and *Corymbia calophylla* over *Banksia attenuata, Banksia grandis, Banksia illicifolia,* and *Banksia menziesii.* Understorey species include *Acacia spp., Dryandra spp., Hibbertia hypericoides, Macrozamia riedlei, Patersonia occidentalis, Patersonia rudis, Sterlingia latifolia, Xanthorrhoea gracilis* and *Xanthorrhoea preissii.* This vegetation association is very susceptible to *Phytophthora cinnamomi,* as the majority of the native species are susceptible (Helyar, 1994).

***Eucalyptus rudis / Melaleuca spp.* open forest.**
This vegetation occurs between the Serpentine River and the access road. The vegetation composition is *Eucalyptus rudis* and *Melaleuca spp.* adjacent to the river, with fringing *Corymbia calophylla* and *Eucalyptus gomphocephala* in the riparian zone adjacent to the Banksia woodland. The understorey consists of sedges, reeds and bracken fern. The vegetation composition has been modified by intermittent clearing, grazing and weed invasion, altering the floral composition and reducing the native species density. The *Eucalyptus rudis / Melaleuca spp.* open forest is not susceptible to *Phytophthora cinnamomi.*

Cleared farmland
There are areas of cleared farmland to the north of the access road on the eastern and western boundaries of the survey area. Vegetation consists of open grasslands on the eastern boundary and *Melaleuca spp.* over grasslands on the western boundary. There are no *Phytophthora cinnamomi* susceptible species within these areas.

5. DISEASE EXPRESSION AND DISTRIBUTION

There are secondary symptoms consistent with *Phytophthora cinnamomi* infestation within the Banksia woodland north of the access road. The disease expression is variable with scattered and intermittent clusters of susceptible species deaths, indicating a relatively convoluted disease front. A soil and root sample taken from *Phytophthora cinnamomi* susceptible *Banksia grandis* and *Banksia attenuata* displaying secondary symptoms of infection returned a positive result for *Phytophthora cinnamomi.*

From the observation of secondary symptoms it was possible to demarcate a continuous disease front. The demarcated disease front is generally parallel to, and within 50 metres of the access road, with two deviations. At the eastern property boundary the disease front extends in a northerly direction, intersecting with a power line easement at a point approximately 400 metres north of the access road. From the major power line easement that bisects the Banksia woodland, the disease front extends in a west north west direction to the western survey boundary.

Evidence suggests that the initial pathogen introduction was through importation of infected road building materials for the access road and/or unhygienic use of the road. Subsequent disease spread has been autonomous along the majority of the road. It is probable that the pathogen was vectored inwards from the road or an alternate source during clearing or farming activities at the eastern and western boundaries of the survey area.

Throughout the survey area there are deaths in mature *Eucalyptus marginata* not attributable to *Phytophthora cinnamomi*. The trees are in infested and uninfested areas and appeared to have died 30 to 40 years ago. There are no signs of mechanical damage such as ringbarking and the cause of the death is unknown.

There were no secondary symptoms within the *Eucalyptus rudis / Melaleuca spp.* open forest or cleared farmland vegetation associations due to the absence of susceptible species.

6. RISK ANALYSIS AND DISEASE IMPACT

The principle aims of *Phytophthora cinnamomi* management are to minimise the risk of increasing the occurrence of disease through vectored spread, and to minimise the impact of existing infections (Shearer and Tippett, 1989). The following sections highlight the issues that have been considered in analysing these risks and the potential impact of vectored and autonomous spread of the pathogen.

6.1 Limitations of the survey

This survey was restricted to the detection and demarcation of one disease front adjacent to the access road. From observation of aerial photography, it is probable that there are infestations beyond the survey area. It is desirable that all infestations are detected, demarcated and mapped for formulation of a Management Plan.

The demarcation has not been mapped and will deteriorate as the demarcation tapes fade. It is possible to record this demarcation and any future demarcation with a Differential Global Positioning System (DGPS). This system is accurate and relatively inexpensive (compared to surveying) and can be utilised to replace demarcation that may be lost due to fire or deteriorating tapes.

6.2 Susceptibility of vegetation associations

The Banksia woodland is highly susceptible to infestation. Autonomous disease spread within the woodland is primarily through root to root transmission. The rate of mycelium growth is dependent upon temperature and moisture content and can be as slow as 20 centimetres per year (Shea & Dillon, 1980), although an average rate of spread of approximately one metre per year can be expected. As the disease progresses through the Banksia woodland, it will infect and kill most species.

Many of the Banksias are keystone species (Shearer, Wills & Stukely, 1991), providing a food source for insects, birds and mammals. The loss of these keystone species would have a negative impact on the populations of dependent animal species as well as the aesthetic and intrinsic values of the native plant community.

Disease impact in the non-susceptible *Eucalyptus rudis / Melaleuca spp.* open forest and cleared farmland is negligible and limited to possible decline in vigour. It is probable that cryptic infestation is present in hosts within these vegetation associations, providing a possible source of inoculum for vectored pathogen spread.

6.3 Pathogen vectors

The infestations within the Banksia woodlands and probable cryptic infestation within the other vegetation associations are a potential source of inoculum. Without hygiene restraints, it is possible that inoculum may be vectored by vehicle movement into the uninfested Banksia woodlands along tracks and the power line easements. In addition, any existing infestations on tracks within the Banksia woodlands (outside the survey area) will be a source of inoculum for further vectoring.

There is some evidence to suggest that fauna (probably kangaroos) may be vectoring inoculum for short distances adjacent to the disease front. The evidence consisted of isolated secondary symptoms within ten metres of the main front, associated with fauna trails.

6.4 Phosphorous acid treatment

Phosphorous acid is a cheap, biodegradable and non-toxic chemical that has been found to be very effective as both a curative and protectant against *Phytophthora cinnamomi* in a range of susceptible hosts (Komorek, Shearer, Smith & Fairman, 1997). The impact that *Phytophthora cinnamomi* will have on the susceptible vegetation within the survey area may be reduced with the application of phosphorous acid.

7. RECOMMENDATIONS FOR MANAGEMENT

7.1 Implementation of hygiene constraints

Hygiene constraints should be implemented to prevent the vectored spread of inoculum to the uninfested Banksia woodlands. All vehicles entering the Banksia woodland to the north of the demarcation boundary should be free of soil and plant material. Access

should be avoided during wet conditions where soil is adhering to tyres. If access is required for fire control, all machinery should be free of soil and plant material prior to entry and movement of soil minimised.

7.2 Extension of survey

It is recommended that the survey area be extended to the Banksia woodland to the north of the demarcated disease front. A proposed structure in order of priority includes:

- Survey of the perimeter of the woodland and DGPS recording of all disease boundaries.
- Survey of vehicle tracks within the woodland and DGPS recording.
- Survey of areas targeted from aerial photography that may be infested within the woodland.
- Survey of major fauna trails that traverse disease fronts.
- Broad scale survey of the entire woodland on a 50 metre grid interval.

As the knowledge of disease distribution increases, management plans should be refined. An example is that once all tracks and boundaries are assessed, access with soil movement can be permitted by use of clean down on entry to the Banksia woodland and avoiding internal infestations on tracks within the Banksia woodland.

7.3 Control of autonomous spread of *Phytophthora cinnamomi*

It is recommended that all susceptible species within 20 metres of the demarcation boundary be treated with phosphorous acid at the rates and frequency recommended by the Department of Conservation and Land Management. Consideration should be given to aerial application. The cost of application is the factor that will determine the viability of this protection strategy.

7.4 Rehabilitation

It is recommended that *Phytophthora* infested areas are rehabilitated with non-susceptible native species. A list of susceptible native species that should not be used for rehabilitation of infested sites or sites with a high potential for cryptic infestation forms Appendix 1. A list of non-susceptible native species that should be considered for rehabilitation of infested sites and sites with a high potential for cryptic infestation forms Appendix 2.

8. REFERENCES

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Appendix 1

Plant species of the coastal plain susceptible to *Phytophthora cinnamomi.*

Family	Species	Common name
Dasypoganaceae	*Lomandra odora*	Tiered mat rush
Dilleniaceae	*Hibbertia hypericoides*	Yellow buttercup
	Hibbertia subvaginata	
Epariedaceae	*Adersonia heterophylla*	
	Adersonia lehmanniana	
	Astroloma xerophyllum	
	Conostephium pendalum	Pearl flower
	Leucopogan conostephioides	
Iridaceae	*Patersonia occidentalis*	Purple flag
	Patersonia rudis	Hairy flag
	Patersonia umbrosa var. xanthina	Yellow flag
Myrtaceae	*Eucalyptus marginata*	Jarrah
	Melaleuca scabra	Rough honey myrtle
	Scholtzia involucrata	Spiked scholitzia
	Verticordia nitens	Feather flower
Papilionaceae	*Bossia ericarpa*	
	Jacksonia floribunda	Holly pea
Proteaceae	*Adenanthos serivea*	
	Adenanthos sygnorum	Woolly bush
	Banksia attenuata	Slender banksia
	Banksia grandis	Bull banksia
	Banksia ilicifolia	Holly leaved banksia
	Banksia litoralis	Swamp banksia
	Banksia menziesii	Menzies banksia
	Banksia prionotes	Acorn banksia
	Banksia sphaerocarpa	Fox banksia
	Conosperma stoechadis	Smoke bush
	Dryandra carduacea	Pingle
	Dryandra nivea	Couch pot dryandra
	Dryandra sessilis	Parrot bush
	Isopogon formosus	Cone flower
	Petrophile linearis	Pixie mop
	Stirlingia latifolia	Blue boy
	Synaphea petiolaris	Synaphea
Xanthorrhoeaceae	*Xanthorrhoea spp.*	Blackboys
Zamiaceae	*Macrozamia riedlei*	Zamia palm

This list of plant species is from the Department of Conservation and Land Management Dieback Interpreters Procedures Manual, Appendix 10. The list is not necessarily complete and is under constant revision.

Appendix 2

Plant species not susceptible to *Phytophthora cinnamomi* suitable for rehabilitation planting in infested areas.

SPECIES	COMMON NAME	DESCRIPTION
	Trees	
Acacia saligna	Orange wattle / Coojong	Dense spreading tree to six metres.
Allocasuarina fraseriana	Sheoak	Erect slow growing tree to 15 metres.
Corymbia calophylla	Marri / Red gum	Large erect tree to 20 metres.
Eucalyptus gomphocephala	Tuart	Large erect tree to 20 metres
Eucalyptus rudis	Flooded gum, River gum	Large erect tree to 15 metres
	Shrubs	
Acacia pulchella	Prickly moses	Dense shrub to 1.5 metres.
Allocasuarina humilis	Dwarf sheoak	Shrub to two metres.
Anigozanthus manglesii	Kangaroo paw	Small plant with red and green flowers.
Bossiaea ericocarpa		Small shrub to 0.5 metres.
Hakea prostrata	Harsh hakea	Erect shrub or small tree to four metres.
Kunzea ericifolia		Erect shrub to three metres.
	Ground Cover	
Hardenbergia comptoniana	Native wisteria	Climbing shrub that tends to be invasive.

Kennedia prostrata	Red runner	Prostrate shrub with red flowers.