Gnangara Sustainability Strategy

An across-government initiative

Groundwater – Biodiversity – Land use

NATIVE PLANT TAXA AND THREATENED ECOLOGICAL COMMUNITIES OF THE GSS STUDY AREA: AN ASSESSMENT OF SUSCEPTIBILITY TO *PHYTOPHTHORA CINNAMOMI*

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Introduction

The Gnangara Sustainability Strategy (GSS) study area is located within south-west Western Australia, one of the world's 32 biodiversity hotspots (Mittermeier *et al.* 2004). The area is renowned for its floristic diversity and endemism (Beard *et al.* 2000; Hopper and Gioia 2004). The impact of *Phytophthora cinnamomi* on flora and ecosystems has been identified as a major threatening process in the Department of Environment and Conservation's Swan Region (DEC 2009). Although there is evidence of the occurrence of *P. cinnamomi* on the Gnangara groundwater system since the 1940s, information on its distribution and impacts is limited.

The effects of *P. cinnamomi* infestation of native vegetation can be severe, leading to major changes in plant community composition, structure and function. The consequences of the disease caused by *P. cinnamomi* (*Phytophthora* dieback) may include species loss of susceptible flora and degradation to remaining habitat for flora and fauna (Garkaklis *et al.* 2004; Shearer *et al.* 2007; Wills 1993; Wills and Keighery 1994).

Approximately 2 300 of the 5 710 described plant species in the south-west botanical province of Western Australia have been recorded as being susceptible to *P. cinnamomi* with 800 being highly susceptible to the pathogen (Shearer *et al.* 2004). Because many of the highly susceptible species occur frequently and are structurally dominant, their death following infestation leads to a prominent decline in biomass, with associated reduced floristic diversity and capacity of infested sites to support dependent biota (Shearer and Dillon 1995; Shearer and Dillon 1996a; b; Wills 1993).

In their audit of biodiversity of the Swan Coastal Plain (SWA2) IBRA subregion, Mitchell *et al.* (2003) identified that, in general, plant communities with susceptible plant species can be considered ecosystems at risk and that there is little quantitative data on the effect of the

pathogen. Six of the ten threatened ecological communities occurring within the Gnangara Sustainability Strategy study area (

Figure 1) are thus identified as being at risk of infestation by *P. cinnamomi* because of the presence of susceptible plant species (Mitchell *et al.* 2003). At least three communities are known to have occurrences infested with *P. cinnamomi*, including the *Banksia attenuata* woodland over species rich dense shrublands (community type 20a as described by Gibson *et al.* 1994), Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain) and *Callitris preissii* forests and woodlands, Swan Coastal Plain (community type 30a as described by Gibson *et al.* 1994) (DEC 2008; Shearer *et al.* 2007).

The objectives of this project were:

- to review the responses of native vascular plant species in the GSS study area to the pathogen
- to identify threatened ecological communities at risk from *P. cinnamomi*
- to determine the likely impacts upon threatened ecological communities that are comprised of *P. cinnamomi*-susceptible plant taxa.

Additional and revised information on species responses to the pathogen has been made available since the GSS Biodiversity Values and Threatening Processes of the Gnangara Groundwater System report (Wilson *et al.* 2009), therefore here we report updated susceptibility assessments for flora and threatened ecological communities found in the GSS study area (hereafter also referred to as 'GSS plant taxa' and 'GSS threatened ecological communities').

Methods

At least 1 372 native vascular plant taxa are known to occur in the GSS study area. A species list for the study area was compiled from specimen records obtained from the Western Australian Herbarium (Western Australian Herbarium 2008) and floristic quadrat surveys carried out for the DEC-GSS Biodiversity Project (Mickle and Swinburn in prep; Swinburn and Hoskins in prep.).

Information on the responses of GSS plant taxa to *P. cinnamomi* was collated during a review of available literature (Appendix 1: List of *P. cinnamomi* references), based on the list of Australian plant responses in Appendix 4 of O'Gara *et al.* (2005). Susceptibility ratings ranged from 'field resistant' to 'highly susceptible'. Field resistant taxa were those that appeared to be unaffected by *P. cinnamomi* in the wild when present and for which deaths in the field could rarely be associated with infection of *P. cinnamomi*. Highly susceptible species were those that were frequently and consistently killed in the wild following infection by *P. cinnamomi*, and/or, appeared to decline or to be rare on infested sites (O'Gara *et al.* 2005). Susceptibility ratings also included species not known to be directly affected by *P. cinnamomi* but rarely found on affected sites (and may be affected either directly through infection or indirectly through changes in habitat) and species which may be killed on some infested sites but appear unaffected on others (variable susceptibility). This may be attributable to genetic differences between populations or differences in site characteristics that influence plant responses. As variable responses occurred within and between populations and between publications, all ratings were pooled into broad "susceptible" or "resistant" ratings. As not all evidence for susceptibility or resistance can be considered equal, this assessment has at best identified the 'potential' response of GSS plant taxa to *P. cinnamomi.*

The flora taxa that occur in threatened ecological community occurrences within the GSS study area (
Figure 1) were identified from the Department of Environment and Conservation's threatened ecological communities database (DEC 2008) and interim recovery plans (CALM 2006; English and Blyth 2000; English *et al.* 2002; Luu and English 2005; Meissner and English 2005). Species that were 'typical' or 'common' (i.e. occur in >75% or 50-75% of floristic plots in that community, respectively) to each threatened ecological community and help define the floristic community were identified (English and Blyth 2000; Gibson *et al.* 1994; Meissner and English 2005). The susceptibility of taxa was then assigned based on information from the review.

A 'threat potential' rating was assigned to each of the communities based on the proportion of species susceptible within the community, the proportions that are typical, common or define the community type and the number or proportion of overstorey species that are known to be susceptible. Removal of overstorey species can affect the community by altering the structure and thus habitat for understorey plant species.

Threat potential ratings are as follows (Table 3):

- Low – few or no susceptible species
- Moderate – between 20% and 30% of species are susceptible but few are typical or define the community, or there are few overstorey species
- High – more than 30% of species are susceptible or a large proportion of susceptible species are typical or define the community, or belong to the overstorey.

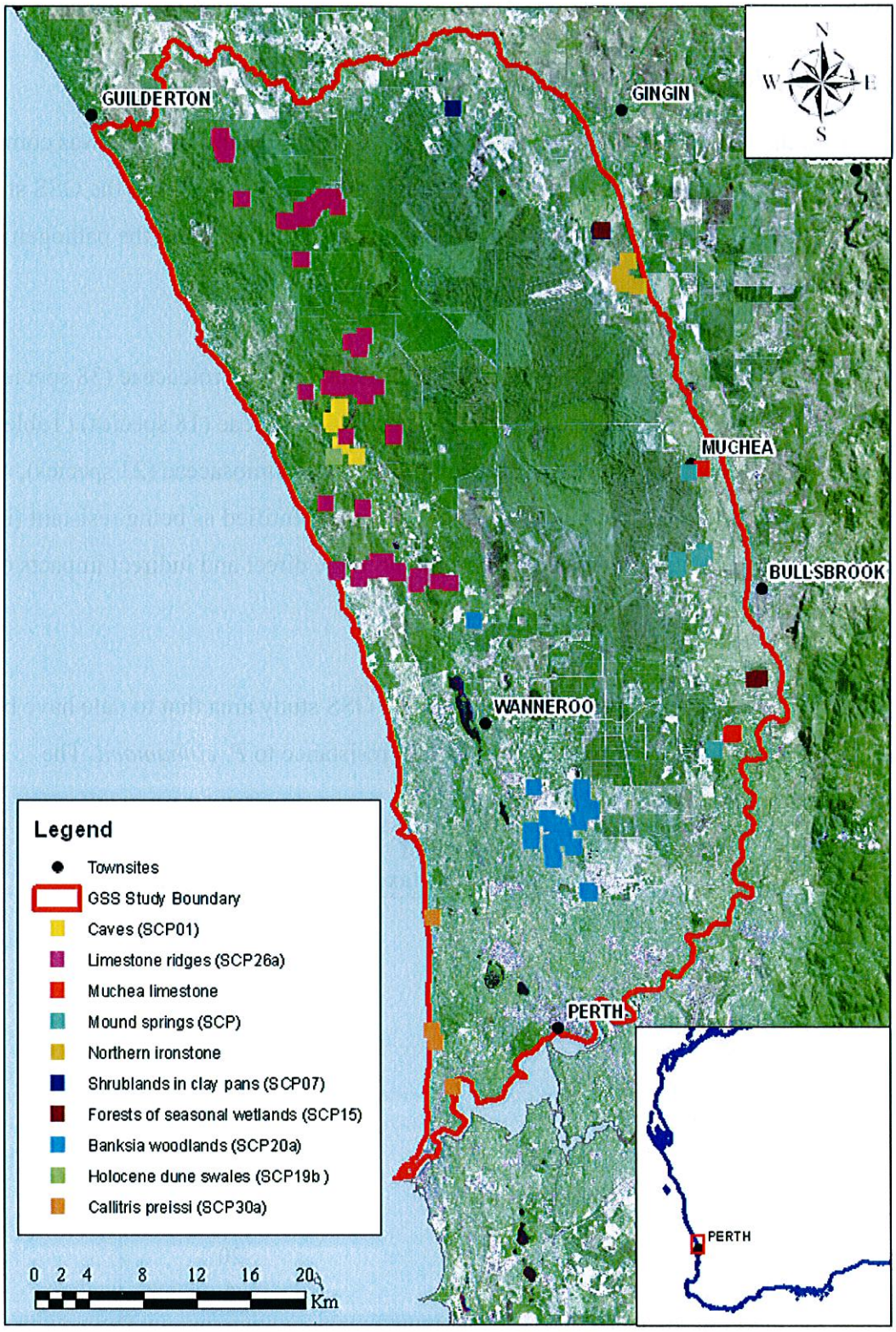

Figure 1: Location of threatened ecological communities in the Gnangara Sustainability Strategy study area. SCP = Swan Coastal Plain.

Results

Susceptible plant species in the GSS study area

Information on the responses to *P. cinnamomi* of 356 native vascular plant taxa was compiled and represents approximately 26% of the 1 372 known native plant taxa from the GSS study area. Of these 356 plant taxa, 45% display some degree of susceptibility to the pathogen or to the indirect effects it has on plant communities (Appendix 2).

The predominant families identified with susceptible taxa were the Proteaceae (38 species), Myrtaceae (20 species), Epacridaceae (19 species) and Papilionaceae (18 species) (Table 1). Taxa from 39 families, namely the Orchidaceae (23 species), Mimosaceae (23 species), Myrtaceae (21 species) and Cyperaceae (20 species), were identified as being resistant (i.e. available evidence suggests these species are resistant to the direct and indirect impacts of *P. cinnamomi*.).

Table 1: Families and the number of taxa found in the GSS study area that to date have been identified as having either a level of susceptibility or resistance to *P. cinnamomi*. The predominant susceptible families are highlighted.

Family	Number of susceptible taxa	Number of resistant taxa
Amaranthaceae	-	1
Anthericaceae	4	4
Apiaceae	2	3
Asteraceae	2	11
Brassicaceae	-	2
Casuarinaceae	5	-
Centrolepidaceae	-	1
Chenopodiaceae	-	1
Colchicaceae	-	2
Cupressaceae	1	-
Cyperaceae	1	20
Dasypogonaceae	5	4
Dennstaedtiaceae	1	-
Dilleniaceae	5	2
Droseraceae	2	3
Epacridaceae	19	1
Euphorbiaceae	1	2
Geraniaceae	1	-
Goodeniaceae	2	2

Family	Number of susceptible taxa	Number of resistant taxa
Haemodoraceae	4	11
Hydatellaceae	-	1
Iridaceae	1	1
Lamiaceae	-	1
Lauraceae	-	2
Lentibulariaceae	-	1
Lobeliaceae	-	2
Loranthaceae	-	1
Meliaceae	-	1
Mimosaceae	4	23
Myoporaceae	-	1
Myrtaceae	20	21
Olacaceae	1	-
Orchidaceae	-	23
Papilionaceae	18	7
Phormiaceae	1	-
Pittosporaceae	-	3
Poaceae	3	9
Polygalaceae	1	2
Proteaceae	38	9
Ranunculaceae	1	-
Restionaceae	2	5
Rhamnaceae	2	-
Rubiaceae	1	-
Rutaceae	-	1
Sapindaceae	-	1
Stackhousiaceae	-	1
Sterculiaceae	2	1
Stylidiaceae	4	8
Thymelaeaceae	2	-
Tremandraceae	2	-
Violaceae	1	-
Xanthorrhoeaceae	1	-
Zamiaceae	1	-
TOTAL	**161**	**195**

Risk potential of threatened ecological communities in the GSS study area

Nine threatened ecological communities were identified as having species susceptible to *P. cinnamomi,* ranging from one to 46 species (Table 2). While the number of taxa susceptible to *P. cinnamomi* in each threatened ecological community was low in most cases, the proportion of susceptible taxa was as high as 42% (Table 3).

Table 2: Flora species susceptible to *P. cinnamomi* in nine threatened ecological communities in the GSS study area. * Indicates species that are typical (occurs in >75% plots in that community) or common (occurs in 50-75% of plots in that community) to the threatened ecological community and help define the floristic community (CALM 2006; Gibson *et al.* 1994; Meissner and English 2005).

Threatened Ecological Community	Family	Species
Shrublands and woodlands on Muchea Limestone	Iridaceae	*Patersonia occidentalis*
	Papilionaceae	*Jacksonia furcellata*
		Kennedia prostrata
	Proteaceae	*Banksia attenuata*
		Banksia littoralis
		Hakea prostrata
		Hakea varia
	Xanthorrhoeaceae	*Xanthorrhoea preissii*
Banksia attenuata woodland over species rich dense shrublands (community type 20a; Gibson *et al.*1994)	Casuarinaceae	*Allocasuarina fraseriana**
		Allocasuarina humilis
	Dasypogonaceae	*Dasypogon bromeliifolius*
	Dilleniaceae	*Hibbertia huegelii**
		*Hibbertia hypericoides**
		Hibbertia subvaginata
	Epacridaceae	*Conostephium pendulum**
		Leucopogon conostephioides
		Leucopogon polymorphus
		Lysinema ciliatum
		Lysinema elegans
		Styphelia tenuiflora
	Goodeniaceae	*Dampiera linearis**
	Haemodoraceae	*Anigozanthos humilis*
		Anigozanthos manglesii
	Iridaceae	*Patersonia occidentalis**
	Mimosaceae	*Acacia pulchella*
	Myrtaceae	*Calytrix flavescens*

Threatened Ecological Community	Family	Species
		Calytrix fraseri
		*Eremaea pauciflora**
		Eucalyptus marginata
		Eucalyptus todtiana
		Hypocalymma angustifolium
		Hypocalymma robustum
		Scholtzia involucrata
		Verticordia nitens
	Papilionaceae	*Bossiaea eriocarpa**
		*Jacksonia floribunda**
		Jacksonia furcellata
		Jacksonia sericea
		Jacksonia sternbergiana
	Proteaceae	*Banksia attenuata**
		Banksia dallanneyi
		Banksia ilicifolia
		Banksia menziesii
		Conospermum stoechadis
		Hakea prostrata
		Hakea ruscifolia
		Persoonia saccata
		*Petrophile linearis**
		*Stirlingia latifolia**
	Restionaceae	*Desmocladus fasciculatus**
		Loxocarya cinerea
	Rubiaceae	*Opercularia vaginata*
	Xanthorrhoeaceae	*Xanthorrhoea preissii*
	Zamiaceae	*Macrozamia riedlei*
Woodlands over sedgelands in Holocene dune swales of the southern SCP (community type 19b; Gibson *et al.* 1994)	Proteaceae	*Banksia grandis*
		Banksia littoralis
	Xanthorrhoeaceae	*Xanthorrhoea preissii**
Callitris preissii forests and woodlands, Swan Coastal Plain (community type 30a; Gibson *et al.* 1994)	Epacridaceae	*Leucopogon australis*
		Leucopogon parviflorus
	Geraniaceae	*Pelargonium littorale*
	Phormiaceae	*Dianella revoluta*
	Poaceae	*Austrostipa flavescens**
	Proteaceae	*Banksia sessilis*
Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain)	Dennstaedtiaceae	*Pteridium esculentum**
	Droseraceae	*Drosera macrantha*
	Myrtaceae	*Eucalyptus todtiana*
	Proteaceae	*Banksia ilicifolia*
		*Banksia littoralis**
	Xanthorrhoeaceae	*Xanthorrhoea preissii*

High risk

Banksia attenuata woodland over species rich dense shrublands (community type 20a) is considered at high risk from *P. cinnamomi.* A high number of susceptible species (n=46) have been identified, representing 54% of the taxa for which responses were available. These species include overstorey taxa such as *Allocasuarina fraseriana, Eucalyptus marginata, E. todtiana, Banksia ilicifolia, B. attenuata* and *B. menziesii.* Other species contributing to habitat structure (e.g. *X. preissii*) are also susceptible. This threatened ecological community is thus at risk as a result of the direct impacts on structural characteristics, particularly loss of overstorey species, and on the composition of the species-rich understorey which defines this community. In addition, understorey species not affected directly by the pathogen are likely to be impacted indirectly as a result of loss of the overstorey and subsequent changes to the growing conditions in the community.

Of the 20 known occurrences of this community in the GSS study area, one is currently highly impacted by *P. cinnamomi*, another is known to be infested however impact is still minimal and the adjacent bushland of a third occurrence is known to be infested by *P. cinnamomi* (DEC 2008). While the dieback status of seven occurrences has not yet been assessed, the remaining ten occurrences are threatened by dieback infestation due to uncontrolled access.

Forty two per cent of plant species (n=8) of the Shrublands and woodlands on Muchea limestone community were found to be susceptible to *P. cinnamomi*, including two overstorey species (*B. attenuata* and *B. littoralis*). *Phytophthora* dieback has not been recorded in this community, however, it may be present but as yet undetected (English and Blyth 2000). *P. cinnamomi* is not commonly isolated from limestone soils (C. Dunne pers. comm.) and therefore may not be as much of a threat to this community as Table 3 suggests.

Moderate risk

Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain (community type 19b) had the lowest number of known species (n=11) out of the floristic communities. It is represented by only one occurrence in the GSS study area, accounting for this low number of species associated with this community. The assessment identified one common species (X. *preissii*) and a further two tree species (*B. grandis* and *B. littoralis*) as

being susceptible. These three species alone account for the 27% of plant taxa found to be susceptible to *P. cinnamomi* in this community and thus its moderate risk rating.

With 6 susceptible species, *Callitris preissii* forests and woodlands, Swan Coastal Plain (community type 30a) was recorded with only one susceptible species that defines the community, a grass species (*Austrostipa flavescens*) common in the community.

A previous assessment of the species that inhabit the Communities of Tumulus Springs (organic mound springs, Swan Coastal Plain) community found that the species were predominantly tolerant to *P. cinnamomi* (CALM 2006). The current assessment identified 21% of species as susceptible including: two species that define the community (*B. ilicifolia* and *Pteridium esculentum*); and overstorey species such as *B. littoralis* and *E. todtiana*. Other species contributing to habitat structure (e.g. *X. preissii*) are also susceptible.

Melaleuca huegelii – Melaleuca systena shrublands of limestone ridges (community type 26a) consists of 21% of species that are potentially susceptible to *P. cinnamomi* including five species that define the community, including *Leucopogon parviflorus*, *Austrostipa flavescens, B. nivea B. sessilis* and *Opercularia vaginata*. There is currently no evidence of *P. cinnamomi* disease in these communities which occur on shallow soils over limestone (V. English pers. comm.). Like the Shrubland and woodlands on Muchea limestone community, *P. cinnamomi* may not be as much of a threat to community 26a as Table 3 suggests, owing to *P. cinnamomi* rarely being isolated from limestone environments (C. Dunne pers. comm.).

Low risk

Communities considered to be at low risk of *P. cinnamomi* impacts include the following communities as they contained few, if any, susceptible species: Herb rich saline shrublands in clay pans (community type 7), Perth to Gingin Ironstone Association (Northern Ironstones), Forests and woodlands of deep seasonal wetlands of Swan Coastal Plain (community type 15) and Aquatic Root Mat Community of Caves of Swan Coastal Plain (Yanchep Caves).

Discussion

Forty five per cent of native flora found in the GSS study area has shown some degree of susceptibility to *P. cinnamomi*, compared to 54% of plants in the south-west botanical province as found by Shearer *et al.* (2004). When only the flora for which responses are available are considered, the flora of the *Banksia attenuata* woodland over species rich dense shrublands (community type 20a) reach 54% susceptibility making it the most at-risk community in the GSS study area.

It is still largely unknown how the GSS plant taxa respond to *P. cinnamomi* within the GSS study area compared to other populations within the species' distributions. Responses have been found for only 26% of the GSS plant taxa with few results from the Swan Coastal Plain, indicating that more work is required within this region. A concurrent study of the DEC-GSS Biodiversity Project is addressing this paucity of response data on the Swan Coastal Plain (Swinburn *et al.* in prep.), by looking at responses of flora to *P. cinnamomi* in the *Banksia* woodland.

There are a number of limitations inherent in the assessment presented in this report. For example, some information on susceptibility or resistance is based on one source in the literature and may only relate to a species' response at a single site. As the responses of plants to dieback used in this assessment were often from areas outside the GSS study area, and therefore could have varied due to differences in topography, site characteristics and plant population genetics, the responses are at best 'potential' responses of the GSS plant taxa to the pathogen. Any conclusions drawn from the available summary data (Appendices 2 & 3) should therefore take into account the biased nature of these interpretations. Another limitation of the assessment is that it can be difficult to determine whether a species is affected directly through infection or indirectly through changes in habitat (O'Gara *et al.* 2005).

Other concerns in this assessment include the arbitrary limits that have been employed to categorise threatened ecological communities into potential risk categories, when it may be more relevant to assess the relative cover provided by susceptible species than the proportion of susceptible species in the community. It is also not known what proportion of species removal is likely to irreversibly modify a threatened community and thus render it destroyed.

This can occur decades after the initial infestation, as a result of indirect impacts following removal of the overstorey and other dominant cover and structural features (Shearer and Dillon 1995).

Generally wetland communities may be at higher risk of infestation due to movement of the pathogen in the water profile and many wetland systems are already inferred to be infested by *P. cinnamomi* (M. Pez, pers. comm.). Permanently and seasonally inundated wetland communities in the GSS study area include Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain (community type 19b), Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain), Herb rich saline shrublands in clay pans (community type 7), Perth to Gingin Ironstone Association (Northern Ironstones) and Forests and woodlands of deep seasonal wetlands of Swan Coastal Plain (community type 15).

Although Shrublands and woodlands on Muchea limestone and *Melaleuca huegelii – Melaleuca systena* shrublands of limestone ridges (community type 26a) contain *P. cinnamomi*-susceptible species, the pathogen is not considered to be a large threat to limestone communities. *P. cinnamomi* is not commonly isolated from limestone soils (C. Dunne, pers. comm.) suggesting that these soils are not conducive to the pathogen and this has been attributed to the inhibition of *P. cinnamomi* within alkaline soils (Benson 1984; Ko and Shiroma 1989; Shearer and Dillon 1996a). However the newly described species, *Phytophthora multivora*, which has been associated with high impact disease, has been isolated from such limestone environments and is known to have a host range of at least seven plant families (C. Dunne pers. comm.; Scott *et al.* 2009). As many as 20 species of *Phytophthora* have been isolated from south-west Western Australia including nine potentially new and undescribed species, of which it is unknown if they are endemic or introduced (Burgess *et al.* 2009; Scott *et al.* 2009). Scott *et al.* (2009) and Burgess *et al.* (2009) highlighted the potential importance that the newly described *P. multivora* and other emerging species of *Phytophthora* may play in natural ecosystems. The management of threatened ecological communities, floral species diversity and other biodiversity values in south-west Western Australia and in the GSS study area may also need to take into account other known and emerging *Phytophthora* species.

Conclusion

The assessment presented in this report is a preliminary assessment of the risk potential of threatened ecological communities in the GSS study area being impacted by *P. cinnamomi.* The number and thus proportions of plant species susceptible to *P. cinnamomi* are likely to change as more flora data from these communities are collected and as additional information on the responses of plant species to *P. cinnamomi* becomes available.

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Appendix 2: GSS plant taxa potentially susceptible to *Phytophthora cinnamomi*

Anthericaceae
Agrostocrinum scabrum
Chamaescilla corymbosa var. *corymbosa*
Thysanotus multiflorus
Thysanotus thyrsoideus
Apiaceae
Platysace compressa
Platysace ramosissima
Asteraceae
Olearia axillaris
Trichocline spathulata
Casuarinaceae
Allocasuarina fraseriana
Allocasuarina huegeliana
Allocasuarina humilis
Allocasuarina microstachya
Casuarina obesa
Cupressaceae
Actinostrobus pyramidalis
Cyperaceae
Mesomelaena graciliceps
Dasypogonaceae
Calectasia sp. Pinjar (C. Tauss 557)
Dasypogon bromeliifolius
Lomandra caespitosa
Lomandra odora
Lomandra sonderi
Dennstaedtiaceae
Pteridium esculentum
Dilleniaceae
Hibbertia amplexicaulis
Hibbertia helianthemoides
Hibbertia huegelii
Hibbertia hypericoides
Hibbertia subvaginata
Droseraceae
Drosera macrantha
Drosera stolonifera
Epacridaceae
Acrotriche cordata
Andersonia heterophylla
Andersonia lehmanniana
Astroloma ciliatum
Astroloma microcalyx
Astroloma xerophyllum
Conostephium minus
Conostephium pendulum
Leucopogon australis
Leucopogon conostephioides
Leucopogon oxycedrus
Leucopogon parviflorus
Leucopogon polymorphus
Leucopogon propinquus
Leucopogon pulchellus
Leucopogon verticillatus
Lysinema ciliatum
Lysinema elegans
Styphelia tenuiflora
Euphorbiaceae
Monotaxis occidentalis
Geraniaceae
Pelargonium littorale
Goodeniaceae
Dampiera alata
Dampiera linearis
Haemodoraceae
Anigozanthos humilis
Anigozanthos manglesii
Anigozanthos manglesii subsp. *manglesii*
Anigozanthos viridis
Iridaceae
Patersonia occidentalis
Mimosaceae
Acacia huegelii
Acacia myrtifolia
Acacia pulchella
Acacia stenoptera
Myrtaceae
Beaufortia elegans
Calytrix flavescens
Calytrix fraseri
Eremaea beaufortioides
Eremaea pauciflora
Eucalyptus decipiens
Eucalyptus marginata
Eucalyptus todtiana
Hypocalymma angustifolium
Hypocalymma robustum
Kunzea ericifolia
Melaleuca thymoides
Pericalymma ellipticum
Regelia inops
Scholtzia involucrata
Verticordia densiflora
Verticordia huegelii
Verticordia lindleyi subsp. *lindleyi*
Verticordia nitens
Verticordia serrata var. *linearis*
Olacaceae
Olax benthamiana
Papilionaceae
Bossiaea eriocarpa
Bossiaea ornata
Daviesia decurrens
Daviesia incrassata
Daviesia physodes
Gastrolobium spinosum
Gompholobium confertum
Gompholobium knightianum
Hovea pungens
Jacksonia floribunda
Jacksonia furcellata
Jacksonia sericea
Jacksonia sternbergiana
Kennedia coccinea
Kennedia prostrata
Pultenaea reticulata
Sphaerolobium medium
Viminaria juncea
Phormiaceae
Dianella revoluta
Poaceae
Amphipogon amphipogonoides
Austrostipa flavescens
Tetrarrhena laevis
Polygalaceae
Comesperma virgatum
Proteaceae
Adenanthos barbiger
Adenanthos cygnorum
Adenanthos cygnorum subsp. *chamaephyton*
Adenanthos obovatus
Banksia armata
Banksia armata var. *armata*
Banksia attenuata
Banksia bipinnatifida
Banksia dallanneyi
Banksia grandis

Banksia ilicifolia
Banksia littoralis
Banksia menziesii
Banksia nivea
Banksia prionotes
Banksia sessilis
Banksia telmatiaea
Conospermum stoechadis
Conospermum triplinervium
Grevillea curviloba
Hakea laurina
Hakea lissocarpha
Hakea myrtoides
Hakea prostrata
Hakea ruscifolia
Hakea trifurcata
Hakea undulata
Hakea varia
Isopogon drummondii
Lambertia multiflora var. *multiflora*
Persoonia saccata
Petrophile biloba
Petrophile linearis
Petrophile seminuda
Petrophile serruriae
Petrophile striata
Stirlingia latifolia
Xylomelum occidentale

Ranunculaceae

Clematis pubescens

Restionaceae

Desmocladus fasciculatus
Loxocarya cinerea

Rhamnaceae

Trymalium ledifolium
Trymalium ledifolium var. *ledifolium*

Rubiaceae

Opercularia vaginata

Sterculiaceae

Lasiopetalum glabratum
Thomasia grandiflora

Stylidiaceae

Stylidium amoenum
Stylidium bulbiferum
Stylidium junceum
Stylidium schoenoides

Thymelaeaceae

Pimelea spectabilis
Pimelea suaveolens

Tremandraceae

Tetratheca hirsuta
Tetratheca pilifera

Violaceae

Hybanthus floribundus

Xanthorrhoeaceae

Xanthorrhoea preissii

Zamiaceae

Macrozamia riedlei

Appendix 3: GSS plant taxa resistant to *Phytophthora cinnamomi*

Amaranthaceae
Ptilotus manglesii
Anthericaceae
Chamaescilla corymbosa
Laxmannia squarrosa
Thysanotus tenellus
Tricoryne elatior
Apiaceae
Actinotus glomeratus
Trachymene pilosa
Xanthosia huegelii
Asteraceae
Brachyscome iberidifolia
Helichrysum macranthum
Hyalosperma cotula
Lagenophora huegelii
Millotia tenuifolia
Olearia paucidentata
Podolepis gracilis
Podotheca angustifolia
Pterochaeta paniculata
Rhodanthe pyrethrum
Waitzia nitida
Brassicaceae
Lepidium pseudohyssopifolium
Lepidium pseudotasmanicum
Centrolepidaceae
Centrolepis aristata
Chenopodiaceae
Threlkeldia diffusa
Colchicaceae
Burchardia congesta
Burchardia multiflora
Cyperaceae
Caustis dioica
Cyathochaeta avenacea
Cyathochaeta teretifolia
Eleocharis keigheryi
Gahnia trifida
Lepidosperma effusum
Lepidosperma gladiatum
Lepidosperma longitudinale
Lepidosperma scabrum
Lepidosperma squamatum
Lepidosperma tenue
Mesomelaena tetragona
Schoenus curvifolius
Schoenus efoliatus
Schoenus grandiflorus
Schoenus natans
Schoenus pedicellatus
Schoenus rigens
Tetraria capillaris
Tetraria octandra
Dasypogonaceae
Lomandra hermaphrodita
Lomandra integra
Lomandra nigricans
Lomandra preissii
Dilleniaceae
Hibbertia racemosa
Hibbertia vaginata
Droseraceae
Drosera erythrorhiza
Drosera pallida
Drosera platystigma
Epacridaceae
Astroloma pallidum
Euphorbiaceae
Phyllanthus calycinus
Stachystemon vermicularis
Goodeniaceae
Goodenia filiformis
Lechenaultia biloba
Haemodoraceae
Anigozanthos humilis subsp. Badgingarra
Conostylis aculeata
Conostylis pauciflora subsp. *euryrhipis*
Conostylis pauciflora subsp. *pauciflora*
Conostylis serrulata
Conostylis setigera
Conostylis setosa
Haemodorum laxum
Haemodorum paniculatum
Macropidia fuliginosa
Phlebocarya ciliata
Hydatellaceae
Trithuria occidentalis
Iridaceae
Orthrosanthus laxus
Lamiaceae
Hemiandra pungens
Lauraceae
Cassytha flava
Cassytha glabella
Lentibulariaceae
Utricularia multifida
Lobeliaceae
Isotoma hypocrateriformis
Lobelia rhytidosperma
Loranthaceae
Nuytsia floribunda
Meliaceae
Melia azedarach
Mimosaceae
Acacia acuminata
Acacia alata
Acacia anomala
Acacia applanata
Acacia barbinervis
Acacia barbinervis subsp. *borealis*
Acacia benthamii
Acacia celastrifolia
Acacia cochlearis
Acacia cyclops
Acacia drummondii
Acacia drummondii subsp. *drummondii*
Acacia horridula
Acacia incurva
Acacia lasiocarpa
Acacia microbotrya
Acacia nervosa
Acacia pulchella var. *pulchella*
Acacia rostellifera
Acacia saligna
Acacia truncata
Acacia willdenowiana
Paraserianthes lophantha
Myoporaceae
Myoporum insulare
Myrtaceae
Agonis flexuosa
Baeckea camphorosmae
Calothamnus quadrifidus
Calothamnus sanguineus
Calytrix leschenaultii
Corymbia calophylla
Darwinia citriodora
Eucalyptus argutifolia

Eucalyptus decurva
Eucalyptus gomphocephala
Eucalyptus patens
Eucalyptus rudis
Homalospermum firmum
Kunzea recurva
Leptospermum erubescens
Melaleuca lanceolata
Melaleuca preissiana
Melaleuca seriata
Melaleuca viminea
Pericalymma crassipes
Verticordia pennigera

Orchidaceae

Caladenia flava
Caladenia huegelii
Caladenia latifolia
Cyrtostylis huegelii
Diuris longifolia
Drakaea elastica
Elythranthera brunonis
Elythranthera emarginata
Epiblema grandiflorum var. *cyaneum*
Eriochilus dilatatus
Leporella fimbriata
Paracaleana nigrita
Prasophyllum elatum
Prasophyllum fimbria
Prasophyllum hians
Prasophyllum odoratissimum
Prasophyllum parvifolium
Pterostylis barbata
Pterostylis pyramidalis
Pterostylis vittata
Pyrorchis nigricans
Thelymitra antennifera
Thelymitra crinita

Papilionaceae

Daviesia longifolia
Gastrolobium calycinum
Gompholobium marginatum
Gompholobium polymorphum
Gompholobium tomentosum
Hardenbergia comptoniana
Hovea trisperma

Pittosporaceae

Billardiera fraseri
Billardiera variifolia
Marianthus paralius

Poaceae

Amphipogon laguroides
Amphipogon turbinatus
Austrostipa campylachne
Austrostipa compressa
Microlaena stipoides
Neurachne alopecuroidea
Poa drummondiana
Poa poiformis
Poa porphyroclados

Polygalaceae

Comesperma calymega
Comesperma confertum

Proteaceae

Grevillea curviloba subsp. *curviloba*
Grevillea curviloba subsp. *incurva*
Grevillea evanescens
Grevillea manglesii subsp. *ornithopoda*
Grevillea pilulifera
Grevillea synapheae
Grevillea thelemanniana
Hakea stenocarpa
Petrophile rigida

Restionaceae

Desmocladus flexuosus
Hypolaena fastigiata
Lyginia barbata
Lyginia imberbis
Meeboldina scariosa

Rutaceae

Philotheca spicata

Sapindaceae

Dodonaea hackettiana

Stackhousiaceae

Tripterococcus brunonis

Sterculiaceae

Lasiopetalum membranaceum

Stylidiaceae

Levenhookia pusilla
Levenhookia stipitata
Stylidium brunonianum
Stylidium calcaratum
Stylidium hispidum
Stylidium longitubum
Stylidium maritimum
Stylidium repens