Gnangara Sustainability Strategy

An across-government initiative

Groundwater – Biodiversity – Land use

PHYTOPHTHORA DIEBACK RISK ASSESSMENT OF GNANGARA MOUND BIODIVERSITY ASSETS.

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Department of Environment and Conservation

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GOVERNMENT OF WESTERN AUSTRALIA

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Phytophthora Dieback Risk Assessment of Gnangara Mound Biodiversity Assets.

Report to the Department of Environment and Conservation and Gnangara Sustainbility Strategy

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Introduction

Phytophthora dieback

Phytophthora cinnamomi is a soil-borne water mould (Class Oomycetes) that is listed as one of the world's 100 most devastating invading species by the IUCN Species Survival Commission. Originally from the south-east Asian tropics, *P. cinnamomi* is an aggressive pathogen of numerous plant species around the world (Cahill *et al.* 2008). The plant pathogen has been shown to alter plant species abundance and richness, as well as the structure of vegetation in sclerophyllous vegetation throughout Australia (McDougall *et al.* 2002; Podger and Brown 1989; Shearer *et al.* 2007; Weste 1974; Weste *et al.* 2002) and has been identified as a 'key threatening process' in the Australian environment (Environment Australia 2002; O'Gara *et al.* 2005). The threatening process is the lethal epidemic of '*Phytophthora* dieback' that occurs when there is a combination of plant species susceptibility, presence of the fungal pathogen and vulnerability due to favourable environments.

P. cinnamomi is widely distributed in *Banksia* woodlands of the Swan Coastal Plain (Podger 1968; Shearer 1994) and has been identified as a major threatening process for biodiversity assets on the GSS study area with the potential to have serious negative impacts on flora, fauna and ecosystems. Information on the distribution of the pathogen in GSS study area is limited due to lack of mapping. The most up-to-date spatial information available is from "Project Dieback" Interpretation Mapping (DEC 2008a; Strelein *et al.* 2008) which classified areas as infested, uninfested, unmappable (disturbances present that mask *P. cinnamomi* impact), uninterpretable (lack of susceptible vegetation) or not interpreted (< 50 hectares, or cleared). Areas were also assigned a confidence level dependent on factors such as disease expression and presence of vectors. From this data it is estimated that 10 % of the GSS study area is infested with *P. cinnamomi* with the majority of infested areas occurring on the Bassendean dune system with only minor areas on the Spearwood dune system and Pinjarra Plain (Kinloch 2009a).

Ecological Risk Assessment

Ecological Risk Assessment has been defined as "the process of estimating likelihoods and consequences of the effects of human actions or natural events on plants, animals and ecosystems of ecological value" (Walshe 2005; Barnthouse and Suter 1986). Walshe (2005) outlined the following steps in the continuous improvement cycle underpinning the Australian risk assessment standard (AS/NZ 4360; AS/NZS 2004):

1. establishing the context by identifying important ecological (biodiversity) values and defining the scope of the assessment;
2. identifying relevant hazards, threats or stressors;
3. analysing the risks by assessing the consequences and likelihood for each of the hazards;
4. evaluating the risks by comparing, ranking and prioritising them in terms of their seriousness with respect to the management objectives identified in the initial problem formulation.

The Australian Standard provides a risk analysis matrix which defines the risk of a hazard as the product of its consequence and likelihood (Table 1; Walshe 2005). To utilise this matrix the person(s) undertaking the risk assessment must assess the probability of the hazard being present (likelihood) and its likely impact on biodiversity values (consequence) and assign these assessments to an ordinal scale. Risk is then determined by multiplying the likelihood and consequence assessments. The Risk score is then assigned to one of three risk ranks (low, moderate or high risk, Table 1). Hart *et al.* (2005) recommends that an quantitative assessment of uncertainty and risk be undertaken when a qualitative assessment (using the AS/NZ 4360 standard) indicates a high risk, or where there is disagreement amongst experts on the importance of an hazard

Table 1: Semi-quantitative descriptors of consequence and likelihood used to rank risk. An ordinal scale of five levels is used to describe the likelihood and consequence of a hazard. Unshaded = low risk, light grey = moderate risk, dark grey = high risk. Taken from Australian Standard 4360 (AS/NZS 2004) and Walshe (2005).

Likelihood		Consequence				
		Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Catastrophic (5)
Almost certain	(5)	5	10	15	20	25
Likely	(4)	4	8	12	16	20
Moderately likely	(3)	3	6	9	12	15
Unlikely	(2)	2	4	6	8	10
Rare	(1)	1	2	3	4	5

Assessing the likelihood and consequence of an hazard can be difficult due to lack of knowledge and the inherent variability of natural systems and therefore variability in how they are affected by threats (Walshe 2005). Conceptual models can be used to document assumptions around cause and effect and preferably the models should be quantified so the uncertainty in the risk assessment can be clearly communicated (Hart *et al.* 2005).

The National Threat Abatement Plan for *Phytophthora* (NTAP) was developed with major objectives to promote the recovery of threatened species and ecological communities under threat, and to limit spread of the pathogen (CPSM 2006; Environment Australia 2001). Projects to address these objectives have developed processes and criteria to assess the risk to biodiversity (Wilson *et al.* 2005), and provide national best practice benchmarks for management (O'Gara *et al.* 2005). Key requirements for risk assessment and management of the disease are: accurate knowledge of where the disease occurs, which species and communities are threatened, and where risks and consequences of infestation are likely.

The aims of this project were to undertake a *Phytophthora* dieback risk assessment using available spatial information on the distribution and location of the pathogen and biodiversity assets across the Gnangara Mound. Two risk assessments were developed to evaluate whether a surrogate measure of biodiversity value (perimeter to area ratio of remnant vegetation patches) would be a suitable measure to give indication of the likely impact of *Phytophthora* dieback in regard to overall loss of biodiversity values.

Databases and Methods Used

The *Phytophthora* dieback Risk Assessment was undertaken using standard semi-quantitative descriptors of likelihood and consequence and the risk analysis matrix provided in the Australian Standard 4360 (Table 1; AS/NZS 2004). Two risk assessments were developed and evaluated:

1. Highest Weighted Rank Model Risk Assessment;
2. Perimeter Area Ratio of Remnant Patches Risk Assessment.

Each used different methods for identifying likely impact (consequence) of *Phytophthora* dieback in regard to overall loss of biodiversity values

Likelihood

Likelihood was defined as the likelihood that an area is currently infested with *Phytophthora* dieback. Usually risk assessments assess the likelihood of a hazard impacting on biodiversity assets into the future. Unfortunately no reliable spatial information relating to the future likelihood of *Phytophthora* infection currently exists for the whole of the Gnangara Mound. However, the Project Dieback Data (DEC 2008a; b) provides spatial information on the current likelihood of *Phytophthora* infection across the Gnangara study area (interpretation mapping; see Appendix A) and susceptibility assessments of Beards Vegetation Types (see Appendix B). Ratings of the likelihood of current infestation were developed from information from these two Project Dieback data sources and applied to Australian Standard 4360 (AS/NZ 2004) likelihood categories by an expert panel as outlined in Table 2. An ordinal scale of six levels was then applied to the likelihood assessments (as per Australian Standard 4360; AS/NZS 2004) and a spatial layer of likelihood was developed.

It is important in Risk Assessments to be explicit about the level of certainty on estimates of the likelihood of hazards (Walshe 2005). Therefore a rating of uncertainty was also estimated using information on the level of confidence of the Project Dieback Interpretation data (DEC 2008a; Appendix A) and the susceptibility of the Beards Vegetation type to dieback (DEC 2008b; Appendix B). These ratings were applied to uncertainty classes by an expert panel (Table 2). An ordinal scale of three levels was applied to the uncertainty assessments and a spatial layer of uncertainty was developed.

Table 2: The likelihood that an area is currently infested with *Phytophthora* dieback and the level of uncertainty of this assessment. Ordinal scale for the likelihood assessments are: almost certain = 5; likely = 4; moderately likely = 3; unlikely = 2; rare = 1 and unknown = 0. Ordinal scale for the uncertainty assessments are: high = 3; medium = 2 and low = 1.

Interpretation Mapping Category	**Beards vegetation types susceptible to dieback**		**Beards vegetation types resistant to dieback**		**Beards vegetation types with unknown susceptibility to dieback**	
	Likelihood Assessment	**Uncertainty Assessment**	**Likelihood Assessment**	**Uncertainty Assessment**	**Likelihood Assessment**	**Uncertainty Assessment**
High Confidence Infested	Almost Certain	Low	Almost Certain	Low	NA	
Moderate Confidence Infested	Likely	Low	Moderate Likely	Medium	NA	
Low Confidence Infested	Moderate Likely	Medium	Unlikely	High	NA	
Unmappable	Unknown	High	Unknown	High	NA	
Uninterpretable	Unknown	High	Unknown	High	Unlikely	High
Low Confidence Uninfested	Unlikely	High	Rare	Medium	Unlikely	High
Moderate Confidence Uninfested	Unlikely	Medium	Rare	Low	NA	
High Confidence Uninfested	Rare	Low	Rare	Low	NA	
Not Interpreted	Unknown	High	Unknown	High	Unlikely	High
(blank)	Unknown	High	Unknown	High	Unlikely	High

Consequence

Phytophthora dieback will more than likely destroy most susceptible vegetation communities but the consequence of the loss will vary depending on the biodiversity values (at the species, community or landscape level) that are sustained by these ecological communities. The likely impact (consequence) of *Phytophthora* dieback in regard to overall loss of biodiversity values was assessed by two different methods:

1. Using the rankings of biodiversity assets from the Highest Weighted Rank Model (hereafter referred to as 'HWRM'). See Appendix C for a map showing the spatial distribution of HWRM ranks across the GSS study area. In this model a multi-criteria ranking of biodiversity assets was undertaken using the Maximax evaluation method (see Kinloch 2009b for a full description of methods);

2. Using the Perimeter to Area Ratio of remnant vegetation patches (hereafter referred to as 'P-A ratio'). See Appendix D for a map showing the spatial distribution of P-A ratio classes across the GSS study area.

An expert panel applied the HWRM ranks and P-A ratio classes to the consequence categories and an ordinal scale of five levels was applied to the consequence categories (as per Australian Standard 4360; AS/NZS 2004; Table 3). It was determined that none of the HWRM ranks fitted into the 'moderate category'. A spatial layer of consequence was produced for each method.

Table 3: The likely impact (consequence) of *Phytophthora* dieback in regard to overall loss of biodiversity values using ranking of biodiversity assets from the HWRM and P-A ratio of remnant vegetation patches. Ordinal scale for the consequence assessments are: catastrophic = 5; major = 4; moderate = 3; minor = 2; insignificant = 1.

Consequence	**HWRM**	**P-A Ratio**
Insignificant	Rank 1 – low biodiversity values	2.000001 - 200.000000
Minor	Rank 2 Rank 3	0.100001 - 2.000000
Moderate		0.010001 - 0.100000
Major	Rank 4 Rank 5 Rank 6 Rank 7	0.002001 - 0.010000
Catastrophic	Rank 8 Rank 9 Rank 10 – high biodiversity values	0.000541 - 0.002000

Risk

The likelihood and two consequence spatial layers (HWRM and P-A Ratio) were converted to a 100 m grid using Spatial Analyst in ArcView 9.1. Risk was then calculated for each 100 m grid cell of remnant vegetation by multiplying the likelihood grid by the consequence grids using the Raster Calculator in Spatial Analyst. Risk scores ranged between 1 (low risk) to 25 (high risk) or were 0 (no dieback interpretation data available). The risk scores were put into three risk categories as per AS/NZ (2004). Summary statistics of the total area in each risk category were then calculated for both the HWRM and P-A Ratio risk analyses.

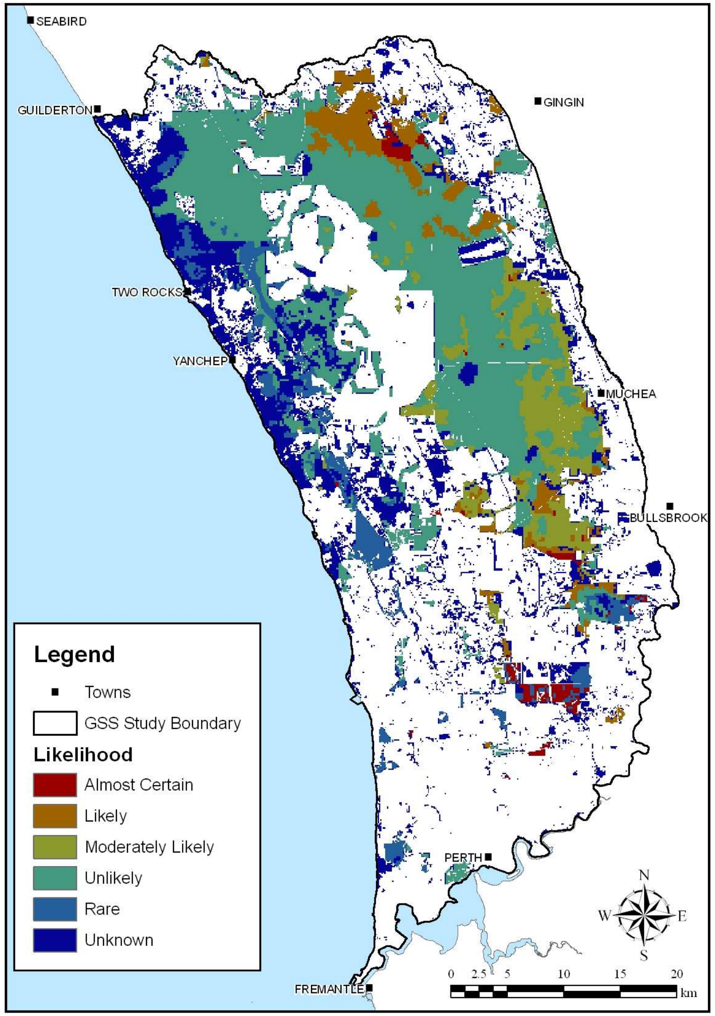
Results

The majority of areas where *Phytophthora* dieback is almost certain, likely or moderately likely to be currently present are in the Bassendean sands soil types (Figure 1a). No current mapping exists for a large proportion of the study area and these areas were classed as having ‘unknown’ likelihood (Figure 1a) and high uncertainty (Figure 1b). Uncertainty is low for only a small proportion of the Gnangara Mound where operational mapping has been undertaken (Figure 1b).

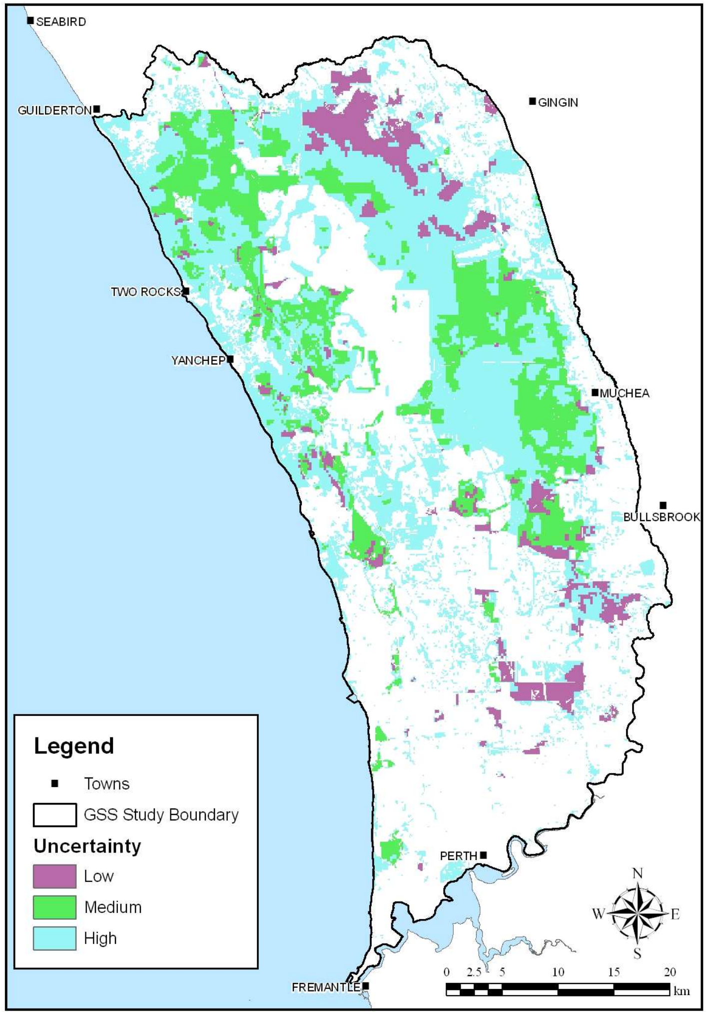
The Risk Assessments have revealed that a significant proportion (HWRM 19 % and P-A Ratio 15.5 %) of remnant vegetation across the Gnangara Mound is currently at High Risk of *Phytophthora* impact (Table 4 and Figure 2a & b). At the very least, it is moderately likely that *Phytophthora* dieback is currently in these areas (Figure 1a) which support significant biodiversity assets (Appendix C; Appendix D; Table 3). Uncertainty in the assessment of likelihood of *Phytophthora* impact is low or medium in these areas due to the availability of operational interpretation mapping (Figure 1b). The majority of remnant vegetation on the Gnangara Mound is categorised as Moderate Risk in both Risk Assessments (Table 4 and Figure 2a & b) but also high uncertainty in regard to the likelihood assessment (Figure 1b).

Table 4: Extent and proportion of land area in each of the *Phytophthora* dieback Risk Categories based on the assessment of biodiversity assets using the Highest Weighted Rank Model (HWRM) and Perimeter to Area Ratio of remnant vegetation patches (P-A Ratio).

Risk Category	**HWRM**		**P-A Ratio**	
	Total area (ha)	**Proportion (%)**	**Total area (ha)**	**Proportion (%)**
High Risk (score 15 – 25)	18351	18.8	15124	15.5
Moderate Risk (score 5 – 12)	50816	52.2	50653	52.0
Low Risk (score 1 – 4)	1942	2.0	5741	5.9
No Dieback Interpretation Data (score 0)	26299	27.0	25890	26.6
Total Area of Remnant Vegetation	97408	100.0	97408	100.0



a)



b)

Figure 1: (a) Likelihood that an area is currently infected with *Phytophthora* dieback and (b) the uncertainty in this assessment.

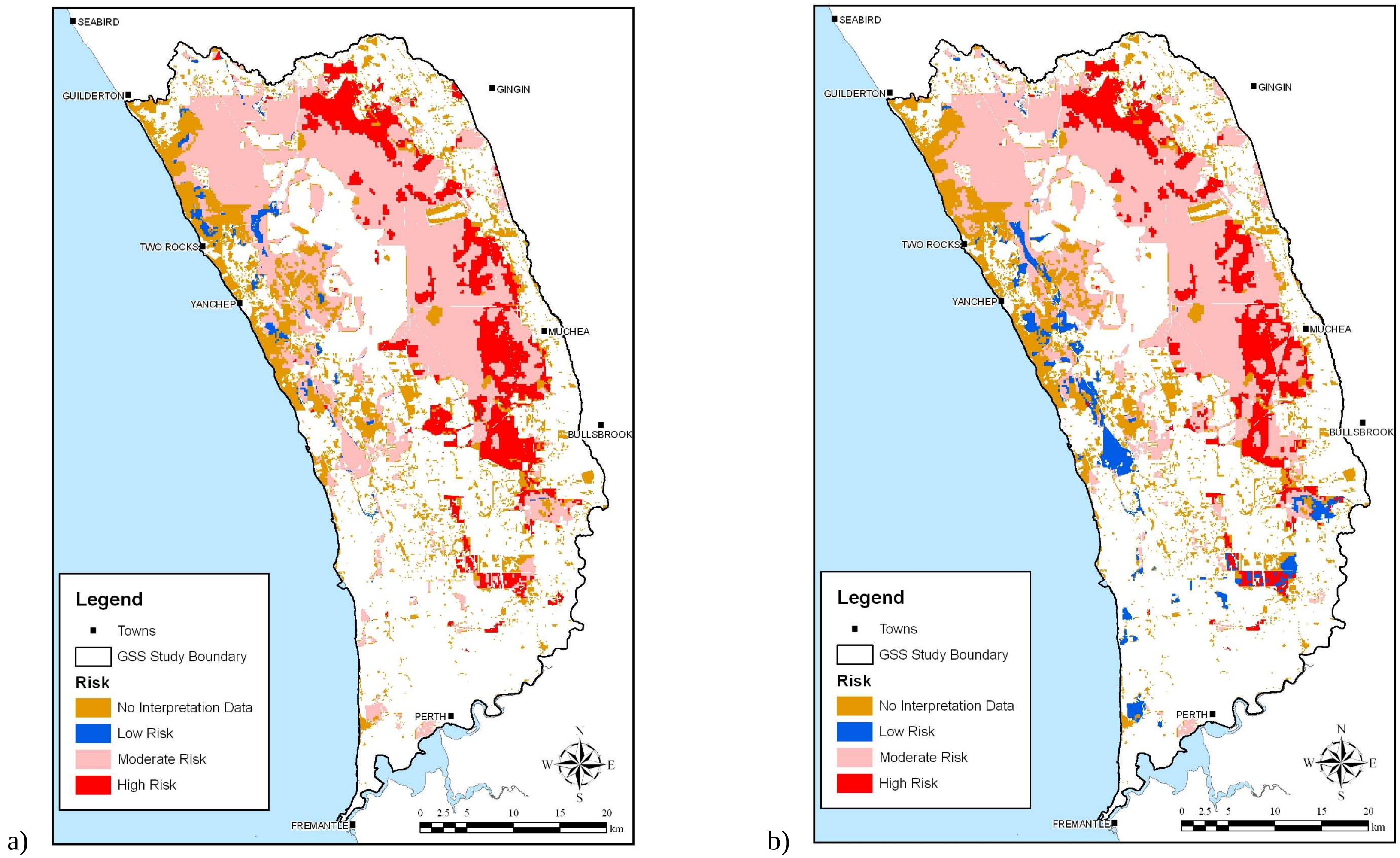


Figure 2: Current risk to biodiversity values of *Phytophthora* dieback across the Gnangara Mound using information on biodiversity assets from (a) Highest Weighted Rank Model and (b) Perimeter to Area Ratio of remnant vegetation patches.

Discussion

Comparison of the two Risk Assessments show that most areas assessed as being high or moderate risk in the HWRM Risk Assessment are also in the same risk category in the P-A Ratio Risk Assessment. In the P-A Ratio Risk Assessment the extent of areas categorised as high or moderate risk is slightly lower (Figure 2a and b, Table 4). This is not surprising as the greater number of biodiversity assets included in the consequence assessment in HWRM Risk Assessment will result in a greater differentiation of areas, in terms of the significance of their biodiversity assets, and therefore more areas being classed in the 'Major' or 'Catastrophic' Consequence categories. The impact of using a broader range of biodiversity assets to assess Consequence is also apparent in the low risk category. The inclusion of assets such as the occurrence of threatened flora and ecological communities and the level of representation of vegetation complexes has meant that fewer areas are categorised as low risk in the HWRM Risk Assessment. Therefore it appears that a more comprehensive estimate of risk will be achieved if a broad range of biodiversity assets are used to estimate Consequence. However, where this information is not available the Perimeter to Area Ratio of remnant vegetation patches could be used as a surrogate.

A more comprehensive risk assessment should be undertaken for those areas assessed as being High Risk in the HWRM Risk Assessment to gain a better understanding of the nature and magnitude posed by *Phytophthora* dieback in these areas (Figure 2a). Due to the urgency of the threat an immediate review of hygiene, quarantine measures and application of the systemic fungicide phosphate should also be undertaken especially for threatened or pristine communities.

The lack of operation interpretation mapping for large areas of the Gnangara Mound is a major limitation of this risk assessment (Appendix A). Of particular concern are the extensive areas of remnant vegetation assessed as being at Moderate Risk, in the HWRM Risk Assessment, which are located on susceptible vegetation communities on the Bassendean Sand Dune System (Figure 2a & Appendix B). These areas should be seen as a priority to be included in future mapping surveys. Not surprisingly the low risk areas are restricted to the Spearwood Dune System (Figure 2a) which is largely resistant to *Phytophthora* dieback (Figure 2a & Appendix B). Operational interpretation mapping has been undertaken in these areas and has revealed that *Phytophthora* dieback is absent (categorised as rare in Figure 2a). Therefore it is likely that more extensive mapping of the Spearwood Dune System would reveal additional low risk areas. However, the Spearwood Dune System is not the priority, in the first instance, for any future mapping surveys.

Although Standards Australia (AS/NZ 4360; AS/NZS 2004) describes risk as being a measure of consequences and likelihood, the term is used inconsistently in *P. cinnamomi* management, and often only describes the probability of an event such as pathogen transmission and/or impact. In this risk assessment we have only been able to assess the **current** likelihood that an area is infested with *Phytophthora* dieback. We have not been able to factor in the likelihood that an area will become infested in the future which is a severe limitation. For example in Whiteman Park, where operational interpretation mapping is available, areas of moderate risk lie alongside areas of high risk (Figure 2a). If the likelihood of an area being infested with *Phytophthora* dieback over a 30 year time period was assessed and the proximity to known infestations, roads and other linear infrastructure as well as the rate of autonomous spread were considered then it is possible that all of Whiteman Park would fall into the high risk category. This highlights the urgent requirement for a landscape predictive model for *Phytophthora* dieback for the GSS study area.

Overall this analysis has shown that it is feasible to undertake a relatively quick Risk Assessment of *Phytophthora* dieback using the framework outlined in Australian Standard 4360 (AS/NZS 2004) and readily available spatial data. This type of Risk Assessment will provide information to decision makers on the location of priority areas for *Phytophthora* dieback management, including operational interpretation mapping, hygiene measures, quarantine measures and phosphite application, and where more detailed risk assessments should be undertaken. This information on risk could also feed into a Cost Benefit Analysis for *Phytophthora* dieback to examine the most effective way to spend the limited funds available for management and rehabilitation.

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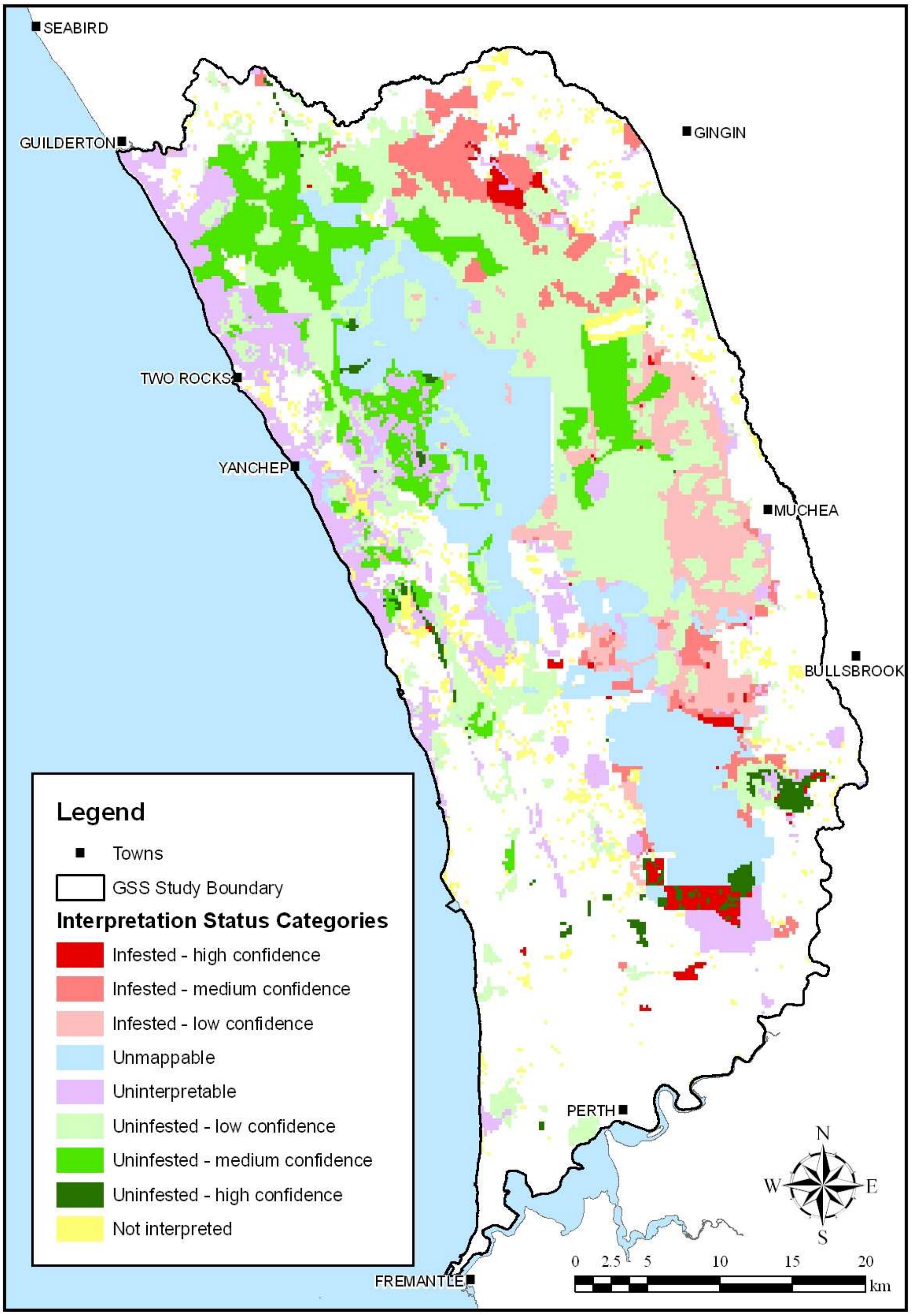
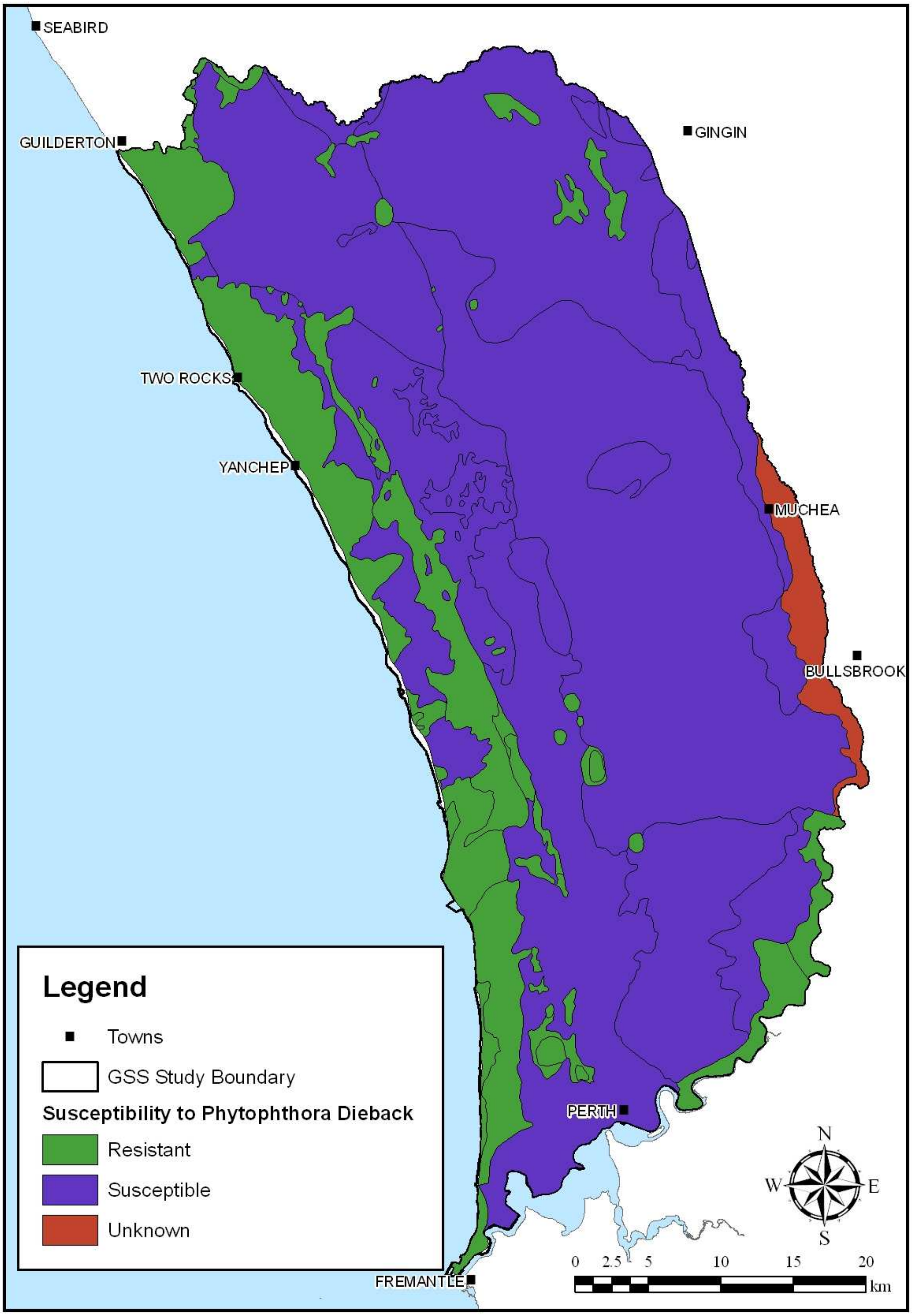
Appendices

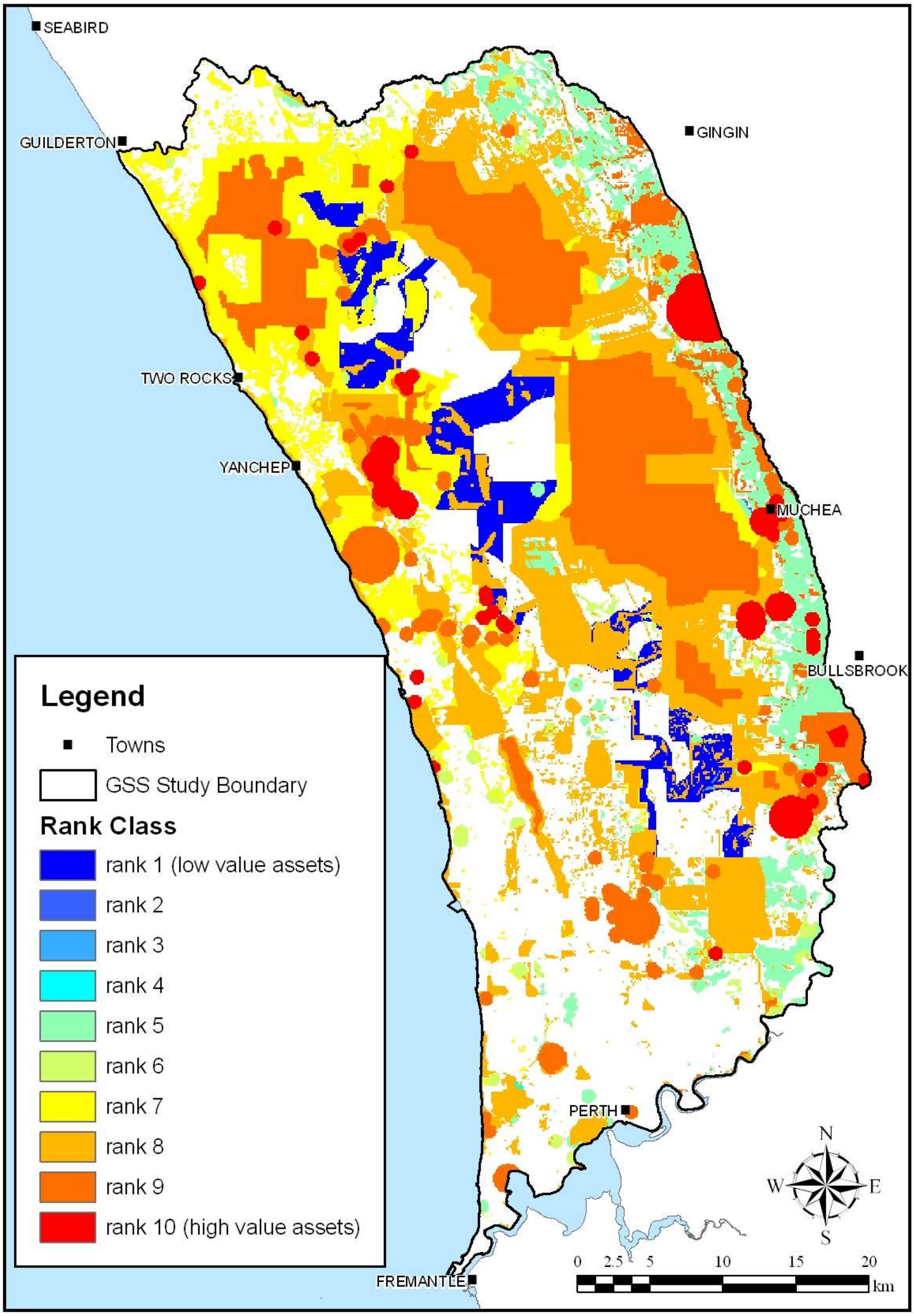
Appendix A: Project Dieback Interpretation Mapping Categories



Appendix B: Project Dieback Susceptibility Assessments of Beards Vegetation Types



Appendix C: HWRM Biodiversity Asset Ranks



Appendix D: Perimeter to Area Ratio of Remnant Vegetation Patches.