

***Phytophthora* Dieback Assessment of Mt. Brown Reserve**

Prepared for the Shire of York

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Joseph Grehan

Principal Ecologist

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ABN 48 159 606 005

3/42 Victoria Street, Midland WA 6056

Telephone: (08) 9250 1163 / Mobile: 0400 003 688

Email: joeg@terratree.com.au

Website: www.terratree.com.au

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Abbreviations and Acronyms

BoM	Bureau of Meteorology
CPSM	Centre for Phytophthora Science and Management
DBCA	Department of Biodiversity, Conservation and Attractions, WA Government
DIDMS	Dieback Information Data Management System
Dieback Interpreter's Manual	<i>FEM047 Phytophthora Dieback Interpreter's Manual for lands managed by the Department</i>
DNA	Deoxyribonucleic Acid
DPaW	Department of Parks and Wildlife
EPA	Environmental Protection Authority, WA Government
EP Act	<i>Environmental Protection Act 1986 (WA)</i>
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999 (Cwth.)</i>
FEMD	Forest and Ecosystem Management Division of DBCA, WA Government
GIS	Geographical Information System
GPS	Geographical Positioning System
IBRA	Interim Biogeographic Regionalisation for Australia
VHS	Vegetation Health Services

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Executive Summary

The Shire of York commissioned Terratree Pty Ltd (Terratree) to undertake a Broadscale Phytophthora Dieback (Dieback) assessment within Mt Brown Reserve. The objective of the Dieback assessment was to determine the Dieback disease status and risks within Mt Brown Reserve.

Mt. Brown Reserve is located, approximately 87 kilometres (km) east of Perth, on the easy boundary of the town of York to the east. The reserve is 145.1 hectares (ha).

The Dieback assessment of Mt Brown Reserve was conducted by a DBCA registered Dieback Interpreter, Joe Grehan of Terratree, on November 4th, 2019 in accordance with the *FEM047 Phytophthora Dieback Interpreter's Manual for lands managed by the Department* (FEMD, 2015).

Three soil samples were collected during the Dieback assessment, all of which returned negative results for *P. cinnamomi* through diagnostic baiting. However, one sample tested positive for another Phytophthora species, *P. rosacearum* (MBS01) and two samples tested positive for *Pythium mercuriale* (MBS02 and MBS03).

Because the mean annual rainfall in the area is in the range of 300 to 400 mm if Dieback were present it would be confined to drainage lines and water gaining sites.

No areas of native vegetation could be observed as definitively infested with Dieback during the assessment. Mapping categorised 118.3 ha (81.5%) of the assessment area as Uninterpretable due to the absence of susceptible vegetation and no positive sample results. 26.6 ha (18.5%) was categorised as Excluded due to the Degraded or Completely Degraded vegetation condition therefore these areas could not be assessed for the presence of Dieback.

Terratree makes the following recommendations to minimise the risk of introducing Dieback into the assessment area:

- As it is not possible to restrict access to dry soil conditions only, install 'green bridges' of compacted crushed limestone in wet areas along tracks of tracks and trails, which will act to reduce the spread of *Phytophthora* through its antagonistic properties and by keeping vehicles and bike tyres and footwear out of wet soil
- Install signage to raise public awareness and control public access within the reserve
- Control access within the reserve through trail consolidation and signage
- Ensure if rehabilitation is undertaken in the reserve that it does not introduce Dieback by utilising only NIASA-accredited nurseries and appropriate hygiene measures

- If soil disturbing works such as trail construction or rehabilitation are to be carried out within the reserve, ensure all vehicles and equipment are clean of soil and vegetative materials before entering the reserve and cleaned before commencing work elsewhere
- Aim to undertake any soil disturbing works during dry soil conditions only.
- Have relevant employees at the Shire of York undertake Green Card Training <https://www.dwg.org.au/green-card-training/>.

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1 Introduction

1.1 Background

The Shire of York commissioned Terratree Pty Ltd (Terratree) to undertake a Broadscale *Phytophthora* Dieback (Dieback) assessment within Mt Brown Reserve. The objective of the Dieback assessment was to determine the Dieback disease status and risks within Mt. Brown Reserve.

1.2 Project Location and Size

Mt. Brown Reserve, (hereafter referred to as 'the assessment area') is located, approximately 87 kilometres (km) east of Perth, on the east boundary of the town of York to the east (**Figure 1**). The reserve is 145.1 hectares (ha).

1.3 Phytophthora Dieback

Phytophthora Dieback (or Dieback) is a disease caused by the introduced soil-borne pathogen *Phytophthora cinnamomi*. While some plant species are resistant, others are susceptible to the disease caused by the pathogen, which can result in chlorosis, dieback and usually death (Wills and Keighery 1994). The pathogen has a range of hosts in Southwest WA, predominantly from the Ericaceae, Fabaceae, Myrtaceae, Proteaceae, and Xanthorrhoeaceae plant families.

Although several *Phytophthora* species occur in Western Australia, the most virulent and pathogenic is *P. cinnamomi*. References to *Phytophthora* Dieback refer to the disease caused by this species unless otherwise specified.

The most recent Western Australian State of the Environment Report lists Dieback as a Priority 1 threat to biodiversity (EPA 2011). A recent review of threats to species listed as threatened under the Federal *Environment Protection and Biodiversity Conservation Act 1999* (Cwth.) [EPBC Act] shows that *P. cinnamomi* is the second greatest invasive species threat in Australia after rabbits (Kearney *et al.* 2019).

Dieback has a significant effect in WA for the following reasons:

- Forty per cent (%) of native plant species in Southwest WA (over 2, 200 species), including almost half the endangered species, are susceptible to the pathogen (Shearer *et al.* 2004). This includes 49% of WA's threatened flora (EPA 2011).
- Changes in the composition and structure of floral communities resulting from the spread of Dieback have flow-on impacts throughout the ecosystem, including habitat alteration negatively affecting indigenous fauna populations.

- Dieback can lead to significant soil erosion through the loss of susceptible vegetation.

Disease expression caused by *Phytophthora* species occurs in native vegetation when the following variables and environmental conditions are present:

- **Host** - plant species are present that are susceptible to *Phytophthora* spp. (e.g. *Banksia*, *Hakea*, *Leucopogon* and *Daviesia* spp.).
- **Pathogen** - a *Phytophthora* spp. pathogen must be present, either residing in susceptible or resistant species.
- **Environment** - soil temperatures of 15 to 30 degrees Celsius (°C) and pH of 5 to 6 (acidic) are required for *P. cinnamomi* survival and activity, although some *Phytophthora* species, including *P. multivora*, can survive in alkaline soils (pH 7+).

Dieback is widespread in areas with greater than 800 millimetres (mm) of annual rainfall, less extensive in regions that receive between 600 and 800 mm, and mainly restricted to water-gaining sites in regions that receive 400 to 600 mm. The pathogen rarely occurs in areas receiving less than 400 mm annual rainfall, however, can survive in water-gaining sites, especially in areas which receive episodic large rainfall events. In WA, Dieback is a significant environmental issue for projects between Geraldton in the Midwest and Esperance on the South Coast, and it is widespread in the Southwest region.

Dieback is spread through the movement of water and soil within the landscape. A primary vector of Dieback is wet soil adhering to vehicle tyres/tracks and earthmoving equipment. Therefore, quarantine management procedures are an effective tool in reducing the spread of Dieback associated with any earthmoving activity.

1.4 Regulatory Context

Phytophthora Dieback management is required under several regulatory mechanisms, including:

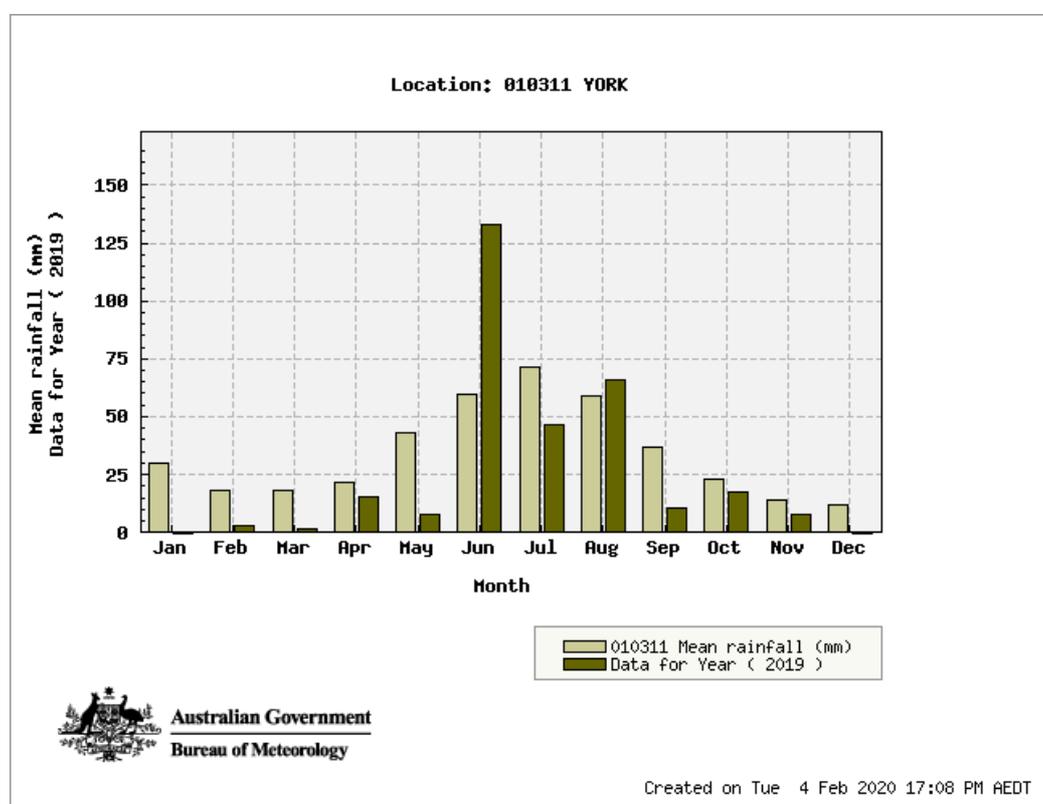
- *Environment Protection and Biodiversity Conservation Act (EPBC Act) 1999* (Cwth.), which lists *Phytophthora* Dieback as a Key Threatening Process
- Projects being assessed under the *Western Australian Environmental Protection Act 1986* (EP Act (WA)), which requires the Department of Biodiversity, Conservation and Attractions (DBCA) and Department of Mines, Industry Regulation and Safety (DMIRS) to comment on Dieback management and provides these agencies with the right to impose conditions on new approvals
- The EP Act Part V S.50A “Serious Environmental Harm” provisions.

2 Existing Environment

2.1 Climate

The assessment area experiences a temperate climate under the Köppen climate classification system and is characterised as by dry, hot summers and cool, wet winters (Peel *et al.* 2007). York (Station Number 010311) is the closest Bureau of Meteorology (BOM) weather station to the assessment area. Historically, York receives an average of 393.3 mm of rainfall annually, with most of this rain falling during the winter months of June, July and August. In 2019, York received 309.2 mm rainfall, with ten months receiving lower than average rainfall, especially during the period from January to March, and during May. June and August exceeded the mean rainfall for those months, as displayed in **Graph 1**.

In low rainfall areas (300-400 mm) such as the Avon-Wheatbelt, Dieback is restricted to drainage lines and water-gaining sites (**Photo 9**). Disease expression can be episodic rather than progressive, as a result of the regional fluctuations in rainfall, hot, dry summer months and free-draining soils. These conditions can result in a mosaic of small isolated infestations which only become active after significant rainfall events during the warmer months of the year (September- April).



Graph 1: Rainfall data for York (BoM, 2019)

2.2 Biogeography

The Interim Biogeographic Regionalisation for Australia (IBRA) system identifies 89 bioregions and 419 subregions across Australia, based on climate, geology, landforms and characteristic vegetation and fauna (Department of the Environment 2012). The assessment area is wholly within the Avon Wheatbelt 2 (AVW02 – Rejuvenated Drainage) sub-region of Avon Wheatbelt IBRA (Hearn *et al.* 2002).

The Avon Wheatbelt is an area of active drainage dissecting a tertiary plateau in the Yilgarn Craton with Proteaceous scrub-heaths on lateritic uplands and sandplains and mixed eucalypt, Western Sheoak (*Allocasuarina huegeliana*) and Jam (*Acacia acuminata*) woodlands on lowland alluvial and eluvial soils (Hearn *et al.* 2002). Within this, AVW02 is an erosional surface of gently undulating rises to low hills with abrupt breakaways and flowing streams with soils of colluvium and in-situ weathered rock (Hearn *et al.* 2002). AVW02 occupies 2, 992, 929 hectares (ha) (Department of the Environment 2012).

2.3 Flora and Vegetation

The remnant native vegetation within the AV02 subregion area includes Wandoo (*Eucalyptus wandoo*), York Gum (*E. loxophleba*) Gum and Salmon Gum (*E. salmonophloia*) with Jam (*Acacia acuminata*) and Casuarina (*Allocasuarina huegeliana*) woodlands.

The Mt. Brown Reserve is dominated by York Gum and Jam woodlands, with various introduced grass species dominating the understorey, in which most native species are significantly reduced. Areas of Sheoak woodland are also present, similarly, with a weedy grass understorey and very sparse native species. These sheoak woodlands often occur along-side the several granite outcrops in Mt Brown Reserve, which are dominated by lichens with little plant cover. No species were observed in the study area that are susceptible to dieback and useful as indicator species for the presence of the pathogen.

2.4 Current Status of *Phytophthora* Dieback in the Avon Wheatbelt

Historically, the impacts of Dieback in Western Australia have been recognised since the 1940s when large stands of Jarrah were observed to be dying off, giving rise to the somewhat misleading title Jarrah Dieback (Davison 2014). While *E. marginata* can succumb to the pathogenic effects of *Phytophthora cinnamomi*, morphological features of Jarrah's root system make them quite resistant to the impacts of Dieback. Many other frequently occurring mid-canopy genera are highly susceptible. These plants make up a significant structural component of the vegetation found on the Swan Coastal Plain and in the Northern Jarrah Forest, and widespread death in these susceptible species caused by *Phytophthora* Dieback results in reduced floristic diversity and a marked reduction in biomass in these areas (Shearer and Dillon 1996).

Dieback assessment has generally concentrated in the state forest in association with forestry and mining developments. Because of this, compared with other bioregions, Dieback has been less well studied in the Avon Wheatbelt and is less well understood. In the Avon Wheatbelt O2 subregion, the mid-story is dominated by genera which are not highly susceptible to dieback, such as *Acacia* spp. and *Allocasuarina* spp. (Hearn *et al.* 2002). Therefore, it has proportionately much fewer genera which are susceptible to Dieback and higher resistance to the pathogen than other bioregions such as the Northern Jarrah Forest and Swan Coastal Plain. Furthermore, vast areas of vegetation in the Avon Wheatbelt have been dramatically altered due to land uses such as clearing for agriculture and livestock grazing. Grazing has dramatically reduced the presence of susceptible mid and lower story species in remnant vegetation.

However, the pathogen may still be present and having an impact on the system where environmental conditions are favourable. Water-gaining sites are at a higher risk of being infested with *P. cinnamomi* as its flagellated zoospores can travel through water or moist substrate. It is possible, however, for the pathogen to survive as stromata, or thick-walled chlamydospores, in resistant plant species in upland areas during summer, and reproduce when conditions become more favourable for survival (Crone 2012). Low rainfall and extreme heat impede the autonomous spread of the Dieback pathogen into upland areas, and it is restricted to water-gaining sites in low rainfall areas such as York. However, it can still be spread mechanically by a vector into upland areas through the movement of infected soil, water or vegetative material.

2.5 Historical Land Use and Disturbance

The area has historically been used for cropping and grazing, and most of the native vegetation was cleared for these purposes. Areas of remnant native vegetation are mostly confined to roadsides, gullies and rocky hilltops and slopes. The vegetation at Mt. Brown Reserve itself is quite disturbed, with evidence of likely historical grazing resulting in a reduced floristic diversity, particularly in the under and mid-stories as well as heavy infestations of invasive flora species present (**Photo 3**). Furthermore, vehicle and mountain bike tracks exist throughout the reserve, which is frequented for recreational use by the community, with a long history of recreational use in the reserve (**Photo 4** and **Photo 5**).

3 Methods

The Broadscale Dieback assessment is conducted in a two-stage process:

- A desktop review of the relevant, available information regarding site characteristics plus previous Dieback mapping and sample results.
- A field assessment to observe disease symptoms, record Dieback occurrence data and collect soil and tissue samples (if possible) for diagnostic testing.

3.1 Desktop Assessment

A desktop assessment was completed to collect information about the assessment area, surrounding landscape and previous history of *Phytophthora* Dieback surveying.

The Dieback Information Data Management System (DIDMS; Project Dieback 2014-2019) was used to obtain data from the Vegetation Health Services (VHS) laboratory at DBCA on Dieback occurrence mapping and sample results from previous assessments in the area.

The desktop assessment also aimed to:

- identify access to the assessment area and internal tracks
- examine the topography and drainage of the assessment area and the broader landscape
- identify possible disease vectors (e.g. tracks, utility corridors and ground disturbance)
- determine the location of high-risk areas (e.g. areas of high disturbance and water-gaining sites)
- review previous reports and other relevant literature.

3.2 Field Assessment

The field assessment consisted of a visual assessment of all native vegetation within the assessment area and in the broader landscape, recording evidence of presence or absence of Dieback, and taking representative samples.

The Dieback assessment was conducted by a DBCA registered Dieback Interpreter, Joe Grehan of Terratree, on November 4th, 2019 in accordance with the *FEM047 Phytophthora Dieback Interpreter's Manual for lands managed by the Department* (FEMD 2015).

3.2.1 Linear Assessment

The Dieback assessment included a Linear assessment of the vegetation adjacent to existing roads, tracks, firebreaks and trails within and adjacent to Mt. Brown Reserve. The Linear component of the assessment

included assessing all the tracks and firebreaks within the assessment area and, collecting spatial data using a hand-held Global Positioning System (GPS) unit. Due to the absence of recently dead disease indicator species soil samples had to be taken instead of plant tissue which is preferable for recovering *Phytophthora*. Data from a Linear assessment has a high confidence level and is suitable for informing hygiene management during ground disturbing operations (DPaW 2015).

3.2.2 Broadscale Assessment

A Broadscale assessment is predominately a risk-based assessment which examines the likelihood of Dieback being present in an area. Data from a Broadscale assessment has a moderate confidence level and is not suitable for operational purposes (DPaW 2015). The Broadscale, rather than Comprehensive assessment method is an appropriate technique to apply in this instance as Dieback is generally restricted to water-gaining sites in the York area and broader Avon Wheatbelt Region, and the interpretability of the vegetation in AV02 is very low. All the vegetation in the assessment area is Uninterpretable due to the absence of species that are susceptible to Dieback, therefore undertaking a comprehensive, transect-based assessment, would reveal little about disease occurrence.

A Broadscale assessment of all other areas of native vegetation outside the assessment area was conducted by:

- Reviewing the data from the DIDMS geospatial dataset to see if Dieback has been previously recorded in the local area
- Examining the condition of areas of remnant native vegetation using aerial photography
- Using the results of the Linear assessment to inform the likelihood of Dieback being present
- Using the environmental conditions, especially mean annual rainfall, to inform the likelihood of Dieback being present.

Table 1 presents the assessability of vegetated and non-vegetated areas (FEMD, 2015). The Dieback Interpreters' Manual categorises land that has been cleared of native vegetation as 'Excluded' from assessment. Non-vegetated areas that are Excluded from assessment include farmland, pasture, pits, easements, development, roads (sealed and unsealed), permanent flooding and parkland tree stands. Vegetated areas that are Excluded from assessment include areas which have a Keighery vegetation disturbance scale score of 5 or 6, and area Degraded or Completely Degraded.

The assessability of vegetated and non-vegetated areas and associated *Phytophthora* Dieback occurrence categories can be determined using the Keighery vegetation disturbance scale (DPaW 2013) presented in **Table 2**. This scale was used to determine the interpretability of the vegetation. Areas with a vegetation condition

rating of 1-3 (Pristine - Very Good) are considered assessable. In addition, there must be enough disease indicator species present to enable a diagnosis of the disease status. An area with a vegetation condition rating of 4 (Good) is possibly assessable; however, it is up to the Interpreter's discretion. Areas with a condition rating of 5 or 6 (Degraded or Completely Degraded) are Temporarily Uninterpretable and or Excluded.

Uninfested vegetation exhibits the following characteristics:

- No positive sample results received for *P. cinnamomi*
- An acceptable diversity of healthy disease indicator species is present, including some of the following genera: *Banksia*, *Persoonia*, *Xanthorrhoea*, *Leucopogon*, *Hakea* and *Adenanthos*
- Vegetation condition is in Pristine-Very Good (1-3) condition according to the Keighery scale with a good density of vegetation cover and no apparent reduction in biomass or masking by resistant species
- No evidence found of disease pattern or chronology.

Infested vegetation was identified and characterised by the following features:

- Positive sample results for *P. cinnamomi* are found either in the immediate area, upslope or upstream of the Infested area
- Multiple disease indicator species deaths (ISDs) are occurring
- Disease pattern and chronology is visible
- Vegetation structure and composition are substantially altered
- Significant biomass reduction or colonisation by resistant species

Uninterpretable vegetation exhibits the following characteristics:

- Insufficient amount of disease indicator species present, including the following genera: *Banksia*, *Persoonia*, *Xanthorrhoea*, *Leucopogon*, *Hakea* and *Adenanthos*
- Vegetation condition is in Pristine-Very Good (1-3) condition according to the Keighery scale with a good density of vegetation cover, possible masking by resistant species and no obvious reduction in biomass or biodiversity
- Environmental conditions occur that discourage the pathogen, such as highly fertile soils, fewer host species or a dominating resistant host (e.g. plant species from the Cyperaceae family).

Uninterpretable areas may contain Dieback (e.g. with low inoculum levels as an endemic or incipient disease) without showing signs of its presence and determining the presence of the pathogen is not possible using interpretation methods (FEMD 2015). Uninterpretable areas that meet the Protocols for Identifying

Protectable Areas (**Section 3.4**) are managed as being both Infested and Uninfested so that the pathogen is neither imported into nor exported from, these areas.

The 'Temporarily Uninterpretable' category is allocated to areas of native vegetation which have been disturbed, but native vegetation will recover over time and may become interpretable and therefore mappable. Examples of Temporarily Uninterpretable areas include vegetation that has been impacted by fire, timber harvesting, flooding or mining with subsequent rehabilitation. The recovery time for Temporarily Uninterpretable areas may be longer than three years (DPaW 2015). Excluded areas are distinguished from Temporarily Uninterpretable areas by the fact that Excluded areas do not generally retain the ability to regenerate and eventually become mappable.

Table 1: Assessability of vegetated and non-vegetated areas (adapted from FEMD 2015)

Description	<i>Phytophthora</i> occurrence category	Typically present	May be present
<p>Naturally vegetated areas Keighery disturbance rating of 3 or less. <i>Phytophthora</i> occurrence categorisation is possible. Small unvegetated areas can exist and may be included in the assessment area considering total environmental context.</p>	INFESTED	Dead and dying reliable indicator species	Healthy reliable indicator species Indicator Species Deaths (ISDs) that have been killed by other agents
	UNINFESTED	Healthy reliable indicator species	ISDs that have been killed by other agents
	UNINTERPRETABLE	Very few reliable indicator species	Occasional reliable indicators, but too few for <i>Phytophthora</i> Dieback interpretation
	NOT YET RESOLVED	Usually reliable indicator species in an environment not favourable to disease development	Negative sample results for all <i>Phytophthora</i> species
<p>Vegetation structure temporarily altered Phytophthora occurrence assessment will be possible when vegetation structure recovers. Recovery times will be variable depending on severity and type of disturbance.</p>	TEMPORARILY UNINTERPRETABLE	Indicator species masked by disturbance typically from fire, harvesting, temporary flooding, poisoning	Occasional reliable indicator species, but disturbance prevents accurate placement of <i>Phytophthora</i> occurrence
<p>Road disturbance area</p>	DISEASE RISK ROAD (DRR)	Unformed track with shoulders of interpretable vegetation	Shoulders and batters with regenerated vegetation Incipient infestation
<p>Vegetation structure severely altered Keighery disturbance rating 5 or greater. <i>Phytophthora</i> occurrence assessment is not possible. Can be determined by desktop assessment (aerial photo). Small vegetated areas can exist and may be excluded from the assessment area considering total environmental context.</p>	EXCLUDED	Pasture, pits, easements, infrastructure, large roads (sealed and unsealed) permanent flooding, plantations, parkland tree stands	Sporadic reliable indicator species

Table 2: Keighery vegetation disturbance scale and assessability (Keighery 1994, as defined in FEMD 2015)

Assessability	Scale		Condition
Assessable	1	Pristine	Pristine or nearly so, no obvious signs of disturbance.
	2	Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
	3	Very Good	Vegetation structure altered, obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
Possibly assessable, discretion required	4	Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, Dieback and grazing.
Not assessable or excluded from assessment	5	Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, Dieback and grazing.
	6	Completely Degraded	The structure of the vegetation is no longer intact, and the area is completely or almost completely without native species. These areas are often described as "parkland cleared" with the flora comprising weed or crop species with isolated native trees or shrubs.

3.2.3 Sampling Strategy and Methods

Sampling strategies for the assessment of Dieback aim to resolve the following scenarios:

- Sampling to support an Infested diagnosis - recently dead and dying indicator species are sampled to support an Interpreter's diagnosis of an area as Infested.
- Sampling to support an Uninfested diagnosis - recently dead and dying indicator species are sampled to support an Interpreter's diagnosis of an area as Uninfested.

Samples must typically be collected of soil and tissue from recently dead or dying disease indicator species to confirm the presence, or indicate the possible absence, of Dieback and to inform the interpretation of the assessment area. However, in the absence of disease indicator species, as is the case in Mt Brown Reserve, only soil samples are possible. Three samples were taken at low-lying, water-gaining sites, particularly in areas with visible wheel rutting indicating vehicle access in wet soil conditions.

Caution must be applied to interpreting the results of sampling and claiming that an area is Uninfested. Prolonged unfavourable conditions for *Phytophthora cinnamomi* can lead to false-negative results due to low levels of inoculum present in a sample. Sample results should be considered within the context of other field evidence, including disease vectors, pattern, chronology, biomass reduction and changes in vegetation structure.

All soil sampling strictly adhered to the following procedures:

- All tools used in the sampling were thoroughly sterilised with a 70:30 mixture of methylated spirits and water then dried before samples were taken so that the results were not compromised.
- Moist soil at a depth of 50-200mm was collected and placed in a polythene bag.
- All relevant information pertaining to the plant sampled including sample location was recorded on the Sample Information Sheet.
- An aluminium tag that displayed the date, project name, sample number, species sampled and the name of the Interpreter was placed in the sample bag.
- The sample hole was backfilled to prevent fauna from becoming trapped.
- All tools were brushed off to remove excess soil and sterilised to prevent contamination of the next sample site and sample.
- All sample point locations were recorded using a hand-held GPS unit.

All soil samples were lodged with the VHS laboratory, where diagnostic baiting and deoxyribonucleic acid (DNA) testing was conducted.

Dieback assessment is conducted in a manner to ensure it does not spread Dieback within the assessment area. The following procedures are followed:

- Start all field assessments with a clean vehicle and footwear free of soil and vegetative material.
- Only work in dry conditions (i.e. when soil is not adhering) to reduce spreading of soil from footwear and vehicle movement.
- In wet conditions on more exposed soils, carry a small cleaning brush and a spray bottle with a 70:30 solution methylated spirits/water to remove soil and mud from footwear when moving from Infested to Uninfested areas.
- In wet conditions:
 - Aim to work from Uninfested into Infested or Uninterpretable or Excluded areas
 - Drive vehicle only on well-formed tracks avoiding muddy and wet areas.
- If Uninfested areas need to be entered, complete an in-field vehicle inspection and clean down if required.

- Where possible, avoid driving through water; however, if a water-crossing or muddy area must be driven through, drive through slowly to reduce mud-spraying and complete an in-field vehicle inspection and clean down if required.

In-field vehicle cleaning can be difficult to achieve. An in-field vehicle inspection and clean down involves the following process:

- Before entering an Uninfested area or after completing a water/mud-crossing, stop at an appropriate site as soon as possible. An appropriate area is a dry and sandy or hard-pan location in the Infested area, draining onto or into the Infested area.
- Remove soil and mud from tyres, bumper, wheel arches, steps and under the vehicle.
- Spray down the undercarriage and wheels of the vehicle with 70:30 solution methylated spirits/water.
- Spray all equipment used to clean the vehicle and footwear with 70:30 solution methylated spirits/water.

3.3 Mapping

Spatial data, including tracks and waypoints recorded on hand-held GPS units, were downloaded into a Geographic Information System (GIS) program, namely QGIS 3.4.

Field evidence and observations plus spatial data were used to prepare a Dieback occurrence map for the assessment area. *Phytophthora* occurrence categories were mapped using the categories defined in **Table 1**.

3.4 Protocols for Identifying Protectable Areas

The Dieback Interpreter's Manual outlines the following primary criteria for defining Protectable Areas as those areas that:

- have been determined to be free of the *Phytophthora* spp. pathogen by a registered Dieback Interpreter (all susceptible indicator plant species are healthy, and no plant disease symptoms normally attributed to *Phytophthora* Dieback are evident)
- are in locations receiving >600 mm rainfall per year or those that are water-gaining sites (e.g. granite outcrops, impeded drainage or engineering works that aggregate rainfall) in the 300-600 mm per year rainfall range
- consist of areas where human vectors are controllable (e.g. not an open road, private property)

- are positioned in the landscape and are of sufficient size (e.g. >4 ha with axis >100 m) such that a qualified Interpreter judges that the pathogen will not autonomously engulf them in the short term (a period of a few decades)
- include areas of high conservation and/or socio-economic value (e.g. a small Uninfested area with a known population of a susceptible species of threatened flora) (FEMD 2015).

For operational purposes, Dieback occurrence mapping is only valid for 12 months after the assessment is completed to counter for the autonomous spread of the pathogen (FEMD 2015).

3.5 Limitations

The following limitations were encountered during the assessment:

- Vegetation condition in some parts of the assessment area was poor; therefore, an Excluded category rating was assigned according to the Dieback Interpreter's Manual.
- The natural vegetation structure and composition in the assessment area meant there was a lack of disease indicator species; therefore, an Uninterpretable category rating was assigned according to the Dieback Interpreter's Manual.
- The lack of susceptible species, means that opportunistic soil samples, rather than recently dead plant tissue samples were taken from water-gaining sites.
- The lack of previous Dieback assessments in the assessment area was a limiting factor for the desktop assessment.
- With an annual mean rainfall of 393.3 mm the study area Dieback expression becomes cryptic, making interpretability more difficult. In 2019, York received below average rainfall, of 309.2 mm.
 - Reduced rainfall impedes disease spread, as a less saturated soil and reduced surface water run-off inhibit pathogen mobility within the soil profile and at the surface. Therefore, disease activity and expression, including indicator species deaths, are likely to be less evident.
 - Additionally, low rainfall can induce drought-stress within vegetation during warmer months, which can imitate and therefore mask disease symptoms.
- Species of *Phytophthora* other than *P. cinnamomi* can only be identified through DNA analysis. Early stages of the analysis were complete at the time of writing; However, identification of some of the samples would take several more weeks.
- Little research has been undertaken into the pathogenicity of some novel *Phytophthora* species such as *P. rosacearum*.
- Little research has been undertaken on impacts of *Pythium* to native vegetation.

4 Results

4.1 Desktop Review

The desktop review didn't identify any previous Dieback mapping or positive sample results in the local area. There are few positive Dieback samples throughout the Avon Wheatbelt region. The natural composition of vegetation in this subregion contains proportionately fewer disease indicator species (Hearn *et al.* 2002), and grazing has further reduced these susceptible species, making vegetation interpretability low. No disease indicator species were observed in the assessment area during the field assessment.

4.2 Sample Results

Three soil samples were taken during the Dieback assessment, all of which returned negative results for *P. cinnamomi* through diagnostic baiting, but positive for other *Phytophthora* species. MBS01 was confirmed to contain *Phytophthora rosacearum*, which was identified through DNA analysis. The Samples MBS02 and MBS03 underwent further DNA analysis and were identified as *Pythium mercuriale*. Sample results are presented in **Table 3**. The VHS laboratory Phytophthora testing results are provided in **Appendix A**.

4.2.1.1 *Phytophthora rosacearum*

Sample MBS01 was found to contain *Phytophthora rosacearum*, which is a newly identified species, recently split from the old *P. megasperma* complex (Hansen *et al.* 2009). This species of *Phytophthora* has not been found wildy in Western Australia but is a significant pathogen of rosaceous fruit trees in North America (Hansen *et al.* 2009). *P. rosacearum*, is not likely to be as virulent as *P. cinnamomi* and in laboratory trials, has had some impact on roots and growth of Eucalyptus and Banksia, but did not cause plant deaths (Pers. Comm. Associate Professor Treena Burgess, Murdoch University, 22 June 2017).

4.2.1.2 *Pythium mercuriale*

Samples MBS02 and MBS03 were found via DNA analysis to contain *Pythium mercuriale*. Related to Phytophthora, and also a root rot, *Pythium*, is a large genus in the class of Oomycetes (water mould), which attack plants in wet soil conditions. *Pythium* is a widespread pest of cereal, horticulture and ornamental crops (DPIRD 2020). Little research has been conducted into the pathogenicity of *Pythium* spp. on native vegetation, however, they all have the potential to be damping-off pathogens (Pers. Comm. Associate Professor Treena Burgess, Murdoch University, 09 March 2020).

Table 3: Sample results from Mt Brown Reserve.

Sample ID	Species	Easting	Northing	Diagnostic Baiting	DNA Analysis
MBS01	Soil Only	479716	6471773	Negative for <i>P. cinnamomi</i>	Positive for <i>Phytophthora rosacearum</i>
MBS02	Soil Only	479900	6472654	Negative for <i>P. cinnamomi</i>	Positive for <i>Pythium mercuriale</i>
MBS03	Soil Only	649944	7472319	Negative for <i>P. cinnamomi</i>	<i>Pythium mercuriale</i>

4.3 Dieback Occurrence

Table 4 lists the interpretability of each of the vegetation units found within Mt. Brown Reserve. **Figure 2** presents a Dieback occurrence map for the assessment area. **Table 5** provides a breakdown of the Dieback occurrence area calculations. No areas of native vegetation infested with Dieback were observed or mapped during the assessment. Mapping categorised 118.3 ha (81.5%) of the assessment area as Uninterpretable due to the absence of disease indicator species (**Photo 1**). A significant proportion of the assessment area, 26.8 ha (18.5%), were categorised as Excluded due Degraded vegetation condition or absent vegetation (such as a granite outcrop) and therefore cannot be assessed for the presence of Dieback (**Photo 2** and **Photo 3**).

Table 4: Interpretability of Vegetation Units within Mt. Brown Reserve.

Vegetation Unit	Interpretability
York Gum and Jam Open Woodland	Uninterpretable
Sheoak Woodland	Uninterpretable
Granite Outcrop	Excluded

Table 5: Dieback occurrence area statement for the Mt. Brown Reserve.

Occurrence Category	Area (ha)	Per Cent of Assessment Area (%)
Uninterpretable	118.3	81.5
Excluded	26.8	18.5
Total	145.1	100 %

5 Discussion

5.1 Disease Occurrence

In areas with a mean annual rainfall of 300 to 400mm, Dieback is confined to drainage lines and water-gaining sites and disease expression is cryptic, making interpretability more difficult. The mean annual rainfall in the assessment area is 393.3mm; however, in 2019 York received below-average rainfall, of 309.2 mm. Reduced rainfall impedes disease spread, as a less saturated soil profile and reduced surface water run-off inhibit pathogen mobility. Therefore, disease activity and expression, including indicator species deaths, are likely to be less evident. Low rainfall can also induce drought-stress within vegetation during warmer months, which can imitate and therefore mask disease symptoms. Despite low annual rainfall, the area periodically receives episodic summer rainfall events from Tropical Lows which arrive from the north-west of the state after cyclones. These significant rainfall events during the warmer months can activate the pathogen and result in the spread of Dieback.

The assessment found no recently dead susceptible disease indicator species, so tissue samples could not be collected, and soil samples only were taken instead. All three soil samples were taken in moist areas along tracks with visible wheel ruts, indicating vehicle access during wet soil conditions, presenting a possible vector for pathogens into the site (**Photo 6**, **Photo 7** and **Photo 8**). None of the samples returned positive results for *P. cinnamomi*, although other species, which were not identifiable through morphological features were visible. These two samples (MBS02 and MBS03) were cultured and sent to the Centre for Phytophthora Science and Management (CPSM) at Murdoch University for DNA analysis. The analysis found *P. rosacearum* present in Sample 1 (MBS01). This species is likely to be less virulent than *P. cinnamomi* and restricted to water-gaining sites, however, should be managed in a similar way to prevent their spread throughout Mt Brown Reserves and other areas. Further testing revealed Samples 2 and 3 (MBS02 and MBS03) to contain not *Phytophthora*, but *Pythium mercuriale*. Little is known about this species, especially regarding the impacts on native vegetation, however some species from the large *Pythium* genus are severe pathogens to agriculture so a precautionary principle should be applied. Like *Phytophthora*, *Pythium* is restricted to wet soils and spread through the same mechanisms, and as such, it can be managed in the same way.

No susceptible vegetation was recorded in the reserve, resulting in the reserve being almost entirely Uninterpretable, with some areas of Excluded, where vegetation was Degraded to assess.

5.1.1 Uninterpretable

Most of the areas of native vegetation, which appear to be in Good condition (Keighery *et al.* 1994), were categorised as Uninterpretable due to no susceptible species being present. The vegetation in the area is naturally without many susceptible genera, and these areas have likely been grazed which has had a significant impact on the understorey vegetation, removing any genera which could have indicated the presence of Dieback, therefore making the vegetation Uninterpretable. These areas meet the Protocol for identifying Protectable areas.

5.1.2 Excluded

The remaining area within the overall project area is comprised of vegetation in Degraded and Completely Degraded condition (Keighery *et al.* 1994), due to completely missing native understory which is dominated by annual weed species including Wild Oats (*Avena barbata*), Blue Lupins (*Lupinus cosentinii*) and Wild Radish (*Raphanus raphanistrum*). This area has been categorised as Excluded and cannot be assessed due to the Degraded to Completely Degraded vegetation condition (Keighery *et al.* 1994). These areas represent a low risk of being infested because:

- there is no evidence of Dieback being present within assessment area; and
- low annual mean rainfall (300 – 400 mm) means that, if it were present Dieback would be mainly confined to surface water, drainage lines and water gaining sites (**Photo 9**).
- an absence of susceptible and resistant host species for the pathogen.

5.2 Management

Uninterpretable areas that meet the Protocols for identifying Protectable Areas (FEMD 2015), as is the case in Mt Brown Reserve, are managed as being both Infested and Uninfested so that the pathogen is neither imported into nor exported from, these areas.

5.2.1 Signage

Installation of signage to increase public awareness of disease risk, manage public access throughout the reserve will help minimise the risk of spreading Dieback outside the reserve. A standard phytophthora dieback signage protocol has been developed for use across all land tenures, including areas managed by local government, using a standardised series of designs to ensure consistency and therefore higher recognition. These standard phytophthora dieback signage protocols are included in **Appendix B**.

5.2.2 Engineering Controls

As it is not possible to restrict access to dry soil conditions only, an effective method to reduce the spread of wet soil on vehicle or mountain bike tyres and footwear is by spreading a layer of compacted crushed limestone in low-lying areas of tracks and trails, which acts as a 'green bridge' (**Photo 10**). As well as keeping vehicle tyres and footwear out of wet soil, the limestone is antagonistic to *Phytophthora cinnamomi*, as it requires acidic soils and alkalinity is unfavourable for survival.

6 Conclusion and Recommendations

The Dieback assessment of Mt Brown Reserve was conducted by a DBCA registered Dieback Interpreter, Joe Grehan of Terratree, on November 4th, 2019 in accordance with the *FEM047 Phytophthora Dieback Interpreter's Manual for lands managed by the Department* (FEMD, 2015).

Three soil samples were collected during the Dieback assessment, all of which returned negative results for *P. cinnamomi* through diagnostic baiting. However, one sample tested positive for another Phytophthora species, *P. rosacearum* (MBS01) and two samples tested positive for *Pythium mercuriale* (MBS02 and MBS03).

Because the mean annual rainfall in the area is in the range of 300 to 400 mm if Dieback were present it would be confined to drainage lines and water gaining sites.

No areas of native vegetation could be observed as definitively infested with Dieback during the assessment. Mapping categorised 118.3 ha (81.5%) of the assessment area as Uninterpretable due to the absence of susceptible vegetation and no positive sample results. 26.6 ha (18.5%) was categorised as Excluded due to the Degraded or Completely Degraded vegetation condition therefore these areas could not be assessed for the presence of Dieback.

Terratree makes the following recommendations to minimise the risk of introducing Dieback into the assessment area:

- As it is not possible to restrict access to dry soil conditions only, install 'green bridges' of compacted crushed limestone in wet areas along tracks of tracks and trails, which will act to reduce the spread of *Phytophthora* through its antagonistic properties and by keeping vehicles and bike tyres and footwear out of wet soil
- Install signage to raise public awareness and control public access within the reserve
- Control access within the reserve through trail consolidation and signage
- Ensure if rehabilitation is undertaken in the reserve that it does not introduce Dieback by utilising only NIASA-accredited nurseries and appropriate hygiene measures

- If soil disturbing works such as trail construction or rehabilitation are to be carried out within the reserve, ensure all vehicles and equipment are clean of soil and vegetative materials before entering the reserve and cleaned before commencing work elsewhere
- Aim to undertake any soil disturbing works during dry soil conditions only.
- Have relevant employees at the Shire of York undertake Green Card Training <https://www.dwg.org.au/green-card-training/>.

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8 Glossary of Terms (adapted from FEMD 2015)

Assessment - any combination of activities including detection, diagnosis (interpretation), mapping and demarcation of Phytophthora Dieback disease (Phytophthora occurrence) in natural ecosystems.

Assessment Area - an area where Phytophthora occurrence assessment is possible or will be possible in the short to medium term. This area may be larger or smaller than the proponent's project area.

Diagnosis - a determining or analysis of the cause or nature of a problem or situation.

Dieback (Phytophthora) - in the south-west of Western Australia, a disease of plants caused by infection by the soil-borne organisms of the genus *Phytophthora*, of which *P. cinnamomi* is the most widespread.

Dieback (Phytophthora) Interpreter - a registered person who conducts Phytophthora Dieback interpretation.

Dieback (Phytophthora) Interpretation - the method of determining Phytophthora Dieback infestation using procedures in the Dieback Interpreter's Manual (Forest and Ecosystem Management Division (2015). FEM047 Phytophthora Dieback Interpreter's manual for lands managed by the department. Version 1.0. Department of Parks and Wildlife, Perth, Western Australia).

Disease - the combination of a pathogen, host and correct environmental conditions, which results in disease symptoms or death of a host.

Environment - the sum of all external factors that act on an individual organism during its lifetime.

Excluded Area - an area that has been disturbed to an extent that it is not assessable and therefore excluded from Dieback interpretation.

Host - the plant that is invaded by a pathogen and from which the pathogen derives its energy.

Indicator species – a plant species that is more susceptible to Phytophthora disease and reliably shows symptoms earlier than other species.

Infection - the invasion of a host organism's bodily tissue by disease-causing organisms. In relation to Dieback, this refers to an individual plant and not the population.

Infested Area - an area that an accredited Dieback Interpreter has determined has plant disease symptoms consistent with the presence of the pathogen *Phytophthora*.

Inoculum - cells, tissue, or viruses that are used to inoculate a new culture.

Not Yet Resolved - an area that is interpretable for Dieback but where a determination regarding the disease status cannot be made due to a lack of evidence in the form of positive sample results.

Pathogen - any organism or factor causing disease within a host.

Pathogenic - causing or capable of causing disease.

Phytophthora Dieback - a term referring to the disease symptoms caused by *Phytophthora* species in susceptible vegetation.

Protectable Area - an area of land managed by the landowner where hygiene management rules for the plant pathogen *Phytophthora*, including clean on entry, will apply. These areas are generally free of disease.

Susceptible - influenced or able to be harmed by *Phytophthora* Dieback.

Symptom - a phenomenon that arises from and accompanies a particular disease or disorder and serves as an indication of it.

Uninfested Area - an area that an accredited Dieback Interpreter has determined to be free of plant disease symptoms that indicate the presence of *Phytophthora* Dieback.

Uninterpretable Area - an area situated in locations receiving >600 mm rainfall per year or are water-gaining sites (e.g. granite outcrops, impeded drainage or engineering works that aggregate rainfall) in the 400-600 mm per year rainfall zone where indicator plants are absent or too few to determine the presence or absence of disease caused by *Phytophthora* Dieback.

Unprotectable Area - a disease-free area that is likely to become infested within a given time.

Vector - any agent that acts as a carrier or transporter.

Zoospore - a motile asexual spore that uses a flagellum for locomotion.

9 Photos



Photo 1: Uninterpretable vegetation, dominated by York Gum (*E. loxophleba*) and Jam (*Acacia acuminata*) with no indicator species and absent understory.



Photo 2: Excluded area due to granite outcrop.



Photo 3: Excluded area with very sparse vegetation in Degraded condition.



Photo 4: Mountain Bike trail for recreational use in Mt Brown Reserve.



Photo 5: Example of soil disturbance in Mt Brown Reserve.



Photo 6: Sample MBS01 location. A water-gaining site, with visible wheel rutting indicating access during wet soil conditions, returned a negative result for *Phytophthora cinnamomi*, but *P. rosacearum* was confirmed.



Photo 7: Sample MBS02 location. Water-gaining site, with visible wheel rutting indicating access during wet soil conditions, returned a negative result for *Phytophthora cinnamomi*, but a positive result for *Pythium mercuriale*.



Photo 8: Sample MBS03 location. Water-gaining site, with visible wheel rutting indicating access during wet soil conditions, returned a negative result for *Phytophthora cinnamomi* but a positive result for *Pythium mercuriale*.



Photo 9: Phytophthora species are restricted to gullies and water gaining sites in low rainfall areas.



Photo 10: A 'green bridge' of limestone through a Dieback infested area on a track (source: Kaylene Watts).

10 Figures

Figure 1: Mt Brown Dieback Assessment Location Map



Legend

 Assessment Area



Project Location

Mt. Brown Reserve

Project Location

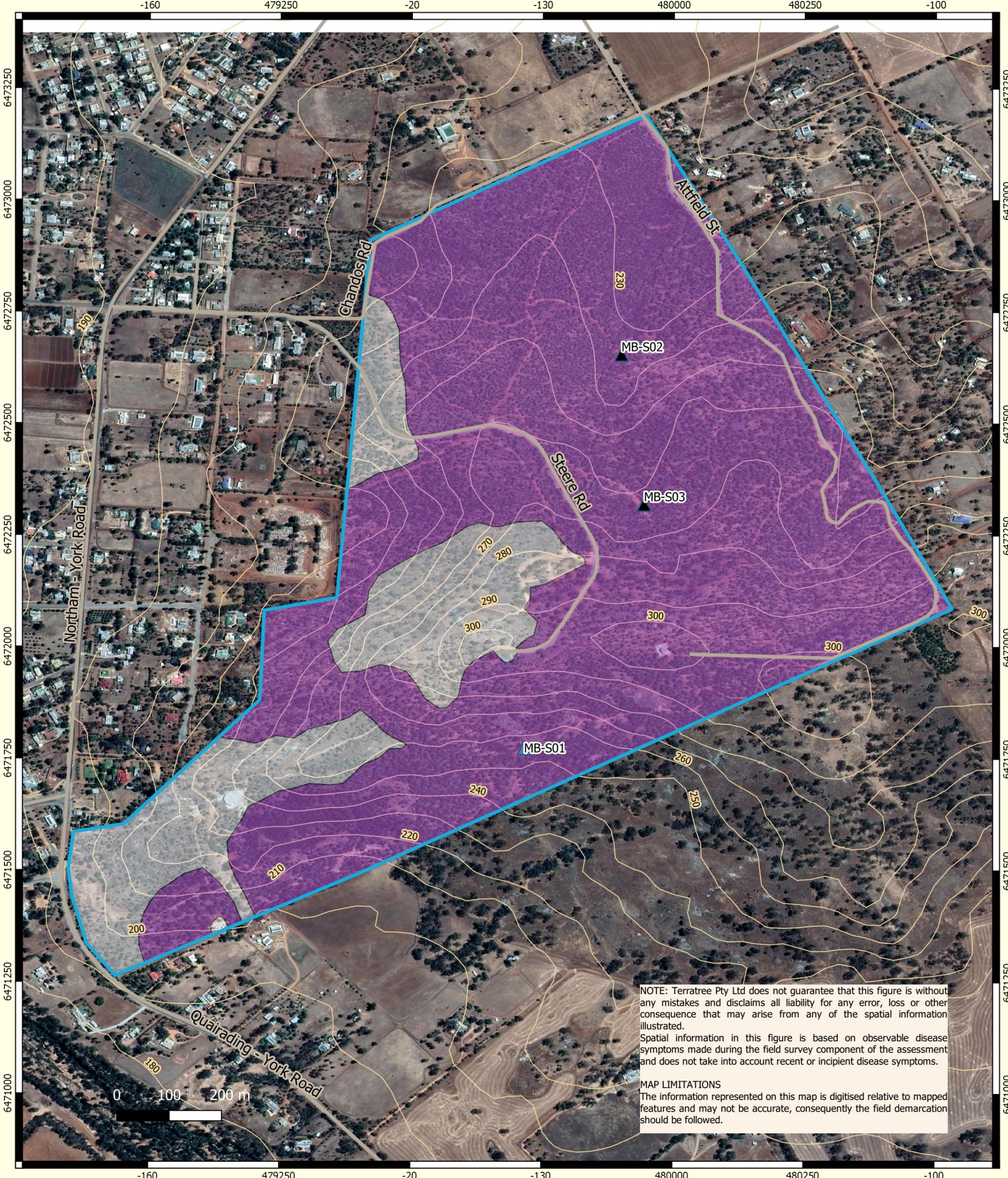


Datum: GDA 1994
Projection: MGA Zone 50

Scale: 1: 25,000
at A3

Date: 10/02/2020	Prepared: K. Jennings	Project No: T19026
Expiry: N/A	Checked: J. Grehan	
Figure 1	Revision: Rev A	
	Review:	

Figure 2: Mt Brown Dieback Occurrence Map



NOTE: Terratree Pty Ltd does not guarantee that this figure is without any mistakes and disclaims all liability for any error, loss or other consequence that may arise from any of the spatial information illustrated.

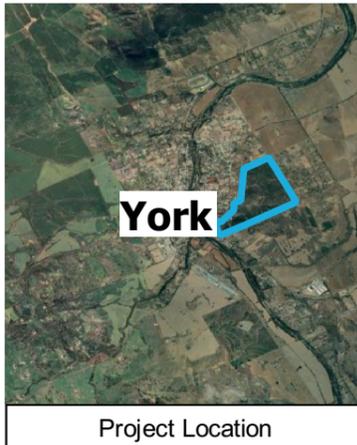
Spatial information in this figure is based on observable disease symptoms made during the field survey component of the assessment and does not take into account recent or incipient disease symptoms.

MAP LIMITATIONS
The information represented on this map is digitised relative to mapped features and may not be accurate, consequently the field demarcation should be followed.

Legend

- Assessment Area
- Contours (10m)
- Dieback Occurrence**
- Uninterpretable
- Excluded
- Dieback Samples**
- ▲ *Phytophthora rosacearum*
- ▲ *Pythium mercuriale*

Occurrence Category	Area (ha)	%
Uninterpretable	118.3	81.5
Excluded	26.8	18.5
Total	145.1	100



Mt. Brown Reserve
Dieback Occurrence

Datum: GDA 1994
Projection: MGA Zone 50

Scale: 1: 5,000 at A3

Date: 10/02/2020	Prepared: K. Jennings	Project No: T19026
Expiry: 4/11/2020	Checked: J. Grehan	
Figure 2		
Revision: Rev A		
Review:		

11 Appendices

Appendix A: VHS Laboratory Sample Result Sheet

VEGETATION HEALTH SERVICE - PHYTOPHTHORA SAMPLE INFORMATION SHEET

SEND TO: VHS Lab, Forest and Ecosystem Management Div - DPaW, 17 Dick Perry Ave KENSINGTON 6151 Phone: (08) 9334 0317 Fax: (08) 9334 0114

CONTACT DETAILS of sender

Name: Joe Grehan
 Phone No. 9250 116 ; M: 0400 003 688; E: joeg@terratree.com.au
 DPaW Office or Company Name: Terratree Pty Ltd

GDA (1)
 GDA 94 X

Job Type (Please indicate)
 DPaW (C) Alcoa (A)
 Recoup (R) FPC
 Private (P) Other _____

VHS USE ONLY
 Date received 11.11.19
 Date faxed 26.11.19

NOTIFY DFWA?

6/2/20

VHS Identification Number (VHS USE ONLY)	Sample Date	Sample label (Give location, eg. Forest Block or Shire, etc. and sample number)	Plant species sampled	Site Impact (2)	Zone 50 or 51	Map Reference (3)	Land Tenure (4)	RESULT sample	RESULT bait (5)
VHS 40202 	4/11/19	MBS01	Soil Only	L	50	E 479 716 N 647 1773	R		P. rosacearum (*)
VHS 40203 	4/11/19	MBS02	Soil Only	L	50	E 479 900 N 647 2654	R	NEG	Pythium mercuriale (*)
VHS 40204 	4/11/19	MBS03	Soil Only	L	50	E 649 944 N 747 2319	R	NEG	P. mercuriale (*)
						E --- N ---			
						E --- N ---			
						E --- N ---			
						E --- N ---			
						E --- N ---			

NOTES:

1. Please tick this box if your map references are supplied in the GDA 94 standard. If not, please specify the datum used.
 2. Site impact - Low, Moderate, or High (as in the Dieback Interpreter's Manual).
 3. An MGA map reference with prefixes **must** be supplied for all samples.
 4. Land Tenure - State Forest (SF), National Park (NP), Reserve (R), Westrail (W), Private (P), Gravel Pit (GP), or other. (Other - describe in comments below).
 5. Result codes used - CIN = *Phytophthora cinnamomi*, MUL = *P. multivora*, CRY = *P. cryptogea*, PI = *P. inundata*, ARE = *P. arenaria*, ELO = *P. elongata*, THE = *P. thermophila*, = *P. megasperma*, PN = *P. nicotianae*, CON = *P. constricta*, ALT = *P. allicola*, NEG = negative, SUB = subcultured for further tests
- Please Note: a). NEG results cannot be used to represent a total absence of *Phytophthora* in the sampled area. b). Information from your samples will be incorporated into the VHS database.

COMMENTS: MB = Mount Brown

⊗ ID by cpsm using DNA techniques

PM

Appendix B: Standard Dieback Signage: Protocol for Use

Standard Dieback Signage Protocol for Use May 2008



This document sets out the protocols for the use of Standard Phytophthora Dieback Signage on all land tenures in Western Australia.



Department of
Environment and Conservation



Project
DIEBACK
Protecting biodiversity from Phytophthora Dieback
NATURAL RESOURCE MANAGEMENT WESTERN AUSTRALIA





Standard Dieback Signage Protocol for Use

Summary

Any person or organisation responsible for the management of lands either with or neighbouring native vegetation in the South West of Western Australia should consider the threat that *Phytophthora Dieback* presents to the maintenance of biodiversity. This is important particularly for areas receiving more than an average annual rainfall of 400mm.

A professional assessment should first be made to determine the disease status of an area. Standard signage is then available which can be used to insure protection of disease free areas.

A range of signs are available depending on the management objectives for an area or works and activities planned.

The signage system is based on the following status symbols:



Soil, gravel, sand and plant material should never be moved from areas that are known to be infested to areas known to be disease free. It is important to get the message across “Be Clean in the Green” and “Don’t Spread the Red”.

Interpreting the disease status of areas can be difficult especially as many areas of the South West have been affected for many decades. Signage should only be used if qualified environmental consultants have sampled and verified the disease situation in an area.

There are many reasons for the cause of plant deaths so it is important to confirm presence of *Phytophthora cinnamomi* in any candidate areas for signage. However, if field interpretation is not available in the short term for a potentially threatened area, non-mapped “Dieback Protection Area” signs are available until a *Phytophthora Dieback* assessment can be made.

Project Dieback, in conjunction with the State Dieback Consultative Council (DCC), Dieback Working Group (DWG) and Department of Environment & Conservation (DEC), have developed this standard dieback signage system to assist in the management of Phytophthora Dieback. Project Dieback is a Natural Resource Management (NRM) initiative to protect environmental, social and economic values from the dieback threat in Western Australia. The Australian Government and Western Australian Government fund the project through the joint National Action Plan for Salinity and Water Quality programme and the Natural Heritage Trust.



Introduction

The south west of Australia is extensively invaded by the introduced soil borne water mould *Phytophthora cinnamomi* known as Phytophthora Dieback. The pathogen is recognised as one of the key threatening processes to Australian biodiversity.

Humans are the greatest vectors in spreading Phytophthora Dieback. People can carry the plant pathogen from infested areas in many ways. Often by mud on footwear or vehicles, shifting infested soil or gravel, grading roads or moving infected plant material.

The aim of the signage is to raise dieback awareness and to assist land managers, operations staff and contractors involved in any earthworks to minimise the risk of spreading existing infestations and protecting areas still free from this invasive species.

The Western Australian Standard Dieback Signage System has been developed for use across all land tenures, including areas managed by local and state government, private property and mining areas. Land managers, government agencies, extractive industries and developers should use the signage system as part of an overall disease risk management plan to minimise the risks of establishing new infestations as a result of human activity.

The signage system is designed particularly to protect valued areas threatened by dieback following the field interpretation and mapping of *Phytophthora cinnamomi*. These areas may be identified as Dieback Protection Areas and dieback infestations can be delineated from dieback free areas using the signs.

The signage has a standardised series of designs to ensure consistency across land tenures and therefore higher recognition and understanding of the threat. Consequently, the signage will be the same format in national parks and reserves, mine sites, along road sides and in local government parks.

To be effective, signs must be considered an integral part of an area's overall management. Use of signage to guide public staff and contractors should be one component of management. Managers, government agencies and developers are advised to also adopt best practise disease management to minimise the risks of establishing new infestations as a result of soil movements.

This protocol describes the signage system, sets out a flow chart to graphically represent the sequencing of steps required to use the signs and provides information required for signage application, installation and management.



Standard Dieback Signage Protocol for Use

Standard Dieback Signage System

The signage system was designed as part of a state communication plan that aims to have consistent relevant themes and messages for stakeholder groups to use in Western Australia in regard to Phytophthora Dieback management.

The signs aim to enable people to gain the right message, do the right actions and be aware of Phytophthora Dieback in the environment.

The signage system is based on the following status symbols:



A range of signs and markers are available depending on an area's requirements including for roadsides, walk tracks and Dieback Protection Areas. (Section 1: Dieback Signs and markers.)



Picture 1: Example of Dieback Protection Area sign.

There is an option to have management logos integrated into Dieback Protection Area signs and changes to wording for specific area requirements. These wording changes however still need to be approved to ensure messages and themes are accurate and consistent with Phytophthora Dieback management.

The Dieback Signage flow chart sets out the procedure to follow in regard to using the signs.



Protocol Flowchart

The following flowchart provides guidance for incorporating the Standard Dieback Signage System into an area.





Section 1: Values Threatened by Dieback

Phytophthora Dieback impacts over 40% of the plant species in Southwest Australia which consequently threatens many environmental values including changes to ecosystems and destruction of habitats. Dieback threatens social and economic values impacting natural resources and horticultural industry.

When assessing the risks from Phytophthora Dieback, values should to be prioritised to ensure management resources are designated effectively.

Area may have access roads, tracks or drainage lines into other areas with values that are threatened by Phytophthora dieback and therefore neighbouring areas should to be taken into consideration in surveying values and Dieback Management planning. Hygiene control is advised during any ground survey.

An overall strategic risk assessment has been carried out for the south west of WA and is also a resource that can assist in value assessment. Details can be accessed through the www.dieback.org.au website as well as a list of the most susceptible species threatened by Phytophthora Dieback. The following lists some of the values that may be impacted.

Environmental Values

Environmental Values may include:

- healthy bushlands with susceptible plant communities,
- endangered plants,
- rare animal habitats.

A susceptible plant species list is available on www.dieback.net.au. Technical advice is available through your NRM Dieback officer, DEC or local environmental officer.

Social Values

Social Values may include:

- wildflower viewing areas,
- cultural places,
- bush tucker resources.

Economic Values

Economic Values may include:

- tourist areas,
- timber resources,
- nurseries
- susceptible horticultural plantations
- honey production.



Section 2: Dieback Interpretation and Mapping

Dieback Interpreters carry out a detailed procedure to determine the presence of Phytophthora Dieback (*Phytophthora cinnamomi*) in bushland and forest areas.

The presence of this soil borne pathogen is typically undertaken using a combination of aerial photography interpretation (API), assessment of existing vegetation using certain susceptible species as indicators and sampling soil and plants to confirm infestation through laboratory testing.

The determination of the presence of Phytophthora dieback requires significant technical knowledge and it is recommended that suitably qualified and experienced professionals undertake this assessment.

Consultants provide a Dieback report, management recommendations, detailed maps of dieback status/protectable areas and ground demarcation usually with coloured tape. Old mapping and demarcation may need to be refreshed as dieback has been known to move downhill over ten metres a year and even uphill one metre a year though root to root contact. Dieback status signage should only be used in areas where the dieback has been recently verified.

Phytophthora Dieback indicator plants include members of the Proteaceae, (Banksia, Grevillea, Hakea etc), Myrtaceae (Eucalyptus, Verticordia, Calothamnus etc), as well as species such as grasstrees (Xanthorrhoea sp.), and zamia palms (Macrozamia sp.). More details of susceptible can be found at www.dieback.org.au

Consultants that can provide assessment of lands and arrange analysis of soil samples for dieback can be found in Section 9: Contacts.



Section 3: Dieback Signs and Markers

1. Dieback Protection Area (DPA) Signs

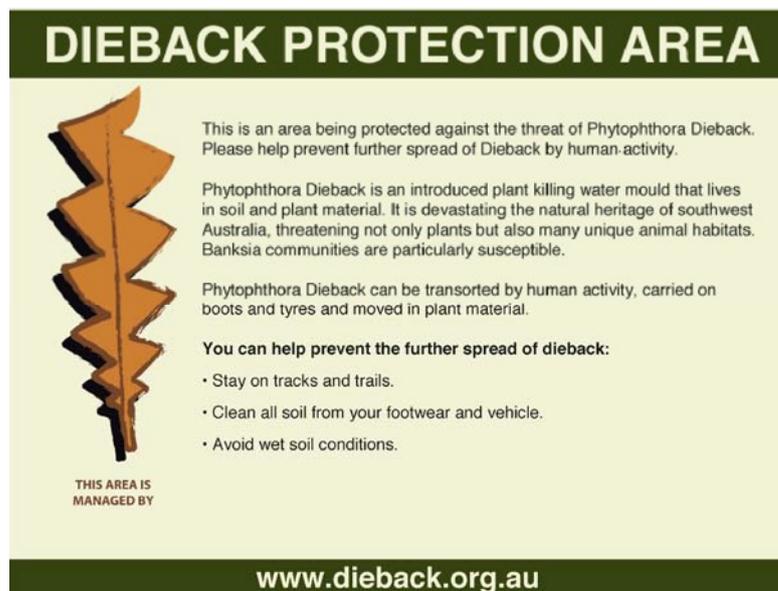
DPA Signs are digitally printed on 600 x 450 aluminium panels.

1.1 DPA Boundary Entry Signs for dieback mapped areas:



Item Code: DPA07-1

1.2 DPA Boundary Entry sign for non-mapped areas



Item Code: DPA07-2



Standard Dieback Signage Protocol for Use

1.3 DPA Boundary Entry Signs for Access By Permit Only Areas:



Item Code: DPA07-3

1.4 DPA Boundary Entry Signs for Hygiene Stations - Footwear:



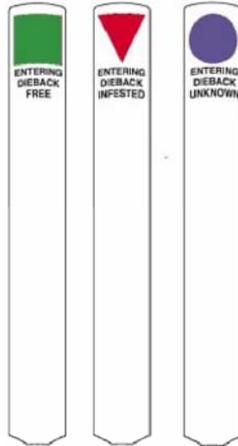
Item Code: BCS-1



Standard Dieback Signage Protocol for Use

2. Dieback Status Markers and Symbols

2.1 Dieback status boundary markers for roads and walk tracks are indicated using status stickers on white steelflex guideposts.



Item Codes:

Steelflex Posts - EDSF1300-WHT

Vinyl Stickers -

- Entering Dieback Free – EDF-TV
- Entering Dieback Infested – EDI-TV
- Entering Dieback Unknown – EDU-TV

2.2 Dieback status symbol alternative for roads and walk tracks are on 95 x 140mm aluminium panels.



Item Codes:

Aluminium Panels -

- Entering Dieback Free – EDF-TA
- Entering Dieback Infested – EDI-TA
- Entering Dieback Unknown – EDI-TA

2.3 Dieback status symbol indicators used within dieback status areas on 95 x 140mm aluminium panels or vinyl stickers.



Item Codes:

Aluminium Symbol Panels -

- Dieback Free Symbol – DF-SA
- Dieback Infested Symbol – DI-SA
- Dieback Unknown Symbol – DU-SA

Vinyl Symbol Stickers

- Dieback Free Symbol – DF-SV
- Dieback Infested Symbol – DI-SV
- Dieback Unknown Symbol – DU-SV

3. Ordering Signs

Signs may currently be ordered directly through Jason Sign Makers or through Cranmill Environmental Services, who are also able to provide organisations signage advice and can coordinate any changes and approvals to signs if required. (See Section 9: Contacts).



Section 4: Dieback Management and Signs Plan

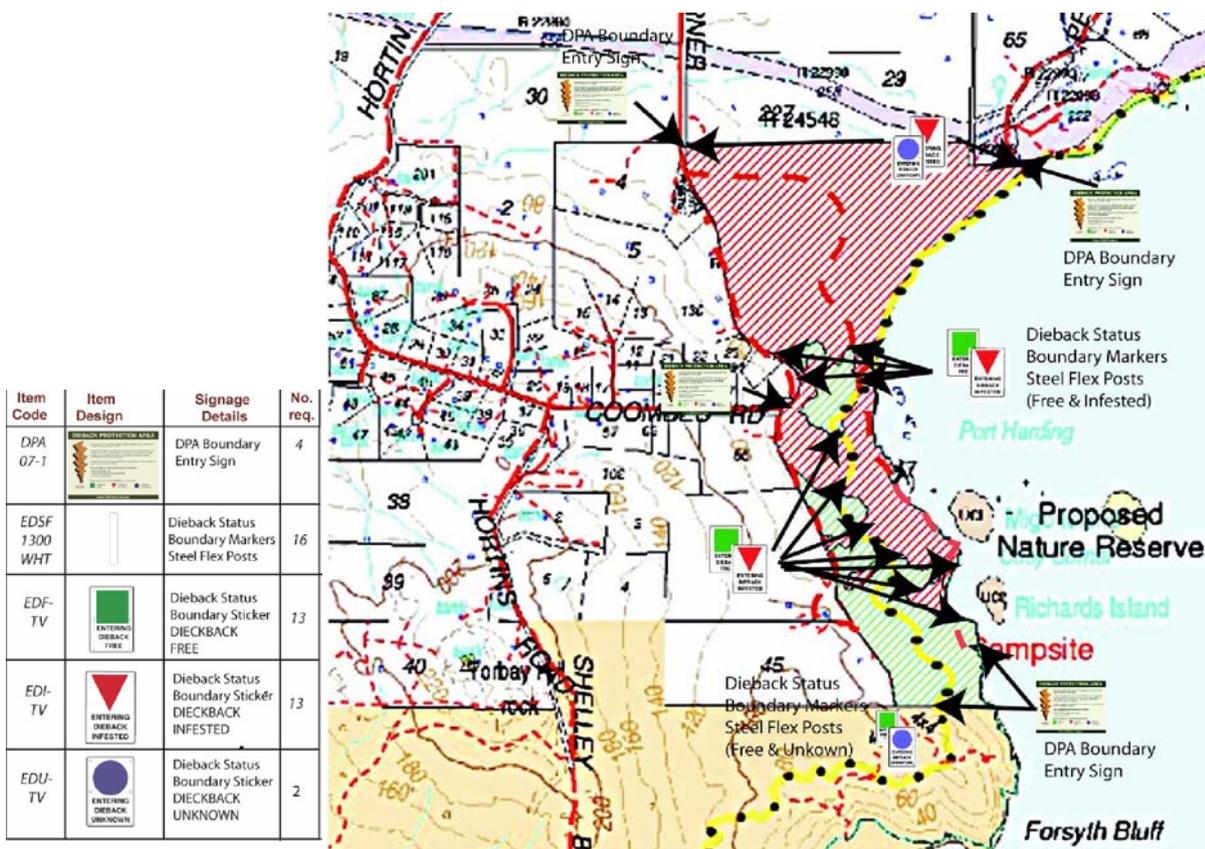
A signs plan is done in conjunction with the area's overall management plan. The Signs plan records required signs in regard to access points, awareness objectives, restrictions, hygiene stations and future predicted autonomous spread.

The Area Signage Plan should also designate hygiene requirements for installation and future dieback monitoring and signs review. It is essential that signs are maintained in good condition and a register of installations be made.

All Dieback Signage used in any area is to be documented as part of the signs plan and a summary is requested to be sent to the DCC State Register (Appendix 1).

Example of a Signs Plan Map

Phytophthora Dieback Signs Plan Map Cosy Corner Reserve, Albany





Section 5: Signage Installation Guidelines

The correct placement of signs along the dieback boundary and at entrances to areas affected by Dieback is important assist in reducing the spread of Phytophthora Dieback.

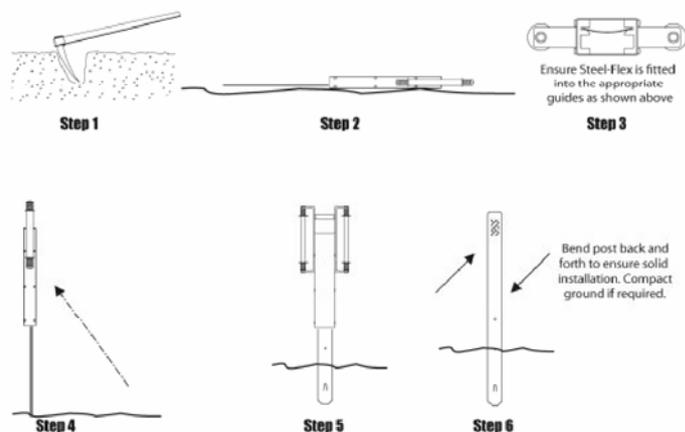
Dieback Protection Area Entry signs (DPA-071, DPA-072;) should be placed at road and walking trail entrances. This should be at a location where vehicle speeds are at a minimum such as a gate, or walking trail entrance. These signs should be installed on posts of sufficient length to enable them to be visible over any vegetation. 4x4 wooden posts are acceptable or the 2250 mm steel posts (code Calm2250-csa) which can be driven directly into the ground.

Posts for the delineation of the dieback front are to be Ezydrive Steel Flex posts. (Code EDSF1300-WHT) with self adhesive symbols (code DF-SA, DI-SA, and DU-SA) to be applied to the posts. These should be installed so that the posts are aligned with the axis of the dieback front as demarcated by the Dieback Interpreters.

Installation of the Posts

The easy drive steel flex posts from Rondo Building services are easy to install using a hand driver. It is critical that care is taken to ensure all equipment is clean before use in installation of posts. Signage should be installed under dry soil conditions and no soil should be moved on vehicles or equipment away from infested areas. Always install signs into disease free areas prior to any with in infested areas. Advice on hygiene and sterilants is provided in Section 7.

It is preferable to locate the correct location for the sign by GPS and ground demarcation. This information is to be provided by the mapping consultants. Be sure to place signs at the correct buffer width from the visible disease front (15m up slope or cross slope, and 25m + down slope depending on rate of spread.) This allows for cryptic disease which will be present but not showing symptoms. Buffers also allow for some movement of the disease as it grows.





Section 6: Standard Hygiene and Management

To manage Phytophthora Dieback in any area, there is a need to plan ahead. The introduction or human-assisted spread of the pathogen can be avoided if activities are well planned and management procedures are in place. Phytophthora Dieback management procedures must be integrated into all land management activities if the spread and impact of this organism is to be minimised.

Organisations such as the Department of Environment and Conservation (DEC), Alcoa World Alumina Australia and Main Roads WA follow procedures to minimise the risk of their activities spreading the pathogen. Many local governments are also adopting Phytophthora Dieback management policies and implementing management procedures. Anyone who owns, manages or uses a bushland area can also take steps to ensure that their activities don't introduce or spread the pathogen. Any operations which involve soil movement can put disease free areas at risk.

Standard hygiene and management may vary for each status area.

DIEBACK FREE	DIEBACK INFESTED	DIEBACK UNKNOWN
<p>Cleandown stations should be used to remove or sterilize mud and soil from footwear, equipment and vehicles when entering Dieback Free.</p> <p>Avoid moist soil conditions. Access may be restricted.</p>	<p>An effective hygiene cleandown must be carried out when leaving a Dieback Infested area into Dieback Free.</p> <p>Ensure no infested soil, gravel or plant material crosses the dieback boundary.</p>	<p>Areas are unknown if they have not been mapped or do not have indicators that identify the presence of Phytophthora Dieback.</p> <p>Areas may still have hygiene and access restrictions.</p>

Hygiene is essential to any operation or activity aiming to minimise the spread of Phytophthora Dieback. Next section details some guidelines applicable to the cleaning of vehicles, equipment and footwear. Also included are some points about sterilisation of water, equipment and footwear. Where practical it is preferable to use the dry cleaning methods (air compressor, brushes) rather than cleaning with water as it has a significantly lower chance of accidentally spreading the pathogen.

It should be noted that dust and grime on vehicles or equipment is not a threat in terms of spreading Phytophthora Dieback.



Section 7: Guidelines for cleaning vehicles/equipment

- Cleaning will be easier and more effective if completed at a depot or designated cleaning area.
- Field-based cleaning requires:
 - A hard, well-drained surface (e.g. road) that is well away from native vegetation. Any washdown effluent should be collected on-site and must not be allowed to drain bushland.
 - Minimise water use to remove soil and mud from equipment/vehicles. This can be achieved by preferentially dry cleaning techniques e.g. stiff brushes.
 - Washdown on ramps if possible.
 - Prevention of mud and slurry from entering into uninfested or uninterpretable bushland. Soil and water can be collected for sterilisation (see guidelines for sterilising below).
 - Pay particular attention to mudflaps and tyres.
 - Do not drive through effluent generated from cleaning when exiting the washdown facility.

Guidelines for cleaning footwear

- Try to remove mud and soil when it is dry. Remove as much mud and soil as possible with a stiff brush or stick and minimise the amount of water used.
- Collect all mud and soil removed and place in a bucket or bag for later disposal at a site that is infested with *P. cinnamomi* or that contains no native vegetation.

Guidelines for sterilising

- Sterilisation of equipment, footwear and vehicle tyres can be used to take an extra precaution. Sterilisation of nursery equipment using steam is common practice, however the use of steam is not practical in the field. The following sterilisation methods can be used in the field.
- Spray methylated spirits on small hand tools and footwear covering all surfaces and allowing a few minutes for it to soak into all soil material.
- Spray diluted bleach (sodium hypochlorite) onto equipment and footwear allowing a few minutes before rinsing the bleach off using water. Dilute bleach so that solution contains 1% active ingredient sodium hypochlorite. Be sure to follow any of the manufacturer's safety instructions provided on the bleach container.
- Spray Phytoclean® can be used in footbaths, washdown facilities and during the cleaning of equipment. See the manufacturer's details for directions.



Standard Dieback Signage Protocol for Use

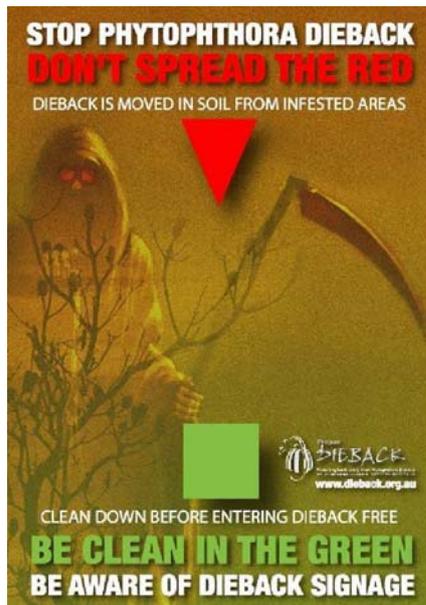
Section 8: Publications and resources

- “Signage For All” DL Pamphlet



Produced by Project Dieback April 2008

- “Botanical Grim Reaper Signage Awareness” A3 Posters



- Project dieback website www.dieback.net.au

Pamphlets and posters are free on request from South Coast NRM Inc. on Mercer Rd., Albany or Cranmill Environmental Services.



Section 9: Contacts

Dieback Consultants

Coffey Environments

Jeremy Spencer

61 Duke Street,
Albany 6330

Ph: 9892 6400

Mob: 0429 208 849

Fax: 9892 6444

Email: Jeremy_Spencer@coffey.com

Dieback Treatment Services

Glenn Tuffnell

PO Box 689
Gosnells WA 6990

Ph: 1300 785 311

Mob: 0428 785 311

Fax: (08) 939 765 55

Email: glenn@diebacktreatemnts.com

Ficifolia Consulting

Simon Watkin

5 Warthwyke court
Bayonet Head.
Albany WA 6330

Ph/Fax: 98 44 9505

Mob: 0400 003 521

Email: simon.watkin@bigpond.com

GHD Bunbury Office

Bruno Rikli

10 Victoria Street
Bunbury WA 6230

Ph: 9721 0700

Mob: 0400 208 582

Email: bruno.rikli@ghd.com.au

Glevan Consulting

Evan Brown

50 Chatsworth Drive,
Erskine. 6210.

Ph: 08 9582 7772

Mob: 0427 12 7772

Fax: 08 9582 9884

E-mail: mail@glevan.com.au

Moore Mapping Pty Ltd

Ian Moore

P O Box 924
Manjimup WA 6258

Ph: 0897771435

Mob: 0418612815

Email: itemoore@primus.com.au

Woodman Environmental Consulting Pty Ltd

Greg Woodman

Ph: (08) 9315 4688

Fax: (08) 9315 4699

Mobile: 0408 940 589

email: office@woodmanenv.com.au

Ordering Signs

Cranmill Environmental Services

12A Wanliss Street
Jarrardhdale

Ph: 08 95260126

Mob: 0407748799

Email Cranmill_env@bigpond.com

Jason Signs

54 Kurnall Road,
WELSHPOOL WA 6106

Ph: 08 9458 7033

Fax: 08 9458 8552

Web: jsm.net.au



State Dieback Signs Register

The following Signage Summary Sheet should be completed and copied for each area where signage is installed. A copy should be sent to Cranmill Environmental Services who are coordinating the state register funded by Project Dieback on behalf of the Dieback Consultative Council.

Reserve or Location:	
Central GPS Reading:	Closest road name:
Contact person or position:	
Organisation:	
Phone:	
Email:	
Values at risk:	
 DPA Entry with Status Symbols	Total Number Used: <input type="text"/>
 DPA Entry without Status symbols	Total Number Used: <input type="text"/>
 Boot Cleaning Station	Total Number Used: <input type="text"/>
 Road/Track Posts	Total Number Used: <input type="text"/>
 Track Markers Panels 95 x 140 (Aluminium)	Total Number used: <input type="text"/>
 Track Markers 95 x 95 (Aluminium)	Total Number Used: <input type="text"/>
Dieback interpretation done by:	
Date of installation:	
Monitoring of disease fronts in vicinity of signs.	Dates to be visited by officer responsible.
Comments/Requests:	



Standard Dieback Signage Protocol for Use

Acknowledgements



Great Southern TAFE

Students assisted in developing this system and have also developed icons representing values and threats which could be made available if any land managers felt they would assist them in communicating with the public.