

Bindaminna North and Bindaminna South: Linear Dieback Assessment

Prepared for Image Resources

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Executive Summary

In August 2017, Image Resources engaged Terratree Pty Ltd (Terratree) to undertake a linear *Phytophthora* Dieback (Dieback) assessment of approximately 36.436 km of proposed exploration drill lines over the Bindaminna North and Bindaminna South project areas (the 'assessment area'). These areas are located within exploration tenements E70/3298, E70/2844 and E70/4794.

The assessment area lies within the Swan Coastal Plain Subregion of the Drummond Botanical Subdistrict, as described in *Plant Life of Western Australia* (Beard, 1990). The Drummond Botanical Subdistrict is described as 'Mainly *Banksia* low woodland on leached sands with Melaleuca swamps where ill-drained; woodland of Tuart (*Eucalyptus gomphocephala*), Jarrah (*E. marginata*) and Marri (*Corymbia calophylla*) on less leached soils. The climate is described as 'warm Mediterranean', with winter precipitation of 600-1000mm and 5-6 dry months per year.

The Dieback assessment was undertaken 12-13 September 2017 by DPaW registered Dieback Interpreters Joseph Grehan and Kelby Jennings and was undertaken in accordance with *FEM047 Phytophthora Dieback Interpreter's Manual for lands managed by the department*. (Forest and Ecosystem Management Division (FEMD), 2015).

A total of five soil and tissue samples were taken from recently dead indicator species, predominately *Banksia attenuata* and *B. menzeisii*. All samples returned a negative result for *P. cinnamomi* or other *Phytophthora* species.

The Dieback assessment found no Dieback infestations within the assessment area. The whole of the assessment area (181.57ha) was categorised as uninfested and protectable. Therefore, appropriate hygiene measures should be implemented to ensure that the *Phytophthora* pathogen is not introduced to the assessment area.

Terratree recommends that all vehicles and other ground moving equipment be inspected and verified clean of any soil or vegetative matter before entry to the assessment area to minimise the risks associated with *Phytophthora* dieback, invasive weed species and other biosecurity issues.

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1 Introduction

In August 2017, Image Resources engaged Terratree Pty Ltd (Terratree) to undertake a linear *Phytophthora* Dieback (Dieback) assessment of approximately 36.436 km of proposed exploration drill lines over the Bindaminna North and Bindaminna South project areas (the 'assessment area'). These areas are located within exploration tenements E70/3298, E70/2844 and E70/4794.

This assessment is required to determine and report on the disease status of the assessment area, and to use this information in the development of a Strategic Conservation Management Plan to be implemented during exploration.

The Dieback assessment was undertaken in accordance with *FEM047 Phytophthora Dieback Interpreter's Manual for lands managed by the department*. (Forest and Ecosystem Management Division (FEMD), 2015).

1.1 Project Location

The assessment area is located in the Shire of Gingin, approximately 125km north of Perth and 26km east of Lancelin.

Bindaminna North is located north of the Moore River, approximately 17km west of Reagans Ford. Significant biodiversity values in the local area include Namming Nature Reserve to the north and South Mimegarra Nature Reserve to the west.

Bindaminna South is located south of the Moore River, approximately 8.5km east of Cowalla. Significant biodiversity values in the area include a Conservation Category wetland which intersects the assessment area (UFI 9231) and the Moore River National Park.

1.2 *Phytophthora* Dieback

Dieback is a soil borne pathogen with a range of hosts in the southwest of WA, predominantly from the Proteaceae, Ericaceae, Myrtaceae, Xanthorrhoeaceae and Fabaceae plant families. 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). Numerous species of *Phytophthora* are found in southwest WA, both introduced and endemic, with the most virulent and pathogenic form being the introduced *P. cinnamomi*.

According to the most recent Western Australian State of the Environment Report, Dieback (listed as a Priority 1 threat) is the third greatest threat to biodiversity after salinity and climate change (EPA, 2011). It is considered a more serious threat than weeds, clearing of native vegetation, acid sulphate soils and soil erosion. The effect of Dieback is significant in WA because:

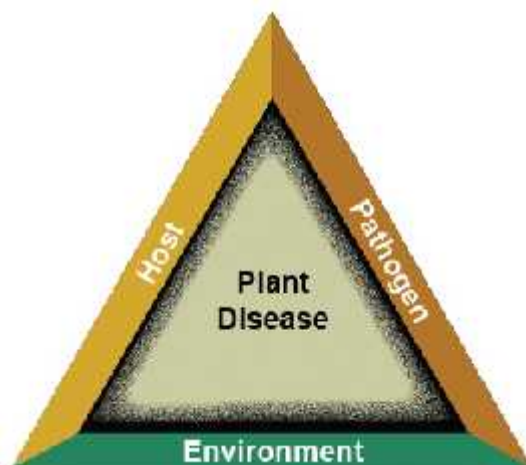
- Over 40% (2,300) of the native plant species, including half of endangered plant species, in the south-west of WA are susceptible to the pathogen;
- Changes in the composition and structure of floral communities as a result of Dieback has impacts throughout the whole ecosystem, including impacts on the indigenous fauna; and
- Dieback can lead to significant soil erosion as a result of the loss of susceptible vegetation.

Dieback is spread through the movement of water and soil within the landscape. Major vectors of Dieback include, but are not limited to, wet soil adhering to vehicle tyres/tracks and earthmoving equipment. Therefore, quarantine management procedures are an effective tool to reduce the spread of Dieback as a result of earthmoving activities.

Three variables are required to have disease expression caused by Dieback:

1. **Host** - plant species present that are susceptible to *Phytophthora* spp. (i.e. *Banksia*, *Hakea*, *Leucopogon*, *Xanthorrhoea* spp.).
2. **Pathogen** - The *Phytophthora* pathogen must be present in the landscape, residing either in susceptible or resistant plant species.
3. **Environment** - Soil temperatures between 15-30° C and pH 5-6 (acidic) are required for *P. cinnamomi* survival and activity. Some species, including *P. multivora*, can survive in alkaline soils (pH 7+).

The disease triangle below represents the three variables required to have disease expression caused by Dieback.



The *Phytophthora* Dieback pathogen is widespread in areas with greater than 800 mm of annual rainfall, less extensive in areas that receive between 600–800 mm, and mainly restricted to water-gaining sites in areas that receive 400–600 mm. The pathogen only very rarely occurs in areas that receive less than 400 mm of annual rainfall. In Western Australia Dieback is a significant environmental issue for projects between Geraldton in the Midwest and Esperance on the South Coast, and is widespread in the Southwest region.

1.3 Regulatory Context

Phytophthora Dieback management is required under several regulatory mechanisms including:

- *Environmental Protection Act* (1986) Part V S.50A “Serious Environmental Harm” provisions;
- Projects being assessed under the *Environmental Protection Act* (1986) which require Department of Biodiversity, Conservation and Attraction (DBCA) and/or Department of Mines Industry Regulation and Safety (DMIRS) to comment on Dieback management and provide these agencies with the right to impose conditions to new approvals; and
- All operations – *Phytophthora* Dieback is listed as a Key Threatening Process with the Federal Government under the *Environment Protection and Biodiversity Conservation Act* (1999).

Existing Environment

1.4 Biogeography

The assessment area is located within the Swan Coastal Plain 2 (SWA2) subregion, in accordance with the Interim Biogeographic Regionalisation for Australia (IBRA). The IBRA system identifies 89 bioregions and 419 subregions across Australia, based on climate, geology, landforms and characteristic vegetation and fauna.

Mitchell, Williams and Desmond (2002) describe the SWA2 subregion (1,333,901 ha) as a low lying coastal plain, dominated by Banksia or Tuart on sandy soils, *Casuarina obesa* on outwash plains and paperbark in swampy areas. The plain rises to duricrusted Mesozoic sediments dominated by Jarrah woodland in the east, with three phases of marine sand dune development providing relief to the west.

The Perth subregion is composed of colluvial and Aeolian sands, alluvial river flats and coastal limestone. Vegetation comprises heath and/or Tuart woodlands on limestone, Banksia and Jarrah/Banksia woodlands on Quaternary marine dunes and Marri on colluvials and alluvials. The climate is Mediterranean, with annual rainfall ranging between 600 to 1000mm.

Dominant land uses include urban development, dry land agriculture, Unallocated Crown Land and Crown reserves, conservation, forestry plantations, and road easements and infrastructure.

1.5 Soils

The Digital Atlas of Australia (Bureau of Rural Science, 1991) identifies the soil types occurring within the assessment area as cb39, described as:

‘subdued dune-swale terrain, with chief soils being leached sands (Uc2.33), with (Uc2.22) and (Uc2.21) on the low dunes. Associated are small areas of other sand soils (Uc).’

P. cinnamomi is generally found within slightly acidic soils, with an optimal pH range of 5-6. Although *P. cinnamomi* can be recovered in neutral soils, it is unlikely to occur within alkaline soils. Other *Phytophthora* species, such as *P. multivora* and *P. citricola*, have been known to occur in soils that are antagonistic to the *P. cinnamomi* pathogen. The described soil type is considered likely to contain areas with favourable pH values for both *P. cinnamomi* and other *Phytophthora* species.

1.6 Regional Vegetation

The assessment area lies within the Swan Coastal Plain Subregion of the Drummond Botanical Subdistrict, as described in *Plant Life of Western Australia* (Beard, 1990). The Drummond Botanical Subdistrict is described as ‘Mainly *Banksia* low woodland on leached sands with *Melaleuca* swamps where ill-drained; woodland of Tuart (*Eucalyptus gomphocephala*), Jarrah (*E. marginata*) and Marri (*Corymbia calophylla*) on less leached soils. The climate is described as ‘warm Mediterranean’, with winter precipitation of 600-1000mm and 5-6 dry months per year.

In accordance with pre-European vegetation mapping in Western Australia, based on the *Beard 1:250,000 series*, the assessment area intersects the Bassendean/Koojan_1030 complex (Department of Agriculture, 2005), while vegetation mapping of the Swan Coastal Plain conducted by Heddle (1980) places it within the Bassendean – North vegetation complex. **Table 1** describes the vegetation composition and structure of these complexes and analyses their interpretability for Dieback.

Table 1: Vegetation Complexes within assessment area

Source	Assessment Area	ID	Name	Structure	Vegetation Composition	Interpretability for Dieback
Department of Agriculture (2005)	Bindaminna North	1030	BASSENDAN-KOOJAN	Banksia woodland	U ⁺ <i>Banksia attenuata</i> , <i>Banksia menziesii</i> , <i>Eucalyptus todtiana</i> \tree\6\i;M <i>Adenanthos cygnorum</i> , <i>Allocasuarina humilis</i> , <i>Jacksonia furcellata</i> \shrub,xanthorrhoea\4\r;G <i>Anigozanthos humilis</i> , <i>Conostylis aculeata</i> , <i>Eremaea fimbriata</i> \forb,shrub,xanthorrhoea,cycad\2\i	Interpretable for Dieback.
Department of Agriculture (2005)	Bindaminna South	949	BASSENDAN	Banksia woodland	U1+ <i>Banksia attenuata</i> , <i>Banksia menziesii</i> , <i>Eucalyptus todtiana</i> , <i>Nuytsia floribunda</i> , <i>Allocasuarina fraseriana</i> \tree\6\i;G1 <i>Conospermum incurvum</i> , <i>Verticordia nitens</i> \shrub\4\c	Interpretable for Dieback.
Heddle (1980)	Bindaminna North and Bindaminna South	43	Bassendean Complex - North	Low Open Forest and Low Woodland and Sedgelands	Vegetation ranges from low open forest and low woodland of <i>Banksia</i> spp. and <i>Eucalyptus todtiana</i> to low woodland of <i>Melaleuca</i> spp. and sedgelands that occupy the moister sites.	Interpretable for Dieback in areas with <i>Banksia</i> spp. Uninterpretable in <i>Melaleuca</i> woodland and sedgeland.

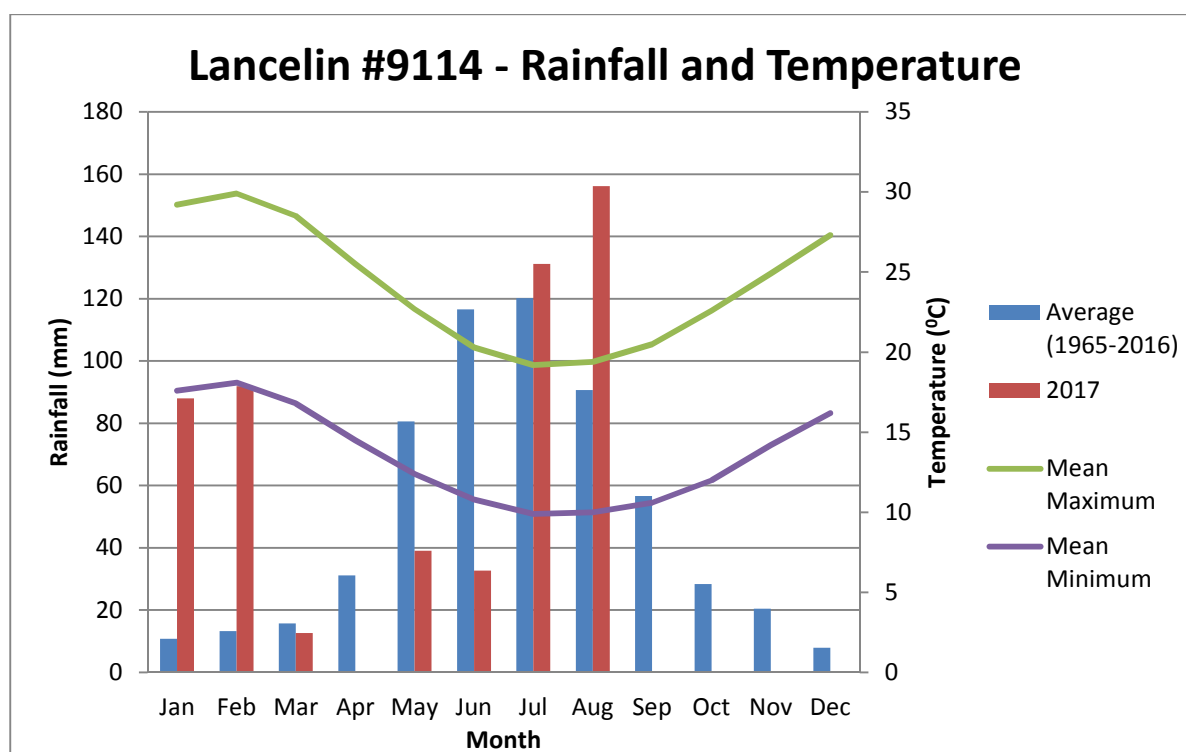
1.7 Climate

The assessment area experiences an Interior Mediterranean climate under the Köppen climate classification system, characterised as mild, with dry, hot summers, where the warmest month averages $>22^{\circ}\text{C}$, with a winter-dominant rainfall (Pidwirny, 2011).

Weather station Lancelin (#9114), located approximately 22.5km west of the assessment area, receives an annual average of 602.2mm, placing it near the low-rainfall zone, where Dieback is predominately restricted to water-gaining sites.

Recorded winter rainfall in the months prior to the assessment was variable, with low rainfall during April - June offset by significant rainfall in July and August (Error! Reference source not found.). Recorded cumulative rainfall for April-August 2017 is 359mm, representing 81.8% of the long-term average of 439mm.

The late start to significant rainfall and low soil temperatures experienced during winter months are likely to result in low pathogen activity. However, the significant rainfall events recorded in January and February 2017, combined with the optimal soil temperatures experienced during warm summer months, are likely to have activated any viable inoculum within the soil profile. This expected pathogen activity greatly increases the likelihood of observing recent Indicator Species Deaths and obtaining accurate results from soil and tissue samples.



Graph 1: Climate data for Lancelin (BoM, 2017)

1.8 Historical Land Use and Disturbance

Land use in surrounding areas includes rural agricultural land, beekeeping, nature reserves and national parks. Assessment areas had evidence of uncontrolled public access, including 4WD vehicles, which represents a potential vector for the introduction and spread of Dieback.

Methods

1.9 Desktop Review

A desktop assessment was undertaken prior to the field assessment to gather background information about the assessment area and surrounding landscape. Maps of the area were accessed through the Dieback Information Data Management System (DIDMS). DIDMS maps use data from the Vegetation Health Services Laboratory to identify *Phytophthora*-positive sample results and Dieback probability mapping from previous assessments, with pertinent literature and biological reports to be reviewed as available. The desktop assessment also sought to use aerial imagery and topographical contour mapping to:

- Identify access to the assessment area and internal tracks;
- Examine topography and drainage of the assessment area and boarder landscape;
- Identify possible disease vectors e.g. tracks, drainage channels, utility corridors and ground disturbance; and
- Determine the location of high risk areas (e.g. areas of high disturbance and water-gaining sites).

1.10 Field Assessment

The Dieback assessment was undertaken 12-13 September 2017 by DBCA registered Dieback Interpreters Joseph Grehan and Kelby Jennings. The linear Dieback assessment was undertaken in accordance with the Dieback Interpreter Guidelines (FEMD, 2015).

1.10.1 Linear Assessment

In accordance with FEMD (2015), the linear assessment involved a visual assessment of native vegetation along a 50-metre-wide corridor over the proposed exploration drill lines. The assessment area was accessed by 4WD, with high risk areas, including all potentially uninfested vegetation, assessed on foot. Evidence of the presence or absence of Dieback was recorded using GPS units, and soil and tissue samples of recently dead disease indicator species were collected for analysis. When necessary, areas outside the linear corridor, including watercourses and disturbed areas, were assessed to determine the broader landscape context and to ensure areas mapped as uninfested are protectable. Spatial data, including disease evidence points and sample locations, was recorded using handheld GPS units.

All soil and tissue samples were lodged with the DBCA's Vegetation Health Services Laboratory (VHS) where diagnostic baiting was conducted. All sample point locations were recorded using georeferenced photos.

1.10.2 Dieback Occurrence Categories

The Dieback Interpreter Guidelines categorise areas in which the native vegetation has been significantly degraded or cleared as 'excluded' from assessment. The Keighery vegetation disturbance scale presented in

Table 2 was used to determine the assessability of disturbed areas (FEMD, 2015). Areas of vegetation may be excluded based on a condition rating of Good (subject to Interpreter discretion) to Completely Degraded. In these areas, significant impacts to vegetation, including grazing, intensive forestry harvesting, weed incursion and frequent fire events, have altered vegetation composition and structure so that it is unlikely to recover in the medium- to long-term. Non-vegetated areas that are excluded from assessment include pasture, pits (including gravel pits), large roads (sealed and unsealed), permanently flooded areas and parkland tree stands. Excluded areas are distinguished from 'temporarily uninterpretable' areas by the fact that they cannot regenerate naturally and eventually become mappable.

Table 2: Keighery Vegetation Disturbance Scale and Assessability (as referenced 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.

Table 3 presents the *Phytophthora* occurrence categories, impacts and syndromes (FEMD, 2015). The ‘temporarily uninterpretable’ category is allocated to areas of native vegetation which have been disturbed, but will recover over time and become interpretable and therefore mappable. Examples of temporarily uninterpretable areas include vegetation that has been impacted by fire, grazing, timber harvesting, temporary flooding and poisoning. Recovery in temporarily uninterpretable areas may take longer than 3 years

The vegetation of ‘uninterpretable’ areas can range from Pristine to Very Good; however, they contain insufficient diversity and/or quantities of disease indicator species. Therefore, determining whether the pathogen is present in resistant hosts or as zoospores in permanent water bodies is not possible using interpretation methods. Uninterpretable areas that meet the protocols for identifying Protectable Areas (CALM, 2004) are managed as being both infested and uninfested so that the pathogen is neither imported into, nor exported from, these areas.

Table 3: *Phytophthora* occurrence categories, impacts and syndromes (FEMD, 2015)

	<i>Phytophthora</i> occurrence category	Typically present	May be present
<p>Naturally vegetated areas</p> <p>Keighery disturbance rating of 3 or less. <i>Phytophthora</i> occurrence categorisation is possible.</p> <p>Small un-vegetated 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.</p> <p><i>Phytophthora</i> 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
Road disturbance area	DISEASE RISK ROAD (DRR)	Unformed track with shoulders of interpretable vegetation	Shoulders and batters with regenerated vegetation. Incipient infestation
<p>Vegetation structure severely altered.</p> <p>Keighery disturbance rating 5 or greater. <i>Phytophthora</i> occurrence assessment is not possible.</p> <p>Can be determined by desktop assessment (aerial photo).</p> <p>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

1.10.3 Disease Indicator Species

Disease indicator species observed within the assessment area include representatives of the Proteaceae, Myrtaceae and Xanthorrhoeaceae families. *Banksia menzeisii* and *B. attenuata* were the most abundant indicator species observed in the assessment area, with secondary indicators, including *Eucalyptus todtiana*, *Adenanthos cygnorum* and *Xanthorrhoea preissii*, also used to provide supplementary evidence. Indicator species observed during the field assessment are listed in **Table 4**.

Table 4: Disease Indicator Species

Family	Species
Casuarinaceae	<i>Allocasuarina humilis</i>
Dasypogonaceae	<i>Dasypogon bromeliifolius</i>
Dilleniaceae	<i>Hibbertia subvaginata</i>
Ericaceae	<i>Conostephium pendulum</i>
Fabaceae	<i>Daviesia decurrens</i>
	<i>Daviesia horrida</i>
	<i>Daviesia nudiflora</i>
	<i>Jacksonia floribunda</i>
	<i>Jacksonia furcellata</i>
	<i>Jacksonia sternbergiana</i>
Iridaceae	<i>Patersonia occidentalis</i>
Myrtaceae	<i>Eucalyptus todtiana</i>
Proteaceae	<i>Adenanthos cygnorum</i>
	<i>Banksia attenuata</i>
	<i>Banksia ilicifolia</i>
	<i>Banksia laricina</i>
	<i>Banksia menzeisii</i>
	<i>Banksia prionotes</i>
	<i>Hakea ruscifolia</i>
	<i>Petrophile linearis</i>
	<i>Stirlingia latifolia</i>
	<i>Synaphea</i> sp.
Xanthorrhoeaceae	<i>Xanthorrhoea preissii</i>
Zamiaceae	<i>Macrozamia fraseri</i>

1.10.4 Sampling

Soil and tissue samples were taken from the roots and collar of recently dead or dying disease indicator species to confirm the presence, or indicate the possible absence of Dieback, and to inform interpretation of the area.

Sampling strategies for the assessment of Dieback were implemented with regard to resolving the following potential hypotheses:

- **Sampling to support infested diagnosis:** Recently dead and dying indicator species were sampled to support an infested diagnosis.
- **Sampling to supporting an uninfested diagnosis:** Recently dead and dying indicator species were sampled to support an uninfested diagnosis. A cautious approach must be adopted when claiming that a negative result means that an area is Uninfested, as false negative results can be

recorded when inoculum levels are depleted due to prolonged unfavourable environmental conditions for the pathogen.

All sampling strictly adhered to the following procedures:

- All tools used in sampling were thoroughly sterilised with a 70:30 mixture of methylated spirits and water before samples were taken. Tools were dry prior to sampling so that the results were not compromised;
- The plant sampled was excavated to a depth to ensure that adequate plant tissue material can be obtained from the roots and cambium layer around the collar of the plant being sampled;
- Material from all around the plant was taken, in addition to any obvious lesions, to avoid missing any infected material. Plant tissue material soil from around the roots and other places in the soil profile were placed in a polythene bag;
- All relevant information pertaining to the plant sampled and sample location was recorded on the Sample Information Sheet;
- Two aluminium tags which provide the date, project name, sample number, species sampled and the name of the interpreter were written. One tag was placed in the sample bag and the other was tied near the sample site, which was also demarcated with a fluorescent pink flagging tape;
- The sample hole was backfilled to prevent fauna becoming trapped; and
- All tools were brushed off (to remove excess soil) and sterilised to prevent contamination of the next sample site and sample.

1.11 Mapping

Spatial data, including tracks, disease occurrence data and disease boundaries, were recorded on hand-held Global Positioning Satellite (GPS) units. This data was downloaded into a Geographical Information Program and used to map Dieback occurrence within the assessment area.

1.12 Protocols for Identifying Protectable Areas

In accordance with the Dieback Interpreters Guidelines (FEMD 2015), 'Protectable Areas' are defined as areas of native vegetation that meet the following criteria:

- 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 situated in areas receiving more than 600 millimetres rainfall a year or those that are water-gaining sites (for example, granite outcrops, impeded drainage or engineering works which aggregate rainfall) in the 400- to 600-millimetres a year rainfall range;
- Consists of areas where human vectors are controllable (e.g. not an open road, private property); and
- Are positioned in the landscape and are of sufficient size such that a qualified Interpreter judges that the pathogen will not autonomously engulf them in the short term (a period of a few decades); or
- Includes areas of high conservation and/or socio-economic value (for example, a small uninfested area with a known population of a susceptible species of Threatened flora). (DPaW 2015, page 113).

Further to this definition, protectable areas may also include Uninterpretable areas. Uninterpretable areas that meet the protocols for identifying Protectable Areas (CALM, 2004) are managed as being both infested and uninfested so that the pathogen is neither imported into, nor exported from, these areas.

1.13 Limitations

The following limitations were encountered during the assessment:

- The impact of drought on vegetation susceptible to *Phytophthora* made interpretation more difficult; and
- The impact of canker on vegetation susceptible to *Phytophthora* made interpretation more difficult.

Results

1.14 Desktop Review

The desktop review identified the vegetation within the assessment area as Banksia woodland, which is interpretable for *p. cinnamomi* and other *Phytophthora* species.

Native vegetation appeared to be intact and continuous, with no obvious signs of human impact to vegetation from clearing, grazing or other land uses.

No high-risk disease vectors were identified during the desktop review.

1.15 Sample Results

A total of five soil and tissue samples were taken from recently dead indicator species, predominately *Banksia attenuata* and *B. menzeisii*.

All samples returned a negative result for *P. cinnamomi* or other *Phytophthora* species. Sample information is detailed in Error! Reference source not found. below (**Appendix 1**).

Table 5: VHS sample results

Sample No.	Species	Easting GDA 94 Zone 50	Northing GDA 94 Zone 50	VHS Laboratory Results
IR – S01	<i>Banksia attenuata</i>	359425	6569377	Negative
IR – S02	<i>Banksia attenuata</i>	360009	6572101	Negative
IR – S03	<i>Banksia menzeisii</i>	360119	6567749	Negative
IR – S04	<i>Xanthorrhoea preissii</i>	367182	6558998	Negative
IR – S05	<i>Banksia menzeisii</i>	363835	6562575	Negative

1.16 Dieback Occurrence

The occurrence category area statements for Bindaminna North and Bindaminna South, along with the total assessed area statement, are listed below in **Table 6**.

Table 6: Dieback occurrence area statement

Area	Dieback Occurrence Category	Length (m)	Area (ha)	% of Assessment Area
Bindaminna North	Uninfested	25629	127.52	70.23
	Sub-total	25629	127.52	70.23
Bindaminna South	Uninfested	10807	54.05	29.77
	Sub-total	10807	54.05	29.77
TOTAL		36436	181.57	100.00

Discussion

The Dieback assessment found no areas of Dieback infestation within the assessment area. The whole of the assessment area (181.57ha) was categorised as uninfested and protectable.

Five soil and tissue samples were subject to diagnostic baiting, with all samples returning a negative result for the presence of *P. cinnamomi* or other *Phytophthora* species. The assessment found the whole of the assessment area to be categorised as uninfested (**Figure 1**).

1.17 Bindaminna North

1.17.1 Infested Areas

Infested vegetation can be diagnosed when the following characteristics are present:

- Positive results for *P. cinnamomi* either in the immediate area, upslope or upstream of the infested area;
- Multiple disease Indicator Species Deaths (ISDs);
- Disease pattern and chronology; and
- Vegetation structure and composition obviously altered.

No infested areas were identified within the Bindaminna North assessment area.

1.17.2 Uninfested Areas

The entirety of the Bindaminna North assessment area (127.52ha) was found to be uninfested. This conclusion was determined based on a lack of disease symptoms within susceptible vegetation, and no recovery of *P. cinnamomi* in soil and tissue samples.

Uninfested vegetation is characterised by:

- No positive sample results for *P. cinnamomi*;
- Notwithstanding the impacts of drought and canker, there is an acceptable diversity of healthy disease indicator species, primarily *Banksia attenuata* and *Banksia menzeisii*;
- Vegetation condition in Pristine-Very Good condition in accordance with the Keighery scale, with an acceptable density of vegetation cover and no obvious reduction in biomass and/or masking by resistant species;
- No evidence of disease pattern or chronology (**Plate 1**).

1.17.3 Uninterpretable Areas

Uninterpretable areas are characterised by:

- Vegetation condition rating from Pristine-Good; and
- Few or no disease indicator species present.

No areas of uninterpretable vegetation were identified within the Bindaminna North assessment area.

1.17.4 Excluded Areas

Excluded areas are characterised by:

- A vegetation condition range from Good -Completely Degraded;
- Few or no native species, especially disease indicator species; and
- Little capacity for natural regeneration of native vegetation.

No excluded areas were identified within the Bindaminna North assessment area.

1.18 Bindaminna South

1.18.1 Infested Areas

Infested vegetation can be diagnosed when the following characteristics are present:

- Positive results for *P. cinnamomi* either in the immediate area, upslope or upstream of the infested area;
- Multiple disease Indicator Species Deaths (ISDs);
- Disease pattern and chronology; and
- Vegetation structure and composition obviously altered.

No infested areas were identified within the Bindaminna South assessment area.

1.18.2 Uninfested Areas

The entirety of the Bindaminna South assessment area (54.05ha) was found to be uninfested. This conclusion was determined based on a lack of disease symptoms within susceptible vegetation, and no recovery of *P. cinnamomi* in soil and tissue samples.

Uninfested vegetation is characterised by:

- No positive sample results for *P. cinnamomi*;
- Notwithstanding the impacts of drought and canker, there is an acceptable diversity of healthy disease indicator species, primarily *Banksia attenuata* and *Banksia menzeisii*;
- Vegetation condition in Pristine-Very Good condition in accordance with the Keighery scale, with an acceptable density of vegetation cover and no obvious reduction in biomass and/or masking by resistant species;
- No evidence of disease pattern or chronology (**Plate 2**).

1.18.3 Uninterpretable Areas

Uninterpretable areas are characterised by:

- Vegetation condition rating from Pristine-Good; and
- Few or no disease indicator species present.

No areas of uninterpretable vegetation were identified within the Bindaminna South assessment area.

1.18.4 Excluded Areas

Excluded areas are characterised by:

- A vegetation condition range from Good -Completely Degraded;
- Few or no native species, especially disease indicator species; and
- Little capacity for natural regeneration of native vegetation.

No excluded areas were identified within the Bindaminna South assessment area.

1.19 Disease Vectors

Native vegetation within the assessment area was found to be relatively intact and undisturbed, with few disease vectors. However, potential vectors identified include:

- Uncontrolled vehicular access; and
- Water-gaining sites.

1.20 Other Impacts to Vegetation

Native vegetation, including Dieback susceptible species and vegetation communities, can display impacts from other sources that resemble impacts caused by Dieback disease. Impacts to vegetation identified within the assessment area are discussed below.

1.20.1 Drought

Impacts to vegetation as a result of prolonged drought are differentiated from impacts caused by *P. cinnamomi* by the following characteristics:

- No disease pattern or chronology in the surrounding vegetation.
- The plant had senesced gradually rather than succumbing quickly as is usually the case with deaths attributed to *P. cinnamomi*.
- No visible lesions or mycelium on the roots of the dead or dying plant.
- Re-shooting or epicormic growth visible on dying plants.

The presence of single or multiple dead branches on otherwise healthy vegetation may be attributed to drought and/or canker caused by pathogenic fungi. Impacts to vegetation symptomatic of drought were evident throughout the assessment area (**Plate 3**).

1.20.2 Other Pathogenic Fungi (Canker)

In addition to the impact of drought the possibility also exists that cankers caused by aerial fungi are having an impact on *Banksia* species. Crane and Burgess (2013) studied the effect of cankers caused by pathogenic fungus on Proteaceous species. The assessment examined the impact that aerial cankers are having on coastal vegetation between Esperance and Cervantes and demonstrated pathogenicity in seven *Banksia* species over a wide geographic range. The pathogenic fungus was identified as a new genus and species within the *Cryphonectriaceae* (Diaporthales) and is described as *Luteocirrhus shearii* gen. sp. nov. The fungus causes the death of single branches; however, it can lead to multiple branch deaths or cause complete crown dieback as occurred with some of the *Banksia baxteri* and *B. verticillata* sampled (Crane and Burgess 2013).

The impacts of canker on species susceptible to Dieback can be distinguished through sampling and visual evidence. Evidence of canker was observed in susceptible vegetation within the assessment area (**Plate 4**).

Conclusion

A total of five soil and tissue samples were taken from recently dead disease indicator species for diagnostic baiting for the presence of *P. cinnamomi*.

The whole of the assessment area was categorised as uninfested and protectable. Therefore, appropriate hygiene measures are recommended to ensure that the *Phytophthora* pathogen is not introduced to the assessment area.

Terratree recommends that all vehicles and machinery be inspected using DBCA's Checklist for Vehicle and Machinery Inspections (**Appendix 2**) and verified clean of any soil or vegetative matter before entering the assessment area to minimise the risks associated with *Phytophthora* dieback, invasive weed species and other biosecurity issues.

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Glossary of Terms (FEMD, 2015)

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 does *Phytophthora* Dieback interpretation

Dieback (*Phytophthora*) Interpretation - The method of determining *Phytophthora* Dieback infestation using procedures in the Dieback Interpreter Guidelines (*FEM047: Phytophthora Dieback Interpreter's Manual for lands managed by the Department, Forest and Ecosystems Management, Department of Parks and Wildlife, March 2015.*)

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 which act on an individual organism during its lifetime.

Excluded Area - areas that have been disturbed to an extent that they are not assessable and therefore excluded from dieback interpretation

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

Infested Areas - areas that accredited person have determined have plant disease symptoms consistent with the presence of the pathogen *Phytophthora*

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

Pathogen - any organism or factor causing disease within a host

Protectable Area - Defines areas of land managed by the department, over which 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

Sporulation - a type of reproduction that occurs in fungi, algae, and protozoa and involves the formation of spores by the spontaneous division of a cell into four or more daughter cells, each of which contains a part of the original nucleus.

Not Yet Resolved - areas that are 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.

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

Uninfested Areas - areas that an accredited person has determined to be free of plant disease symptoms that indicate the presence of the pathogen *Phytophthora* Dieback

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

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

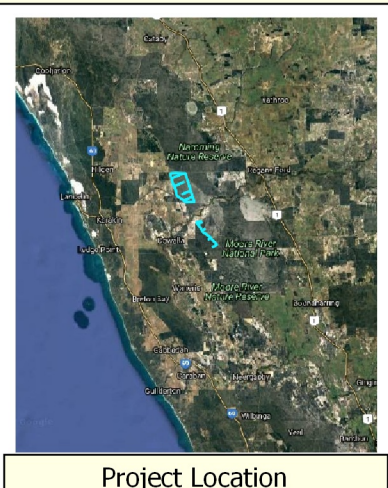
Figures



Legend

Sample Locations BD North Linear Assessment Area — Elevation

▲ Negative ■ Uninfested Google Satellite



Bindaminna North: Dieback Occurrence

Image Resources Dieback Assessment

Datum: GDA 1994
Projection: MGA Zone 50

Scale: 1: 20,000

Created: 13/09/2017 Prepared: K Jennings Project #: T17020

Expiry: 13/09/2018 Checked: J Grehan

Figure 1a Review: Revision: Rev A



Legend

Sample Locations

▲ Negative

■ Uninfested

BD South Linear Assessment Area

■

Elevation

—

Google Satellite

Project Location

Bindaminn South: Dieback Occurrence

Image Resources Dieback Assessment

N

Datum: GDA 1994
Projection: MGA Zone 50

Scale: 1: 20,000

Prepared: 13/09/2017

Prepared: K. Jennings

Project No: T17020

Expires: 13/09/2018

Checked: J. Grehan

Review:

Revision: Rev A

Figure 1b

Plates



Plate 1: Uninfested vegetation, with an acceptable abundance of disease indicator species, particularly *Banksia attenuata*.



Plate 2: Geomorphic wetland UFI 9231, with sufficient *Xanthorrhoea preissii*, *Banksia ilicifolia* and other indicator species to facilitate interpretation.



Plate 3: Susceptible species deaths attributed to drought, due to the uniform age of deaths and evidence of epicormic reshooting.



Plate 4: Sample IR-S02, which returned a negative result for *P. cinnamomi*. Possible attributable to pathogenic cankers.

Appendix A: VHS Sample Results



Vegetation Health Service – Phytophthora sample information sheet

FORM
FEM046

CONTACT DETAILS of sender			Job Type (Please indicate)		VHS use only		SEND TO: Vegetation Health Service, Ecosystem Health Branch – Dept. Parks & Wildlife, 17 Dick Perry Ave, KENSINGTON 6151 Phone: (08) 9334 0317 Fax: (08) 9334 0114		
Name <u>Kelby Jennings</u> Fax No. <u>Phone No. 0416 765 956</u> DPaW Office or Company Name <u>Terratree</u>			DPaW (C) Alcoa (A) Recoup (R) FPC (FPC) Private (P) Other _____		Date received <u>15/9/17</u> Date reported <u>23.9.17</u> GDA(1) _____				
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 s/s root (5)	RESULT bait (5)
VHS 36908 	12/09/2017	IR-S01	Banksia attenuata	L	50	E 359425 N 6569377	UCL		NEG
VHS 36909 	12/09/2017	IR-S02	Banksia attenuata	L	50	E 360009 N 6572101	UCL		NEG
VHS 36910 	13/09/2017	IR-S03	Banksia menzeisii	L	50	E 360119 N 6567749	UCL		NEG
VHS 36911 	13/09/2017	IR-S04	Xanthorrhoea preissii	L	50	E 367182 N 6558998	UCL		NEG
VHS 36912 	13/09/2017	IR-S05	Banksia menzeisii	L	50	E 363835 N 6562575	UCL		NEG
						E - - - - - N - - - - -			
						E - - - - - N - - - - -			
						E - - - - - N - - - - -			

NOTES:

- Please tick this box if your map references are supplied in the GDA 94 standard. If not, please specify the datum used.
- Site impact - Low, Moderate, or High (as in the Dieback Interpreter's Manual).
- An MGA map reference with prefixes **must** be supplied for all samples.
- Land tenure - State Forest (SF), National Park (NP), Reserve (R), Westrail (W), Private (P), Gravel Pit (GP), or other. (Other - describe in comments below).
- Result codes used - CIN = *Phytophthora cinnamomi*, MUL = *P. multivora*, CRY = *P. cryptogea*, PI = *P. inurdata*, ARE = *P. arenaria*, ELO = *P. elongata*, THE = *P. thermophila*, PM = *P. megasperma*, PN = *P. nicotianae*, CON = *P. constricta*, 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 and map products, which may be made available to the public and third parties to be used for research and other purposes.

COMMENTS:

Appendix A: DBCA Checklist for Vehicle and Machinery Inspections



Checklist Vehicle & Machinery Inspections

In order for an item to be certified free of leaks, seeds, weeds and other infestation it must undergo an inspection and be certified clean by an accredited person.

Taking an infested disease vector onto CALM Act estate may constitute a breach of the Conservation and Land Management Act (1984) & Regulations.

Registration/ID:	Make & Model:				
Item	Type/Examples	Not Applicable	Not Compliant	Compliant	Initial
Scrub bars	Front, Rear, Side				
Fenders:	Front, Rear, Side				
Fenders:					
Radiator area					
Belly plates / Underside Protection					
Bucket /blade /forks					
Rippers					
Suspension					
Spare wheels					
Wheels / tracks					
Mud flaps					
Flat sections	Esp. horizontal				
Cupped sections					
Chassis areas	H- or C- sections				
Hinged Points:	Esp articulated areas e.g. FEL / Truck/ Crane/ Excavator arm				
Leaks:	Motor, Transmission / Driveline / Hoses / Tanks / Hydraulics / Reservoirs				
Leaks:	Excessive Grease				
Spill kit(s)	(e.g. Hydrocarbon)				
Water Tanks:	Potable /Treated /Untreated/ Capacity				
Trailer(s)	Light/ Heavy/ Number/Capacity/Type				
Cargo space					
Clean down kit					
Cabin; front	Floor and seats				
Cabin; rear	Floor and seat				
floormats					
*Previous worksite(s)					
Fire suppression gear (Bushfire Act compliant?)	Extinguishers, Drafting, Capacity, Hi-Pressure-Low-Volume,				

*Previous work sites may entail sighting records of Clean-on-Exit checks & documents.

Assessing Person(Owner or Representative):				
Signature	Name	Date & Time	Company/Agency	Contact Details
				M: T: F:



Certificate

Soil, Leak, Weed, Seed & Feral Free

The purpose of this certificate is to demonstrate that the potential vector(s) listed below was inspected to an agreed standard and is now certified free of leaks, soil or vegetative material that may carry animals, weeds, seeds or spores onto CALM Act Land, namely:

_____.

Vehicle / Plant / Equipment item	Make & Model	Registration Engine No VIN/ Identifier	Owner: Person /Company /Agency	Site last used

This vehicle has been declared free of leaks, soil and vegetative material and other contaminants prior to entry to CALM Act Land:

Declaring Person:

Signature	Name	Date & Time	Company/Agency	Contact Details
				M: T: F:

This vehicle has been inspected and verified as clean prior to entry to site:

Site Supervisor/Representative:

Signature	Name	Date & Time	Company/Agency	Contact Details
				M: T: F:

This vehicle has been inspected and verified as clean prior to entry to site:

Departmental auditing officer:

Signature	Name	Date & Time	Company/Agency	Contact Details
				M: T: F: