Interim Report

Wungong Rate of Spread

Department of Parks and Wildlife
Forest Management Branch

Report prepared for: Water Corporation of Western Australia

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Summary

This study was established to monitor the rate of spread of *Phytophthora cinnamomi* (commonly referred to as jarrah dieback or *Phytophthora* dieback) within the Wungong Catchment Trial (WCT) to determine whether the implemented thinning treatments increase the rate of spread compared to untreated areas. The study was one of 16 proposed in the *Water Corporation's response to submissions from 2005 public review,* 2007 (Water Corporation August 2005 Topic 3 pp 73-74).

The WCT area is located within state forest and is managed by the Department of Parks and Wildlife (DPaW), as part of the land vested in the Conservation Commission (s33 (1)(a) CALM Act 1984). Forest thinning operations were conducted by the Forest Products Commission (FPC) under DPaW approvals and guidelines.

Forest thinning treatments were applied (with some variations to standard harvesting practices) and dieback mapping was undertaken to ensure hygienic management of *Phytophthora* dieback. Monitoring sites were established on disease boundaries to measure rates of autonomous disease spread into the disease free areas.

The results showed that there was no significant difference in spread rates between treated and untreated sites and thus it was concluded that the thinning treatments did not increase the rates of disease spread.

Jarrah forest in the Wungong Catchment Trial Area

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1. Introduction

The Wungong Catchment Trial (WCT), which began in 2005, is a project being conducted by the Water Corporation, to determine if forest thinning practices can increase water yields and offset the effects of a drying climate. The trial includes numerous research projects commissioned to investigate the effects of these treatments on biodiversity and ecosystem function.

Dieback caused by *Phytophthora cinnamomi* (*P. cinnamomi*) is recognised as a significant threat to the health and vitality of many ecosystems in the Southwest and this includes the Wungong Catchment. Dieback reduces the distribution and abundance of many plant species and their dependent fauna.

A soil-borne microscopic pathogen, *P. cinnamomi* requires warm moist conditions to survive and spread. The pathogen is mainly spread by root-to-root contact, in sub-surface water and by human or animal vectors where infested soil and root material is picked up and moved elsewhere.

Knowledge of the current extent (*P. cinnamomi* occurrence) of the disease is essential for determining hygiene tactics to minimise new introductions or extensions. However, for predicting impact of the disease on biodiversity and ecosystem function, knowledge of spread rates and pattern is an important tool used in management planning by DPaW. Other studies are designed to investigate some of the possible biodiversity impacts.

Opinion varies as to whether forest thinning practices have the potential to exacerbate the, autonomous (not spread by human or animal vectors) rate of spread of *P. cinnamomi (hereafter* referred to as dieback ROS*)*. Research also suggests that general dieback ROS cannot be applied broadly across a bioregion. The Water Corporation therefore proposed key performance indicator (KPI #9.2) to ascertain relevant information against which they will be able to evaluate their performance in the WCT (Table 1).

Table 1: Water Corporation's Key Performance Indicator Number 9.2

Key Performance Indicator # 9.2	**Dieback (monitoring) and research**
Performance measure	Rate of Spread Impact of dieback compared to untreated sites
Performance target(s)	No additional increase in rates of spread No additional increase in the impact on native vegetation
Reporting (frequency)	4-yearly to DPaW and CCWA
Response to target shortfall	Review research and monitoring outcomes and recommend for implementation

The objective of this study is to review whether forest thinning practices increase the dieback ROS within the WCT area and record site factors that may be influencing the ROS.

This study looks at the dieback ROS in the treatment areas in the WCT designed to reduce the standing basal area of the forest (stand density) and increase water yields. With decreased basal area of the forest there is some conjecture that there will be an increase in soil temperature and moisture levels favourable to dieback disease.

This study was carried out by Forest Management Branch (FMB) of the Department of Parks and Wildlife (DPaW) to inform the Water Corporation as to whether there has been a change in the dieback ROS in thinned versus un-thinned forest areas.

The WCT seeks to minimise the impact of pathogens and their associated diseases on the health and vitality of forest ecosystems. An integral aspect of dieback management within the WCT area is to ensure that all operations are undertaken in compliance with a *P. cinnamomi* disease hygiene management plan suited to each research project or operation.

It was important to therefore evaluate hygiene security to ensure that disease boundary extension was due solely to autonomous spread and not to any hygiene failure or breach. This requirement did limit the suitability of possible sites for the study.

Performance Measure

Monitoring the dieback ROS in treatment areas[1] compared to untreated sites. The performance measure therefore, is that the rate of disease extension into uninfested areas (as assessed by an accredited Dieback Interpreter) will not exceed the rates of extension into uninfested areas adjacent to untreated sites within the WCT area.

Performance Target

The Water Corporation's performance target is, no additional increase in the dieback ROS and subsequent increase in the impact on native vegetation as a result of management actions. (Water Corporation's response to submissions from 2005 public review, 2007).

Reporting

This report fulfils both interim and final reporting requirements of the project due to a curtailed completion date and details the findings of monitoring Water Corporation's KPI 9.2 dieback ROS component and will be provided to the Water Corporation for their reporting to Conservation Commission of Western Australia (Conservation Commission).

Response to Target Shortfall

Based on the results of this study the Water Corporation, in consultation with DPaW and the Conservation Commission will be responsible for evaluating the need for revision of any administrative, management or monitoring practices in the context of its assessment and auditing function.

[1]Treatments include non-commercial thinning, standard harvest, standard harvest with notching and un-thinned control sites.

2. Method

Site Selection

Monitoring sites were placed on dieback boundaries adjacent to protectable areas (uninfested areas greater than 4ha) within the dominant Havel vegetation site types (Havel, 1975), in both treated and untreated areas.

Protectable areas are usually defined for hygiene management purposes however for this study they were used to ensure that there was sufficient room for disease boundary spread into uninfested areas without encountering another disease boundary before this study ended.

Havel vegetation site types provided a sound basis for pairing monitoring sites between treated and untreated sites because they correlate well with the physiological drivers of host resistance, site susceptibility and pathogen physiology represented in the disease triangle, particularly in the absence of extensive soil and vegetation sampling.

Site selection was limited to those areas which had been interpreted in the past 10 years (to provide good boundary records and currency of spread information) and had not been disturbed (by treatments, fire, etc) in the previous three years (to allow vegetation recovery and symptom identification).

GIS analysis of DPaW’s corporate datasets (forest treatment, disease mapping and vegetation type mapping) indicated that treatment areas were significantly infested and there were not enough protectable areas to provide systematic replication of the dominant vegetation types (predominantly upland). Replicates were to be situated in Havel vegetation types with similar site characteristics such as vegetation density, slope, aspect but this was generally not possible. Consequently, mixed vegetation types had to be chosen (i.e. influences of other vegetation types).

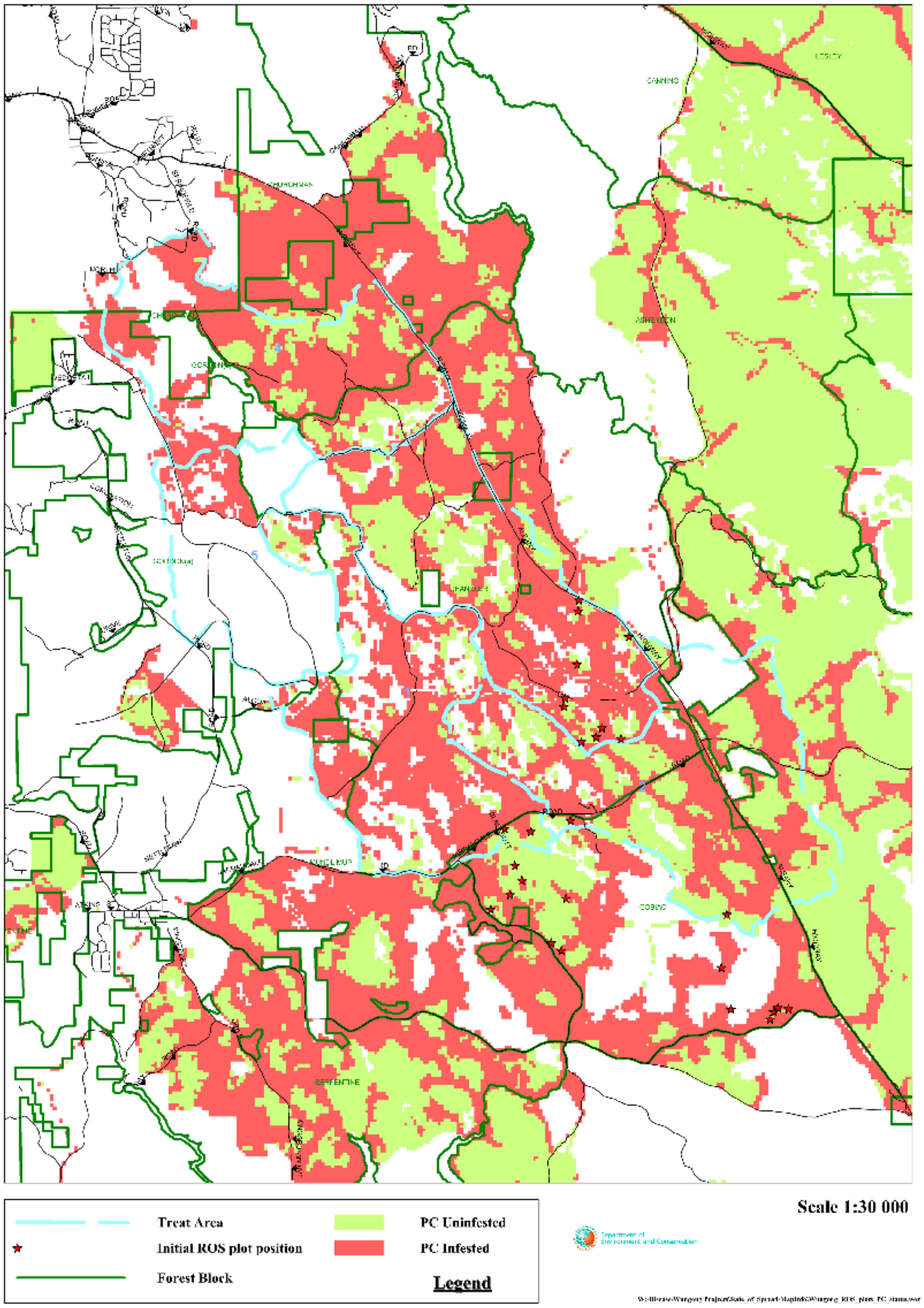
Using GIS, possible sample sites were identified by intersecting; areas with dieback mapping (<10 years old) with uninfested areas (Map 1). These sites were then field checked and assessed for suitability based on the following factors;

- interpretability (good disease symptom identification, e.g. not burnt last 3 years)
- minimum boundary length (approximately 50m)
- no other disease vectors that may possibly contribute to disease spread (e.g. being too close to a open road)
- sites unaffected by drought deaths or *Armillaria luteobubalina* symptoms

Particular attention was paid to locating sites that measured uphill spread because this is less variable than down-hill or across-slope spread and hence would reduce sample variance.

Although not required in this study, for KPI 9.2, an evaluation of the dieback ROS between variations in treatments was attempted but proved too difficult due to a lack of suitably paired monitoring sites.

LOCATION OF DIEBACK RATE OF SPREAD MONITORING SITES



Map 1: Possible Dieback Rate of Spread Sample site.

Field Assessment

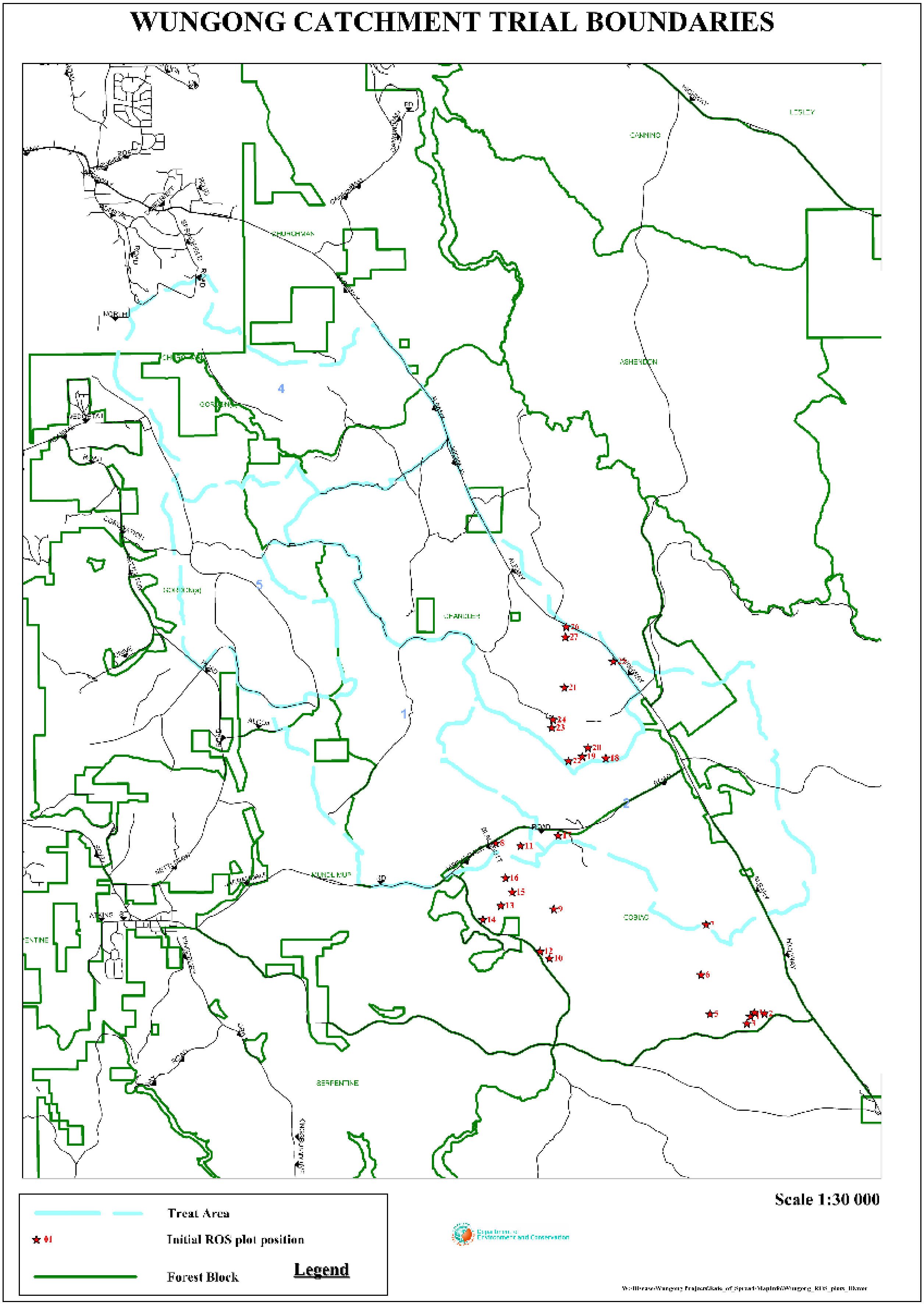
The field assessment was carried out by an accredited senior Disease Hygiene Coordinator due to the high level of disturbance to vegetation. The assessment was done in accordance with "*Phytophthora cinnamomi* and disease caused by it. Volume II Interpreter guidelines for detection, diagnosis and mapping" (Forest Management Branch 2001).

Once sample sites were assessed as suitable in the field, the Havel vegetation type was determined and the dieback boundary (of the previously mapped area) was marked with a steel dropper. This older baseline boundary, informed by the previous disease mapping, was identified using a chronology of death pattern to identify where the front was at the time. This procedure introduces some prospect for error but correlates with the method of initial placement of any mapping of a disease boundary as an interpretation of visible symptoms. A GPS was used to mark the boundary. A second steel dropper was used to mark the current position of the front. A GPS was used to mark this new dieback front.

Initially, baseline measurements were planned to be recorded in 2010, followed by subsequent measurements in 2013 and 2015. However, this was not possible due to the severe drought conditions during 2009/2010 and a lack of protectable areas within the study area restricting the choice of suitable sites. The severe drought conditions made the establishment of boundaries in many of the potential sites impossible as there were insufficient deaths to make a reliable interpretation even by experienced staff.

Determination of boundaries was therefore delayed until conditions for the expression of disease symptoms improved. Some sites had to be established using older interpretation of disease fronts to increase the number of sites available for analysis.

After considerable field reconnaissance, it was possible to establish twenty seven sites (see Map 2) for this study. However, disease expression was still poor in some vegetation types. With more time and better seasons more sites may become available for repeat measurements.



Map 2: Dieback Rate of Spread sample sites.

Data Capture and Analysis

Interpretation of dieback boundaries was carried out by an accredited senior Disease Hygiene Co-ordinator and site assessments were recorded using a proforma (Appendix 1) developed for the WCT dieback ROS study. Information collected was stored for interrogation and summarizing results (Appendix 2).

Data was entered into Excel spreadsheets and spread measurements were converted to spread rates per annum for analysis of basic means and variance comparison between vegetation types and treated versus untreated sites.

Significance of differences between means was calculated using a square root transformation to produce a more normal distribution of data and compared in a one way ANOVA.

Limitations & Assumptions

There are limitations to this monitoring program that need to be considered:

- Severe drought has made areas difficult to interpret.
- Locating protectable areas was limited due to the extent of dieback within the study area.
- Locating protectable areas with the various Havel types within each different treatment areas were limited.
- Locating replicates of protectable areas with the same Havel types was limited.

3. Results

Monitoring site assessment data is catalogued in Appendix 2 (Site descriptive records and spread data) and summarised here in Table 2 with site type and spread distance.

Table 2: A summary of Dieback Rate of Spread monitoring site records showing; DPaW Region, Forest Block, Landscape unit, Havel Vegetation Site Type, the site ID number, slope direction, Easting/Northing of the original front, Date the site was first interpreted, and Easting/Northing of current dieback front, calculated distance, and date of measurement.

ID	Region	Forest Block	Landscape Unit	Havel Veg Type	Site ID	Slope Direction	Easting (Original front)	Northing (Original front)	Date first Interpreted	Easting	Northing	Distance (m)	First Measurement
1	Swan	Cobiac	North Western Jarrah	sP	JCO3	Upslope	0426467	6419643	07.06.2002	0426476	6419617	8.1	22.11.2012
2	Swan	Cobiac	North Western Jarrah	S	JCO4	Upslope	0426721	6419597	07.06.2002	0426717	6419591	0	15.03.2013
3	Swan	Cobiac	North Western Jarrah	SP	JCO5	Upslope	0426333	6419368	07.06.2002	0426296	6419354	16.6	15.03.2013
4	Swan	Cobiac	North Western Jarrah	S	JCO6	Upslope	0426374	6419531	07.06.2002	0426382	6419528	0	15.03.2013
5	Swan	Cobiac	North Western Jarrah	S	JCO11	Upslope	0425370	6419575	11.06.2002	0425396	6419582	5.7	18.03.2013
6	Swan	Cobiac	North Western Jarrah	S	JCO14	Upslope	0425196	6420515	8.06.2002	0425178	6420542	13.7	18.03.2013
7	Swan	Cobiac	North Western Jarrah	S	JCO17	Upslope	0425309	6421771	11.06.2002	0425301	6421760	11.3	22.11.2012
8	Swan	Cobiac	North Western Jarrah	P	CO1	Upslope	420193	6423737	24.07.2008	0420198	6423737	5.30	02.04.2013
9	Swan	Cobiac	North Western Jarrah	S	CO2	Upslope	421615	6422134	24.07.2008	0421605	6422131	8.90	02.04.2013
10	Swan	Cobiac	North Western Jarrah	S	CO3	Upslope	421510	6420934	24.07.2008	0421503	6420937	5.50	02.04.2013
11	Swan	Cobiac	North Western Jarrah	P	CO4	Upslope	420795	6423663	24.07.2008	0420797	6423663	1.70	02.04.2013
12	Swan	Cobiac	North Western Jarrah	pS	CO5	Upslope	421267	6421109	24.07.2008	0421267	6421110	2.90	03.04.2013
13	Swan	Cobiac	North Western Jarrah	S	CO6	Downslope	420321	6422232	24.07.2008	0420321	6422212	18.60	03.04.2013
14	Swan	Cobiac	North Western Jarrah	pS	CO7	Downslope	419875	6421880	24.07.2008	0419875	6421873	5.30	03.04.2013
15	Swan	Cobiac	North Western Jarrah	S	CO8	Upslope	420588	6422544	24.07.2008	0420589	6422546	2.10	03.04.2013
16	Swan	Cobiac	North Western Jarrah	S	CO9	Upslope	420429	6422884	24.07.2008	0420430	6422887	3.50	03.04.2013
17	Swan	Cobiac	North Western Jarrah	pS	CO10	Upslope	421710	6423918	24.07.2008	0421710	6423921	5.00	03.04.2013
18	Swan	Chandler	North Western Jarrah	wS	CH01	Upslope	422871	6425795	17.12.2008	0422869	6425803	3.10	21.05.2013
19	Swan	Chandler	North Western Jarrah	O, S	CH02	Upslope	422302	6425838	17.12.2008	0422297	6425844	5.70	21.05.2013
20	Swan	Chandler	North Western Jarrah	S	CH03	Upslope	422441	6426048	17.12.2008	0422436	6426048	6.00	21.05.2013
21	Swan	Chandler	North Western Jarrah	S	CH04	Upslope	421852	6427514	17.12.2008	0421860	6427513	7.50	21.05.2013
22	Swan	Chandler	North Western Jarrah	W - S	CH05	Upslope	421961	6425732	17.12.2008	0421961	6425730	1.10	22.05.2013
23	Swan	Chandler	North Western Jarrah	S	CH06	Upslope	421560	6426540	17.12.2008	0421560	6426540	8.50	22.05.2013
24	Swan	Chandler	North Western Jarrah	PS	CH07	Downslope	421591	6426738	17.12.2008	0421584	6426734	7.70	22.05.2013
25	Swan	Chandler	North Western Jarrah	P	CH08	Upslope	423059	6428147	17.12.2008	0423051	6428145	9.80	22.05.2013
26	Swan	Chandler	North Western Jarrah	P	CH09	Upslope	421910	6428990	17.12.2008	0421906	6428987	6.70	22.05.2013
27	Swan	Chandler	North Western Jarrah	PS	CH10	Upslope	421888	6428740	17.12.2008	0421885	6428739	3.30	22.05.2013

Vegetation Type

The predominant Havel vegetation types available were P and S with some combinations and minor influences of W and O. It was therefore only possible to compare between the distinct P and S types. The analysis showed no difference in the mean ROS between these vegetation types (Table 3).

Table 3: Comparison of the Dieback Rate of Spread between the two dominant Havel vegetation types.

Uphill Spread (m)	P	S
Average of ROS/year	1.3	1.0
Count of ROS/year	4	12
StdDev of ROS/year	0.8	0.7
Significance	n	n

Thinning Treatment

Monitoring sites in thinned stands were compared with un-thinned areas (for uphill spread only). This was the main aim of the study to report on this component of KPI 9.2. Since there was no significant difference between sites based on vegetation types, all sites were grouped to test for differences between treatment and no treatment. The analysis showed no significant difference (Table 4).

Table 4: Thinning treatment comparison

Site ID	Forest Block	Slope Direction	Treated	ROS/year
CO3	Cobiac	Upslope	N	1.17
CO5	Cobiac	Upslope	N	0.62
CH01	Chandler	Upslope	N	0.70
CH02	Chandler	Upslope	N	1.29
CH03	Chandler	Upslope	N	1.36
CH05	Chandler	Upslope	N	0.25
CH08	Chandler	Upslope	N	2.21
CH09	Chandler	Upslope	N	1.51
JCO14	Cobiac	Upslope	N	1.27
JCO11	Cobiac	Upslope	N	0.53
JCO6	Cobiac	Upslope	N	0.00
JCO5	Cobiac	Upslope	N	1.54
JCO4	Cobiac	Upslope	N	0.00
JCO3	Cobiac	Upslope	N	0.74
CO1	Cobiac	Upslope	Y	1.13
CO2	Cobiac	Upslope	Y	1.90
CO4	Cobiac	Upslope	Y	0.36
CO8	Cobiac	Upslope	Y	0.45
CO9	Cobiac	Upslope	Y	0.75
CO10	Cobiac	Upslope	Y	1.07
CH04	Chandler	Upslope	Y	1.70
CH06	Chandler	Upslope	Y	1.92
CH10	Chandler	Upslope	Y	0.75
JCO17	Cobiac	Upslope	Y	1.03

Groups	*Count*	*Sum*	*Average*	*Variance*
untreated	14	12.176839	0.8697742	0.1998831
treated	10	10.172017	1.0172017	0.0766568

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.1267867	1	0.1267867	0.8482287	0.367044	4.30095
Within Groups	3.2883919	22	0.1494724			
Total	3.4151787	23				

* P value indicates no significant difference between treated and untreated

Discussion

The similar results for vegetation type indicate that the treatment areas should be sufficiently similar to compare since the monitoring sites are evenly distributed across vegetation types.

Comparing the dieback ROS between the broader grouping of all thinned areas against the un-thinned (control) sites indicates there is no difference between treated and untreated areas within the WCT. There is a possibility that this may be due to the monitoring sites not being similar enough (due to other micro site attributes or stand characteristics) leading to greater variability within the treated and untreated areas. However most management by DPaW is at the level of vegetation type or higher aggregations and thus trying to define site differences at a more detailed level is unlikely to be applied in routine forest management. Therefore these results should be considered valid at this level of resolution.

In the northern jarrah forest, including the WCT, the predominant Havel vegetation types by area are P and S and this is reflected in the sites available for this study. This study indicated there is no significant difference between the dieback ROS in these two vegetation types. This is supported by dieback ROS studies for the broader jarrah forest, completed by Strelein (Unpublished, 2013) for the Forest Management Plan (FMP) 2014-2023 which also indicated no significant difference in spread rates was found between vegetation site types (Havel or Strelein).

Although not intended for this study, there were insufficient sites available to evaluate differences in across slope or down slope spread rates in the Wungong trial areas. However under the more recent low rainfall climatic conditions in the FMP 2014-2023 ROS study there was no significant difference in spread rates with slope direction. This was attributed to the change in climate interaction with disease activity and host susceptibility, since a distinct difference was evident in the higher rainfall periods reported by Strelein et al (2006) used for predicting disease impact in the Forest Management Plan 2004-2013 analysis. Slope direction was therefore not considered to be a significant variable in interpreting the results.

The overall average spread for the Wungong ROS study was greater than the figure calculated for the equivalent western zone of the northern jarrah forest used in the FMB FMP 2014-2023 ROS studies. This is most likely due to the longer period of measurement used for the Wungong sites (five to ten years compared to two to four years). The FMP2-14-2023 sites were measured over a shorter recent period corresponding to a drier period than the Wungong work and disease spread would have been more constrained by unsuitable growing conditions.

4. Conclusion

The study results indicate there has been no increase in the Dieback ROS between the two treatment types trialed in the Wungong area. However, further monitoring is recommended at an increased number of sites and over a longer period of time, to allow for inter seasonal/yearly variations and to provide greater representation of different vegetation types.

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Appendix 1. Rate of Spread Monitoring Sites Proforma

Estimated rate of spread measurements Wungong Catchment
Recording Sheet

Interpreter	
Date	
Forest Block	
Site number	
Native Jarrah Forest site type	
Soil description	
Overstorey tree species	
Upslope	Downslope
UTM location Peg 1	
UTM location Peg 2	
Field measured distance between Peg 1 and Peg 2	
Confidence Description (Peg 1)	
Comments	