Woolgoolga to Ballina Pacific Highway upgrade

Threatened Rainforest Communities and Rainforest Plants Monitoring Program Annual Report 2020

Year 1 Operational Phase Report

NSW GOVERNMENT

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Woolgoolga to Ballina Pacific Highway Upgrade, Sections 10 & 11, Threatened Rainforest Communities and Rainforest Plants, Annual Monitoring Report (2020)

(Year 1 Operational Phase Report)

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CONTENTS

Executive Summary 5
1 Introduction 6
2 Threatened Rainforest Communities 7
2.1 Methods 7
2.1.1 Identification of rainforest types 7
2.1.2 Data collection at Control and Impact sites 7
2.2.1 Ordination and point sequences 13
2.2.2 Abundance of exotic species 13
2.3 Results 14
2.3.1 Summary of rainforest community plots spring 2020 14
2.3.2 Ordination and point sequences 19
2.3.3 Abundance of exotic species 21
3 Threatened Rainforest Plant Monitoring 25
3.1 Species included in monitoring program 25
3.2 Data collection and analysis 25
3.4 Results` 26
3.4.1 Summary 26
3.4.2 Rainfall 29
3.4.2 Condition of Threatened Species 2020 30
4 Conclusion 33
4.1 Threatened rainforest communities 33
4.2 Threatened rainforest plant species 33
4.3 Work Plan 2021-2022 33
5 References 34
Appendix 1. 35
Ordination outputs – comparison of floristics in Impact and Control plots. 35
Appendix 2. 40
Photos of threatened rainforest plants – spring 2020 40

Executive Summary

As part of the rainforest management plan for the Woolgoolga to Ballina (W2B) Pacific Highway upgrade (Roads and Maritime 2015), a monitoring programme was implemented to record potential impacts to threatened rainforest communities and threatened plants during the construction and operation phases on Sections 10 and 11. Permanent plots were established to monitor changes in the composition and structure of rainforest communities. Threatened rainforest plants were also tagged to record changes in their growth and condition. The rainforest plots consisted of Impact and Control pairs and were in four types of rainforest. Impact sites were positioned next to the highway and Control sites further back inside the rainforest. Threatened plants closest to the highway and further inside the rainforest were monitored. A total of 14 Impact and Control rainforest community plots and 210 threatened rainforest plants were included in the monitoring program.

EMM and Ecos Environmental recorded baseline data for the monitoring programme in February 2014 before construction of Sections 10 and 11 began (see EMM 2014 for results). During construction, Ecos Environmental carried out monitoring in 2017, 2018 and 2019 (see Ecos 2017, 2018 and 2019 for results). In September 2020, Sections 10 and 11 opened to traffic and in November 2020 Ecos Environmental undertook the first year of operational phase monitoring (two more years of operational phase monitoring are planned for 2021 and 2022), the results of which are described in this annual monitoring report.

PCA ordination of the plot data revealed that the rate of vegetation change (from February 2014 to Spring 2020) at the Impact sites was not consistently greater compared to the Control sites, suggesting no/minimal edge effects from vegetation clearing. There has been increases in the abundance of exotic species at some of the Impact sites since 2014, however this has also occurred at Control sites, suggesting edge effects were not necessarily the cause.

Since monitoring of the threatened rainforest plants began in 2014, there has been seven plant mortalities - two White Laceflower plants, four Smooth Davidsonia plants, and one Green-leaved Rose Walnut plant. All of these plants except one of the White Laceflowers died in 2019, which was one of the driest years on record, and so it is likely that moisture stress was the cause.

Some of the threatened rainforest plants died back in the 2019 drought and then reshot and grew in 2020 but surprisingly most plants continued to grow through 2019 despite the extreme conditions.

Ongoing operational phase monitoring of the threatened rainforest communities and threatened rainforest plants will help determine if there are any longer-term impacts of the highway upgrade.

1 Introduction

Transport for NSW (Transport) aims to minimise impacts on threatened rainforest communities and rainforest plant species during construction and operation of Sections 10 and 11 of the Woolgoolga to Ballina (W2B) upgrade of the Pacific Highway. To achieve this aim, a management plan was prepared specifically for threatened rainforest communities and species, which included methods for monitoring the potential impacts of highway construction and changes in species composition and condition. For details see *Woolgoolga to Ballina Threatened Rainforest Communities and Rainforest Plants Management Plan* (RMS 2015). Transport prepared this management plan based on data collected in preconstruction surveys and baseline monitoring by EMM and Ecos Environmental (see EMM 2014 for details).

The objective of the monitoring program was to determine the effectiveness of mitigation measures in avoiding direct and indirect impacts and maintaining the condition of threatened rainforest communities and species during highway construction and operation (RMS 2015).

The schedule for the monitoring program includes three years of construction phase monitoring and three years of operational phase monitoring. The results of the construction phase monitoring are described in three annual monitoring reports (Ecos 2017, 2018 and 2019). In September 2020, Sections 10 and 11 of the W2B upgrade opened to traffic and in November 2020, Ecos Environmental undertook the first year of operational phase monitoring, the results of which are described in this annual monitoring report. The contents of this report are set out as follows:

- Section 2: methods, data analysis and results of the threatened rainforest communities component of the monitoring program
- Section 3: methods, data analysis and results of the threatened rainforest plants component of the monitoring program, and
- Section 4: conclusion and recommendations.

2 Threatened Rainforest Communities

2.1 Methods

2.1.1 Identification of rainforest types

Two listed threatened rainforest communities occur within and adjacent to sections 10 and 11 of the W2B Pacific Highway upgrade:

- Lowland Rainforest of the NSW North Coast and Sydney Basin Bioregion - an Endangered Ecological Community (EEC) listed under the NSW *Biodiversity Conservation Act 2016* (BC Act). This community is equivalent with the Commonwealth *Environment Protection and Biodiversity Conservation Act 199*9 (EPBC Act) listed Lowland Rainforest of Subtropical Australia, which has the status of critically endangered ecological community (CEEC); and

- Littoral Rainforest in the South East Corner, Sydney Basin and NSW North Coast Bioregions (herein referred to as Littoral Rainforest) - listed under the BC Act as an EEC, equivalent with the EPBC Act listed Littoral Rainforest and Coastal Vine Thickets of Eastern Australia, which is listed as a CEEC.

These two threatened rainforest communities encompass four rainforest types identified in the preconstruction survey and data analysis carried out in 2014 (EMM 2014), as follows:

- Littoral rainforest
- Swamp rainforest
- Rainforest on alluvium
- Hillside rainforest regrowth.

The first community is equivalent to the EEC *Littoral Rainforest* and the other three are equivalent to, or sub-forms of, the EEC *Lowland Rainforest*. This initial classification of rainforest types by EMM was subsequently confirmed by cluster analysis of plot data, as described in Ecos (2017).

2.1.2 Data collection at Control and Impact sites

A total of 14 Control and Impact monitoring sites were positioned in the four different rainforest types within and adjacent to Sections 10 and 11 of the highway upgrade (Figure 1). Each Impact site was paired with a Control site in the same rainforest type, as indicated in Table 1. Control sites were located at a minimum of 20 m from the clearing boundary and within 100 m of the project boundary, as specified in the management plan (RMS 2015). Impact sites were located as close as possible to the clearing boundary. The Impact sites are potentially subject to negative edge effects such as elevated light intensity, higher temperatures, lower moisture availability, stronger wind, weed invasion and lower seedling

survival due to branch fall. Control sites are expected to be unaffected by highway construction and operation.

Each monitoring plot was 20 m x 20 m and divided into four 20 m x 5 m sub-plots, labelled *a*, *b*, *c* and *d*. The long edge of each sub-plot was aligned parallel with the clearing boundary (Figure 2). Sub-plot *a* was always closest to the clearing boundary and subplot *d* was placed furthest from the boundary.

GPS coordinates and photographs were taken at the corners of each plot. 1.2 m hardwood stakes were used to mark the corners of each plot, while smaller 60 cm stakes were used to mark the ends of each sub-plot.

Within each of the four sub-plots, the following data were recorded:

- The general health of plants
- Any disturbances or weed invasion
- General landscape features (slope, aspect, soil, etc)
- All species and their abundance in five fixed vertical height strata or layers: 0-1 m, 1-5 m, 5-10 mm, 10-20 m, and 20+ m.

Species abundance was recorded as crown-cover, which can be defined as the percentage of the plot area (or sub-plot in the case of this monitoring program) covered by the vertical projection onto the ground of the perimeter or outline of plant crowns. The area within the crown perimeter contributes to crown cover regardless of spaces between leaves. As a guide, in this monitoring study a plant crown covering 1 m x 5 m of the sub-plot is equal to a crown cover of 5%, a plant crown covering 2 m x 5 m of the sub-plot is equal to a crown cover of 10%, and so on. Species crown cover was recorded for each height stratum.

Distance from forest edge/clearing

The distance from each Impact plot to the forest edge was recorded to assess which Impact plots are most likely to be susceptible to edge effects.

Monitoring Schedule

The first annual operational phase monitoring of the rainforest communities was carried out in November (Spring) 2020 (Table 2).

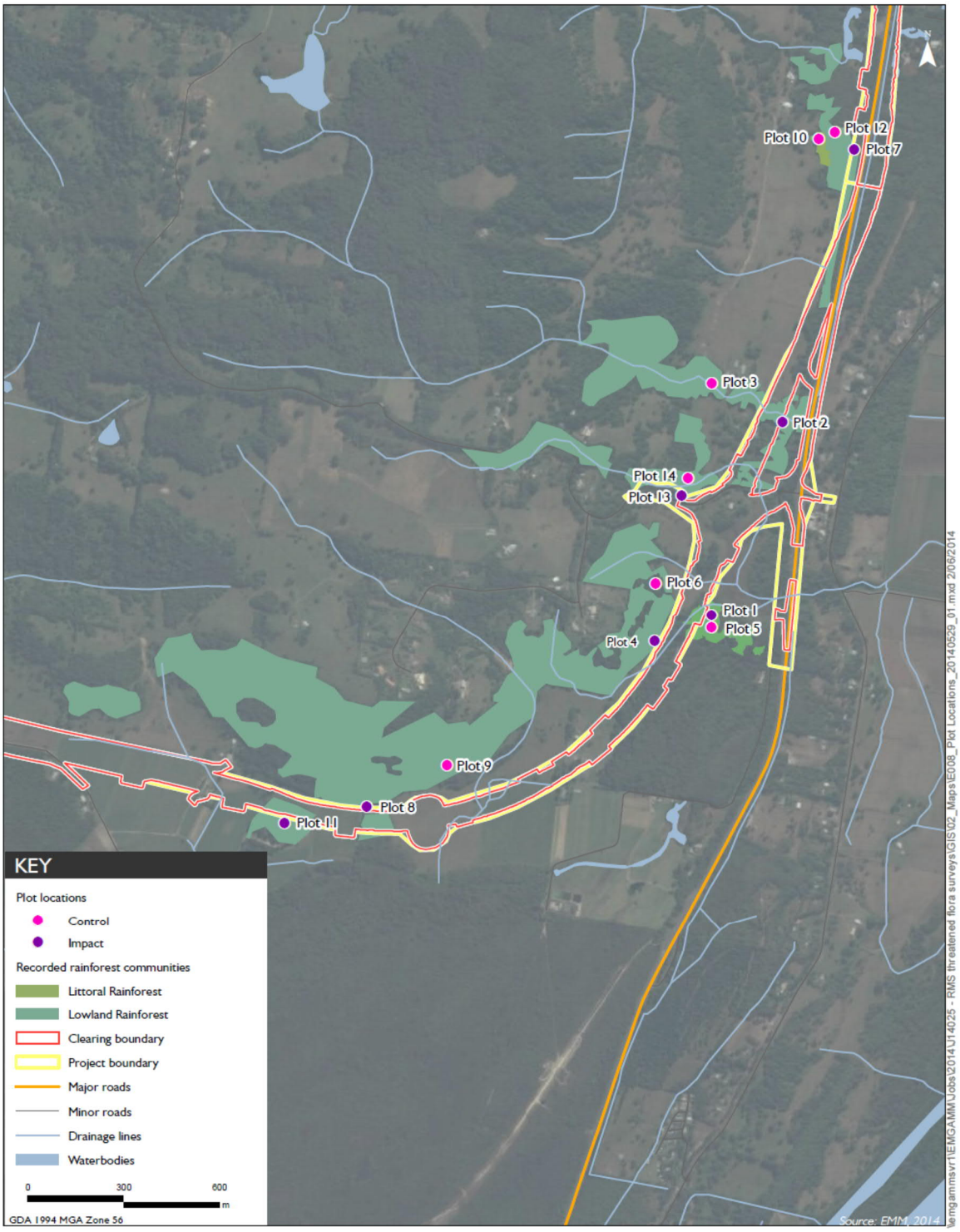


Figure 1. Monitoring plots in relation to W2B Pacific Highway upgrade project boundary and threatened rainforest communities. Map is sourced from EMM (2014).

Table 1. Details and habitat description of paired Impact and Control monitoring plots.

Paired sites	Impact/ Control	Rainforest type/subtype	Habitat/Location
1	Impact	Littoral rainforest	Flat, Pleistocene sand bench, off Kays Rd
5	Control		~20m east
2	Impact	Lowland Rainforest on creek alluvium	Both plots on Randell's Creek
3	Control	Disturbed, mostly open canopy	~300m upstream
4	Impact	Rainforest regrowth on rocky hillside	Regrowth, weedy, lower slope
6	Control		~300m north
7	Impact	Swamp rainforest – Bangalow Palm	Flat floodplain swale, flood-prone, peaty soil
12	Control		~100m apart very similar
8	Impact	Rainforest regrowth on rocky hillside	Regrowth, weedy, lower to mid slope
9	Control		~300m north
11	Impact	Littoral rainforest/Lowland Rainforest	Flat Pleistocene sand merging with bedrock hillslope
10	Control		~2.5km north; not merging with bedrock
13	Impact	Rainforest regrowth on hillside	Lower slope, north of Çoolgardie Rd.
14	Control		~50m north

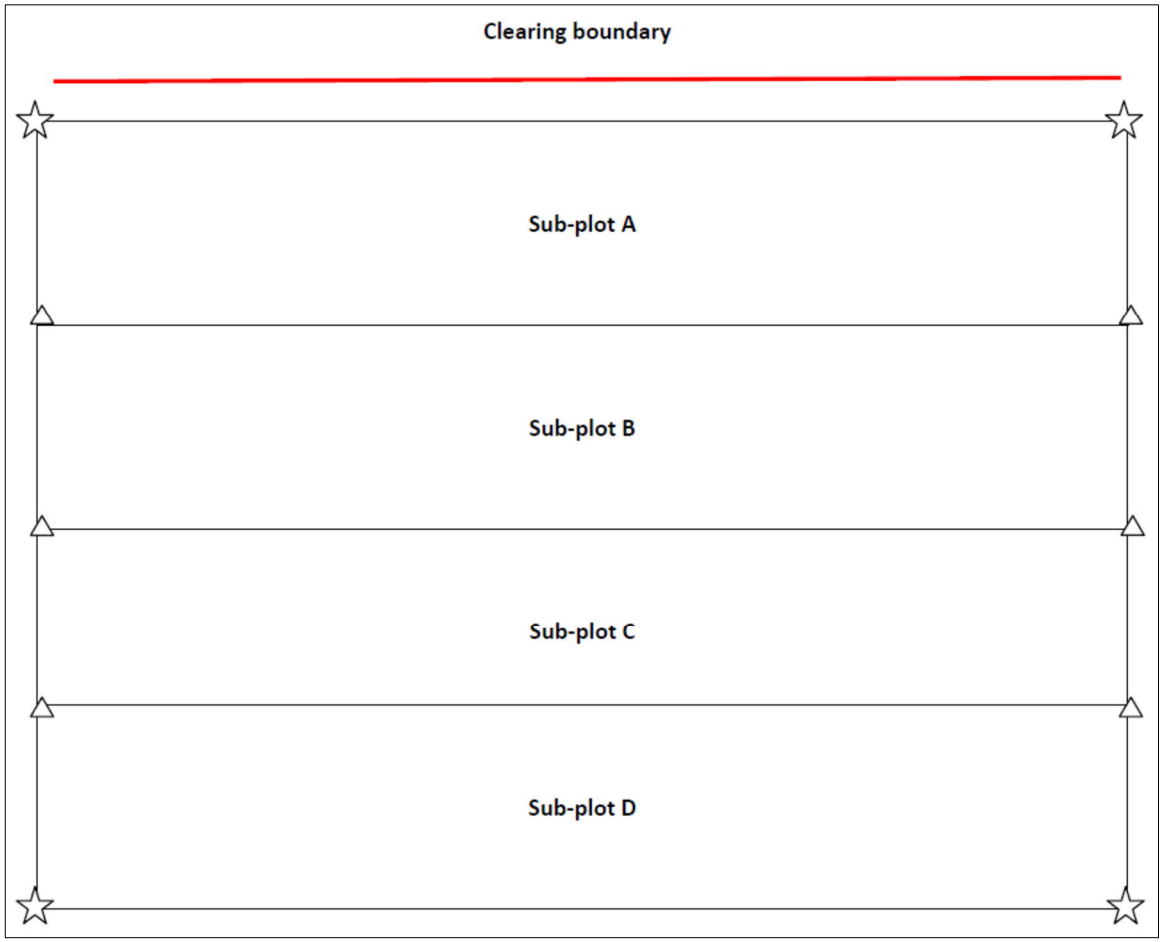


Figure 2. Plot layout for threatened rainforest communities monitoring plots. Plots were 20 m x 20 m and divided into four 20 m x 5 m sub-plots. Diagram is sourced from EMM (2014).

Table 2. Schedule for W2B Threatened Rainforest Plants and Rainforest Communities monitoring program. Table sourced RMS (2015).

Monitoring	Year	Phase	Section
1st quarter - Rainforest Plant Monitoring	1	Construction	S10-11
2nd quarter - Rainforest Plant Monitoring	1	Construction	S10-11
3rd quarter -Rainforest Plant Monitoring	1	Construction	S10-11
4th quarter - Rainforest Plant Monitoring	1	Construction	S10-11
Autumn - Rainforest Community Monitoring	1	Construction	S10-11
Spring - Rainforest Community Monitoring	1	Construction	S10-11
1st half - Rainforest Plant Monitoring	2	Construction	S10-11
2nd half - Rainforest Plant Monitoring	2	Construction	S10-11
Autumn - Rainforest Community Monitoring	2	Construction	S10-11
Spring - Rainforest Community Monitoring	2	Construction	S10-11
Annual monitoring - Rainforest Plants	3	Construction	S10-11
Autumn - Rainforest Community Monitoring	3	Construction	S10-11
Spring - Rainforest Community Monitoring	3	Construction	S10-11
Annual monitoring - Rainforest Plants	4	Operation	S10-11
Annual monitoring - Rainforest Communities	4	Operation	S10-11
Annual monitoring - Rainforest Plants (Provisional)	5	Operation	S10-11
Annual Monitoring - Rainforest Communities (Provisional)	5	Operation	S10-11
Annual monitoring - Rainforest Plants (Provisional)	6	Operation	S10-11
Spring - Rainforest Community Monitoring (Provisional)	6	Operation	S10-11

2.2 Data Analysis

2.2.1 Ordination and point sequences

The perceived threat of the highway upgrade to the adjacent threatened rainforest communities is that it will cause edge effects resulting in a decrease in habitat condition (through weed invasion and death of plants due to exposure to harsher abiotic factors). Based on this assumption we can make predictions about how the vegetation at the monitoring sites will change following construction and operation of the highway, such as:

> After construction begins, the rate of vegetation change at the Impact sites will be greater than at the Control sites.

To test these predictions, the following data analysis method was used, which is taken from Chapter 7 of *Data Analysis In Vegetation Ecology* (Wildi 2017) and is used for detecting and investigating temporal trends in vegetation.

An excel spreadsheet containing the baseline data (Autumn 2014) for subplot *a* of each site and the 2020 operational phase data for sub-plot *a* of each site was imported into a data matrix object in the statistical software *R* (R Core Team 2018). Principal Component Analysis (PCA) was performed separately on each pair of Control and Impact sites (e.g. Plot 2 and Plot 3, Plot 1 and Plot 5, etc) using the *pcaser* function in the *dave* package (Wildi 2017). Like all ordination methods, PCA enables complex multivariate datasets to be arranged in two-dimensional space where the closer samples (represented by points) are to each other, the more similar (in terms of the variables measured) they are. To make it clearer to see trends in ordination space, only the baseline data and the 2020 operational phase data for sub-plot *a* of each site were analysed. Note, that the rate of vegetation change at the impact sites is expected to be greatest at sub-plot *a* as it is closest to construction.

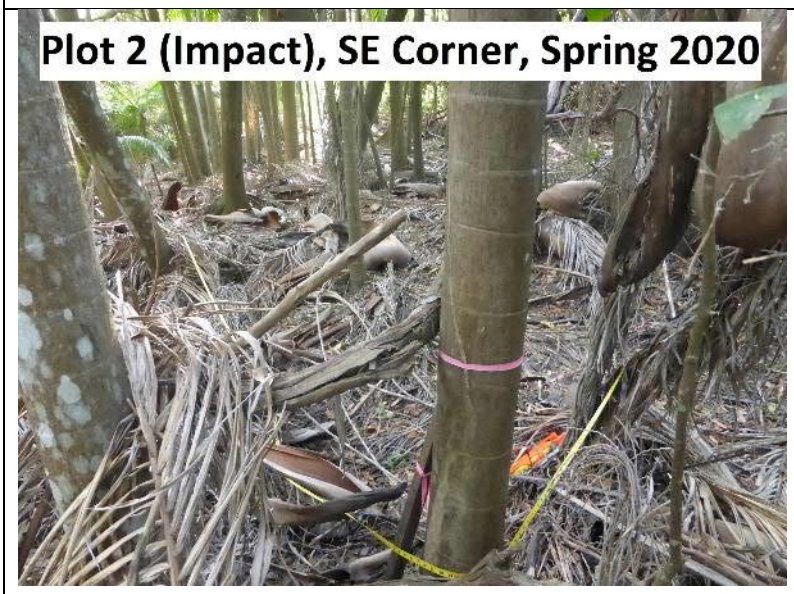
2.2.2 Abundance of exotic species

The abundance of exotic species was used as an indicator of rainforest condition. An increase in the abundance of exotic species was interpreted as a decline in vegetation condition. The abundance of exotic species per plot was derived by summing the crown cover of each sub-plot and then averaging across the four sub-plots.

2.3 Results

2.3.1 Summary of rainforest community plots spring 2020

Table 3. Changes in composition and structure of rainforest communities. The Spring 2020 data (first year of operational phase monitoring) was compared with the previous year's monitoring data (Spring 2019) to determine overall floristic changes.

Monitoring sites	Spring 2020 monitoring findings
	• Increase in weed abundance, esp. Ochna and Camphor Laurel • Tree fall in subplot *a* resulting in canopy gap • Large decrease in vine species *Cissus hypoglauca* and Smilax • Medium decrease in native grass spp.
	• Increase in weed (Devil's Fig and Broad-leaved Paspalum) abundance in subplot *a* • Large increases in vines *Cissus hypoglauca* and Native Wisteria • Several annual weed species died out • Small increase in Cherry Guava (weed)

	• Increase in Lantana in subplot *a* • Increase in Broad-leaved Paspalum across subplots • Increase in vine *Flagellaria indica* • Increase in *Carronia multisepalea*, host plant for endangered Pink Underwing Moth
	• Increase in Large-leaved Privet • Increase in scrambler *Calamus muelleri* • Decrease in vines Smilax and Cockspur • Tree fall in subplot *b* resulting in canopy gap.
	• Increase in *Flindersia bennettiana* recruitment • Increase in *Litsea australis*, esp. in 0-1 m and 1-5 m strata • Most species relatively unchanged • Newly recorded species *Cryptocarya triplinervis* and *Diospyros pentamera*

	• Increase in Large-leaved Privet • Medium increase *Gahnia aspera* • Flagellaria remains dominant vine • Most species relatively unchanged
	• Increase in Small-leaf Privet in subplot *a* • Most noticeable changes in subplot *a*, e.g. increase in *Trophis scandens*, *Cordyline stricta* and *Hypolepis muelleri* • Increase in Flagellaria across subplots • Increase in *Allocasia brisbanensis* across subplots
	• Large-leaved Privet remains dominant species in subplots but abundance is stable (i.e. has changed little) • Broad-leaved Paspalum newly recorded in subplot *a* • Ochna newly recorded in subplots *a, b* and *c* • Floristics mostly stable (relatively unchanged)

	• Increase in scrambler *Calamus muellerii*, esp. in subplots *b* and *c* • Large-leaved Privet remains dominant species • Increase in vine *Cissus antarctica* • Floristics mostly stable (relatively unchanged)
	• Small increase in weed Broad-leaved Paspalum • Increase in vines *Cissus hypoglauca* and Flagellaria • In ground cover, increase in fern *Pellaea falcata* and sedge *Gahnia clarkei* • Newly recorded species *Kennedia rubicunda* and *Pomax umbellata*
	• Signs of recent weed control in plot • Increase in weed Climbing Asparagus in subplot *a* • Camphor Laurel seedlings newly recorded in subplots *a*, *c* and *d* • Small-leaf Privet (weed) newly recorded

	• Increase in ferns *Blechnum cartilagineum* and *Hypolepis muelleri* • Increase in sedge *Carex maculata* • Increase in ground cover *Alpinia arundelliana* • Some increase in ground covers (above) but overall floristics relatively unchanged, esp. in higher stratum
	• Small increase in aggressive weed Madeira Vine • The weeds Broad-leaved Paspalum and Small-leaf Privet remain dominant in ground layer in NE Corner where there is canopy gap • Small increase in weed Climbing Asparagus • Decrease in native grass spp.
	• Increase in weed Climbing Asparagus in subplot *d* • Increase in vines Cockspur and *Cissus antarctica* • Decrease in vines *Derris involuta* and Giant Prickle Vine • Decrease in native grass *Oplismenus imbecillis*

2.3.2 Ordination and point sequences

Each PCA graph showed the rate of vegetation change at sub-plot *a* of each pair of Control and Impact sites (Figure 3 and 4). In each PCA graph the length of the line connecting the two points in the time series indicates the rate of change, i.e. the longer the line, the greater the rate of change. If the highway upgrade has negatively affected the adjacent rainforest communities through edge effects, we would expect the rate of change at the Impact sites to be greater than at the Control sites. This was the case for some areas, for example, Plot 2 and Plot 3. Sub-plot 2a (Impact) has changed more than sub-plot 3a (Control) (Figure 3). However, for other areas, the Control site has changed more than the Impact site, for example, Plot 8 and Plot 9 (Figure 4). As the rate of vegetation change is not consistently greater at the Impact sites compared to the Control sites, it is difficult to draw conclusions about the impact of the highway upgrade on the neighbouring rainforest communities.

The PCA graphs for the other paired sites are included in Appendix 1.

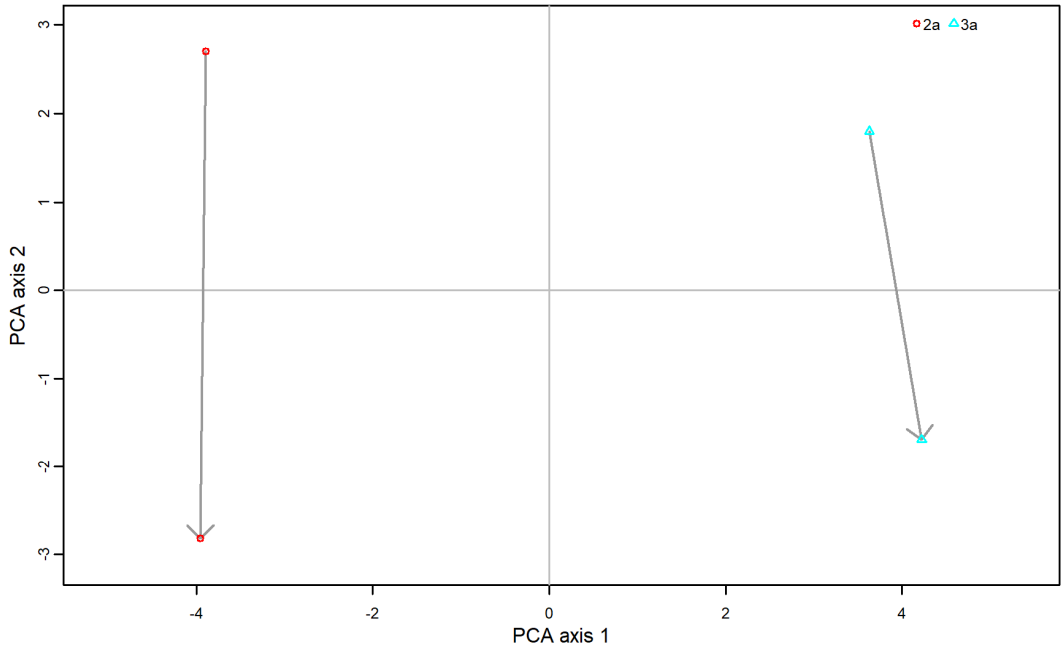


Figure 3. PCA ordination graph of a time series of sub-plot 2a (Impact) and sub-plot 3a (Control). The arrow points from the beginning state (i.e. autumn 2014) to the end state (i.e. spring 2020). Note that the rate of vegetation change is greater at the Impact site.

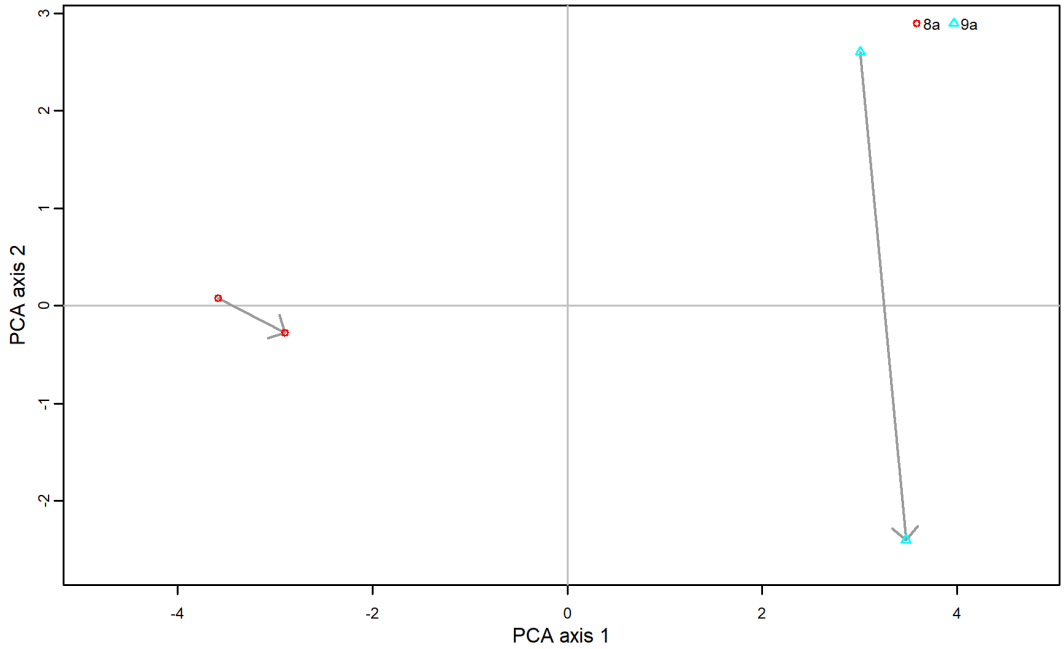


Figure 4. PCA ordination graph of a time series of sub-plot 8a (Impact) and sub-plot 9a (Control). The arrow points from the beginning state (i.e. autumn 2014) to the end state (i.e. spring 2020). Note that the rate of vegetation change is greater at the Control site.

One possible explanation for the absence of a temporal trend is that not enough time has elapsed for one to emerge. So far, the rainforest plots have been monitored for seven years (2014-2020), which is a small time-scale in the context of ecological succession.

A factor worth considering, however, is that some of the Impact plots were not situated directly beside the forest edge (edge of clearing) and therefore, are not expected to be subject to strong edge effects (Table 4). For some Impact plots the forest edge has become closer due to clearing for the highway upgrade, while the distance to the forest edge has not changed for others as there was a cleared edge already, at the start of construction.

Table 4. Variable distance of Impact plots from edge of clearing or construction and whether clearing was effective or ineffective. Effective clearing is where clearing of forest took place next to the plot and ineffective clearing is where clearing (of the construction footprint) next to the plot did not result in removal of forest, only pasture.

Impact plot	Approx. distance of plot to edge of clearing/ construction	Effective/ineffective clearing
1 (LRF Kays Ln)	15 m	effective
2 (STRF Randall's Ck)	0 m	effective
4 (RF rocky)	10 m	ineffective
7 (Swamp RF)	0 m	effective
8 (RF rocky)	10 m	ineffective
11 (LRF Lumleys)	10 m	effective
13 (Coolgardie Rd)	5 m	ineffective

Previous monitoring studies of the impact of clearing on threatened rainforest flora found that weed incursion into threatened species habitat generally extended no more than 10 m inside newly created forest edges (Ecos 2006). Four of the seven impact monitoring plots for this study are 10 m or more from the edge of clearing and therefore, based on Ecos (2006), would be unlikely to register a significant increase in weediness due to reduced distance to the forest edge.

Positioning of the Impact plots away from the actual edge of clearing was unavoidable as they were installed in 2014 and relied on early models of the road design and construction footprint. In retrospect, and with a view to similar monitoring in future, the monitoring plots should have been installed immediately after vegetation clearing, so they were situated right on the edge of clearing, and able to measure vegetation changes in the zone most strongly affected by clearing. A setback of one metre would ensure no physically disturbed habitat (from clearing) was in the plot.

Ordination methods are useful for simplifying complex datasets and detecting overall tends in plant communities. A limitation of this approach, however, is that common or abundant species in plant communities can mask small but important changes occurring among less frequent species. Therefore, it is important to also investigate trends that may be occurring at the species level or among certain components of the flora (e.g. exotic species, specific growth forms or strata within the plant community) as described below.

2.3.3 Abundance of exotic species

A total of 33 exotic species were recorded in spring 2020 across the 14 monitoring plots. Like in previous monitoring events, most were common garden escapees or herbaceous annuals that do not pose a serious threat to the integrity of rainforest communities. Eleven

species were recorded that are considered serious weeds in rainforest communities, these were Madeira Vine, Climbing Asparagus Fern, Camphor Laurel, Coastal Morning Glory, Large-leaved Privet, Ochna, Broad-leaved Paspalum, Devil's Fig, Winter Senna and Crofton Weed. Of these eleven weed species, Camphor Laurel, Large-leaved Privet, Broad-leaved Paspalum, Climbing Asparagus Fern and Ochna were most common among the monitoring plots. Devils Fig is an emerging environmental weed with only scattered plants in Section 10 but common to the north.

Exotic abundance averaged across the seven Impact plots has increased from 32% crown cover in February 2014 to 55% crown cover in Spring 2020 (Table 5). Impact plots 2, 4 and 13 had the largest increases in exotic abundance since February 2014 (11%->42%, 61%->113%, and 38%->90%, respectively). The other Impact plots either had small increases in exotic abundance or remained relatively unchanged.

The increase in exotic abundance in the Impact plots could be indicative of detrimental edge effects (i.e. an increase in light availability favouring weed species), however, there has also been an increase in exotic abundance in the Control plots. Exotic abundance averaged across the seven Control plots has increased from 17% crown cover in February 2014 to 29% crown cover in Spring 2020. In all of the Control plots there has been an increase in exotic abundance throughout the monitoring program. Control plots 3, 5 and 6 had the largest increases in exotic abundance since February 2014 (4%->24%, 12%->25%, and 28%->67%, respectively).

Weeds establish in rainforest where there is increased light availability, which can either be at the edge of the rainforest or underneath canopy gaps as a result of tree fall. In the rainforests of north-eastern Queensland, Pohlman (2006) found that weeds were confined exclusively to the forest edge or where there were large canopy gaps. Once some rainforest weeds are established however, they can continue to grow in scare light conditions. This is true for the weed species Climbing Asparagus, Madeira Vine and Ochna (Darren Bailey pers. comm.). The finding in this monitoring study that there has been an increase in weed abundance at both the Impact and Control plots suggests that weed abundance has increased not because of construction-related edge effects but because weeds were established at the plots prior to the monitoring study commencing, and have continued to increase regardless of increased light availability from clearing, possibly due to other factors

One factor that may explain the increase in weed abundance is the removal of cattle grazing. The monitoring sites have a history of cattle grazing and it is generally recognised that removal of cattle from forest where they formerly grazed is followed by an increase in weediness. Weeds can become established in a forest as a result of cattle foraging but as long as cattle continue to graze the forest the weeds are controlled.

The monitoring sites that are positioned on the rocky slopes of the Blackwall Range (Plots 4, 8, 9 and 13) have a canopy dominated by Broad-leaved Privet and to a lesser extent Camphor Laurel. These exotic species are often the first trees to establish in cleared areas that previously had rainforest and a range of birds feed on these species fruit. Although Broad-leaved Privet and Camphor Laurel are aggressive competitors, they may serve as an initial nursery layer that enables native species dispersed by birds to establish. Indeed, Plots 4, 8, 9 and 13 all had native trees, shrubs, ferns and herbs establishing in the lower canopy strata, and native vines were already abundant in the higher strata.

Table 5. The abundance of exotic species in each pair of Control and Impact plots, compared across monitoring events. Abundance is percentage crown cover. Values can be higher than 100% because species abundance values were summed for the five strata. Averages rounded to the nearest integer.

		February 2014	Autumn 2017	Spring 2017	Spring 2018	Spring 2019	Spring 2020
1	Impact	2	4	14	12	11	18
5	Control	12	10	18	25	22	25
2	Impact	11	36	18	35	30	42
3	Control	4	7	7	18	15	24
4	Impact	61	81	102	106	95	113
6	Control	28	41	37	57	52	67
7	Impact	2	1	1	2	1	4
12	Control	1	1	<0.5	1	1	1
8	Impact	103	92	127	114	117	108
9	Control	68	42	63	73	72	71
11	Impact	4	12	19	12	10	9
10	Control	4	2	2	4	5	5
13	Impact	38	54	37	92	81	90
14	Control	5	2	6	9	6	10
Overall Impact		32	40	45	53	49	55
Overall Control		17	15	22	27	25	29

It is noted that following recommendations in the last monitoring report, a Rainforest Weed Management Plan was prepared by Jacobs and implemented in 2021. According to information supplied by Pacific Complete, Bushland Restoration Services (BRS) carried out weed control work in relation to the Weed Plan in Feb/March 2021. This was followed by further work by GMC Environmental Consulting in August 2021. Further exotic species removal in the area relevant to the Weed Plan was carried out by Ecos Environmental surrounding the Coolgardie Rd translocation area in 2021. A copy of the Rainforest Weed Management Plan (Jacobs 2020) and a work completion report are appended to this report.

3 Threatened Rainforest Plant Monitoring

3.1 Species included in monitoring program

The threatened rainforest plants being monitored are located on Sections 10 and 11 of the highway upgrade. Section 10 extends from the Richmond River north to Coolgardie Rd and Section 11 from Coolgardie Rd north to the Ballina bypass tie-in. Individuals closest to the forest edge as well as a selection of plants further back inside the forest were included in the monitoring program.

The following eight threatened rainforest plant species are located adjacent to Sections 10 and 11 of the W2B Pacific Highway upgrade and are being monitored as part of the *Woolgoolga to Ballina Threatened Rainforest Communities and Rainforest Plants Management Plan* (RMS 2015):

- Rough-shelled Bush Nut (*Macadamia tetraphylla*) (vulnerable under the Biodiversity Conservation Act, 2016 (BC Act) & Environment Protection and Biodiversity Conservation Act (EPBC Act)
- Rusty Green-leaved Rose Walnut (*Endiandra muelleri* subsp. *bracteata*) (endangered under the BC Act)
- White Lace Flower (*Archidendron hendersonii*) (vulnerable under the BC Act)
- Rusty Rose Walnut (*Endiandra hayesii*) (vulnerable under the BC Act & EPBC Act)
- Stinking Cryptocarya (*Cryptocarya foetida*) vulnerable under the BC Act & EPBC Act)
- Southern Ochrosia (*Ochrosia moorei*) (endangered under the BC Act & EPBC Act)
- Red Lilly Pilly (*Syzygium hodgkinsoniae*) (vulnerable under the BC Act & EPBC Act)
- Smooth Davidsonia (*Davidsonia johnsonii*) (endangered under the BC Act & EPBC Act).

Streblus brunonianus and *Acronychia littoralis* were included in the initial monitoring program (EMM 2014) but have since been removed. *Streblus brunonianus* was taken out as it is no longer listed as a threatened species and *Acronychia littoralis* was removed due to misidentification. For further details see Ecos (2017).

3.2 Data collection and analysis

A total of 210 plants were tagged and recorded in the baseline monitoring and pre-construction survey carried out by EMM in February 2014 (Table 6). The tagged plants were positioned close to the highway construction footprint and further back inside the forest.

The following plant attributes were recorded: plant condition on a scale of 0-5 (Table 6), height and girth, presence of flowers or fruit, any insect/grazing damage, evidence of disease, and signs of recruitment.

Plant height was recorded with a tape measure for plants up to about 3.5 m high and visually estimated for taller plants.

Plant height was averaged across individuals of the same species and compared across 2017, 2019 and 2020. The 2017 monitoring data was included instead of the 2018 data in order to compare plants across a longer timeframe. Heights that were visually estimated (i.e. individuals higher than 3.5 m) were excluded from averaging. Averages were not calculated for Endiandra haysii and Ochrosia moorei because there is only one plant being monitored for each species.

The tagged plants were monitored quarterly in year 1 (2017), biannually in year 2 (2018), annually in year 3 (2019), and annually in year 4 (2020) (Table 2).

Table 6. Condition scores applied to threatened rainforest plant species.

Score	Condition
0	Dead
1	Leafless, possibly still alive and may reshoot
2	Small (<0.7- 1m), seedling or sapling, reasonably healthy; or taller plant that has dieback but still has some leaves
3	Sapling or small tree, healthy, evidence of recent new growth, not reproductively mature; or tree showing evidence of minor dieback
4	Reproductively mature, healthy but relatively small for the species
5	Reproductively mature, healthy, good size

3.4 Results`

3.4.1 Summary

In the monitoring period between 2014 and 2020, seven of the tagged threatened plants died – two White Laceflower, four Smooth Davidsonia plants, and one Green-leaved Rose Walnut (Table 7). In 2019, five Smooth Davidsonia plants were dead but in 2020 one of these "dead" plants reshot. Survival for Stinking Cryptocarya, Rough-shelled Bush Nut, , Southern Ochrosia, and Red Lilly Pilly were 100% in 2020.

Figure 5 shows the growth of plants below 3.5 m high (i.e. those measured with a tape measure) for each species in 2017, 2019 and 2019. Note, Rusty Green-leaved Rose Walnut and Southern Ochrosia were not included in the graph because there is only one plant being monitored for each species.

The year 2019 was one of the driest years on record (Figure 6). It was not surprising that some of the plants being monitored died back in 2019 or did not grow, most likely due to water-stress. This was true for plants of the species White Laceflower, Rough-shelled Bush Nut, Smooth Davidsonia and Rusty Green-leaved Rose Walnut (Figure 7). Also, some Smooth Davidsonia plants appeared dead in 2019 (5 plants), however, one of these plants reshot in 2020. The year 2020 had above average rainfall and most of the drought-affected

plants reshot and grew, which can be seen in Figure 7. One Rusty Green-leaved Rose Walnut plant that died back in 2019, however, appeared to be dead in 2020 (Plate 1, Appendix 2).

It was surprising that most of the tagged threatened plants continued to grow in 2019, despite it being one of the driest years on record, and most of the plants that died back in 2019, reshot and grew in 2020. Our data suggest that some rainforest species are better adapted to drought than what one might find in the literature.

Table 7. The number of plants being monitored for each threatened species and their survival for the years 2017, 2019 and 2020. Total number of plants being monitored is 210.

Species	No. of plants monitored	Survival (%) 2017	Survival (%) 2019	Survival (%) 2020
Archidendron hendersonii	36	100	94	94
Cryptocarya foetida	12	100	100	100
Davidsonia johnsonii	26	100	81	85
Endiandra hayesii	1	100	100	100
Endiandra muelleri subsp. *bracteata*	56	100	100	98
Macadamia tetraphylla	74	100	100	100
Ochrosia moorei	1	100	100	100
Syzygium hodgkinsoniae	4	100	100	100
	210			

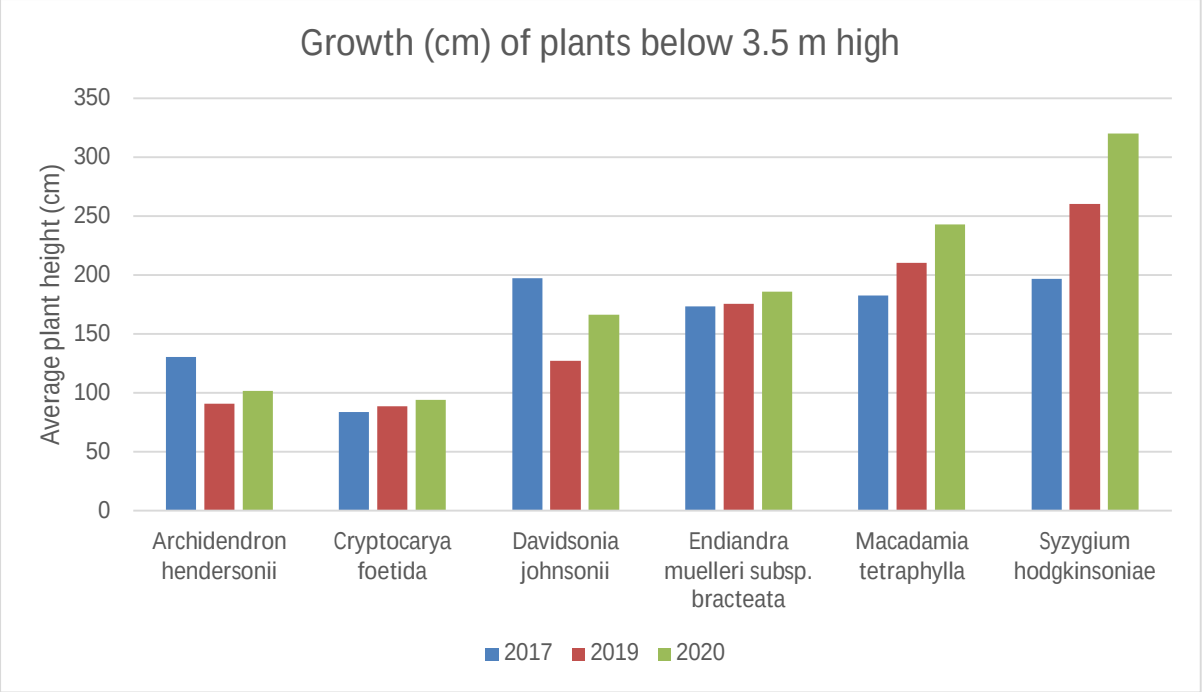


Figure 5. Average plant height (cm) of threatened species in 2017, 2019 and 2020, for plants under 3.5 m high. Note, Velvet Laurel and Southern Ochrosia were not included because there is only one plant being monitored for each species.

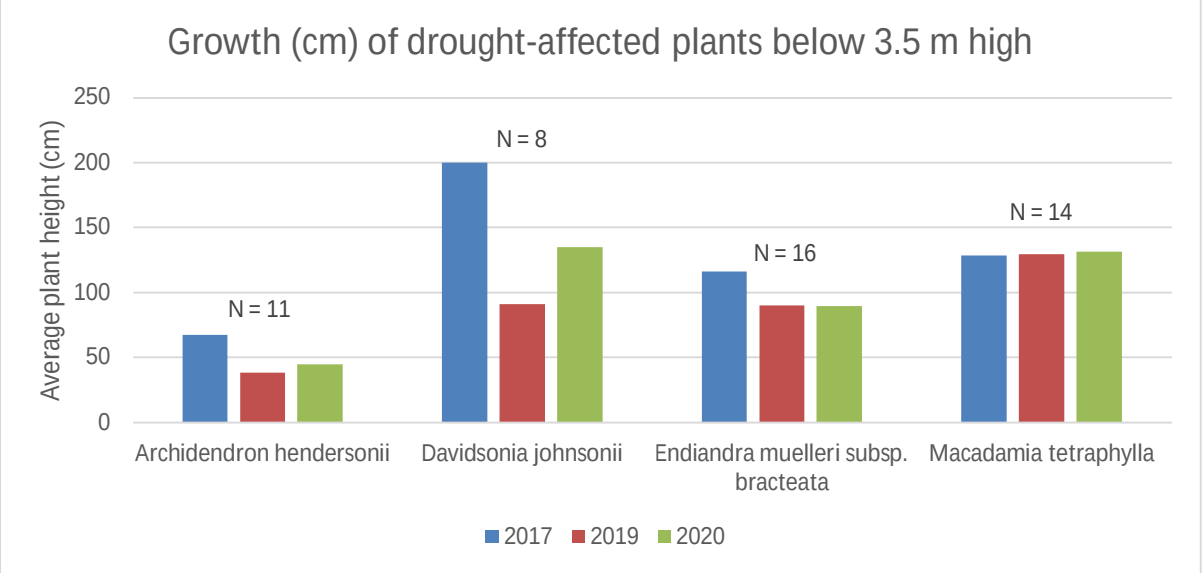


Figure 7. Average plant height (cm) of threatened species in 2017, 2019 and 2020, for drought-affected plants under 3.5 m high. *N*, sample size.

Table 8. Effect of the 2019 drought, one of the most prolonged and intense on record, on threatened species individuals less than 3.5 m high. Total number of plants being monitored is 210.

Species	No. of plants monitored	No. strongly affected by drought*	No. that died	No. that recovered	No. unaffected
Archidendron hendersonii	36	12	2	10	24
Cryptocarya foetida	12	0	0	0	12
Davidsonia johnsonii	26	8	4	4	18
Endiandra hayesii	1	1	0	0	1
Endiandra muelleri subsp. *bracteata*	56	16	1	15	40
Macadamia tetraphylla	74	14	0	14	60
Ochrosia moorei	1	0	0	0	1
Syzigium hodgkinsoniae	4	0	0	0	1
	210				

*i.e. partial or complete stem die back, or leaf browning over one quarter or more of plant

3.4.2 Rainfall

Figure 6 shows the monthly rainfall for Ballina Airport AWS (the closest weather station to the monitoring sites) in 2017, 2019 and 2020, and the mean monthly rainfall for the last 21 years (1992-2020).

The year 2019 was exceptionally dry with a total annual rainfall of 687 mm. Long-term records for the Ballina Airport AWS weather station indicate that 2019 was the fifth driest year on record and that 1902 was the driest year (586 mm). By comparison, the total annual rainfall for 2020 was 2174 mm, which was above average (1725 mm).

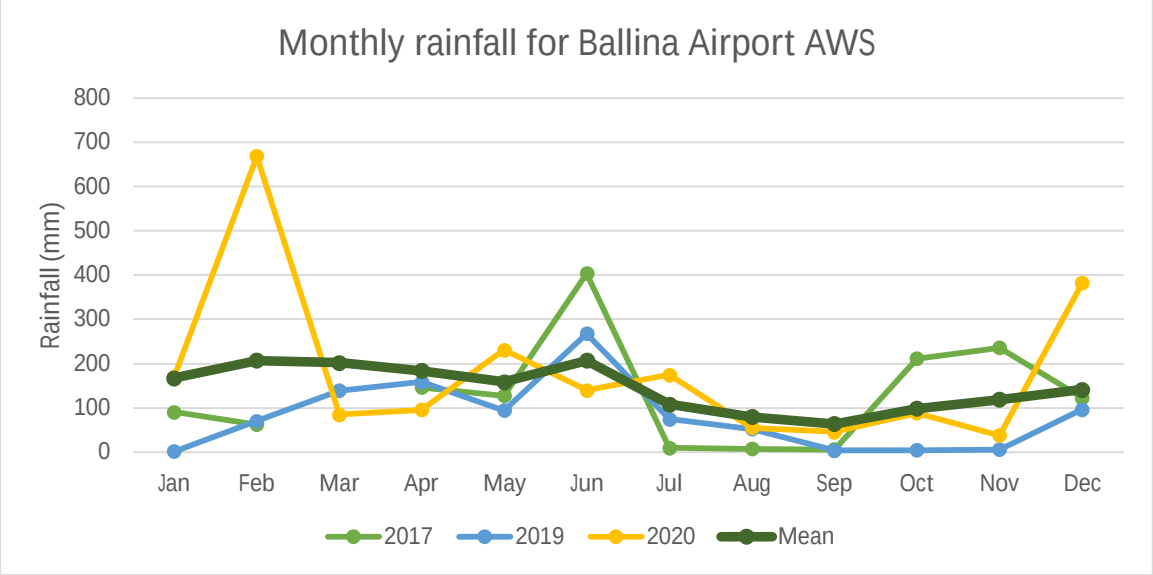


Figure 6. Monthly rainfall for Ballina Airport AWS, in 2017, 2019 and 2020, and mean montly rainfall for 21 years (1992-2020). Note data was absent for March 2017. Data sourced from http://www.bom.gov.au/climate/averages/tables/cw_058198.shtml.

3.4.2 Condition of Threatened Species 2020

Rough-shelled Bush Nut (*Macadamia tetraphylla*)

Survival/condition: 100% survival; some plants have been damaged by insects (e.g. Plate 2, Appendix 2) but the growth of these plants has not been drastically impaired.

Growth: some plants have not grown since 2017 (Figure 7), most likely due to the drought in 2019, but most plants have grown since 2017 (Figure 5); for plants under 3.5 m high, average height was 183 cm in 2017, 210 cm in 2019, and 243 cm in 2020.

Reproduction: 9 of the 74 plants being monitored were reproductive in 2020 (i.e. flowers and/or fruit present) (e.g. Plate 3, Appendix 2).

Rusty Green-leaved Rose Walnut (*Endiandra muelleri* subsp. *bracteata*)

Survival/condition: 98% survival; 1 plant appeared to be dead in 2020 (Plate 1, Appendix 2); this plant most likely died from drought-related factors as it died back in 2019.

Growth: some of the plants died back during the 2019 drought (Figure 7) but most of the plants continued to grow through 2019; for plants under 3.5 m high, average height was 173 cm in 2017, 176 cm in 2019, and 186 cm in 2020.

Reproduction: no flowers or fruit were recorded in 2020, as in previous years.

White Lace Flower (*Archidendron hendersonii*)

Survival/condition: 94% survival; 2 plants that appeared dead in 2019 did not reshot in 2020.

Growth: most plants died back in 2019 but reshot and grew in 2020; for plants under 3.5 m high, average height was 130 cm in 2017, 91 cm in 2019 and 102 cm in 2020.

Reproduction: flowers were recorded on three plants (Plate 4, Appendix 2).

Velvet Laurel (*Endiandra hayesii*)

Survival/condition: only one plant of this species is being monitored; this plant was in healthy condition in 2020.

Growth: the single plant was 4.6 m in 2017, 6 m in 2019, and 7 m in 20202.

Reproduction: no flowers or fruit were recorded in 2020, as in previous years.

Stinking Cryptocarya (*Cryptocarya foetida*)

Survival/condition: survival was 100% in 2020 and plants were in healthy condition.

Growth: most plants continued to grow through the 2019 drought; for plants under 3.5 m high, average height was 84 cm in 2017, 88 cm in 2019 and 94 cm in 2020.

Reproduction: no flowers or fruit were recorded, as in previous years.

Southern Ochrosia (*Ochrosia moorei*)

Survival/condition: only one plant of this species is being monitored; this plant was in healthy condition in 2020.

Growth: the single plant was 300 cm in 2017, 320 cm in 2019, and 330 cm in 2020.

Reproduction: no flowers or fruit were recorded, as in previous years.

Red Lilly Pilly (*Syzygium hodgkinsoniae*)

Survival/condition: survival was 100% in 2020 and plants were in healthy condition.

Growth: all plants continued to grow through the 2019 drought; for plants under 3.5 m high, average height was 197 cm in 2019, 260 cm in 2019, and 320 cm in 2020.

Reproduction: no flowers or fruit were recorded in 2020.

Smooth Davidsonia (*Davidsonia johnsonii*)

Survival/condition: survival was 85% in 2020; five plants appeared dead in 2019 but one of these plants reshot in 2020; these five plants were all growing in a clump with other tagged Smooth Davidsonia plants and it is likely that these five plants were all stems of the same genetic individual as Smooth Davidsonia reproduces vegetatively via root-sucking (it is the species only known form of reproduction).

Growth: most plants died back in 2019 but some of these plants reshot and grew in 2020; for plants under 3.5 m high, average height was 197 cm in 2017, 127 cm in 2019, and 166 cm in 2020.

Reproduction: no flowers or fruit were recorded in 2020, as in previous years.

See Plates 5 and 6, Appendix 2.

4 Conclusion

4.1 Threatened rainforest communities

The main findings of the first year of operational phase monitoring of the threatened rainforest communities were:

- PCA ordination of the monitoring data revealed that the rate of vegetation change (from February 2014 to Spring 2020) at the Impact sites was not consistently greater compared to the Control sites, suggesting no/minimal edge effects from construction.
- There were increases in the abundance of exotic species at some of the Impact sites but this has also occurred at Control sites, suggesting edge effects were not necessarily the cause
- There were changes in the composition and structure of the rainforest at the monitoring sites but these changes are most likely due to natural ecosystem processes rather than construction-related edge effects

Ongoing monitoring of the threatened rainforest communities for indirect impacts may gauge longer-term effects as operation of the highway upgrade continues.

4.2 Threatened rainforest plant species

The main findings of the first year of operational phase monitoring of the threatened rainforest plant species were:

- Survival was 100% for Red Lilly Pilly, 100% for Southern Ochrosia, 100% for Stinking Cryptocarya, 100% for Rough-shelled Bush Nut, 100% for Rusty Green-leaved Rose Walnut, 98% for Green-leaved Rose Walnut (1 dead plant), 94% for White Lace Flower (2 dead plants), and 85% for Smooth Davidsonia (4 dead plants)
- One Smooth Davidsonia appeared dead in 2019 but reshot in 2020
- Plants of the species Green-leaved Rose Walnut, White Lace Flower and Smooth Davidsonia that died back in 2019 (most likely due to drought) reshot and grew in 2020
- 2019 was one of the driest years on record but most of the threatened rainforest plants continued to grow through 2019 and 2020

4.3 Work Plan 2021-2022

- Carry out annual operational phase monitoring (Year 2) of rainforest communities and species in November 2021, as per last year.

- Prepare annual monitoring report by February 2022

5 References

EMM (2014) 'Rainforest Communities and Threatened Rainforest Plants Preconstruction Targeted Surveys and Baseline Monitoring Report'.

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Wildi O (2017) 'Data Analysis In Vegetation Ecology 3rd Edition'. (CABI: Oxfordshire, UK).

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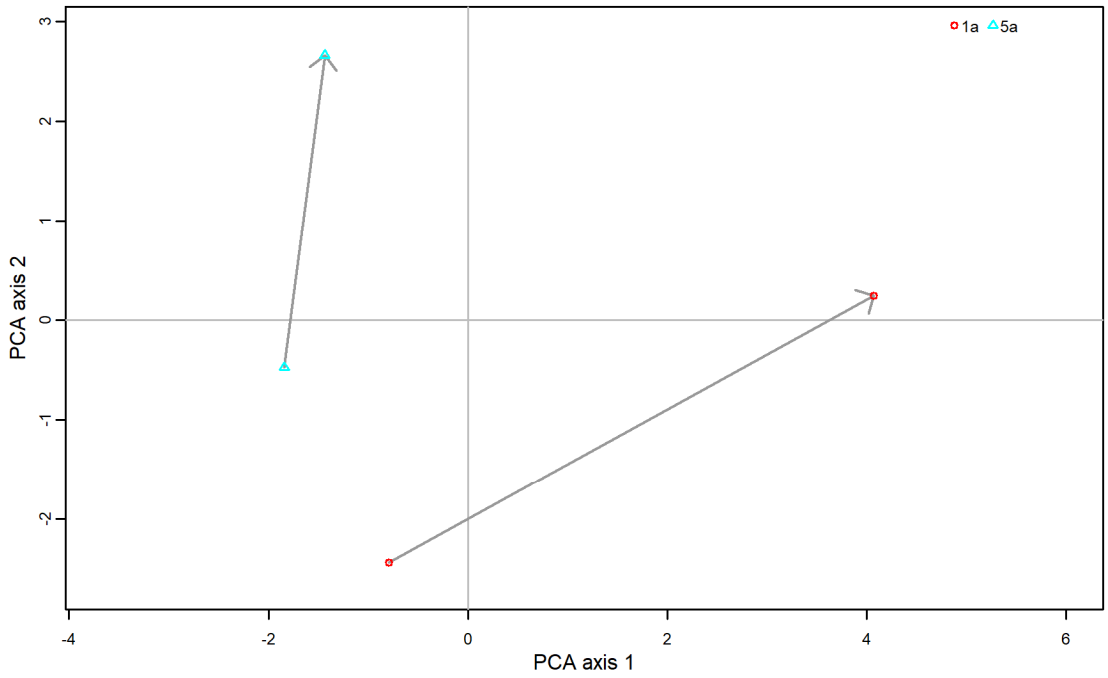
Ecos Environmental (2006) 'Monitoring of Roadside Threatened Plant Species for Brunswick Heads to Yelgun Pacific Highway upgrade, Year 4'. Report prepared for Roads and Traffic Authority, Grafton.

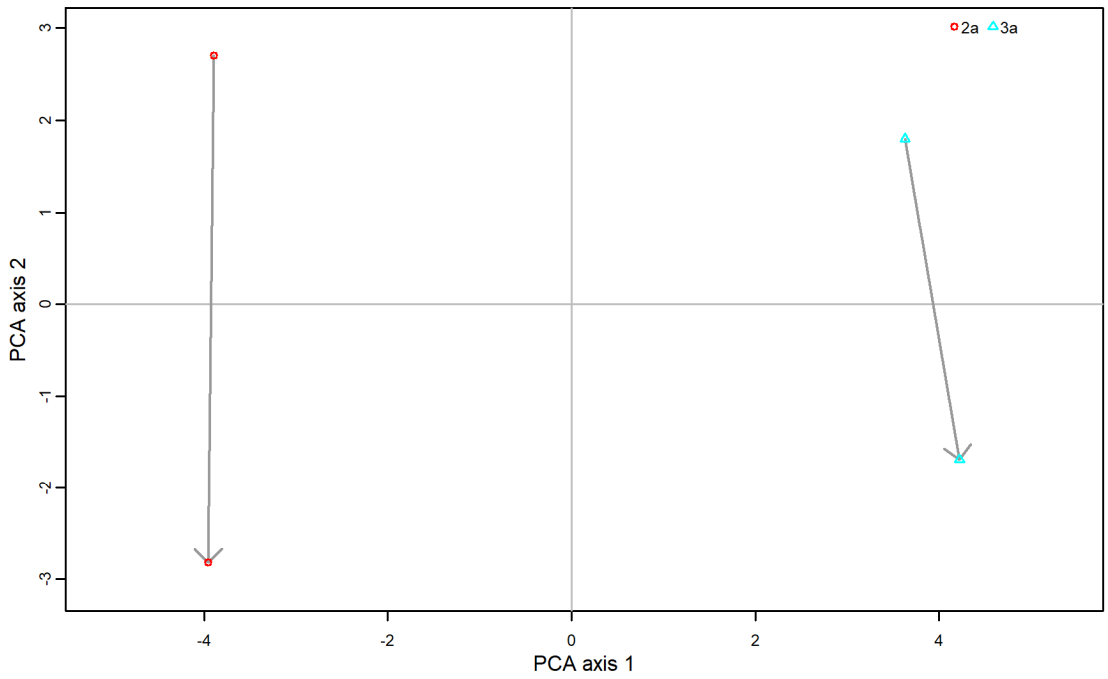
Pohlman CL (2006) 'Internal fragmentation in the rainforest: edge effects of highways, powerlines and watercourses on tropical rainforest understorey microclimate, vegetation structure and composition, physical disturbance and seedling regeneration'. PhD thesis, James Cook University.

Appendix 1.

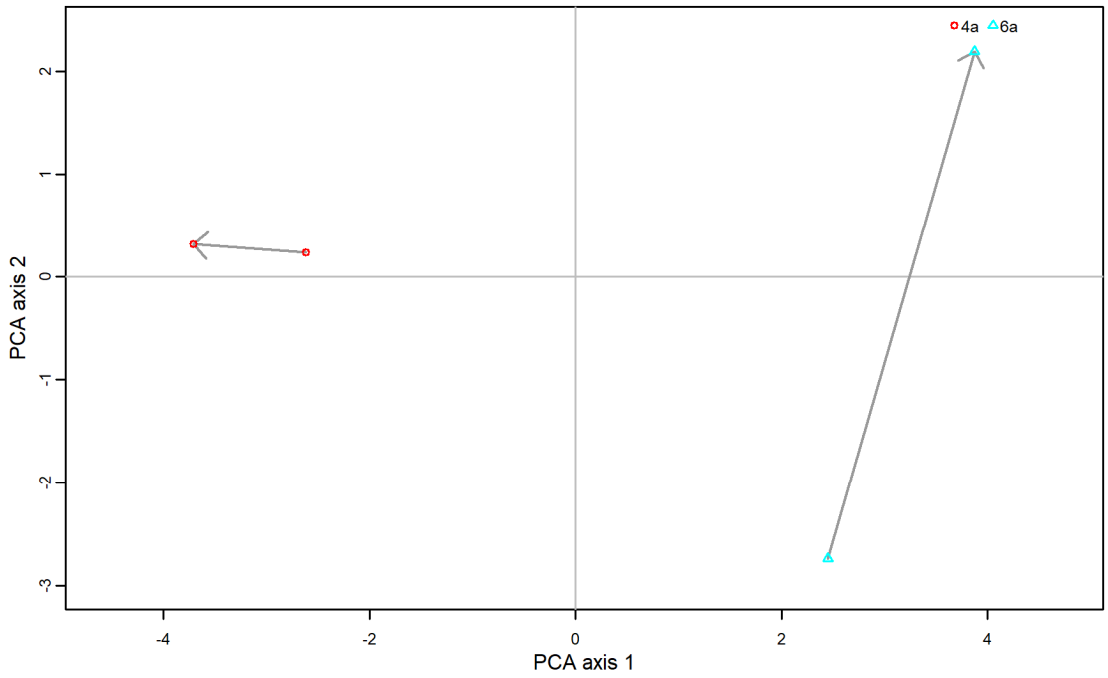
Ordination outputs – comparison of floristics in Impact and Control plots.



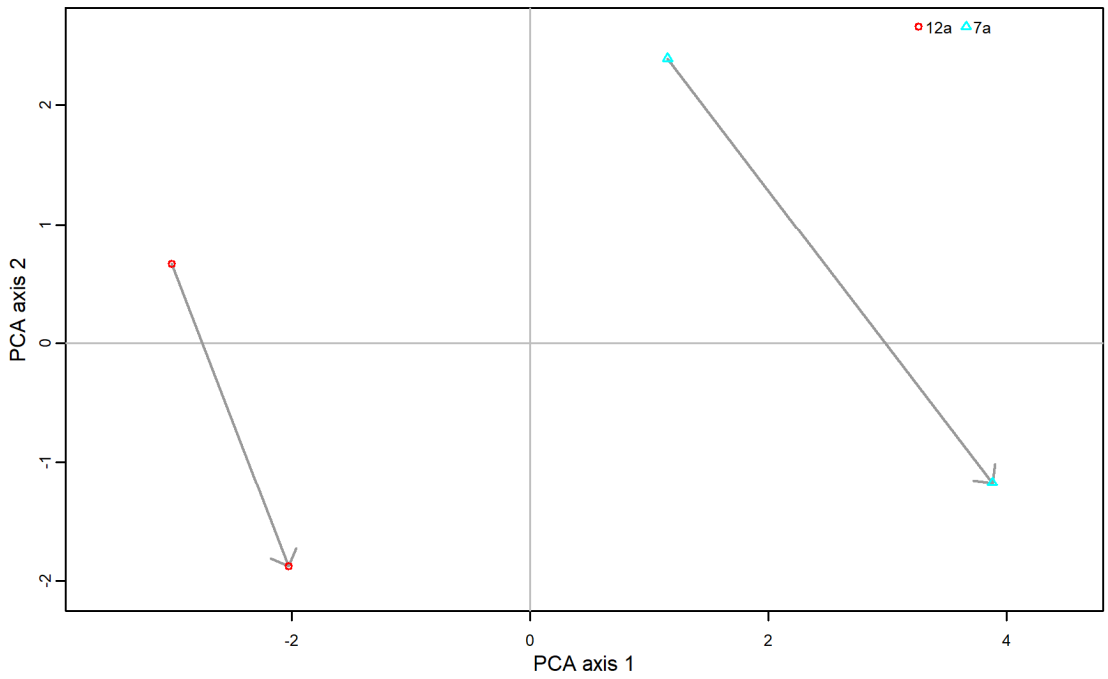
Sites 1a and 5a – Site 1 red = impact; Site 5 blue = control



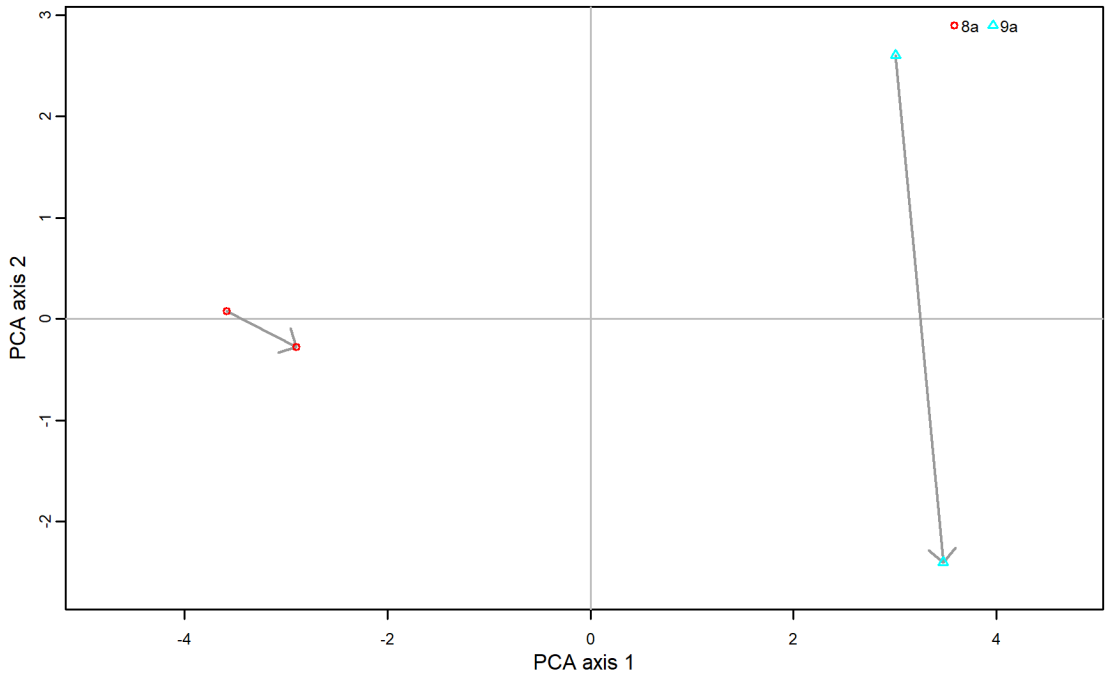
Sites 2a and 3a – Site 2 red = impact; Site 3 blue = control



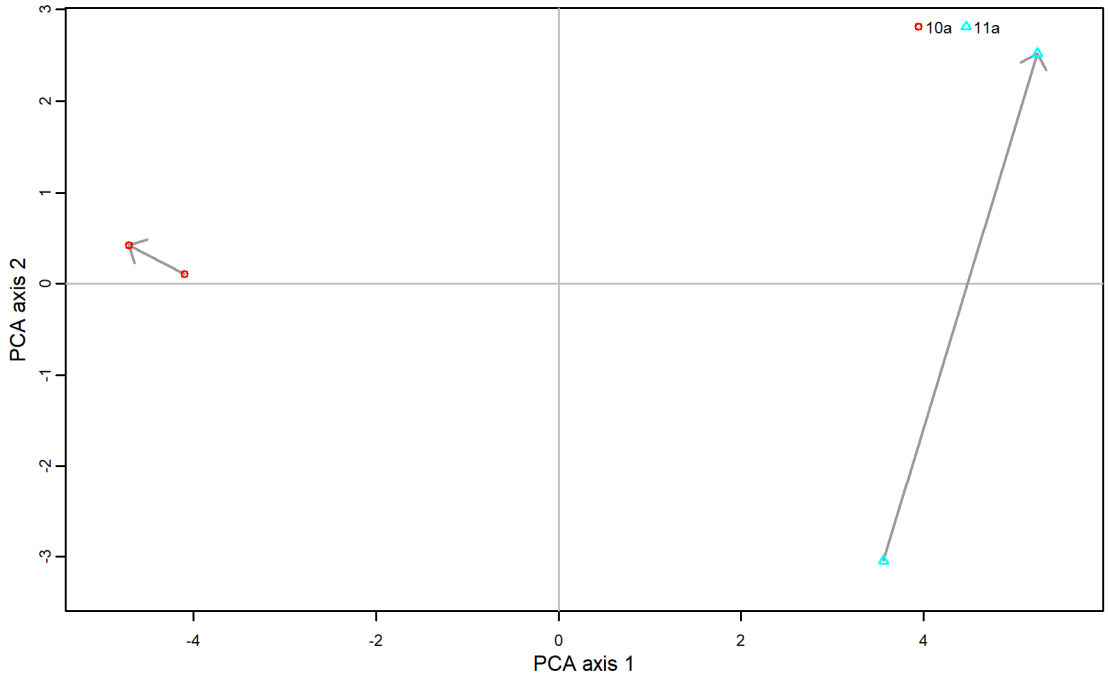
Sites 4a and 6a – Site 4 red = impact; Site 6 blue = control



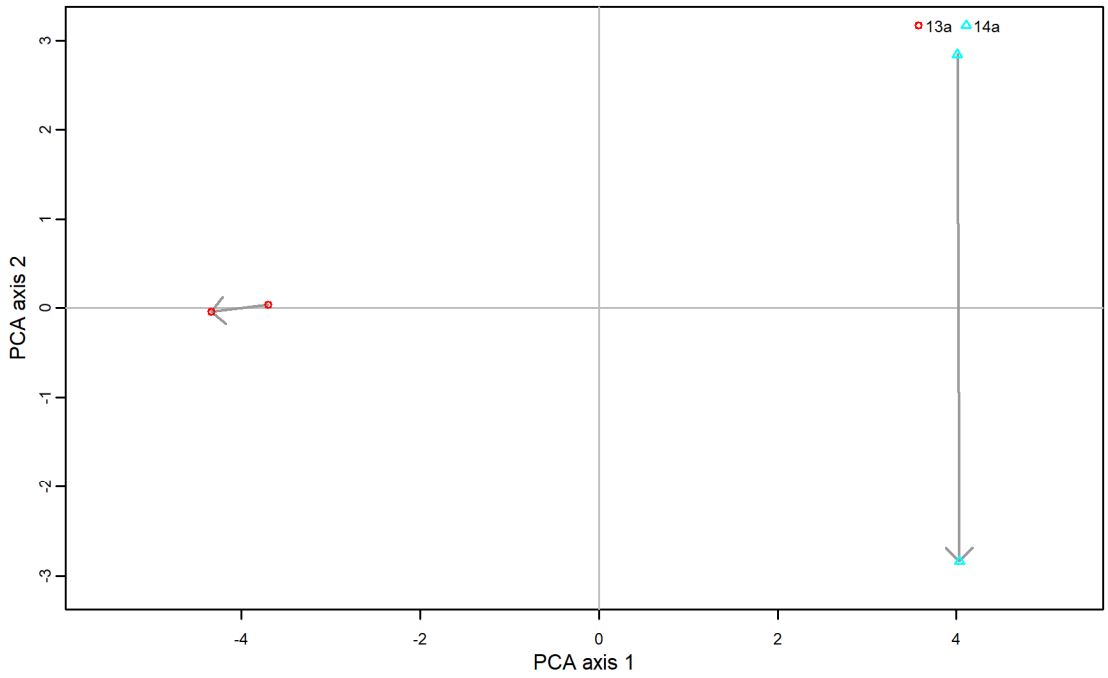
Sites 12a and 7a – Site 12 red = impact; Site 7 blue = control



Sites 8a and 9a – Site 8 red = impact; Site 9 blue = control



Sites 10a and 11a – Site 10 red = impact; Site 11 blue = control



Sites 13a and 14a – Site 13 red = impact; Site 14 blue = control

Appendix 2.

Photos of threatened rainforest plants – spring 2020

Plate 1. Green-leaved Rose Walnut, monitoring ID 119. Pleant appears to be dead.

Plate 2. Insect damage of *Macadamia tetraphylla*, monitoring ID 31.

Plate 3. *Macadamia tetraphylla* fruiting. Monitoring ID 170.

Plate 4. *Archidendron hendersonii* flowering. Monitoring ID 169.

Plate 5. *Davidsonia johnsonii* plant that appeared dead. Monitoring ID 812.

Plate 6. *Davidsonia johnsonii* plants suckering.

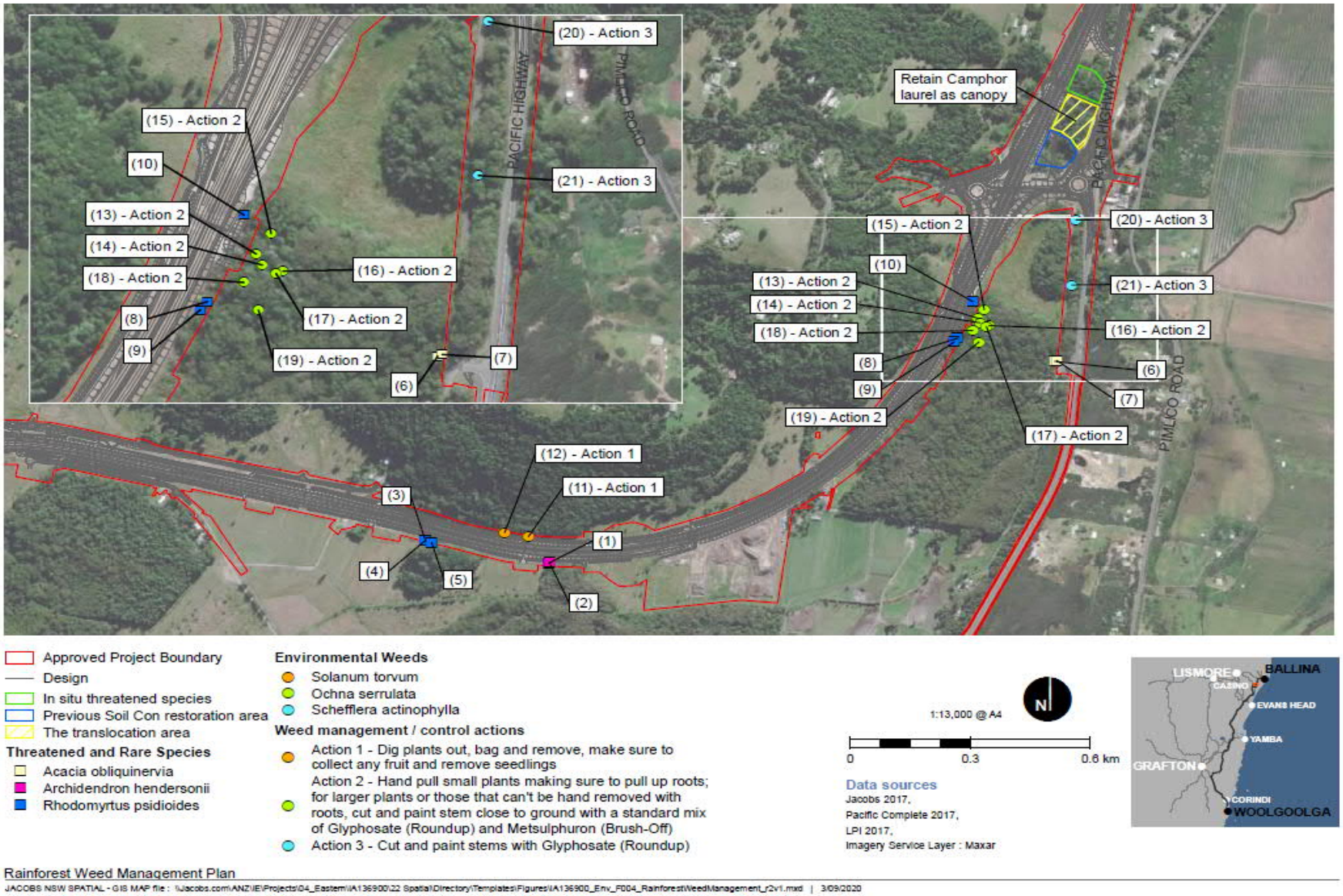


Figure 1. Rainforest Weed Management Plan

Note: Camphor laurel within the project boundary will be retained in the translocation area and on the edge of the in situ threatened species area at Coolgardie Road for shelter and microclimate (Camphor Laurel trees are of scattered occurrence and do not form a dense canopy in these areas). Large-leaved Privet occurs outside the project boundary on the hillsides above the highway, hence no specific control measures are required for this species. Specific weed control and maintenance measures will be applied in zones corresponding to the translocation area and in situ threatened species by the translocation contractor (refer to Figure 1 and Table 1.1).

Table 1.1 Rainforest Weed Management Plan map data and management actions

Map ID	Species scientific name	Species common name	Latitude	Longitude	Location description	Action	Weed management / control actions
	Threatened and Rare Species						
1	Archidendron hendersonii	White Lace Flower	28° 55' 53.77"	153° 27' 43.57"	Tree at corner of sandy track (no. 223)	N/A	To be avoided
2	Archidendron hendersonii	White Lace Flower	28° 55' 53.74"	153° 27' 43.65"	Root sucker edge of sandy track	N/A	To be avoided
3	Rhodomyrtus psidioides	Native Guava	28° 55' 51.87"	153° 27' 32.21"	Forest edge next to highway	N/A	To be avoided
4	Rhodomyrtus psidioides	Native Guava	28° 55' 51.86"	153° 27' 32.16"	Forest edge next to highway	N/A	To be avoided
5	Rhodomyrtus psidioides	Native Guava	28° 55' 51.99"	153° 27' 32.75"	Forest edge next to highway	N/A	To be avoided
6	Acacia obliquinervia	Mountain Hickory	28° 55' 35.89"	153° 28' 30.29"	At entrance to track off Kays Lane west to highway	N/A	To be avoided
7	Acacia obliquinervia	Mountain Hickory	28° 55' 35.83"	153° 28' 30.46"	At entrance to track off Kays Lane west to highway	N/A	To be avoided

8	Rhodomyrtus psidioides	Native Guava	28° 55' 33.89"	153° 28' 21.27"	Forest edge next to highway	N/A	To be avoided
9	Rhodomyrtus psidioides	Native Guava	28° 55' 34.20"	153° 28' 21.00"	Forest edge next to highway	N/A	To be avoided
10	Rhodomyrtus psidioides	Native Guava	28° 55' 30.67"	153° 28' 22.69"	Forest edge next to highway	N/A	To be avoided
	Environmental Weeds						
11	Solanum torvum	Giant Devils Fig	28° 55' 51.48"	153° 27' 41.72"	2 m high just outside fauna fence	1	Dig plants out, bag and remove, make sure to collect any fruit and remove seedlings
12	Solanum torvum	Giant Devils Fig	28° 55' 51.12"	153° 27' 39.51"	1.5 m high just outside fauna fence; other smaller ones	1	Dig plants out, bag and remove, make sure to collect any fruit and remove seedlings
13	Ochna serrulata	Ochna	28° 55' 32.12"	153° 28' 23.18"	Scattered in littoral rainforest	2	Hand pull small plants making sure to pull up roots; for larger plants or those that can't be hand removed with roots, cut and paint stem close to ground with a standard mix of Glyphosate (Roundup) and Metsulphuron (Brush-Off)
14	Ochna serrulata	Ochna	28° 55' 32.52"	153° 28' 23.41"	Scattered in littoral rainforest		Hand pull small plants making sure to pull up roots; for larger plants or those that can't be hand removed with roots, cut and paint stem close to ground with a standard mix of Glyphosate (Roundup) and Metsulphuron (Brush-Off)
15	Ochna serrulata	Ochna	28° 55' 31.36"	153° 28' 23.75"	Scattered in littoral rainforest	2	Hand pull small plants making sure to pull up roots; for larger plants or those that can't be hand removed with roots, cut and paint stem close to ground with a standard mix of Glyphosate (Roundup) and Metsulphuron (Brush-Off)

16	Ochna serrulata	Ochna	28° 55' 32.75"	153° 28' 24.22"	Scattered in littoral rainforest	2	Hand pull small plants making sure to pull up roots; for larger plants or those that can't be hand removed with roots, cut and paint stem close to ground with a standard mix of Glyphosate (Roundup) and Metsulphuron (Brush-Off)
17	Ochna serrulata	Ochna	28° 55' 32.84"	153° 28' 23.96"	Scattered in littoral rainforest	2	Hand pull small plants making sure to pull up roots; for larger plants or those that can't be hand removed with roots, cut and paint stem close to ground with a standard mix of Glyphosate (Roundup) and Metsulphuron (Brush-Off)
18	Ochna serrulata	Ochna	28° 55' 33.18"	153° 28' 22.70"	Scattered in littoral rainforest	2	Hand pull small plants making sure to pull up roots; for larger plants or those that can't be hand removed with roots, cut and paint stem close to ground with a standard mix of Glyphosate (Roundup) and Metsulphuron (Brush-Off)
19	Ochna serrulata	Ochna	28° 55' 34.21"	153° 28' 23.27"	Scattered in littoral rainforest	2	Hand pull small plants making sure to pull up roots; for larger plants or those that can't be hand removed with roots, cut and paint stem close to ground with a standard mix of Glyphosate (Roundup) and Metsulphuron (Brush-Off)
20	Schefflera actinophylla	Umbrella Tree	28° 55' 23.45"	153° 28' 32.21"	In remnant forest next to road	3	Cut and paint stems with Glyphosate (Roundup)
21	Schefflera actinophylla	Umbrella Tree	28° 55' 29.17"	153° 28' 31.84"	In remnant forest next to road	3	Cut and paint stems with Glyphosate (Roundup)

Appendix A. Photos of target environmental weeds

Photo 1: Giant Devils Fig (Solanum torvum)

Photo 2: Ochna (Ochna serrulata)

Photo 3: Umbrella Tree (Schefflera actinophylla)

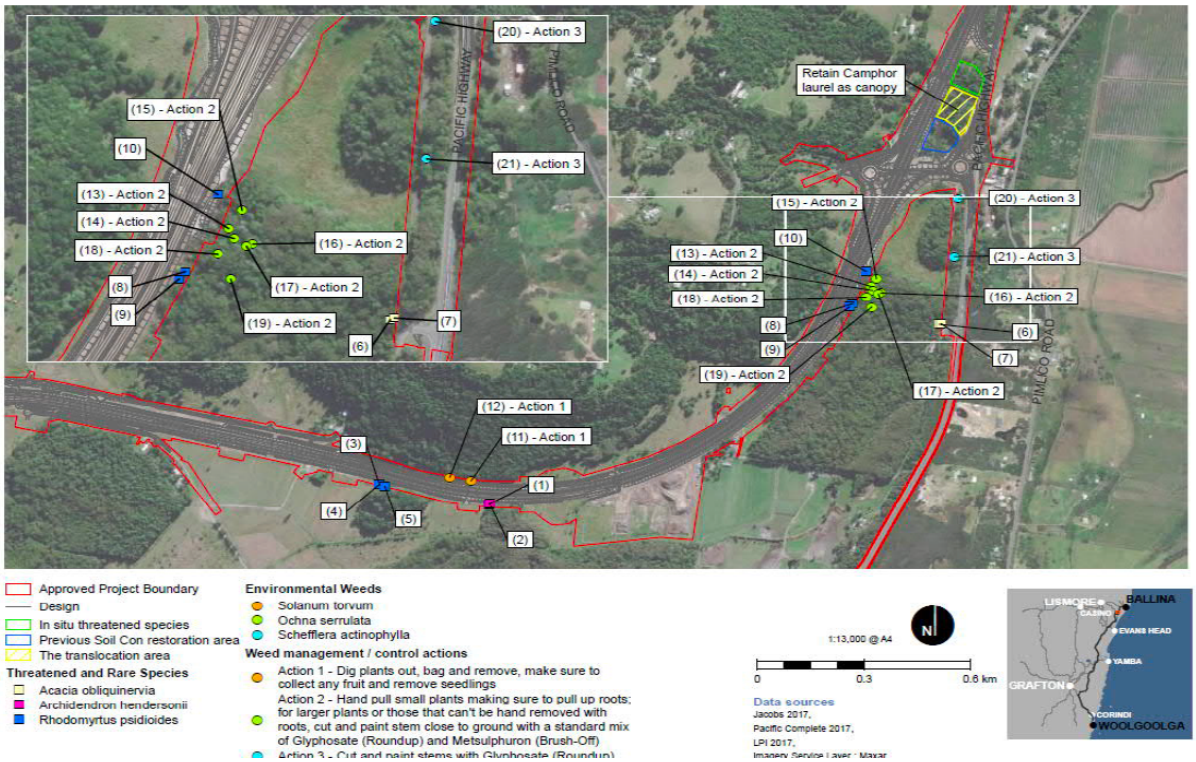
GMC-QA-Corr- RMS142

10 August 2021

Brock/Simon,

RE: W2B Section 11 Rainforest Weed Removal Works

As per PC request – 2/8/21, GMC has undertaken works in the W2B Section 11 - Rainforest Area near Kays Rd as per attached map.



Work Dates:

The works involved three personnel over 2 days – 2 & 3 August 2021.

Works Details:

The works were to identify and treat/remove Ochna Serrulata (Ochna) but the crew were also looking out for Solanum torvum (Giant Devels Fig) and Schefflera actinophylla (Umbrella Tree). Overall almost all the works involved Ochna treatment with only 1x Giant Devils Fig being identified and treated and no Umbrella Tree being identified.

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The Ochna treatment / removal consisted off:

- Large shrubs – stems cut and then immediately pasted with a 50:50 mix of glyphosate / water. Removed plants were collected and then transported off-site to Ballina Landfill for disposal.
- Smaller plants – Plants (including roots) hand pulled out. Removed plants were collected and then transported off-site to Ballina Landfill for disposal.
- Germinating Plants – Sprayed with glyphosate.

Herbicide application sheets for the two days' work within the rainforest area are attached.

A final inspection of the site deeper into the rainforest the requested north-eastern corner was undertaken to identify if additional weeds were to be identified other than those on the supplied PC map. Some additional Ochna and 1x small giant devil's fig was identified and treated.

Follow-up Works:

It is planned that in a couple of weeks a team will go back to the affected areas to assess treatment works and undertake further spraying if some germinating Ochna was missed.

Works Photos:

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Regards

Guy Corbett

Project Director

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Herbicide Application Sheet

Information to Be Recorded	
Start date and time	2/8/21 - 7:30
Finish date and time	2/8/21 - 3:00
Full operator name	DD/AK - BL/AM
Operator contact address	
Operator contact phone	
Full owners/occupier's name	RMS
Owner/occupiers address	
Owner/occupiers contact phone	
List treated areas and order of treatment, preferably with reference to the map. List order of treatment	S6 - Pacific highway - South Bound opp Mororo Rd S11 - FF between Coolgardie Rd & Kays Rd - SB S11 - Rainforest Area - Kays Rd - Ochna removal
Identify the pest or problem treated (e.g. controlling of spot weed infestation)	S6 - FF - General weeds/grasses/vines/trees S11 - FF - General weeds/grasses/vines/trees S11 - Rainforest - Ochna removal
Record either full name, or a product code if a list of full product names of pesticides you use	RoundUp CT
Describe the equipment used (e.g. boom-spray, hand-held backpack sprayer etc)	S6 - Backpacks S11 - Can Am S11 - Cut & Paste
Total amount of pesticide product mix used. Write down whether the mix was concentrated product or a diluted mixture (note the rate of dilution)	10mls/L S6 - 6x backpacks S11- 150 L S11 - 10 L
Area of application (in square metres or hectares)	S6 & 11- 0.5hec
Estimate of wind speed and direction (only if the pesticide is applied through the air). Write down any changes in weather during application	Light km/hr NNE
Record any weather details such as temperature, humidity and/or rainfall where the pesticide product label requires you to assess these.	Sunny 18C
Discussion with near neighbors prior to spraying	Nil required
Other Relevant Information:	

Herbicide Application Sheet

Information to Be Recorded	
Start date and time	3/8/21 - 7:30
Finish date and time	3/8/21 - 3:00
Full operator name	DD/AK - BL/AM
Operator contact address	
Operator contact phone	
Full owners/occupier's name	RMS
Owner/occupiers address	
Owner/occupiers contact phone	
List treated areas and order of treatment, preferably with reference to the map. List order of treatment	S6 - Pacific highway - South Bound opp Mororo Rd S11 - Rainforest Area - Kays Rd - Ochna removal
Identify the pest or problem treated (e.g. controlling of spot weed infestation)	S6 - FF - General weeds/grasses/vines/trees S11 - Rainforest - Ochna removal
Record either full name, or a product code if a list of full product names of pesticides you use	RoundUp CT
Describe the equipment used (e.g. boom-spray, hand-held backpack sprayer etc)	S6 - Backpacks S11 - Cut & Paste
Total amount of pesticide product mix used. Write down whether the mix was concentrated product or a diluted mixture (note the rate of dilution)	10mls/L S6 - 6x backpacks S11 - 10 L
Area of application (in square metres or hectares)	S6 & 11- 0.5hec
Estimate of wind speed and direction (only if the pesticide is applied through the air). Write down any changes in weather during application	Light km/hr NW
Record any weather details such as temperature, humidity and/or rainfall where the pesticide product label requires you to assess these.	Sunny 22C
Discussion with near neighbors prior to spraying	Nil required
Other Relevant Information:	