# Warrell Creek to Nambucca Heads Pacific Highway Upgrade

## Operational Phase Monitoring of Threatened Flora Translocations, In-situ Threatened Plants and Slender Marsdenia and Woolls' Tylophora Habitat Condition

Transport for NSW | February 2020

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Document Review

| Date | Version | Status | Sent to | Represent | Delivered Format | Dispatched By |
|---|---|---|---|---|---|---|
| 2/1/2020 | A | Draft | Jeremy Benwell-Clarke | Ecos | MSW | A. Benwell |
| 10/1/2020 | 1 | Draft | Sean Hardiman | RMS | MSW | D. Rohweder |

## Document Distribution

| Date | Version | Status | Sent to | Represent | Delivered Format | Dispatched By |
|---|---|---|---|---|---|---|

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## Warrell Creek to Nambucca Heads Upgrade

# Operational Phase Monitoring of Threatened Flora Translocations, In-situ Threatened Plants and Slender Marsdenia and Woolls' Tylophora Habitat Condition – Year 2


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**18/2/2020**

# Contents

# Executive Summary

This report presents the results of the second year of operational phase monitoring of threatened flora for the Warrell Creek to Nambucca Heads (WC2NH) section of the Pacific Highway upgrade. The monitoring program includes monitoring of threatened flora translocations, in situ threatened flora and Slender Marsdenia and Woolls' Tylophora habitat condition.

Five threatened and one nationally rare plant species impacted by the WC2NH highway upgrade are subject to the *Warrell Creek to Urunga Upgrade Threatened Flora Management Plan* (RMS 2016), which includes the monitoring of management measures:-

- Slender Marsdenia (*Marsdenia longiloba*) (listed as endangered under the *Biodiversity Conservation (BC) Act 2016* and vulnerable under the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*)
- Woolls' Tylophora (Tylophora woollsii) (listed as endangered under the BC Act and the EPBC Act)
- Rusty Plum (*Niemeyera whitei*) (listed as vulnerable under the BC Act)
- Spider Orchid (*Dendrobium melaleucaphilum*) (listed as endangered under the BC Act)
- Floyds Grass (*Alexfloydia repens*) (listed as endangered under the BC Act)
- Koala Bells (*Artanema fimbriatum*) (nationally rare and proposed for State listing).

Three years of construction phase monitoring and one year of operational phase monitoring have already been carried out. The second year of operational phase monitoring for the present report was conducted by Ecos Environmental in November 2019.

Two years into operational phase monitoring and five years after salvage translocation, reasonably high survival rates were recorded for all six species:- : Slender Marsdenia (70%), Woolls' Tylophora (67%), Spider Orchid (100%), Rusty Plum (86%) and Floyds Grass (substantial cover). The lower survival rate of Koala Bells (37%) was due to the annual or biennial life cycle of most individuals (i.e. growth, flowering and seeding, then dying off in 1-2 years), which appears to be common in this species.

A detailed analysis of growth patterns in translocated Slender Marsdenia was carried out to better understand the population dynamics and complex growth rhythms of this species and how its responds to translocation.

The monitoring plot data suggest that to date there have been no declines in Woolls' Tylophora and Slender Marsdenia habitat condition along the edge of clearing.

The survival rate of the in-situ threatened species at the end of Year 5 (spring 2019) was 100% for Spider Orchid, Rusty Plum and Slender Marsdenis. The crown cover of Maundia was <1% compared to 40% in spring 2018. The high mortality rate of Maundia is most likely a result of the drought in 2019. For Slender Marsdenia, survival rate was stable although there was evidence that stems had died back and reshot, from the same point or close-by from tuberous roots. No signs of construction-related impacts on in situ threatened species were observed in spring 2019.

# 1 Introduction

The Warrell Creek to Nambucca Heads (WC2NH) project is 19.6 km section of the Pacific Highway upgrade between Warrell Creek and Nambucca Heads on the NSW Mid North Coast (Figure 1). Construction of the WC2NH project began on 9 February 2015 and the new section of highway was opened to traffic (i.e. operational) in July 2018.

A Threatened Flora Management Plan (TFMP) was prepared for threatened flora impacted by the project (RMS 2016) and included a monitoring program directed at recording and assessing three components of threatened flora management: (i) threatened flora translocation (ii) in-situ threatened flora populations and (iii) Slender Marsdenia and Woolls' Tylophora habitat condition, to be monitored during construction and operation of the project.

Three years of construction phase monitoring (Year 1 - Ecos Environmental 2016a, Year 2 - Ecos Environmental 2017, Year 3 - Ecos Environmental 2018a) and one year of operational phase monitoring (Ecos Environmental 2018b) have already been carried out. Operational phase monitoring is being conducted yearly for four years.

In November 2019, Ecos Environmental conducted the second yearly operational phase monitoring for Sandpiper Ecological Services. Results are described and analysed in the following sections of this report:

- Section 2: Threatened Flora Translocations
- Section 3: In-situ Threatened Flora Populations
- Section 4: Slender Marsdenia and Woolls' Tylophora Habitat Condition.

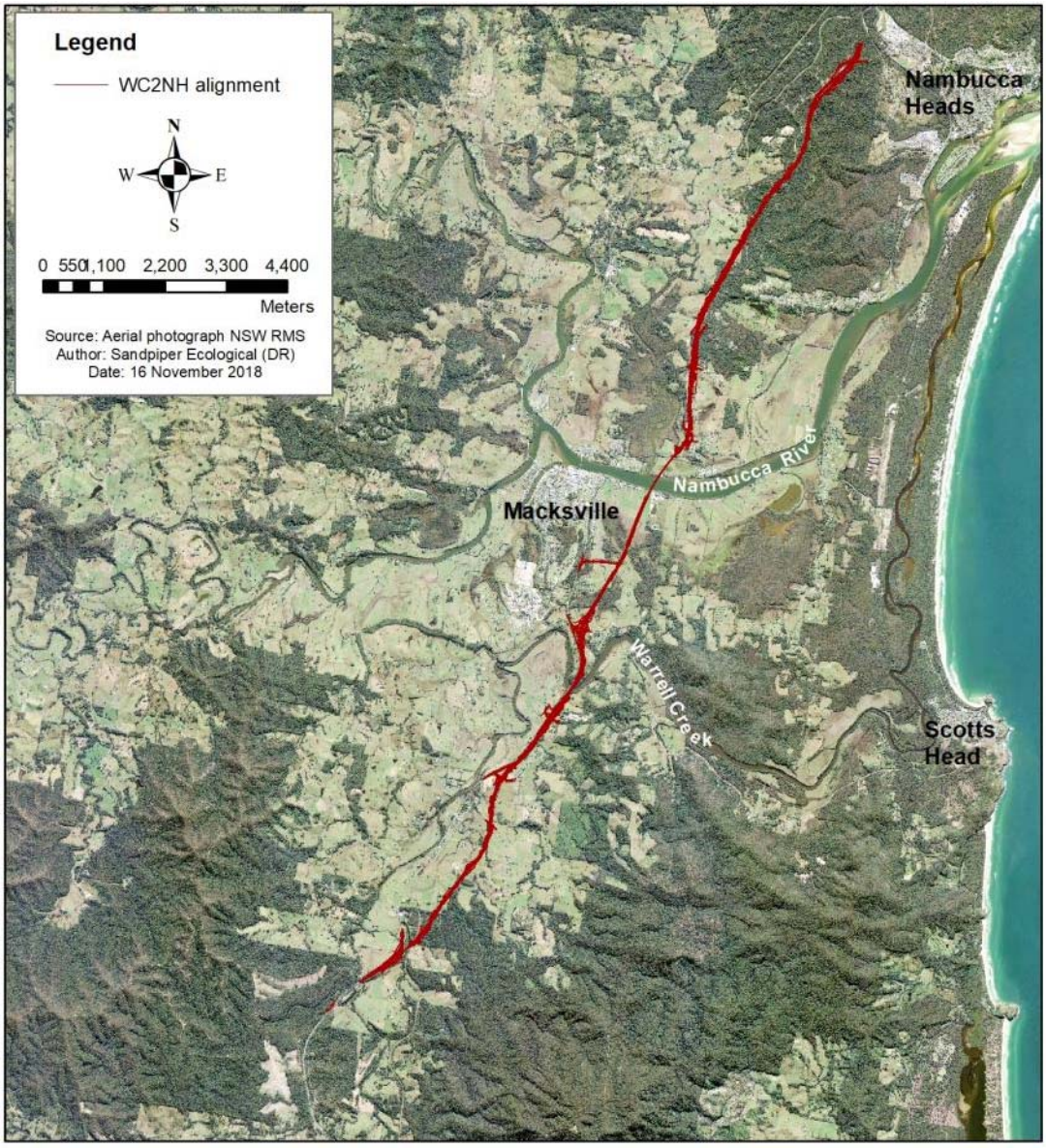


**Figure 1:** Location of the WC2NH alignment.

# 2 Threatened Flora Translocation

## 2.1 Aim and Species Translocated

The translocation component of the TFMP (RMS 2016) was prepared according to the Australian Network for Plant Conservation guidelines for planning threatened flora translocations (ANPC 2004).

The general aim of translocation was to salvage individuals of threatened species impacted by construction and re-establish them in suitable habitat adjacent the highway corridor, near the impact sites. Some propagation was also carried out to provide replacements for potential losses during salvage transplanting. The purpose of translocating threatened flora is to maintain population size and avoid loss of numbers occurring in local threatened flora populations during construction. Translocation of each species involved three main actions:

- Salvage transplanting of impacted individuals and re-establishment at receival sites containing habitat closely approximating the impact/donor sites;
- Propagation and introduction of additional individuals as back-up in case of losses; and
- Follow-up maintenance to promote successful establishment and ensure good habitat condition.

Five threatened and one nationally rare plant species were translocated on the WC2NH project:

- Slender Marsdenia (*Marsdenia longiloba*) (listed as endangered under the *BC Act* and vulnerable under the *EPBC Act*)
- Woolls' Tylophora (*Tylophora woollsii*) (listed as endangered under the *BC Act* and the *EPBC Act*)
- Rusty Plum (*Niemeyera whitei*) (listed as vulnerable under the *BC Act*)
- Spider Orchid (*Dendrobium melaleucaphilum*) (listed as endangered under the *BC Act*)
- Floyds Grass (*Alexfloydia repens*) (listed as endangered under the *BC Act*)
- Koala Bells (*Artanema fimbriatum*) (nationally rare and has been proposed for State listing).

## 2.2 Methods

### 2.2.1 Receival Sites

Nine receival sites were selected for the species being translocated. All were located in the road reserve (i.e. on RMS property), seven where the highway corridor crosses Nambucca State Forest, one adjacent the new highway bridge at Warrell Creek, and one at the southern end of the upgrade (Table 1 and Figure 2). For further details on receival site selection and a description of each site, refer to any of the construction phase monitoring reports (Ecos Environmental 2016a, 2017 and 2018a).

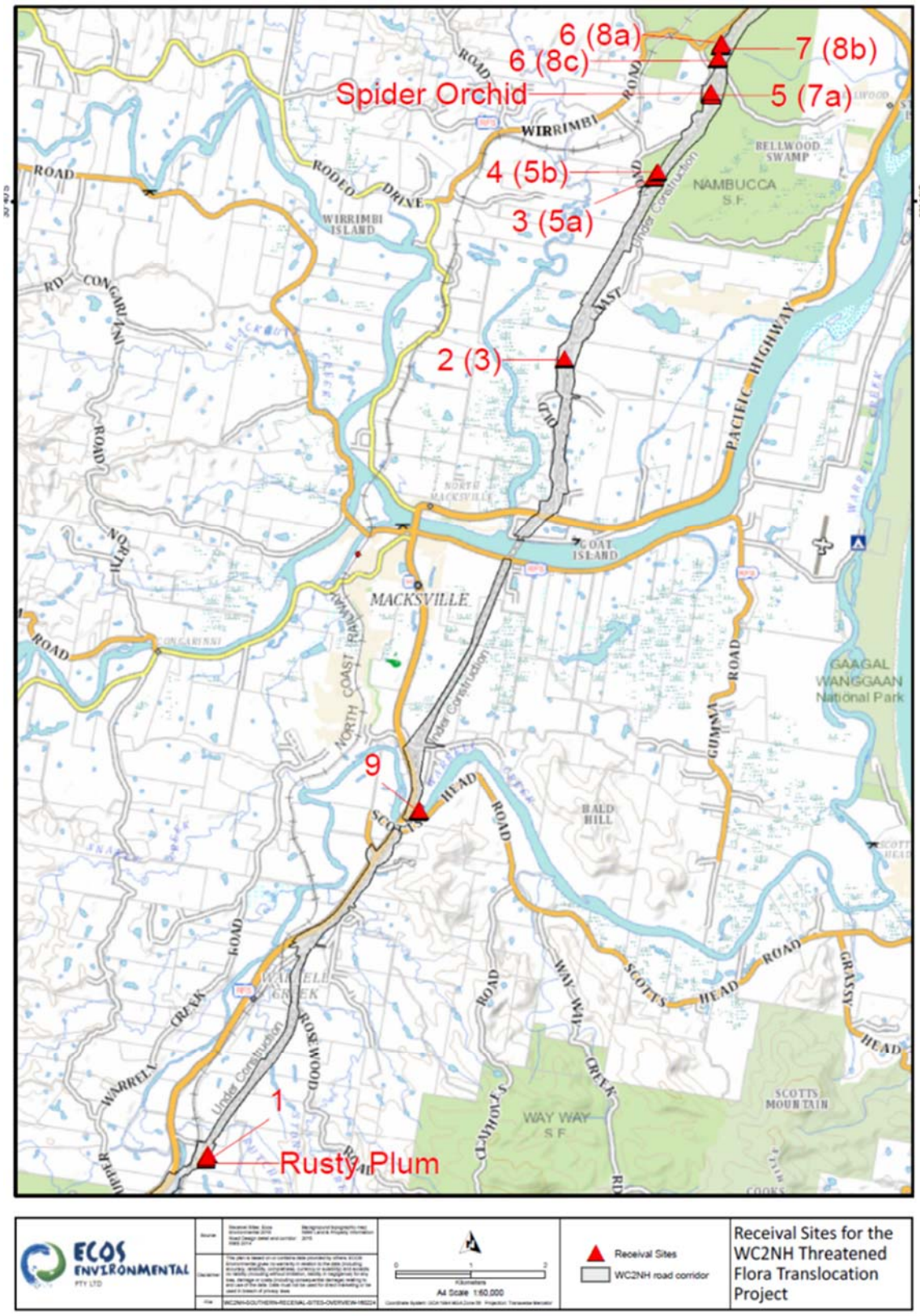


**Figure 2:** Location of threatened flora translocation receival sites for the WC2NH section of the Pacific Highway upgrade.

**Table 1:** Translocation receival sites and species translocated. The bracketed identifier is the original number used during selection of the receival sites. A question mark is placed after Woolls' Tylophora and identification not confirmed (based on leaves not flowers).

| Receival Site | Species |
|---|---|
| 1 (Cockburns Lane) | Slender Marsdenia, Rusty Plum |
| 2 (3) | Slender Marsdenia |
| 3 (5a) | Slender Marsdenia |
| 4 (5b) | Slender Marsdenia (and Large-flowered Marsdenia) |
| 5 (7a) | Slender Marsdenia, Spider Orchid, Rusty Plum direct seeding, Slender Marsdenia population enhancement. |
| 6 (8a) | Slender Marsdenia, Woolls' Tylophora(?) |
| 7 (8b) | Koala Bells |
| 8 (8c) | Slender Marsdenia |
| 9 (Warrell Creek) | Floyds Grass, Koala Bells population enhancement |

### 2.2.2 Direct Transplanting

Threatened species were translocated from the construction footprint using the direct transplanting method. Direct transplanting involves excavation of plants, transport to the receival site and replanting as expeditiously as possible. Trees and saplings were dug out with an excavator and small plants with hand tools. The general approach is to move each plant with a shoot and root system reduced but intact enough so the plant is able to regenerate and regrow to reproductive maturity. Horticultural techniques were applied to improve survival such as pruning and intensive watering, which work mainly by minimising evapotranspiration stress, the main cause of mortality during transplanting.

Compared to other translocation techniques such as propagation and gradual transplanting, direct transplanting has several advantages including:

- Speed and cost-effectiveness
- Suitable for salvaging large numbers of individuals
- Suitable for implementation in rough, forested terrain
- Reduced risk of transferring disease and pests to the wild.
- Mycorrhizae and soil microflora are maintained by moving plant and soil together.

In a development situation, translocation by propagation of seed or cuttings in an ex situ environment and introduction to the field site is preferred by some workers. However, Primack (1996) has pointed out the advantages of transplanting when such plants are available: "There are nonetheless ecological advantages to using transplanted plants rather than seeds in reintroduction (translocation) efforts. Plants, particularly adult plants have a higher likelihood of successful establishment than seeds (or seedlings) if they are planted into a suitable site and well-tended. These plants have overcome the most vulnerable stages in their life cycle (seed germination and seedling establishment) so that their chances of surviving in the new habitat are greatly increased. These individuals also have proven genotypes that are free of lethal mutations and adapted to the general environmental conditions. When reintroduction efforts involve reproductively mature adult plants, the new population has the potential to flower, produce and disperse seeds and create a second generation of plants within a year (or so) of transplantation".

Translocation methods applied to each species are described in more detail below.

### 2.2.3 Slender Marsdenia

#### 2.2.3.1 Salvage Transplanting

Slender Marsdenia plants were planted at seven receival sites (Table 6) in February 2015. Single stems were removed in a block of soil about 30 cm wide by 20 cm deep with a spade. This often involved breaking rhizomes which spread horizontally through the topsoil. Some may have two or more shoots or stem-individuals within one or a few square metres. Mapped points in the TFMP often included more than one stem-individual. All were transplanted including new unrecorded one. .

Plants and soil were kept damp during transport to the receival site. The 'stem-individuals' were planted at regular intervals (5 m) along lines, which minimised planting point bias with respect to microhabitat patterning. Additional plants were translocated in 2016 due to modification to the road design. In total, 175 plants were translocated.

They were watered thoroughly straight after planting, then once every two days for one week and once a week for four weeks. Wire cylinders were installed to prevent animal grazing, to act as a climbing frame and to facilitate monitoring. Flagging tape was attached to the base of each stem just above the ground to make it easier to check if stems that had died back were still alive. Flagging tape was attached to each cage showing the individual's monitoring number and source code as per the TFMP. Multiple individuals from the same mapped point were indicated by an additional suffix on the source code – e.g. ML46-7.

#### 2.2.3.2 No Fertiliser

As previous translocations of Slender Marsdenia indicated that addition of slow release fertiliser had an adverse effect on survival (although not when grown in pots), no fertilisers or mulch were applied during the WC2NH translocation of Slender Marsdenia. Experimental comparison of fertiliser and no fertiliser treatments on the NH2U project indicated that even light applications of slow release fertiliser resulted in depressed plant growth (Ecos Environmental 2016).

#### 2.2.3.3 Propagation of Population Enhancement Plants

The results of propagation of Slender Marsdenia from rhizome pieces collected during transplanting were poor, as recorded on the NH2U project. Less than 5% of cuttings produced shoots and shoot growth was very slow. The few plants propagated were grown-on for two years and planted out in November 2017.

Slender Marsdenia produces viable seed, but the seed pods are very hard to find. About 15 large individuals of Slender Marsdenia were checked for pods adjacent to the Nambucca Heads to Urunga and Sapphire to Woolgoolga sections of the Pacific Highway, and Nambucca State Forest adjacent to WC2NH in December 2016, unsuccessfully.

### 2.2.4 Woolls' Tylophora

#### 2.2.4.1 Species Identification

Woolls' Tylophora has not been positively identified on the WC2NH project, as no flowering plants have been observed. A few plants were identified as possibly this species during TFMP

surveys, based on leaf features. However, the leaves of Slender Marsdenia vary in shape and texture and some are similar to Woolls Tylophora leaves. Typically, Slender Marsdenia has a more elongated leaf, pinnate venation, cordate leaf base, paler green colouration and is glabrous (without hairs). Woolls' Tylophora has a broader leaf with purplish tinges, tends to be more 3-veined at the base and is sparsely hairy. The two species flower at different times - Woolls' Tylophora from the Bonville project flowered in late August, whereas Slender Marsdenia populations from the NSW Mid North Coast flowered in November or occasionally later.

Several Slender Marsdenia were observed flowering on the WC2NH footprint. If Woolls' Tylophora was in fact present, it was much rarer than Slender Marsdenia.

#### 2.2.4.2 Salvage Transplanting and Population Enhancement

Individuals tentatively identified as Woolls' Tylophora were transplanted using the same method applied to Slender Marsdenia. Both species are vines with tuberous roots. Woolls' Tylophora was translocated to Receival Site 8a, which also received some Slender Marsdenia.

No population enhancement was carried out for Woolls Tylophora as it was not possible to positively identify this species in the absence of flowers.

### 2.2.5 Rusty Plum

#### 2.2.5.1 Salvage Transplanting

Rusty Plum trees up to 12 m high were trenched around with an excavator to form a soil-root ball about 1-1.5 m wide and 0.7 m deep. Undercutting the root ball, the trees were leaned to the side and the trunk-branch system cut back by 75% or more to remove all foliage. If the root ball was small due to soil breaking up, the trunk was sometimes reduced further.

All Rusty Plums were transplanted from Cockburn's Lane at the southern end of the project into the adjacent road reserve (Receival Site 1). Several Rusty Plums outside the clearing boundary remained in-situ. The transplants received additional watering for a month. Sugar cane mulch was spread around each plant to provide a mild growth stimulant and hessian barriers erected for additional shade, as the site was exposed to the afternoon sun. No fertilisers were used.

#### 2.2.5.1 Population Enhancement by Direct Seeding

Enhancement aimed to establish additional individuals by direct seedling. About 50 fruits, which have a single large seed, were collected in Nambucca State Forest in November 2017. Three seeds were also found beneath a Rusty Plum in the Coffs Harbour Regional Botanical Gardens. Seeds were separated from the fleshy outer layer and direct seeded into an area next to Receival Site 5 (7a) on 7 December 2017. This site is a minor gully with moist open forest and a rainforest understory. As the seeds are eaten by animals, and seedlings can also be grazed quite heavily (Ecos Environmental 2015), seed were sown into wire mesh cylinders. Fourteen cylinders were set up and three or four seeds placed on the soil surface in each cylinder and covered lightly with leaf litter. The cylinders were tagged for monitoring and locations recorded with a GPS.

### 2.2.6 Spider Orchid

#### 2.2.6.1 Salvage Transplanting

Two mature Spider Orchid plants were salvaged from Prickly Paperbark trees (*Melaleuca styphelioides*) on the WC2NH footprint. Branch and stem sections supporting the orchids were removed so there was minimal disturbance to the orchid root system. The branch and trunk pieces with orchids were attached to small trees in a shaded gully at Receival Site 5 (7a). Apart from watering during transport, no watering was carried out.

#### 2.2.6.2 Population Enhancement

The TFMP aimed to propagate additional Spider Orchids for population enhancement. As the number of wild plants was very low there weren't enough to sacrifice for propagation by vegetative division, so propagation by seed was proposed.

The two translocated plants flowered in spring 2015, 2016 and 2017, but no seed pods were produced. In situ plants were monitored for seed production but none were produced.

In a translocated population of 55 Spider Orchids on the NH2U project, one seed pod was formed in Spring 2016. Unfortunately, the pod opened in November between site visits so no seed was collected.

### 2.2.7 Koala Bells

#### 2.2.7.1 Salvage Transplanting

Koala Bells was transplanted in blocks of soil 40 cm wide by 20 cm deep. Plants were pruned and the soil block planted and watered. Site 8b was used as the receival site as this was the only site in the road reserve with swamp forest similar to Koala Bells habitat. Wire cages were installed and follow-up watering carried out. No fertilisers were applied.

#### 2.2.7.2 Population Enhancement

Cuttings of Koala Bells were propagated at Ecos Environmental's nursery in summer 2015-2016. The cuttings struck and grew rapidly, flowered in summer-autumn 2016, died back over winter then reshot in spring 2016, while the plants were still in pots. Regrowth in spring 2016 was less vigorous and small adventitious shoots were produced around the edge of the pots, as observed in some transplanted specimens in the field on NH2U. Twenty plants were introduced to Receival Site 9b (also part of the Floyds Grass translocation site) at Warrell Creek in January 2017. This site on alluvial soil has an open, partly bare ground layer with little competition from other plants (part of the preparation for Floyds Grass), which seems to be preferred by Koala Bells.

### 2.2.8 Floyds Grass

#### 2.2.8.1 Topsoil Stripping

The receival site for Floyds Grass on the northern side of Warrell Creek consisted of two areas – 9a and 9b – about 25 m apart. It was overgrown with exotic Broad-leaved Paspalum (BLP), which was removed before translocating Floyds Grass to the site.

To create conditions with minimal weed competition for Floyds Grass, BLP and the uppermost topsoil seedbank were stripped off with an excavator. As the site was on

relatively deep alluvium, it was expected that sufficient depth of topsoil would remain for Floyds Grass to establish after the stripping operation.

Using herbicide would have still left the soil seedbank to contend with. Follow-up spraying of weed germination from the soil seedbank would have been impractical, as it is not possible to spray weed seedlings without hitting Floyds Grass, which produces runners.

Preparation of the site was carried out as follows. First, ground layer vegetation consisting mainly of BLP and Lantana was scrapped off using an excavator bucket. After exposing the soil surface, the top 10 cm of soil was scrapped off and placed on the edge of the site. The soil beneath the uppermost 10 cm was found to have a higher clay content, but reasonable texture and drainage for young plant growth. Sed fencing was installed around the site to prevent run-off of soil material to Warrell Creek and also to act as a barrier to deter wallaby grazing.

#### 2.2.8.2 Salvage Transplanting

Small clumps of Floyds Grass approximately 10 $cm^2$ were dug up with a spade and planted in Area 9a. The clumps were watered thoroughly and sugar cane mulch (weed free) spread lightly over the soil surface to reduce raindrop compaction. Follow-up watering was carried out as conditions were dry. 'Seasol' (seaweed and fish emulsion) fertiliser was applied two weeks after introduction to stimulate growth. As the site was exposed to the afternoon sun, shade-cloth fences approximately 1 m high running north-south were erected to provide additional shade.

#### 2.2.8.3 Population Enhancement

To promote population establishment, approximately 100 additional Floyds Grass clumps were propagated at Ecos Environmental's nursery and planted in Area 9b in March 2016. They were propagated vegetatively from small pieces of runner that broke off during transplanting. As Area 9b was more exposed than Area 9a, the shade cloth fences had a roof to protect from the overhead sun. Hand weeding to remove competing exotic and native species was carried out by Pacifico workers after training by Ecos Environmental. Although most the soil seedbank had been removed, some seed germinated from deeper in the soil., notably *Phytolacca octandra* (Ink Weed), a large herbaceous shrub. Very little BLP germinated.

### 2.2.9 Monitoring and Data Analysis

During the construction phase, monitoring was conducted quarterly in 2015 (start of translocations project), biannually in 2016 and yearly in 2017 and 2018. Monitoring during the operation phase was carried out annually.

The following data were recorded enabling analysis of plant growth and survival:

- All species except Spider Orchid: Monitoring Number, Date, Line, Source Label (species translocation plant label), Species (Current ID), Overall Condition (see below), Height (cm), New Shoots (Y/N), Comments, Significant Growth (+) or Significant Dieback (-), Coordinates.
- Spider Orchid: Monitoring Number, Date, Source Label, Species, Number of Pseudobulbs with Leaves, Length of the Longest Pseudobulb, New growth, Overall Condition, Coordinates.

The data were entered into an Excel file with separate sheets for each monitoring event.

Plant condition was scored on a scale of 0 to 5, where zero is dead and 5 is fully mature and reproductive. The scale is defined slightly differently for each species, as indicated in Tables 2-4 below.

Percent Survival was defined as: number of individuals in condition classes (2+3+4+5/total)*100.

Species height at monitoring events was averaged for all plants present at the start of monitoring in June 2015, therefore included plants in the total that may have had died back to ground level (i.e. height = 0; condition class 1 or 0 in the case of Slender Marsdenia).

**Table 2:** Condition scores applied to Slender Marsdenia and Woolls' Tylophora.

| **Score** | **Condition** |
|---|---|
| 0 – dead | Dead, no sign of reshooting after 1 year |
| 1 –poor | Stem died back to ground level, possibly dead, live stem stub may be present |
| 2 – fair | Plant <75 cm tall, with leaves or leafless, new shoots or active growth present or absent |
| 3 – good | Plant >75 cm tall, stem with leaves, new shoots or active growth present or absent, if stem leafless or leaves discoloured score as 2 |
| 4 – advanced | Plant >2.5m tall with >15 leaves |
| 5 – mature | Mature, plant flowering or seeding |

**Table 3:** Condition scores applied to Rusty Plum and Koala Bells.

| **Score** | **Condition** |
|---|---|
| 0 | Dead |
| 1 | Leafless and no sign of re-shooting |
| 2 | Pruned foliage retained, or small amount of re-shooting after defoliating, or foliage sparse/discoloured (<40 cm tall for Koala Bells) |
| 3 | Vigorous re-shooting (>40 cm tall for Koala Bells) |
| 4 | Crown recovering, foliage healthy |
| 5 | Growing actively, flowering or seeding recorded |

**Table 4:** Condition scores applied to Spider Orchid.

| Score | Condition |
|---|---|
| 0 | Dead |
| 1 | Pseudobulbs discoloured or grazed or withering, no new growth |
| 2 | Pseudobulbs healthy in colour, not withering, no new growth |
| 3 | Plant small, few healthy pseudobulbs, new growth occurring |
| 4 | Several healthy pseudobulbs present, new growth occurring |
| 5 | Several good sized, healthy pseudobulbs, flowering or seeding recorded |

Slender Marsdenia – Stem Height Growth Syndromes

Slender Marsdenia plants showed complex variation in height growth after transplanting. Some plants stayed small and showed little change in five years, while others grew vigorously the whole time. Many plants died back then reshot a year or even two years later. It was difficult to make sense of the range of different growth responses when the volume of soil with plant and rhizome was initially about the same size, or not greatly different.

To analyse stem growth patterns in Slender Marsdenia after transplanting in more detail, 12 categories of stem height growth change over a five year period were defined, as shown in Table 5. These were derived by combining the data from all monitoring events in a single sheet for each receival site then identifying the main patterns of height change. Numbers were tallied for each category and expressed as percentages of the total.

**Table 5:** Pattern of stem height change in stem-individuals of Slender Marsdenia over a five year period after salvage transplanting. Three primary categories or syndromes can be discerned– D, S and T, and 12 sub-categories

| Code | Response syndromes of transplanted individuals |
|---|---|
| **D** | **Dead (or appears to be dead) – all individuals with ht = 0 in Nov/19** |
| D1 | Never reshot |
| D2 | Small shoot then died back, probably dead |
| D3 | Reshot, reached small to medium height (<1.2 m) then died back to ground, some bell-shaped, some dieback-reshot-dieback |
| D4 | Reshot, grew tall (~2 m+) then died back to ground, possibly dead |
| **S** | **Small, growing very slowly, or declining** |
| S1 | Stayed small, most less than 10 cm high (to 40 cm), little change in height in 5 years |
| S2 | Diedback to ground and reshot once or twice, stem continuously small (mostly <0.5 m) |
| S3 | Declining or bell shaped (increase-decrease), to ~130cm at peak, not tiny, continuously alive |
| S4 | Fluctuating – e.g. 'small-medium/tall-small'; or 'grew medium/tall then died back to small |
| **T** | **Thriving, plant tall, continuing to grow, or maintaining size, healthy** |

| | |
|---|---|
| T1 | Thrived – tall (1.5 m+), substantial increase in height/number of leaves, or ~maintained tall height (some decreased slightly Nov 18) |
| T2 | Thrived – moderate increase in height (0.5 – 1 m+), or constant height (1 m+) |
| T3 | Died back to ground then reshot vigorously (>1 m) |
| T4 | Small for 5 or 6 events then suddenly grew big (>1 m) |

## 2.3 Translocation Results

### 2.3.1 Survival Summary – All Species

Survival rate five years after salvage transplanting (Table 6) was fairly high for all threatened species: Slender Marsdenia 70%, Woolls' Tylophora 67%, Spider Orchid 100%, Rusty Plum 86% and Floyds Grass (substantial cover).

The lower survival rate of Koala Bells (37%) was due to individuals exhibiting an annual or biennial life cycle (i.e. rapid growth, flowering and seeding, then dying off) after transplanting, as recorded previously with this species (e.g. NH2U).

**Table 6:** Percent survival of species per receival sites over 5 years (2015-2019), after salvage translocation.

| **Species/Receival Site** | **No. plants transl.** | **Survival (%)** | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Aug 2015 (~6 mth)** | **Feb 2016 (~1 Yr)** | **Jan 2017 (~2 Yrs)** | **Nov 2017 (~3 Yrs)** | **Nov 2018 (~4 Yrs)** | **Nov 2019 (~5 Yrs)** |
| Slender Marsdenia(*Marsdenia longiloba*) | | | | | | | |
| Receival Site 1 - Cockburns Lane | 27 | 93 | 93 | 75 | 63 | 59 | 59 |
| Receival Site 2 (3) – Old Coast Rd | 17 | 100 | 91 | 93 | 88 | 88 | 88 |
| Receival Site 3 (5a) – Old Coast Rd | 22 | 81 | 81 | 91 | 73 | 77 | 77 |
| Receival Site 4 (5b) – Old Coast Rd | 16 | 100 | 94 | 81 | 69 | 69 | 50 |
| Receival Site 5 (7a) – Old Coast Rd | 57 | 90 | 90 | 72 | 74 | 72 | 56 |
| Receival Site 6 (8a) – Old Coast Rd | 8 | 88 | 75 | 75 | 75 | 88 | 86 |
| Receival Site 8 (8c) – Old Coast Rd | 28 | 93 | 100 | 86 | 82 | 79 | 70 |
| Total | 164 (175) | 92 | 91 | 80 | 74 | 74 | 70 |
| Rusty Plum(*Niemeyera whitei*) | | | | | | | |
| Receival Site 1 - Cockburns Lane | 7 | 100 | 100 | 86 | 86 | 86 | 86 |
| Wooll's Tylophora (*Tylophora woollsii* – unconfirmed) | | | | | | | |
| Receival Site 6 (8a) – Old Coast Rd | 6 | 100 | 100 | 100 | 83 | 67 | 67 |
| Spider Orchid (*Dendrobium melaleucaphilum*) | | | | | | | |

| Species/Receival Site | No. plants transl. | Survival (%) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Aug 2015 (~6 mth) | Feb 2016 (~1 Yr) | Jan 2017 (~2 Yrs) | Nov 2017 (~3 Yrs) | Nov 2018 (~4 Yrs) | Nov 2019 (~5 Yrs) |
| Receival Site 5 (7a) – Old Coast Rd | 2 | 100 | 100 | 100 | 100 | 100 | 100 |
| Floyds Grass (*Alexfloydia repens*) | | | | | | | |
| Receival Site 9a – Warrell Creek | 54 clumps | 100 | 94 | Substantial cover | Substantial cover | Substantial cover | Substantial cover |
| Receival Site 9b – Warrell Creek | 61 clumps | Not planted yet | Not planted yet | 98 | 93 | 70 | Reasonable cover |
| Koala Bells (*Artanema fimbriatum*) | | | | | | | |
| Receival Site 7 (8b) – Old Coast Rd | 16 | 75 | 63 | 25 | 13 | 6 | 0 |
| Receival Site 9 – Warrell Creek | 14 | Not planted yet | Not planted yet | Not yet planted | 57 | 86 | 75 |
| Total | 30 | 75 | 63 | 25 | 34 | 43 | 37 |

### 2.3.2 Slender Marsdenia (*Marsdenia longiloba*)

#### 2.3.2.1 Summary

Combining data for all six receival sites, the survival rate of Slender Marsdenia after 5 years was 70%, a slight decrease from 74% the previous year (Table 6). Survivorship per site ranged from 56% to 86% after 5 years, slightly less than the previous year.

The decrease in survival rate was relatively small considering the severe drought conditions in 2019. Given the phenology of Slender Marsdenia and its tendency to die back and reshoot again, some individuals recorded as dead (ie Ht = 0) may reshoot later, so the actual survival rate (given dead stems with live rhizomes) is probably 70-80%.

When observed in November 2019 during drought conditions there was no sign of drought stress such as wilting and many plants were actively growing, with new shoots present. The tuberous rhizome in Slender Marsdenia may store water as well as food which the plant can draw on to maintain growth during spring when conditions are often dry.

#### 2.3.2.2 Height performance

Mean plant height is a rough indicator of how well Slender Marsdenia is performing at each site. Mean height was calculated by averaging across all individuals including those with zero height which underestimates the mean height of live plants, but arguably gives a better estimate of overall height performance. Mean stem height of Slender Marsdenia per receival sites after five years ranged from 33.7 cm to 106.9 cm (Table 7).

Mean height increased at receival sites 1, 2, 5 and 8 and decreased in 3 and 6. No signs of habitat deterioration, disease or herbivory were observed, therefore, it is unlikely that declines in mean plant height were caused by these factors.

Monitoring has shown that Slender Marsdenia does not always exhibit a linear or steady increase or decrease in height but fluctuates, undergoing cycles of stem dieback and regrowth, often repeated.

Likewise, mean plant height per receival sites did not consistently increase or decrease during the monitoring program, rather it has fluctuated. For example, in Receival Site 8 mean plant height was 43.68 cm in June 2015, increased to 69.57 cm in February 2016, decreased to 50.82 cm in January 2017, decreased further to 43.96 cm in November 2017, then increased to 62.21 cm in November 2018 and 84.1 cm in November 2019.

**Table 7:** Table of mean height (cm) ± standard error of Slender Marsdenia per receival site from the first monitoring in June 2015 to November 2019 (five years after translocation) and graph of size class distribution

| Receival site | n | June 2015 (6 months) | Feb 2016 (~1 yr) | Jan 2017 (~2 yrs) | Nov 2017 (~3 yrs) | Nov 2018 (~4 yrs) | Nov 2019 (~5 yrs) |
|---|---|---|---|---|---|---|---|
| Receival Site 1 | 27 | 26.5±6.5 | 39.0±10.4 | 39.2±10.6 | 31.1±10.3 | 41.13±9.5 | 43.7±8.8 |
| Receival Site 2 (3) | 11 | 25.6±10.1 | 60.8±15.5 | 67.3±13.6 | 97.1±14.2 | 84.8±12.7 | 106.4±13.2 |
| Receival Site 3 (5a) | 22 | 29.3±7.5 | 49.8±11.2 | 46.4±9.5 | 45.7±9.3 | 46.3±10.8 | 33.7±9.5 |
| Receival Site 5 (7a) | 57 | 29.5±3.7 | 51.7±6.9 | 47.7±7.6 | 43.8±8.1 | 35.0±6.3 | 47.7±5.7 |
| Receival Site 6 (8a) | 8 | 55.1±22.2 | 53.0±17.9 | 60.5±17.5 | 84.7±18.3 | 82.1±19.1 | 68.0±17.7 |
| Receival Site 8 (8c) | 28 | 43.6±6.3 | 69.5±9.1 | 50.8±5.9 | 43.9±5.4 | 62.2±10.6 | 84.1±9.6 |

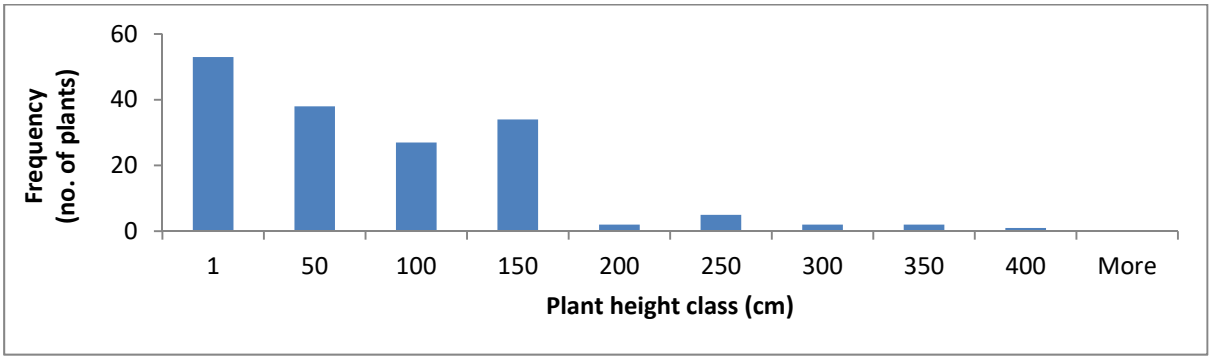


**Figure 3:** Size class distribution of Slender Marsdenia stem-individuals in Nov/2019

#### 2.3.2.3 Patterns of change in stem height

Pattern of stem height change over five years in Slender Marsdenia were sorted into three primary categories (Ht = 0/ Dead or possibly Dead; Small; Thriving) and 12 sub-categories, as defined in Table 5.

Table 8 shows the breakdown of stem height change per receival site and combining the data from all six receival sites (note - site 5b omitted as most Marsdenia plants were a different species – *M. liisae*/Large-flowered Milk Vine). Results are shown graphically in Figs 3 and 4.

Overall percentages of the three primary categories of stem height growth (i.e. D, S and T) in Table 8 were as follows:-

Dead/Ht = 0 – 30.5%

Small – 27.4%

Thriving – 42%

Of the D group (Dead/Ht = 0)

- Only 3% out of 164 transplants failed to show any reshooting after transplanting (i.e. D1)
- Most in the D group reshot, grew to medium size, died back, then failed to reshoot (so far), sometimes in two cycles

Of the S group (Small)

- 10% stayed small (<10 cm high) for 5 years (i.e. S1)
- Some died back and reshot one or more times, but stayed small (i.e. S2)
- Some fluctuated from small to medium or large and then small again (i.e. S4)

Of the T group (Thriving)

- Maintained tall or medium height for 4- 5 years, often starting small probably as a result of pruning (T1 & T2)
- Some died back then reshot and grew tall again (T3)
- Some stayed small for several monitoring events then grew tall (T4)

**Table 8:** Percentage of 12 Stem Height Growth (SHG) categories in Slender Marsdenia plants after salvage transplanting, at six receival sites. (Note –receival site 5b is not included as the majority of transplants at this site were Marsdenia liisae.)

| | **Stem Height Growth Syndromes of transplanted individuals** | | **Receival sites** | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **1 (Cb)** | **2 (3)** | **3 (5a)** | **5 (7a)** | **6 (8a)** | **8 (8c)** | **All** |
| **D** | **Dead (or appears to be dead)** (all plants with ht=0 were classed as D) | | | | | | | |
| D1 | Didn't reshoot | 3.7 | 0 | 0 | 5.3 | 7.1 | 0 | 3.0 |
| D2 | Small shoot then died back | 18.5 | 11.7 | 0 | 8.8 | 7.1 | 3.7 | 8.5 |
| D3 | Reshot, reached small to medium height (<1.2 m) then died back to ground, some bell-shaped, some died back twice. | 14.8 | 0 | 13.6 | 26.3 | 0 | 22.2 | 17.7 |
| D4 | Reshot, grew tall (~2 m+) then died back to ground, sometimes twice | 3.7 | 0 | 0 | 0 | 0 | 3.7 | 1.2 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Sub-total | 40.7 | 11.8 | 18.2 | 40.4 | 14.3 | 29.6 | 30.4 |
| **S** | **Alive but small, growing very slowly, or declining** | | | | | | | |
| S1 | Stayed small, most less than 10 cm tall (to 40 cm), little change in 5 years | 7.4 | 0 | 9.1 | 15.8 | 0 | 7.4 | 9.8 |
| S2 | Continuously small (mostly <0.5 m), dieback to ground and reshot once or twice, still alive | 11.1 | 5.9 | 18.2 | 5.3 | 14.3 | 0 | 7.3 |
| S3 | Declining or bell shaped (increase-decrease), to ~130cm at peak, not tiny, continuously alive | 0 | 0 | 0 | 1.8 | 0 | 3.7 | 3.0 |
| S4 | Fluctuating – i.e. 'small-medium/tall-small'; or 'grew medium/tall then died back to small' | 7.4 | 0 | 0 | 7.0 | 7.1 | 14.8 | 7.3 |
| | Sub-total | 25.9 | 5.9 | 45.5 | 29.8 | 21.4 | 25.9 | 27.4 |
| **T** | **Thriving, plant tall, continuing to grow, or maintaining size, healthy** | | | | | | | |
| T1 | Thrived – tall (1.5 m+), substantial increase in height/number of leaves, or ~maintained tall height (some decreased slightly Nov 18) | 3.7 | 5.9 | 0 | 5.3 | 7.1 | 14.8 | 6.1 |
| T2 | Thrived – moderate increase in height (0.5 – 1 m+), or constant height (1 m+) | 7.4 | 64.7 | 27.3 | 21.1 | 50.0 | 25.9 | 27.4 |
| T3 | Died back to ground or close to ground then reshot vigorously (>1 m) | 14.8 | 0 | 9.1 | 3.5 | 7.1 | 0 | 5.5 |
| T4 | Small for 5 or 6 monitoring events then suddenly grew big (>1 m) | 7.4 | 11.8 | 0 | 0 | 0 | 3.7 | 3.0 |
| | Sub-total | 33.3 | 82.4 | 36.4 | 29.8 | 64.3 | 44.4 | 42.0 |
| | % Survivorship 5 yrs | 59.3 | 88.2 | 77.3 | 56.1 | 85.7 | 70.4 | 69.5 |
| | Total individuals | 27 | 17 | 22 | 57 | 14 | 28 | 164 |

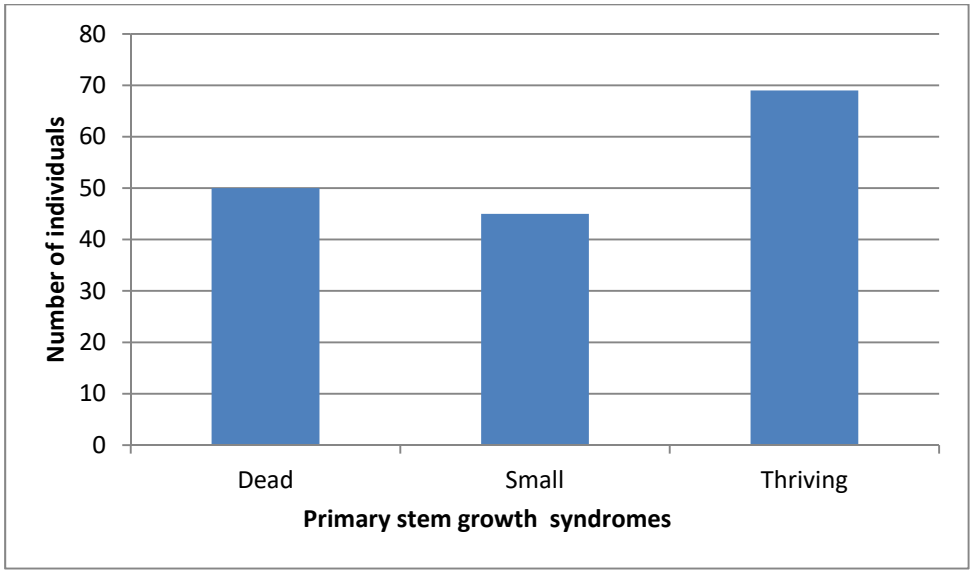


**Figure 4:** Stem growth pattern in translocated Slender Marsdenia over 5 years. Data pooled for 6 receival sites.

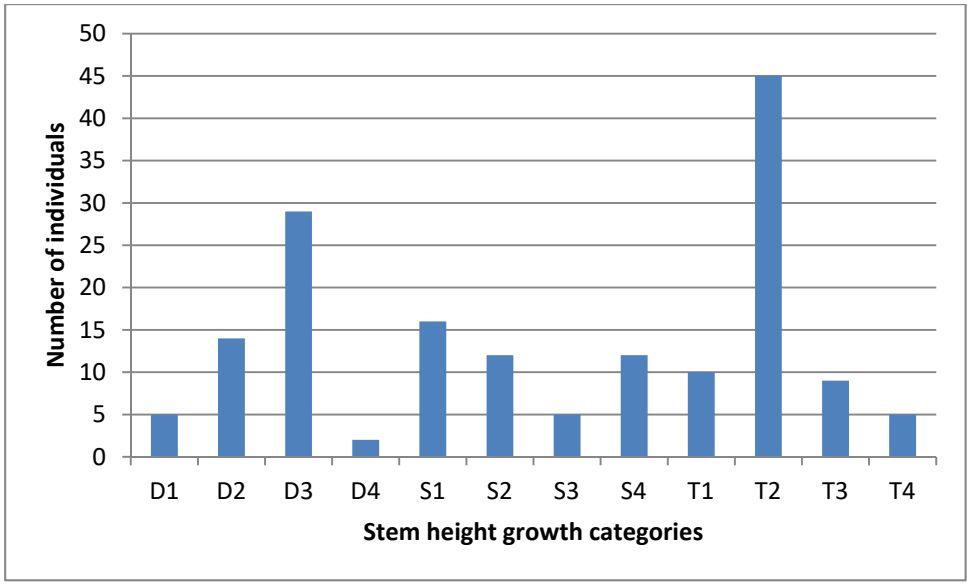


**Figure 5:** Stem growth pattern of 164 translocated Slender Marsdenia after five years. Data from six receival sites combined. Primary categories: D = dead, S = surviving, T = thriving. See Table 5 for definition of stem height growth sub-categories.

#### 2.3.2.4 Effect of receival site

Inspection of Table 8 shows that the 6 receival sites fall into 3 groups with respect to patterns of stem height growth:-

> Receival sites 1 and 7a have high D and S and low T; these sites also had a lower incidence of plants with new shoots.
>
> Receival sites 3 and 8a have low D and S and high T; these sites also had a higher incidence of plants with new shoots.
>
> Receival sites 8a and 5 have intermediate values of D, S and T.

As there were no obvious major differences in habitat between receival sites and at least some individuals at all receival sites reached the T1 or T2 category (i.e thriving), it is more likely that the different proportions of D, S and T at receival sites (just summarised), is due to the quality or vigour of stem individuals transplanted from donor sites to the receival sites.

Donor sites for 1 and 7a included many small, possible suppressed stem-individuals, while receival sites 3 and 8a received larger, more vigorous plants.

#### 2.3.2.5 High incidence of stem height fluctuation

Several of the categories in Table 5 (Pattern of stem height change in stem-individuals over 5 years) involve stems dying back then regenerating again, often more than once in 5 years (i.e. D3, D4, S2, S4, T3).

Stem height fluctuation was not a regular seasonal growth pattern in all plants. New shoot growth appeared to be mainly seasonal as it was concentrated in spring and early summer, but only some of these plants were regrowing after dying back (the others had maintained height and were reshooting). .

Stem height fluctuation was more common in smaller plants but also recorded occasionally in large plants. Reshooting after dieback generally occurred within 12 months, but sometimes not for 18 months, and in a few cases longer.

Modifying the primary categories of stem height change in Table 8 to emphasise stem height fluctuation (i.e. D3+D4+S2+S4+T3), four primary categories can be derived with the following percentages:-

Fluctuating – 39%

Dead or probably dead – 12%

Small or resultant size small – 13%

Thriving 37%

Possible functions of stem height fluctuation in Slender Marsdenia may be:-

(i) To replenish storage in tuberous roots during the reshooting phase, while avoiding use of stored food when conditions for photosynthesis decline during the die back phase.

(ii) Fluctuating small shoots may represent the plant testing microsites for growth potential before committing to expenditure of stored resources by producing stem and leaf growth.

(iii) Stem height fluctuation may represent a strategy for budgeting the consumption of limited resources amongst changing conditions of supply (ie. of photosynthate, or raw materials for photosynthesis) and demand (i.e. consumption of photosynthate).

#### 2.3.2.6 Comparison of stem height pattern in in-situ plants

Monitoring of in-situ plants of Slender Marsdenia on the WC2NH and NH2U projects indicates that stem height fluctuation is present to much the same extent in naturally occurring in situ populations and size class distribution is also much the same and not an artefact of translocation. For example, most plants observed in in situ populations were small stem shoots and these were often short-lived. Large plants (>2.5 m) with foliage in the forest mid-stratum were rare.

#### 2.3.2.7 Reproduction

One individual out of 164 had flowers in November 2019 (Receival Site 2(3), plant no. 5). This plant was 2.8 m high and had 40 leaves. This is the first flowering plant recorded during the5 years of monitoring.

The same very low incidence of flowering in translocated Slender Marsdenia was recorded on the NH2U project (one individual). Flowering is also uncommon or rare in in-situ plants.

### 2.3.3 Rusty Plum (*Niemeyera whitei*)

Survival rate of Rusty Plums at Receival Site 1 (Cockburns Lane) remained at 86% after five years. All six increased in height and are in good condition. It may be another 5-10 years before the largest individuals reach reproductive maturity.

At Receival Site 5, Rusty Plum seeds had germinated in 8 out of 14 chicken-wire cylinders direct-seeded with Rusty Plum seeds in 2017. In November 2019, seedlings were still present in 8 plots, the tallest being 28 cm in height and most showing new shoot growth. At

least half the seed sown (3 per cylinder) rotted and failed to germinate. This was due to the poor quality of the seed (undersized), not the translocation technique.

### 2.3.4 Wooll's Tylophora (*Tylophora woollsii* – unconfirmed)

At Receival Site 6 (8a), six transplanted individuals that could be Woolls' Tylophora (identification unconfirmed) were mainly in good condition, showing new shoot growth and maintaining or increasing stem height.

### 2.3.5 Large-flowered Milk Vine (*Marsdenia liisae*)

Most Marsdenia vines salvaged and planted at Receival Site 4 (5) are *Marsdenia liisae*, not *Marsdenia longiloba*. This species was positively identified from flowers during transplanting. It can also be distinguished from *Marsdenia longiloba* by its leaves, which are larger and dark green.

*Marsdenia liisae* ranges between the Hastings River (Pt Macquarie) and the Nightcap Range and is considered rare, but is not listed as threatened.

The survival rate of *Marsdenia liisae* after five years was only about 20%, much less than *Marsdenia longiloba*. Both had received the same treatment during maintenance.

### 2.3.6 Spider Orchid (*Dendrobium melaleucaphilum*)

The two translocated Spider Orchid plants survived to year 5 and are in good condition. Both plants flowered in spring (August to September) each year from 2015 to 2019 but no seed pods have been produced, possibly due to lack of pollinators. Some pseudobulbs (stem units) died and new ones were produced each year demonstrating active growth.

### 2.3.7 Floyds Grass (*Alexfloydia repens*)

Floyds Grass has persisted at Receival Site 9 after recording high survival rates up to 2018. Merging of patches and loss of tags due to floods have made previous monitoring of individuals impractical, which has been replaced by an overall assessment of the extent of Floyds Grass and habitat condition in the two sub-areas (9a and 9b).

Area 9a

At least 10 square metres of Floyds Grass has established in Area 9a which is probably more than the area of Floyds Grass impacted by clearing.

The tall, dense growth of native Ottochloa grass recorded in the last two years, competing with Floyds Grass, had died down considerably by November 2019. A carpet of Floyds Grass was clearly visible particularly in the half of Area 9a (fenced) close to Warrell Creek.

A significant amount of exotic Broad-leaved Paspalum was regenerating in Area 9a, which poses a threat to the persistence of Floyds Grass which can be overtopped and crowded out by this aggressive exotic grass.

Area 9b

This section of the Floyds Grass translocation area is in poor condition. The work crew at Pacifico failed to carry out proper maintenance of this part of the site before leaving the project, which they were supposed to do. (Pacifico took on the responsibility of maintenance

of the translocation areas on the WC2NH project, including the Floyds Grass area. Ecos Environmental implemented and monitored the translocations and advised on maintenance by email and phone.)

The site is being overrun with Broad-leaved Paspalum which needs urgent hand weeding to prevent it displacing Floyds Grass. A good amount of Floyds Grass is still present in Area 9b (with Koala Bells) but maintenance is essential to prevent the translocation work carried out to date failing over the short to medium term.

### 2.3.8 Koala Bells (*Artanema fimbriatum*)

Koala Bells transplanted to Receival Site 7 have died out, but as flowering and seeding occurred for two years, dormant seed is probably present in the soil seedbank and plants may reappear in future if suitable conditions for regeneration occurs, such as a bushfire, or track maintenance. Koala Bells appears to be a short-lived perennial so this is a normal pattern of growth in this species.

Propagated Koala Bells introduced to Receival Site 9b established successfully, flowering and seeding, and recruitment from seed was recorded in spring 2017. These plants persisted in spring 2019, but there no evidence of further recruitment. This is probably because the site is growing over with Broad-leaved Paspalum which will inhibit seed germination. Koala Bells is a short-lived perennial and prefers disturbed areas where there is abundant light and minimal competition from other plant species. These conditions were created at Receival Site 9b by stripped away ground layer vegetation, enabling planted Koala Bells to recruit seedlings.

## 2.4 Performance Criteria

**Table 9:** Performance Criteria for Assessing Threatened Translocation Areas

| Performance criteria | Yes/No |
|---|---|
| 1. All recorded directly impacted individuals were translocated. | Yes |
| 2. At least 60% of transplant and enhancement individuals are surviving after the first year, 50% after five years and 40% after eight years. | Yes – survival rate between 67% and 100% in year 5 (excluding Koala Bells but this species is short-lived and persists in the soil seedbank) |
| 3. At the end of the monitoring program at least 50% of surviving individuals have a Condition Class of 3. | Not applicable yet |
| 4. Habitat at receival sites in good condition conducive to medium term survival (i.e. 10 years) | Most sites Yes. In the case of Floyds Grass No, particularly Receival Ste 9b where habitat condition has deteriorated significantly in the last 12 months, mainly due to inadequate maintenance being carried out by the contractor at the end of construction. |

## 2.5 Work Plan for Year 6 (November 2019 – November 2020)

**Table 10:** Work plan for Threatened Translocation Areas for the period of November 2019 – November 2020.

| **Task** | **Time** |
|---|---|
| Monitoring | |
| Third yearly operational phase monitoring | November 2020 (to coincide with flowering of Slender Marsdenia and Rusty Plum) |
| Reporting | |
| Third yearly operational phase monitoring report | January 2021 |
| Maintenance | |
| Propose maintenance of Receival Site 9b to remove exotic species, particularly Broad-leaved Paspalum, spray out surrounding exotics, fix up shade cloth shelters, maintain planted Swamp Oak, fix monitoring tags. | Autumn 2020 |

# 3 In-Situ Threatened Flora Populations

## 3.1 Methods

The In-situ Threatened Flora Populations component of the TFMP comprises the following threatened plant species:

- Maundia (*Maundia triglochinoides*)
- Rusty Plum (*Niemeyera whitei*)
- Slender Marsdenia (*Marsdenia longiloba*)
- Spider Orchid (*Dendrobium melaleucaphilum*)
- Woolls' Tylophora (*Tylophora woollsii*).

Individuals of these threatened species were located and tagged before clearing and construction of the WC2NH section of the Pacific Highway began. All individuals occurred within the project boundary but outside the clearing limit (Figures 5-9) and have remained in-situ during the pre-construction, construction and operation phases of the upgrade.

GeoLINK conducted pre-construction and construction monitoring of the in-situ threatened species between January 2015 and October 2017. The following identification and condition data were recorded for each in-situ plant:

- Genus and species
- Plant identification number
- Overall plant condition scored on scale between 0 and 5 (see Tables 2-4)
- Presence of flowers and/or fruit
- Any new growth
- Any recruitment
- Any weed infestations or other impacts.

See *Warrell Creek to Nambucca Heads Monitoring of In-situ Threatened Flora (Annual Report – Spring 2017)* (GeoLINK 2017) for more information.

Andrew Benwell and Jeremy Benwell-Clarke of Ecos Environmental conducted the first yearly operation phase monitoring of the in-situ threatened species in November 2018. All tagged plants were located and the same condition data as recorded by GeoLINK were collected. Additionally, Ecos Environmental recorded the height of each individual to assess plant growth throughout the monitoring program. In 2019, Ecos Environmental conducted the second yearly operation phase monitoring, which is described in this report.

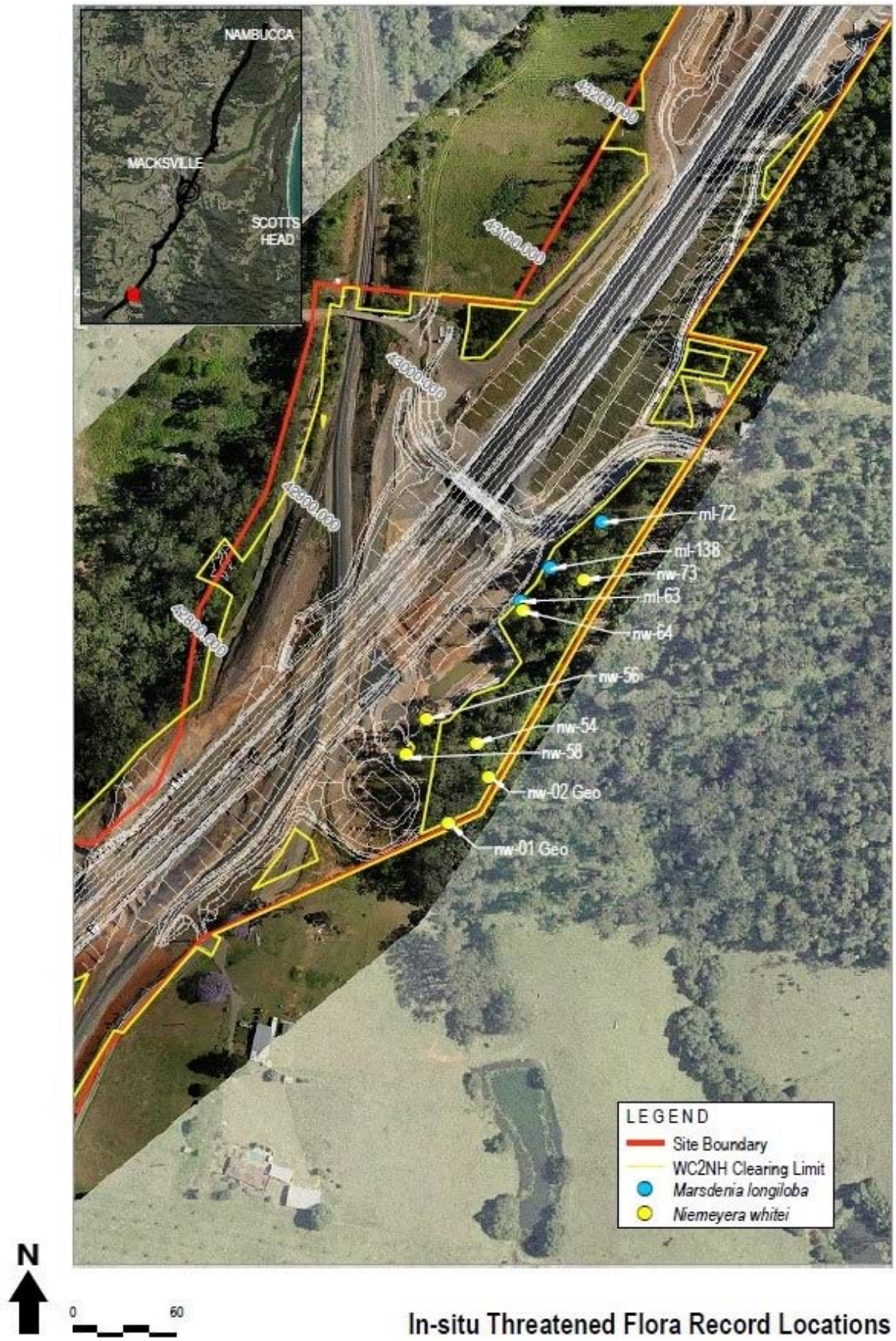


**Figure 5:** In-situ Slender Marsdenia and Rusty Plum at Cockburns Lane, WC2NH. Map sourced from GeoLINK (2017).


**Figure 6:** Maundia population at Nambucca Floodplain, WC2NH. Map sourced from GeoLINK (2017).


**Figure 7:** In-situ Slender Marsdenia, WC2NH. Map sourced from GeoLINK (2017).

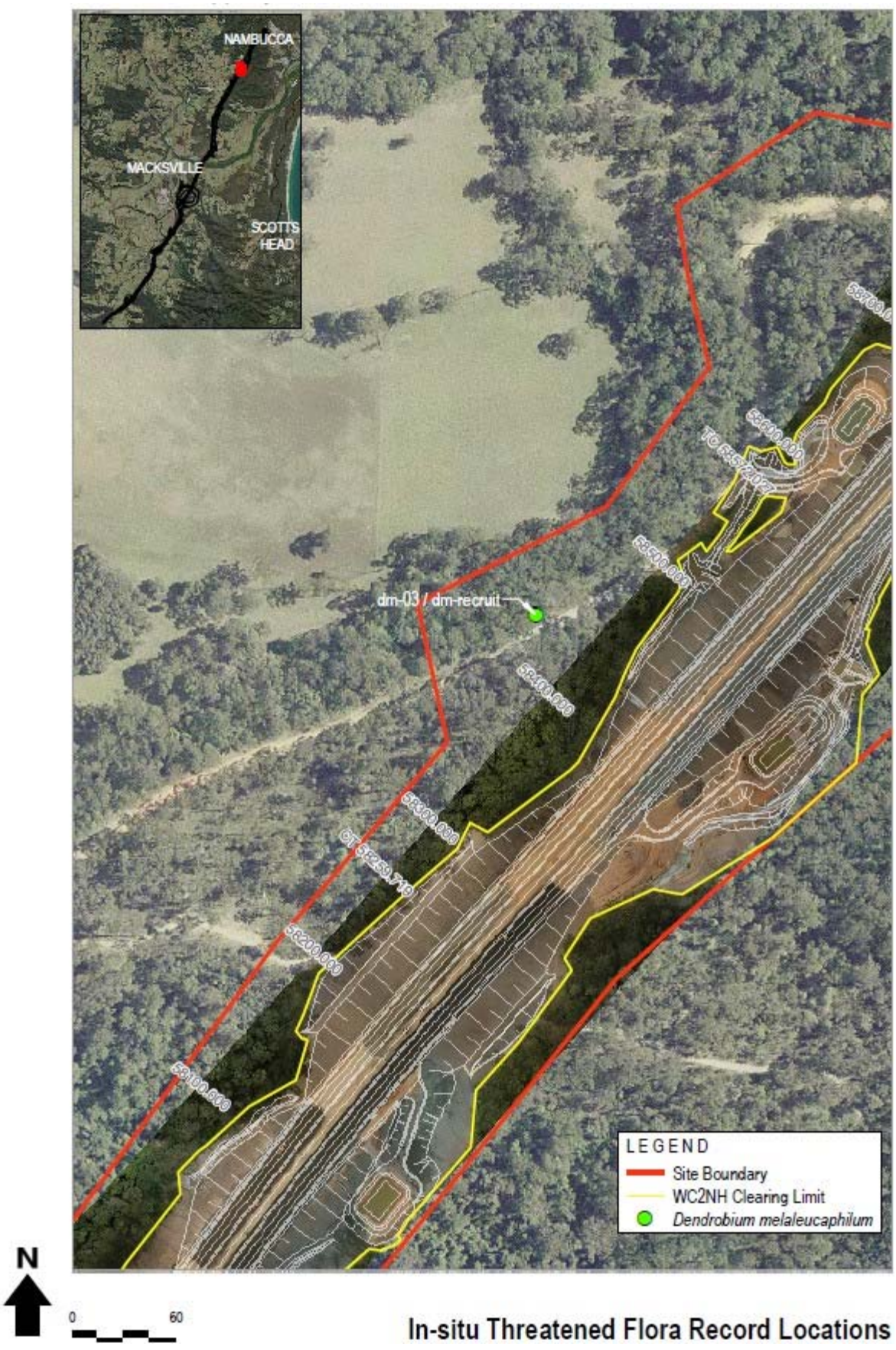


**Figure 8:** In-situ Spider Orchid, WC2NH. Map sourced from GeoLINK (2017).


**Figure 9:** In-situ Slender Marsdenia, WC2NH. Map sourced from GeoLINK (2017).

## 3.2 Results

### 3.2.1 Maundia (*Maundia triglochinoides*)

In November 2018, Maundia in the monitoring plot covering 50 m x 20 m had a crown of 40% and extended beyond the plot. In November 2019, Maundia had almost completely disappeared from the plot and the site (Table 11). Only a few yellowing leaves were seen. There was no standing water in the swamp and it was dry enough to walk across. The main wetland plant, an *Eleocharis* species, was unaffected by the dry conditions, as were Ludwigia and several other species. It appears that Maundia requires at least some standing water and a flooded substrate to maintain green growth, otherwise it dies off.

See Appendix 2 for photos of the in-situ threatened plant species in November 2019.

### 3.2.2 Spider Orchid (*Dendrobium melaleucaphilum*)

The Spider Orchid plants were in healthy condition in November 2019. The mature plant had flowered in spring this year (inflorescence axes still present) , but no fruit (seed pods) were observed. The number of pseudobulbs of the mature plant was about the same as spring 2018 (Table 12).

### 3.2.3 Rusty Plum (*Niemeyera whitei*)

All seven Rusty Plum individuals in-situ at Cockburns Lane were in healthy condition in November 2019 (Table 13). No fruiting was observed, unlike last year.

In spring 2016, nw-56 appeared to be suffering from construction-related edge effects as its leaves had turned yellow and become stunted (GeoLINK 2017). For this reason supplementary watering was carried out by Pacifico in 2016 and 2017, which appeared to have been beneficial as the health and growth of nw-56 improved. nw-56 was also in good condition in spring 2019, suggesting that it is no longer suffering from edge effects.

The habitat condition at Cockburns Lane in November 2019 was generally good. Lantana was scattered throughout the site, which did not appear to be having any negative effects on Rusty Plum or Slender Marsdenia (also occurs at site, see below), but could threaten their health and survival in the future if it were to further invade the site.

### 3.2.4 Slender Marsdenia (*Marsdenia longiloba*)

The monitoring program includes five in-situ Slender Marsdenia occurrences (most with more than one stem, one with 20-30 stems in a small area) across three sites (Table 14). Monitoring Slender Marsdenia through time can be difficult as plants often die back and reshoot and new stems emerge from underground rhizomes away from old stems, making it appear that plants have changed location. This is most likely part of Slender Marsdenia's natural life cycle rather than a response to human-related disturbances.

In November 2019, Slender Marsdenia was actively growing (i.e. green stem and leaves) in all five in-situ locations. In most locations there was more than one stem and so height and plant condition was recorded for the largest stem. The height (of the largest stem) of individuals ranged from 10 to 250 cm and condition score ranged from 2 to 4 (Table 14).

In-situ location ML93 consists of a clonal patch growing between the base of a large *Eucalyptus microcorys* tree and the edge of Old Coast Road. In November 2019, this clonal patch consisted of about 20 stems within an area 15 m wide (right angles to the road) and 10 m long (parallel with the road). Most stems were small (<20 cm high), the largest stem was 120 cm high and most stems had new growth. No flowering or fruiting was recorded. Recruitment is mostly likely by asexual means (i.e. production of stems from underground tuberous roots). New tags were installed.

At ML132 shoots from last year had died back to the ground and two new small shoots were present 2 m apart. Specimens ml-72, ml-138 and ml-63 occur at Cockburns Lane (same site as in-situ Rusty Plum). The height of these plants had decreased since last year.

**Table 11:** In-situ threatened flora monitoring results for Maundia (*Maundia triglochinoides*). Pre-construction (PC) 2015 (data recorded by GeoLINK) and spring (Spr) 2018 and 2019 (data recorded by Ecos Environmental).

| Maundia (*Maundia triglochinoides*) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population | Cover-Abundance and (Condition Class Score) | | | Flower/ Fruit Present | | | New Growth | | | Recruitment | | | Damage/ Disturbance | | | Site Conditions (Spr 2019) |
| | PC 2015 | Spr 2018 | Spr 2019 | PC 2015 | Spr 2018 | Spr 2019 | PC 2015 | Spr 2018 | Spr 2019 | PC 2015 | Spr 2018 | Spr 2019 | PC 2015 | Spr 2018 | Spr 2019 | |
| Nambucca Floodplain | 10-20% (3) | 40% (5) | <1% | N | Y | N | N | Y | N | N | Y | N | N | N | M | Canopy height 10-13 m with *Melaleuca quinquenervia* dominant species; ground stratum 100% crown cover; water dried up; exotic grass spp. along fenceline but few weeds within site. |

**Table 12:** In-situ threatened flora monitoring results for Spider Orchid (*Dendrobium melaleucaphilum*). Pre-construction (PC) 2015 (data recorded by GeoLINK) and spring (Spr) 2018 and 2019 (data recorded by Ecos Environmental). Y = yes, N = no.

| Plant ID # | Length of longest pseudobulb (cm) | | | Leaf Condition | | | Number of pseudobulbs with leaves | | | New Growth | | | Recruitment | | | Damage/ Disturbance | | | Site Conditions | GeoLINK notes (PC 2015-Spr 2017) | Ecos Environmental notes (Spr 2019) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PC 2015 | Spr 2018 | Spr 2019 | PC 2015 | Spr 2018 | Spr 2019 | PC 2015 | Spr 2018 | Spr 2019 | PC 2015 | Spr 2018 | Spr 2019 | PC 2015 | Spr 2018 | Spr 2019 | PC 2015 | Spr 2018 | Spr 2019 | | | |
| 3 | 30 | 35 | 35 | 2 | 5 | 5 | 6 | 50+ | 50) | Y | N | Y | N | N | N | N | N | N | Canopy height 25 m and crown cover approx 90% comprised of Eucalyptus spp. | Very healthy with signs of increased flowering activity. | Fairly healthy, effect of dry conditions evident in many scrappy pseudobulbs |
| DM Recruit | - | 12 | 12 | - | 3 | 3 | - | 4 | 4 | - | N | N | - | N | N | - | N | N | | This new recruit was first observed during Spring 2016. | Fairly healthy |

**Table 13:** In-situ threatened flora monitoring results for Rusty Plum (*Niemeyera whitei*). Pre-construction (PC) 2015 (data recorded by GeoLINK) and spring (Spr) 2018 and 2019 (data recorded by Ecos Environmental). Y = yes, N = no.

| Plant ID # | Height (cm) | | | Leaf Condition | | | Flower/ Fruit Present | | | New Growth | | | Recruitment | | | Damage/ Disturbance | | | Site Conditions (Spr 2019) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PC 2015 | Spr 2018 | Spr 2019 | PC 2015 | Spr 2018 | Spr 2019 | PC 2015 | Spr 2018 | Spr 2019 | PC 2015 | Spr 2018 | Spr 2019 | PC 2015 | Spr 2018 | Spr 2019 | PC 2015 | Spr 2018 | Spr 2019 | |
| NW58 | 700 | 800 | 820 | 5 | 4 | 4 | N | N | N | Y | Y | Y | N | N | N | N | N | N | Canopy height 20 m with crown cover 70%; some medium to large patches of Lantana scattered throught site. |
| NW56 | 100 | 120 | 130 | 5 | 4 | 4 | N | N | N | Y | Y | Y | N | N | N | N | N | N | |
| NW73 | 600 | 700 | 750 | 5 | 5 | 4 | N | Y | N | Y | N | Y | N | N | N | N | N | N | |
| NW54 | 400 | 600 | 640 | 5 | 4 | 4 | N | N | N | Y | N | Y | N | N | N | N | N | N | |
| NW64 | 500 | 800 | 850 | 5 | 5 | 4 | N | Y | N | Y | N | N | N | N | N | N | N | N | |
| NW01-Geo | - | 450 | 450 | - | 4 | 4 | - | N | N | - | N | Y | - | N | N | - | N | N | |
| NW02-Geo | - | 500 | 530 | - | 4 | 4 | - | N | N | - | N | Y | - | N | N | - | N | N | |

**Table 14:** In-situ threatened flora monitoring results for Slender Marsdenia (*Marsdenia longiloba*). PC (pre-construction) 2015 and Spr (spring) 2017 data recorded by GeoLINK, Spr 2018 data recorded by Ecos Environmental. Y = yes, N = no

| Plant ID # | Height (cm) | | | Leaf Condition | | | Flower/ Fruit Present | | | New Growth | | | Recruitment | | | Damage/ Disturbance | | | Site Conditions | GeoLINK notes (PC 2015-Spr 2017) | Ecos Environmental notes (Spr 2018-Spr 2019) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PC 2015 | Spr 2018 | Spr 2019 | PC 2015 | Spr 2018 | Spr 2019 | PC 2015 | Spr 2018 | Spr 2019 | PC 2015 | Spr 2018 | Spr 2019 | PC 2015 | Spr 2018 | Spr 2019 | PC 2015 | Spr 2018 | Spr 2019 | | | |
| ML93 | 5 | 100 | 130 | 3 | 2 | 3 | N | N | N | N | Y | Y | N | N | Y | N | N | N | Canopy height 20 m; crown cover 100% with Eucalyptus microcorys dominant species. | 15 live plants now within 1 m radius of subject plant. All range from 2 – 4 in condition class. Some plants recorded during spring 2016 have died back however new recruits have also been recorded and are now at a count of 23 flagged individual plants. | Clonal patch of about 20-30 stem-individuals in an area 15m x 10 m, from the base of Eucalyptus microcorys to the edge of O)ld Coast Rd. Most plants small (<20cm high), a few >1 m high. |
| ML132 | 40 | 8 | 10 | 3 | 2 | 3 | N | N | N | Y | Y | Y | N | N | N | N | N | N | Canopy height 25 m; crown cover 80% | During Spring 2016 partially natural die back was recorded. The plant recorded during spring 2017 is fresh, green with new growth indicating possibly a new plant to the one previously recorded. | Shoots tagged last year had died off. Two new small shoots this year about 1 m apart |
| ML72 | 5 | 40 | 10 | 2 | 2 | 3 | N | N | N | N | N | N | N | N | N | N | N | N | Canopy height 20 m; crown cover 70% | Natural die back of the stem, possibly live stem bulb. No obvious signs of construction related impacts. | Died back and reshot |
| Ml138 | 5 | 90 | 10 | 2 | 3 | 3 | N | N | N | N | Y | N | N | N | N | N | N | N | | Tall plant with mature leaves some yellowing. | Died back and reshot |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ML63 | 10 | 300 | 250 | 2 | 4 | 4 | N | N | N | N | Y | Y | N | N | N | N | N | N | | Healthy |

## 3.3 Conclusion

The survival rate of the in-situ threatened species at the end of Year 5 (spring 2019) was 100% for Spider Orchid, Rusty Plum and Slender Marsdenia. (Table15). The crown cover of Maundia was <1% compared to 40% in spring 2018. The high mortality rate of Maundia is most likely a result of the drought in 2019. For Slender Marsdenia, survival rate was stable although there was evidence that stems had died back and reshot, from the same point or close-by from tuberous roots.

No signs of construction-related impacts were observed in spring 2019. The monitoring results meet the performance criteria – *survival rate at the end of Years 4-8 is >70%* and *of surviving plants at end of each year >75% are in good condition (class 3 or >)* – for Spider Orchid, Rusty Plum and Slender Marsdenia and therefore no corrective actions are required for these species. Note that >75% of in-situ Slender Marsdenia plants do not have a class score of 3 or > but this is not of concern for reasons described above.

The monitoring results do not meet the performance criteria for Maundia, however above average rainfall is likely to return and when this occurs the species is expected to recover, and therefore, no corrective actions are required.

**Table 15:** Performance measures for In-situ Threatened Flora Populations monitoring.

| Species | Survival rate at finish of clearing (October 2015/ Spring 2015) is 100%, no accidental damage due to clearing | Survival rate at end of Years 1-3 is >80% | Survival rate at end of Year 4 (2018) | Survival rate at the end of Years 4-8 is >70% | Of surviving plants at end of each year >75% are in good condition (class 3 or >) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Year 1 - 2015 | Year 2 - 2016 | Year 3 - 2017 | Year 5 - 2019 |
| Spider Orchid (*Dendrobium melaleucaphilum*) | Yes - 100% survival<br><br>No accidental damage due to clearing | Yes - 100% survival | Yes - 100% | Not applicable yet | Yes - 100% in good condition | Yes - 100% in good condition, with new recruit. recorded also in good condition (score 3) | Yes - 100% (including new recruit) in good condition (Score 4) | Yes - 100% with one plant reproductive |
| Maundia (*Maundia triglochinoides*) | Yes - 100% survival<br><br>No accidental damage due to clearing | Yes - 83% survival | No - <1% survival (trace)% | Not applicable yet | Yes - 100% in good condition (score 4) | Yes - 100% in good condition (score 5) | Yes - 100% of visible plants in good condition (score 3) | No – poor condition (score 1) |
| Maundia (*Maundia triglochinoides*) | Yes - 100% survival<br><br>No accidental damage due to clearing | Yes - 83% survival | Yes - 100% | Not applicable yet | Yes - 100% in good condition (score 4) | Yes - 100% in good condition (score 5) | Yes - 100% of visible plants in good condition (score 3) | Yes - 100% with some plants reproductive |
| Rusty Plum (*Niemeyera whitei*) | Yes - 100% survival<br><br>No accidental damage due to clearing | Yes - 100% survival | Yes - 100% | Not applicable yet | Yes - 100% in good condition (score 4 - 5) | Yes - 80% in good condition (score 2 - 5) | Yes - 100% in good condition (score 3 - 5) | Yes - 100% with some plants reproductive |
| Slender Marsdenia (*Marsdenia longiloba*) | No - 62% of plants were recorded as living<br><br>But no construction related impacts were recorded | No - 60% | Yes - 100% | Not applicable yet | No - 62% (5 of 8 records) recorded scores 0 - 3 | Yes - 100% (5 of 5 records) recorded scores 3 - 4 | No - 60% (3 of 5 records) recorded scores 1 - 4 | No - 40% in good condition |

# 4 Slender Marsdenia and Woolls' Tylophora Habitat Condition

## 4.1 Methodology

This component of the TFMP aims to monitor Slender Marsdenia and Woolls' Tylophora habitat within the indirect impact zone – i.e. within 10 m of the edge of clearing – for potential edge effects and declines in habitat condition. The study design involves ten permanent plots along the edge of clearing in known Slender Marsdenia and Woolls' Tylophora habitat (Figures 10-12). Each plot is 10 m * 20 m with the long axis parallel to the edge of clearing. Within each plot, the following vegetation and landscape attributes are measured:

- Native vegetation structure (according to Native Vegetation Interim Type Standard)
- Level of weed incursion (measured by summing the abundance of all exotic species)
- Microclimate class (Table 16).

The plots were established by GeoLINK on 26 November 2015 around the time that clearing operations in the northern zone of the project were being completed. The plots were again monitored by GeoLINK during autumn and spring 2016 and spring 2017. See GeoLINK (2017) for more information.

Ecos Environmental carried out the first yearly operation phase monitoring of the ten plots in November 2018. The plots were located and data on the above parameters were collected. Native vegetation structure was measured according to Roads and Maritime Services (2018) which states that: "Structure consists of the height, crown cover and dominant species in each vegetation layer and will be recorded according to the current OEH vegetation standard (Native Vegetation Interim Type Standard – http://www.environment.nsw.gov.au/research/VISplot.htm)."- p27.

Ecos Environmental was sent GeoLINK (2017) after the data were collected and when it was read it became apparent that GeoLINK measured native vegetation structure slightly different to the Interim Type Standard. Specifically, overall crown cover was estimated for each stratum rather than individually for the three most dominant species. As Ecos Environmental followed the Interim Type Standard as per Roads and Maritime Services (2018), our vegetation structure data had to be compared qualitatively rather than quantitatively with GeoLINK's data. Appendix 4 includes GeoLINK (2017) data on vegetation structure.

Ecos Envrionmetal carried out the second yearly operation phase monitoring in November 2019, which is described in this report.

**Table 16:** Microclimate exposure classes for Slender Marsdenia and Woolls' Tylophora habitat.

| **Microclimate Class (less exposed to more exposed)** | **Microclimate Type** |
|---|---|
| 1 | Sheltered aspect (e.g. south) and vegetation understorey slightly more open and exposed than before clearing. |
| 2 | Sheltered aspect (e.g. south) and vegetation understorey moderately more open and exposed than before clearing. |
| 3 | Sheltered aspect (e.g. south) and vegetation understorey much more open and exposed than before clearing. |
| 4 | Exposed aspect (e.g. east, north and west) and vegetation understorey slightly more open and exposed than before clearing. |
| 5 | Exposed aspect (e.g. east, north and west) and vegetation understorey moderately more open and exposed than before clearing. |
| 6 | Exposed aspect (e.g. east, north and west) and vegetation understorey much more open and exposed than before clearing. |


**Figure 10:** Slender Marsdenia and Woolls' Tylophora Habitat monitoring quadrats 5, 6, 7 and 8, WC2NH. Map sourced from GeoLINK (2017).


**Figure 11:** Slender Marsdenia and Woolls' Tylophora Habitat monitoring quadrats 9 and 10, WC2NH. Map sourced from GeoLINK (2017).


**Figure 12:** Slender Marsdenia and Woolls' Tylophora Habitat monitoring quadrats 1, 2, 3 and 4, WC2NH. Map sourced from GeoLINK (2017).

## 4.2 Results

Comparing (qualitatively) the vegetation structure data recorded by Ecos Enviromental (Table 18) with that recorded by GeoLINK (Appendix 4), no major changes in vegetation structure could be inferred.

It appears that since spring 2015 the level of weed incursion has increased in some plots but decreased in others (Table 17). All changes, however, are minor with weed crown cover remaining far below the performance measure threshold of 25% at the end of year 4.

The data also indicate that the microclimate of some plots in spring 2019 differs from previous years. Specifically, that plots 6, 7, 8, 9 and 10 became more exposed. The data, however, should be interpreted cautiously as it were collected by two different observers – GeoLINK from 2015-2017 and Ecos Environmental in 2018-2019 – and therefore likely reflects observer variability. In the field, Ecos Environmental was of the impression that the vegetation understorey of plots was either moderately or much more exposed than before clearing. Consequently, no plots were assigned a microclimate class of 1 or 4 (for different aspects but both meaning only slightly more exposed than before clearing). GeoLINK, on the other hand, assigned plots 6, 7, 8, 9 and 10 either a 1 or 4 depending on their aspect.

See Appendix 3 for photos of each Slender Marsdenia and Woolls' Tylophora habitat condition plot in 2019.

**Table 17:** Weed level and microclimate class of Slender Marsdenia and Woolls' Tylophora habitat plots.

| Plot | Weed Level (% crown cover) | Microclimate Class |
|---|---|---|
| | | |
| 1 | Lantana | |
| Spring 15 (GeoLINK) | <5% | 5 |
| Autumn 16 (GeoLINK) | 5 | 5 |
| Spring 16 (GeoLINK) | 5 | 5 |
| Spring 17 (GeoLINK) | 5 | 5 |
| Spring 18 (Ecos) | <5% | 5 |
| Spring 19 (Ecos) | 5 | 5 |
| 2 | Lantana, Whisky Grass | |
| Spring 15 (GeoLINK) | <5% | 5 |
| Autumn 16 (GeoLINK) | 5 | 5 |
| Spring 16 (GeoLINK) | 10 | 5 |
| Spring 17 (GeoLINK) | 10 | 5 |
| Spring 18 (Ecos) | <5% | 5 |
| Spring 19 (Ecos) | <5% | 5 |
| 3 | Lantana | |
| Spring 15 (GeoLINK) | <5% | 1 |
| Autumn 16 (GeoLINK) | <5% | 1 |
| Spring 16 (GeoLINK) | <5% | 1 |
| Spring 17 (GeoLINK) | <5% | 1 |
| Spring 18 (Ecos) | <5% | 2 |
| Spring 19 (Ecos) | <5% | 2 |
| 4 | Lantana | |
| Spring 15 (GeoLINK) | 0 | 2 |
| Autumn 16 (GeoLINK) | 0 | 2 |
| Spring 16 (GeoLINK) | 0 | 2 |
| Spring 17 (GeoLINK) | 0 | 2 |
| Spring 18 (Ecos) | <5% | 2 |
| Spring 19 (Ecos) | <5% | 2 |
| 5 | Lantana, Setaria, Broad-leaved Paspalum | |
| Spring 15 (GeoLINK) | <5% | 5 |
| Autumn 16 (GeoLINK) | <5% | 5 |
| Spring 16 (GeoLINK) | <5% | 5 |
| Spring 17 (GeoLINK) | <5% | 5 |
| Spring 18 (Ecos) | <5% | 5 |
| Spring 19 (Ecos) | <5% | 5 |

| Plot | Weed Level (% crown cover) | Microclimate Class |
|---|---|---|
| 6 | Lantana | |
| Spring 15 (GeoLINK) | 5 | 4 |
| Autumn 16 (GeoLINK) | 5 | 4 |
| Spring 16 (GeoLINK) | 5 | 4 |
| Spring 17 (GeoLINK) | 5 | 4 |
| Spring 18 (Ecos) | <5% | 5 |
| Spring 19 (Ecos) | 10 | 5 |
| 7 | Broad-leaved Paspalum | |
| Spring 15 (GeoLINK) | 0 | 1 |
| Autumn 16 (GeoLINK) | 0 | 1 |
| Spring 16 (GeoLINK) | 0 | 1 |
| Spring 17 (GeoLINK) | 0 | 1 |
| Spring 18 (Ecos) | <5% | 2 |
| Spring 19 (Ecos) | 0 | 2 |
| 8 | Lantana | |
| Spring 15 (GeoLINK) | 5 | 1 |
| Autumn 16 (GeoLINK) | 5 | 1 |
| Spring 16 (GeoLINK) | 7 | 1 |
| Spring 17 (GeoLINK) | 5 | 1 |
| Spring 18 (Ecos) | <5% | 2 |
| Spring 19 (Ecos) | <5% | 2 |
| 9 | Lantana, Broad-leaved Paspalum, Coastal Morning Glory | |
| Spring 15 (GeoLINK) | 5 | 1 |
| Autumn 16 (GeoLINK) | 5 | 1 |
| Spring 16 (GeoLINK) | <5% | 1 |
| Spring 17 (GeoLINK) | <5% | 1 |
| Spring 18 (Ecos) | <5% | 2 |
| Spring 19 (Ecos) | <5% | 2 |
| 10 | Lantana, Billygoat Weed, Setaria | |
| Spring 15 (GeoLINK) | <5% | 4 |
| Autumn 16 (GeoLINK) | <5% | 4 |
| Spring 16 (GeoLINK) | <5% | 4 |
| Spring 17 (GeoLINK) | <5% | 4 |
| Spring 18 (Ecos) | <5% | 5 |
| Spring 19 (Ecos) | 6 | 5 |

**Table 18:** Vegetation structure of ten Slender Marsdenia and Woolls' Tylophora habitat monitoring plots, WC2NH. Data recorded November 2019 by Ecos Environmental.

| Stratum | Dominant species | Cover (% crown cover) | For the entire | | |
|---|---|---|---|---|---|
| Plot 1 | | | | | |
| Upper | *Eucalyptus grandis* | 10 | Upper stratum Height to crown (m) min-mode-max | | |
| Upper | *Syncarpia glomulifera* | 15 | | | |
| Upper | | | 20 | 20 | 30 |
| Mid | *Lophostemon confertus* | 20 | | | |

| Stratum | Dominant species | Cover (% crown cover) | For the entire | | |
|---|---|---|---|---|---|
| Mid | *Cissus hypoglauca* | 65 | Mid stratum Height to crown (m) min-mode-max | | |
| Mid | *Acacia binervata* | 15 | 4 | 5 | 10 |
| Lower | *Blechnum cartilagineum* | 30 | Lower stratum Height to crown (m) min-mode-max | | |
| Lower | *Dodonaea triquetra* | 10 | | | |
| Lower | *Cordyline stricta* | 10 | 0.5 | 2 | 4 |
| Plot 2 | | | | | |
| Upper | *Syncarpia glomulifera* | 40 | Upper stratum Height to crown (m) min-mode-max | | |
| Upper | *Eucalyptus microcorys* | 20 | | | |
| Upper | *Allocasurina torolosa* | 10 | 15 | 24 | 28 |
| Mid | *Cissus hypoglauca* | 40 | Mid stratum Height to crown (m) min-mode-max | | |
| Mid | *Calicoma seratifolia* | 15 | | | |
| Mid | *Trochocarpa laurina* | 15 | 2 | 8 | 15 |
| Lower | *Blechnum cartilagineum* | 15 | Lower stratum Height to crown (m) min-mode-max | | |
| Lower | *Morinda jasminoides* | 20 | | | |
| Lower | *Cryptocarya rigida* | 30 | 0.5 | 1 | 2 |
| Plot 3 | | | | | |
| Upper | *Syncarpia glomulifera* | 15 | Upper stratum Height to crown (m) min mode max | | |
| Upper | *Eucalyptus grandis* | 30 | | | |
| Upper | *Eucalyptus anchorphylla* | 10 | 28 | 28 | 30 |
| Mid | *Cryptocarya rigida* | 50 | Mid stratum Height to crown (m) min mode max | | |
| Mid | *Callicoma seratofolia* | 30 | | | |
| Mid | *Cissus hypoglauca* | 30 | 4 | 5 | 12 |
| Lower | *Blechnum cartilagineum* | 30 | Lower stratum Height to crown (m) min mode max | | |
| Lower | *Livistonia australis* | 30 | | | |
| Lower | *Ripognum forcetianum* | 15 | 0.5 | 1 | 3 |
| Plot 4 | | | | | |
| Upper | *Eucalyptus grandis* | 30 | Upper stratum Height to crown (m) min mode max | | |
| Upper | *Eucalyptus glomulifera* | 25 | | | |
| Upper | *Eucalyptus acmenoides* | 10 | 20 | 30 | 30 |
| Mid | *Livistonia australis* | 5 | Mid stratum Height to crown (m) min mode max | | |
| Mid | *Alphitonia excelsa* | 20 | | | |
| Mid | *Synoum glandulosum* | 10 | 4 | 5 | 15 |
| Lower | *Cissus hypoglauca* | 50 | Lower stratum Height to crown (m) min mode max | | |
| Lower | *Gahnia sieberana* | 15 | | | |
| Lower | *Lepidosperma laterale* | 5 | 0.5 | 1 | 2 |
| Plot 5 | | | | | |
| Upper | *Syncarpia glomulifera* | 40 | Upper stratum Height to crown (m) min mode max | | |
| Upper | *Glochidion ferdinandii* | 10 | | | |
| Upper | *Gmelina leichhardtii* | 10 | 15 | 18 | 20 |
| Mid | *Livistonia australis* | 15 | Mid stratum Height to crown (m) min mode max | | |
| Mid | *Guioa semiglauca* | 25 | | | |
| Mid | *Cissus hypoglauca* | 20 | 7 | 10 | 12 |
| Lower | *Cordyline stricta* | 20 | | | |

| Stratum | Dominant species | Cover (% crown cover) | For the entire | | |
|---|---|---|---|---|---|
| Lower | *Gahnia aspera* | 15 | Lower stratum Height to crown (m) min mode max | | |
| Lower | *Lomandra longifolia* | 10 | 0.8 | 1 | 1.5 |
| Plot 6 | | | | | |
| Upper | *Eucalyptus pilularis* | 40 | Upper stratum Height to crown (m) min mode max | | |
| Upper | *Lophostemon confertus* | 20 | | | |
| Upper | *Eucalyptus microcorys* | 20 | 15 | 22 | 27 |
| Mid | *Trochocarpa laurina* | 15 | Mid stratum Height to crown (m) min mode max | | |
| Mid | *Acacia melanoxylum* | 15 | | | |
| Mid | *Tabernaemontana pandacaqui* | 20 | 5 | 8 | 12 |
| Lower | *Cordyline stricta* | 20 | Lower stratum Height to crown (m) min mode max | | |
| Lower | *Livistonia australis* | 20 | | | |
| Lower | *Blechnum cartilagineum* | 10 | 0.5 | 1 | 2 |
| Plot 7 | | | | | |
| Upper | *Eucalyptus microcorys* | 80 | Upper stratum Height to crown (m) min mode max | | |
| Upper | *Eucalyptus grandis* | 10 | | | |
| Upper | | | 14 | 20 | 22 |
| Mid | *Leptospermum polygalifium* | 35 | Mid stratum Height to crown (m) min mode max | | |
| Mid | *Archirhodomyrtus beckleri* | 10 | | | |
| Mid | *Glochidion ferdinandi* | 10 | 1.5 | 3 | 5 |
| Lower | *Calochlaena dubia* | 75 | Lower stratum Height to crown (m) min mode max | | |
| Lower | *Lomandra longifolia* | 5 | | | |
| Lower | *Blechnum cartilagineum* | 5 | 0.5 | 0.7 | 1 |
| Plot 8 | | | | | |
| Upper | *Eucalyptus grandis* | 70 | Upper stratum Height to crown (m) min mode max | | |
| Upper | | | | | |
| Upper | | | 30 | 24 | 18 |
| Mid | *Cissus hypoglauca* | 20 | Mid stratum Height to crown (m) min mode max | | |
| Mid | *Rubus moluccanus* | 20 | | | |
| Mid | *Guioa semiglauca* | 20 | 12 | 8 | 7 |
| Lower | *Blechnum cartilagineum* | 25 | Lower stratum Height to crown (m) min mode max | | |
| Lower | *Oplismenus imbecilis* | 20 | | | |
| Lower | *Morinda jasminoides* | 15 | 2 | 1 | 0.3 |
| Plot 9 | | | | | |
| Upper | *Eucalyptus grandis* | 15 | Upper stratum Height to crown (m) min mode max | | |
| Upper | *Corymbia intermedia* | 30 | | | |
| Upper | *Eucalyptus microcorys* | 10 | 14 | 25 | 32 |
| Mid | *Cryptocarya rigida* | 30 | Mid stratum Height to crown (m) min mode max | | |
| Mid | *Livistonia australis* | 15 | | | |
| Mid | *Synoum glandulosum* | 10 | 1.5 | 2.5 | 7 |
| Lower | *Gahnia siberana* | 5 | Lower stratum Height to crown (m) min mode max | | |
| Lower | *Lastreopsis* sp. | 25 | | | |
| Lower | *Cordyline stricta* | 2 | 0.1 | 0.5 | 1 |
| Plot 10 | | | | | |

| Stratum | Dominant species | Cover (% crown cover) | For the entire | | |
|---|---|---|---|---|---|
| Upper | *Eucalyptus grandis* | 70 | Upper stratum Height to crown (m) min mode max | | |
| Upper | | | | | |
| Upper | | | 20 | 25 | 28 |
| Mid | *Melaleuca stypeloides* | 10 | Mid stratum Height to crown (m) min mode max | | |
| Mid | *Lophostemon confertus* | 10 | | | |
| Mid | *Cissus antarctica* | 20 | 2 | 8 | 10 |
| Lower | *Morinda jasminoides* | 40 | Lower stratum Height to crown (m) min mode max | | |
| Lower | *Opplismenus imbecilis* | 40 | | | |
| Lower | *Cissus antarctica* | 20 | 0.3 | 1.2 | 2 |

## 4.3 Conclusion

The monitoring plot data suggest that to date there have been no declines in Woolls' Tylophora and Slender Marsdenia habitat condition along the edge of clearing.

Ecos Environmental, applying the method specified by RMS (2018), assigned different microclimate exposure scores for some plots than GeoLINK (2017), which most likely reflects observer variability rather than physical changes. Plot crown-cover of exotic species at the end of year 5 – which ranged from 0 to 10% – was below the performance threshold of 25% and vegetation structure appeared to have remained the same since year 4. Therefore, no corrective actions are required (Table 19).

**Table 19:** Performance measures for Slender Marsdenia and Woolls' Tylophora Habitat Condition monitoring.

| **Performance measure** | **Yes/No – comments** |
|---|---|
| *Plot crown-cover of exotic species is no more than 25% at the end of Years-2 to 8.* | Yes – plot crown cover of exotic species at the end of year 5 is 0-10% |
| *Baseline vegetation structure (height and crown cover) remains the same or increases in height and crown cover at the end of each year compared to the previous year.* | Yes – qualitative assessment of vegetation structure data revealed no major decreases in height and crown cover at the end of year 5 compared to year 4 |
| *There is no increase in the microclimate exposure class (e.g. 1 to 2, or 4 to 5) compared to the previous year.* | No – the plots 6 and 10 increased from a microclimate exposure score of 4 to 5 and plots 6-9 increased from 2 to 1, but this most likely reflects observer variability rather than physical changes. |

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