Warrell Creek to Nambucca Heads

Operational Phase Monitoring of Threatened Flora Translocations, In-situ Threatened Plants and Slender Marsdenia and Woolls' Tylophora Habitat Condition- Year 1

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Operational Phase Monitoring of Threatened Flora Translocations, In-situ Threatened Plants and Slender Marsdenia and Woolls' Tylophora Habitat Condition on the Warrell Creek to Nambucca Heads Section of the Pacific Highway Upgrade – Year 1

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Executive Summary

This report presents the results of the year one operational phase monitoring of threatened plant species along the Warrell Creek to Nambucca Heads (WC2NH) section of the Pacific Highway upgrade. Specifically, it relates to three monitoring components that were planned in the *Warrell Creek to Urunga Upgrade Threatened Flora Management Plan* (RMS and Ecos 2016) - In-situ Threatened Flora Populations, Slender Marsdenia and Woolls' Tylophora Habitat Condition, and Threatened Flora Translocation Areas.

Five threatened and one nationally rare plant species occur within the highway upgrade area:

- 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 has been proposed for State listing).

Ecos Environmental conducted year one operational phase monitoring in November 2018, which followed on from pre-construction and construction phase monitoring undertaken also by Ecos Environmental, and GeoLINK.

In November 2018, survival of the translocated species was 67-100% and of the surviving plants most were in healthy condition. Survival of the threatened in-situ populations was 100% and no plants were in poor condition. The condition of Slender Marsdenia and Woolls' Tylophora habitat along the edge of clearing appears to have remained the same since construction of the WC2NH section began.

The results of the first year of operation phase monitoring mostly meet the performance criteria and no corrective actions are required.

1 Introduction

The *Warrell Creek to Urunga Upgrade Threatened Flora Management Plan* (TFMP) was prepared by NSW Roads and Maritime Service and Ecos Environmental as part of the Project Environmental Assessment for the Warrell Creek to Urunga (WC2U) Pacific Highway upgrade (RMS & Ecos 2016). The Minister for Planning approved the project on 19 July 2011 under Part 3A (now repealed), Section 75J of the Environmental Planning and Assessment Act 1979 (EP&A Act). One of the Minister's Conditions of Approval (CoA) was a monitoring program for threatened flora likely to be impacted by the project, as outlined in the TFMP. The monitoring program would comprise three components - In-situ Threatened Flora Populations, Slender Marsdenia and Woolls' Tylophora Habitat Condition, and Threatened Flora Translocation Areas – and would be undertaken during the pre-construction, construction and operation phases of the project.

The WC2U upgrade was completed in two stages: Nambucca Heads to Urunga (NH2U) and Warrell Creek to Nambucca Heads (WC2NH). The following report addresses operational phase monitoring for the WC2NH stage, which extends for 19.6km from Warrell Creek in the south to Nambucca Heads (Figure 1). Construction of the WC2NH upgrade began on 9 February 2015 and the entire alignment was open to traffic in July 2018.

Operation phase monitoring in the WC2NH section of the upgrade is to be conducted yearly for four years, as specified in *Warrell Creek to Nambucca Heads Operational Ecological and Water Quality Monitoring Brief* (Roads and Maritime Services 2018). In November 2018, Ecos Environmental conducted the first yearly operation phase monitoring of In-situ Threatened Flora Populations, Slender Marsdenia and Woolls' Tylophora Habitat Condition, and Threatened Flora Translocation Areas. The results are described in this report in the following sections:

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

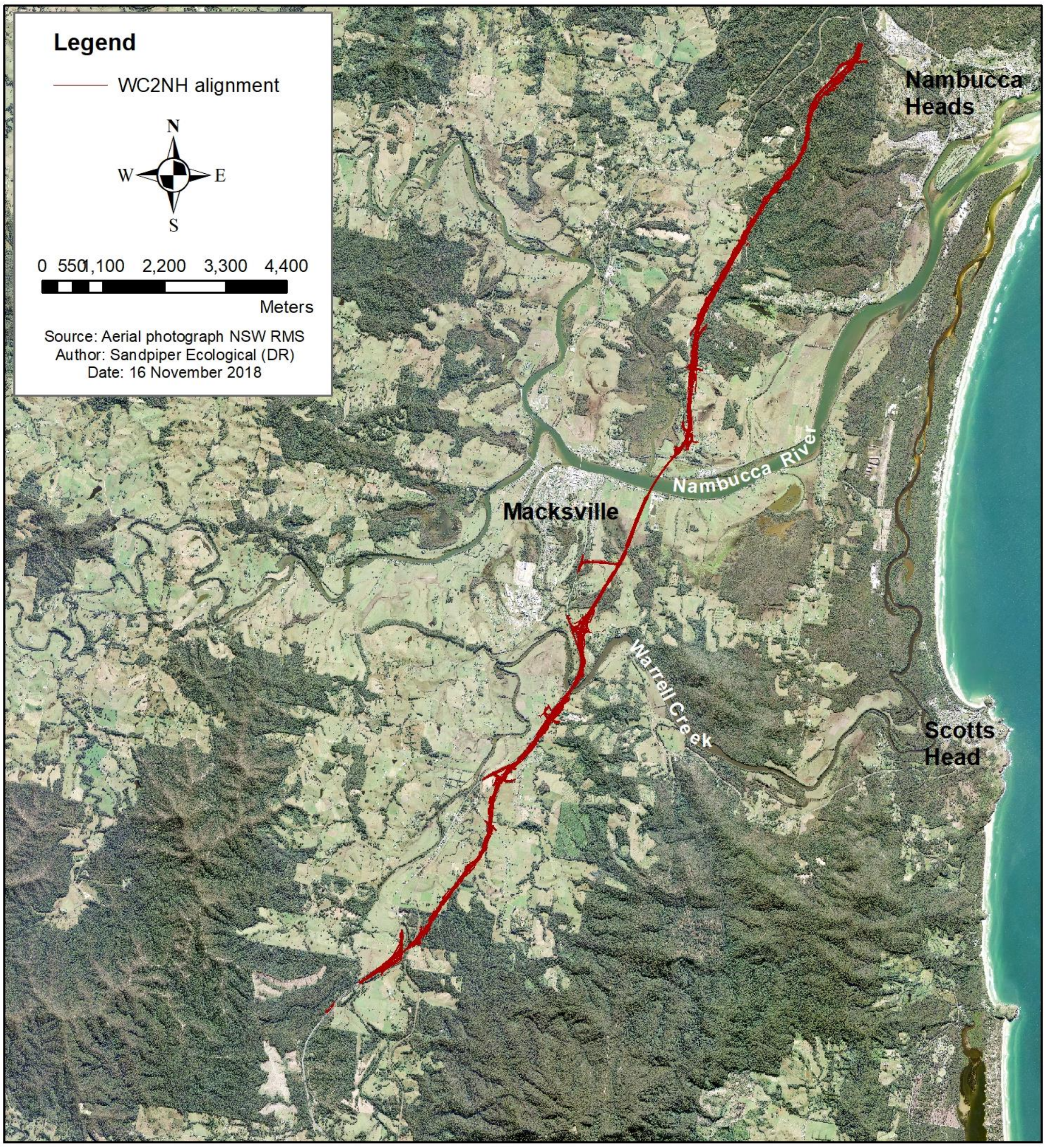

Figure 1: Location of the WC2NH alignment.

2 Threatened Flora Translocation

2.1 Aim and Species Translocated

The translocation component of the WC2U TFMP was prepared according to the Australian Network for Plant Conservation guidelines for planning threatened flora translocations (ANPC 2004). The overall translocation aim was to maintain population numbers of threatened plant species in the local area by salvaging plants impacted by construction and re-establishing them in suitable habitat alongside the highway corridor. A propagation component would make up for potential losses incurred during salvage transplanting. Translocation of each species involved three main actions:

- Salvage transplanting of impacted individuals and establishing them at receival sites with habitat closely approximating the donor sites
- Population enhancement by propagating and introducing additional individuals
- Habitat restoration to ensure the receival sites provided good quality habitat.

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. RMS property) – seven where the highway corridor crossed Nambucca State Forest, one adjacent to the new highway bridge at Warrell Creek, and one at the southern end of the upgrade (Table 1 and Figure 2). For further information on the receival site selection process and a description of each site, refer to any of the construction phase monitoring reports: (Ecos Environmental 2016a (construction phase Yr 1), 2017 (construction phase Yr 2), 2018 (construction phase Yr 3)).

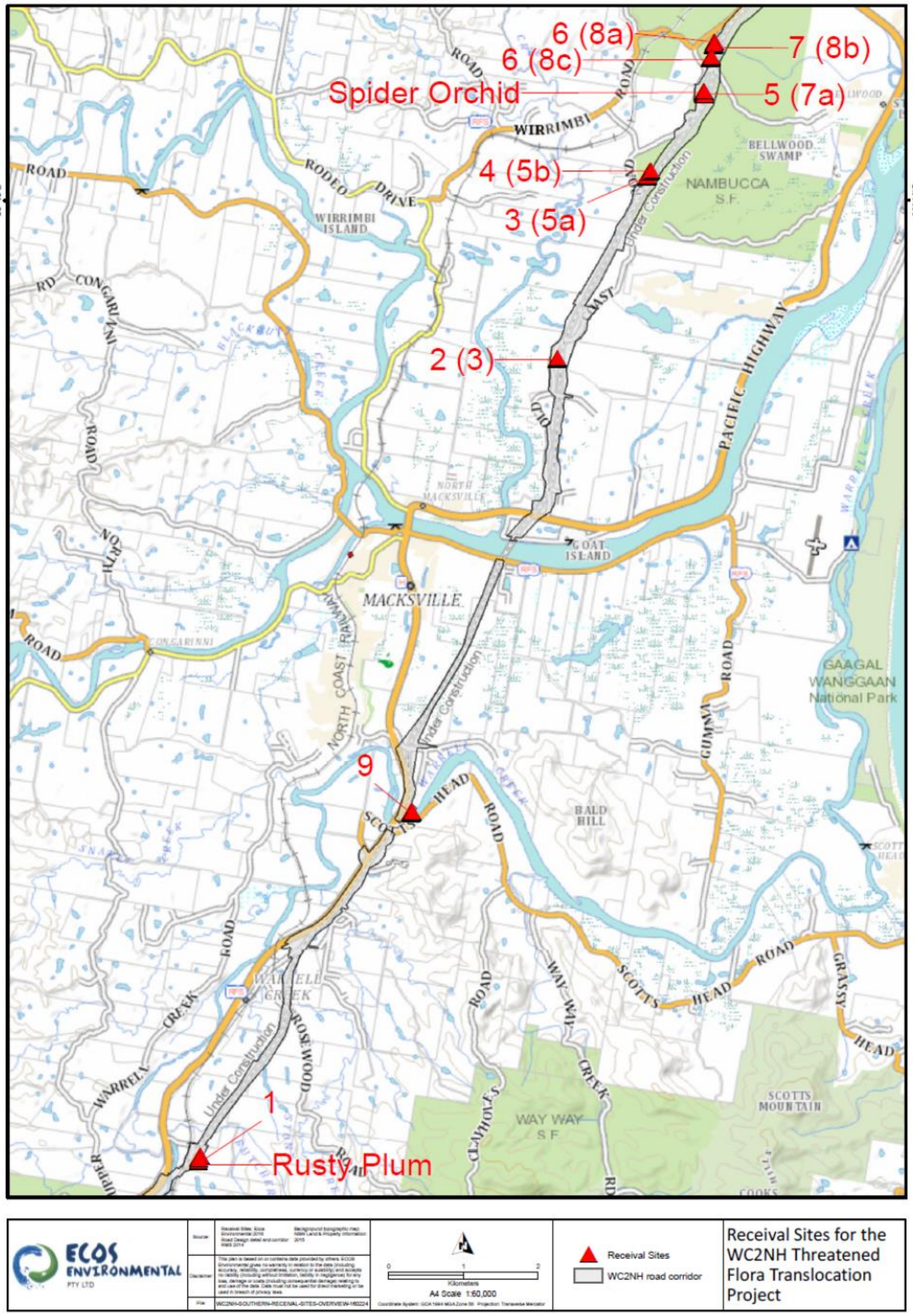

Figure 2: Location of threatened flora translocation receival sites for the WC2NH section of the Pacific Highway upgrade.

Table 1: Translocation receival sites and species translocated. The bracketed identifier is the original number used in selecting the receival sites. Both numbers are still being used.

Receival Site	Species
1 (Cockburns Lane)	Slender Marsdenia, Rusty Plum
2 (3)	Slender Marsdenia
3 (5a)	Slender Marsdenia
4 (5b)	Slender 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

All threatened species were translocated from the construction footprint using the direct transplanting method. Direct transplanting involves excavation, transport to the receival site and replanting in one action rather than as a gradual process. Excavation is carried out with an excavator or with hand tools if plants are small. The objective is to remove the shoot system and enough of the root system to enable regeneration and plant survival. Basic horticultural measures are applied such as pruning and watering to minimise transpiration stress, which is the principal cause of mortality during transplanting. Substantial pruning of the shoot system and watering, to ensure high soil moisture is maintained, in the first months are essential to achieve a high survival rate using the direct transplanting method.

Advantages of direct transplanting over other transplanting methods include:

- Relatively fast and cost-effective
- Suited to rough terrain and significant numbers of individuals
- Minimises duration of the translocation process and therefore potential risk of disease and pest transfer to the wild (a risk of propagation)
- Natural soil microflora conditions are maintained by transferring plant and soil material together.

Primack (1996) pointed out other advantages of transplanting: "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 transplanting began by marking plants with pink tape at the base and higher up so as not to damage them while digging. The stem usually with leaves was removed in a block of soil about 40 cm wide by 20 cm deep with a spade. Mapped points from the TFMP often included more than one stem at varying distance apart (e.g. 10-50 cm or more). All stems were transplanted, each being treated as a ‘stem-individual’, although some may have been connected underground. Plants and soil were kept damp during transport to the receival site. The ‘stem-individuals’ were planted in approximate rows at points pre-marked with pink tape. These points were at regular intervals (5 m) along a row and therefore essentially random (i.e. planting location determined by distance and not a selective bias).

Slender Marsdenia plants (stem individuals) were salvaged and planted at seven receival sites (refer to Table 12016) in February 2015. Additional plants were translocated in 2016 due to a modification to the road design. During transplanting, several individuals found that were not specified in the TFMP were also salvaged. It is not unusual for plants of the species to be missed during surveys because of their well camouflaged growth form. In total, 175 Slender Marsdenia plants were translocated.

The transplants received a thorough watering straight after planting, then watered once every two days for one week and once a week for four weeks, ensuring the soil remained damp. Chicken wire cylinders were installed around individuals to prevent damage by 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, which made it easier to check any stems that died back to see if it was still alive. Flagging tape was attached to each wire cage showing the individual’s monitoring number and source code as per the TFMP. Multiple individuals at 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 use of fertiliser and soil improvement during translocation of Slender Marsdenia had an adverse effect on growth and survival, fertiliser was not applied during the WC2NH translocation. Experimental comparison of fertiliser and no fertiliser treatments on the NH2U project indicate 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

Propagation of Slender Marsdenia from rhizome pieces collected during transplanting had poor results, as 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 had previously been recorded flowering in November and ripe pods were collected in December. It is not known if pods grow rapidly to maturity after flowering (i.e. in one or two months), or take longer, although the scant observations suggest they grow rapidly to maturity. On the NH2U project approximately 100 seedlings of Slender Marsdenia were propagated from one seed pod. In contrast to rhizome/tuber cuttings, seedlings grew rapidly, both in the nursery and after planting-out (Ecos Environmental 2016). Propagation of Slender Marsdenia from seed to 30 cm tall seedlings ready for planting-out took only about 8 months on the NH2U project (Ecos Environmental 2016).

Seed propagation was the preferred method of propagation on WC2NH, but no seed pods were found. Large individuals of Slender Marsdenia were located and checked for pods adjacent to the Nambucca Heads to Urunga and the Sapphire to Woolgoolga sections of the Pacific Highway, and Nambucca State Forest adjacent to WC2NH in December 2016.

The study of population genetic structure in Slender Marsdenia conducted for the WC2NH and NH2U projects (Shapcott *et al.* 2016) found genetic evidence that out-crossing was common in Slender Marsdenia, which implied that seed was produced quite frequently. Given the difficulty of finding seed pods for propagation this result was intriguing and two possible explanations have been put forward: (i) it is possible the genetic evidence of outcrossing relates to recent, pre-European ecological conditions when cross-pollination and seed production were more frequent. Forestry, clearing and other impacts have disrupted the ecology of this species, so cross-pollination and seed set occur less frequently now although the genetic imprint of pre-settlement conditions persists. (ii) It is also possible that seed pods are more common than realised. They may be forming on tall individuals in the forest mid-stratum, where the sparse foliage and similar green colouration of Slender Marsdenia vines make them difficult to see. However, tall individuals with thicker stems (still only a few millimetres in diameter) are few and far between. Most stem individuals are small. Also, only one instance of possible seedling recruitment has been observed under natural conditions (a cluster of small plants – probably seedlings – on NH2U). These observations suggest that seed production in current populations is rare.

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 were 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 colour and is glabrous (without hairs). Woolls' Tylophora, on the other hand, 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 Mid North Coast flowered in November and occasionally later as well.

Only Slender Marsdenia were observed flowering on the WC2NH footprint. If Woolls' Tylophora is in fact present, it appears to be 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 the species in the absence of flowers. Without knowing we were definitely dealing with plants of this species, propagation efforts were likely to be a waste of time and resources. Seed pods are likely to be as rare as for Slender Marsdenia.

2.2.5 Rusty Plum

2.2.5.1 Salvage Transplanting

Direct transplanting of larger Rusty Plums trees (~10 m high) began by trenching to form a soil-root ball about 1-1.5 m wide and 0.7 m deep. After undercutting the root ball, the trunk-branch system was cut back by at least 50% to remove all foliage. Depending on the size and intactness of the root ball, the trunk was sometimes reduced further. Previous transplanting of this species by Ecos Environmental on the Bonville and S2W projects had shown that survival rate was increased by cutting back the trunk to bring the shoot system (i.e. above ground plant) into balance with the reduced root system of the relatively small root ball (compared to the original in-situ root system) (ref).

All Rusty Plums occurred at Cockburn's Lane at the southern end of the project and were translocated from the footprint to the adjacent road reserve (Receival Site 1). Several Rusty Plums that occurred at Cockburn's Lane but 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 other fertilisers were used.

2.2.5.1 Population Enhancement by Direct Seeding

The enhancement component of the Rusty Plum translocation aimed to establish additional individuals by direct seedling. Only three Rusty Plum seeds were found in Nambucca State Forest in November 2016 but the same location was searched at the start of November 2017 and about 50 fruits collected. Three seeds were also found beneath a Rusty Plum in the Coffs Harbour Regional Botanical Gardens. Rusty Plum produces a large black fruit containing a single seed about the size of a golf-ball. 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 mesic, small tree mid-stratum. As seeds may be taken by animals, and seedlings can also be grazed quite heavily (Ecos Environmental 2015), seed were sown inside wire mesh cylinders. Fourteen cylinders were set up and three or four seeds placed on the soil surface in each cylinder then 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 the highway footprint from Prickly Paperbark (*Melaleuca stypheloides*) trees. The orchids were translocated by cutting off the branch or stem supporting the orchids so there was minimal disturbance of the orchids root system. The branch with orchids was then attached to a suitable small rainforest tree in a gully at Receival Site 5 (7a) in a shaded situation. Apart from watering during transport, no additional watering or other treatment was applied.

2.2.6.2 Population Enhancement

The TFMP aims to propagate additional Spider Orchid plants for population enhancement. As there were not sufficient wild plants to sacrifice some for vegetative division, propagation by seed was proposed. Both plants translocated from the WC2NH upgrade flowered in spring 2015, 2016 and 2017, but no seed pods were formed. On the NH2U project, one seed pod was formed in a translocated population of 55 Spider Orchids in Spring 2016, but the pod opened in November between site visits before seed could be collected.

2.2.7 Koala Bells

2.2.7.1 Salvage Transplanting

Transplanting of Koala Bells was carried out by digging plants out in a block of soil 40 cm wide by 20 cm deep, pruning the stems back, planting the soil block and watering. Receival Site 8 was the only site in the road reserve with swamp forest similar to Koala Bells habitat. Follow-up watering was 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 and grown-on in pots. The plants grew rapidly and flowered in summer-autumn 2016, died back over winter then reshot in spring 2016, all while the plants were still in pots. Regrowth in 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 9 at Warrell Creek in January 2017. This site is on alluvial soil and has open ground layer habitat with little competition from other plants, the type of situation Koala Bells seems to prefer.

2.2.8 Floyds Grass

2.2.8.1 Topsoil Stripping

Receival site no. 9 for Floyds Grass on the northern bank of Warrell Creek consisted of two areas – 9a and 9b. As the site was overgrown with exotic Broad-leaved Paspalum (BLP), it was necessary to remove this grass before translocating Floyds Grass to the site. Killing BLP with herbicide would have left seedlings of this species and myriad other weeds from the soil seedbank to contend with. Follow-up spraying of weed germination from the soil seedbank would be impractical, as it is not possible to spray weed seedlings without hitting Floyds Grass which also sends out long runners.

To create conditions suitable for establishment of Floyds Grass, BLP and the uppermost topsoil seedbank was stripped off with an excavator bucket. As the site was on a floodplain with relatively deep topsoil, it was expected that sufficient depth of topsoil would remain for Floyds Grass to establish after carrying out the stripping operation. Preparation of the site was carried out as follows. Firstly, the ground layer vegetation consisting mainly of BLP and Lantana was scrapped off with an excavator bucket. After exposing the soil surface, the top 10 cm of soil was scrapped off and placed to the side of the site. The soil beneath the uppermost 10 cm had a higher clay content, but had reasonable texture and drainage for young plant growth. Sediment fencing was installed around the site to prevent run-off to Warrell Creek and 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 at area 9a. The clumps were watered thoroughly and sugar cane mulch (weed free) spread lightly over the soil surface to protect from 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 and running north-south were erected to provide additional shade. These have since been removed from area 9a.

2.2.8.3 Population Enhancement

To promote population establishment by increasing initial population size, approximately 100 additional Floyds Grass clumps were propagated at Ecos Environmental's nursery and planted at area 9b in March 2016. These plants were propagated from small pieces of runner that broke off during transplanting. As area 9b was more exposed than area 9a, the shade cloth fences installed had a roof to protect from the overhead sun. Hand weeding to remove competing exotic and native species was carried out by Pacifico (the project construction contractors for the Warrell Creek to Nambucca Heads section of the upgrade) workers under the supervision of the plant ecologist, as in area 9a. Although most the soil seedbank had been removed, seed germination occurred from seed buried deeper in the soil of a range of native and exotic species. The density of exotic species was very low but some grew rapidly into large plants, particularly *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. Monitoring during the operation phase will be carried out annually, including for this report (2018). Andrew Benwell and Jeremy Benwell-Clarke of Ecos Environmental carried out the first operation phase monitoring on 7 and 8 November 2018.

Plant growth and survival was monitored by recording the following data:

- 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.

In analysing the results, species performance and survival were evaluated in terms of species survival and plant condition, the latter 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 calculated as follows: number of individuals in condition classes (2+3+4+5/total)*100.

When mean species height was calculated it was averaged for all plants present at the start of monitoring in June 2015, therefore included plants that 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

Species survival rate does not really indicate how individuals are performing. Some may be thriving and others may be barely alive. Breaking down survival into condition classes provides more information on how a species is responding to translocation. In the case of Slender Marsdenia, a more nuanced response was needed so that a closer analysis could shed more light on factors underlying individual growth and survival. Although survival rates for Slender Marsdenia on WC2NH are quite high (see below), plants often remain small or repeatedly grow and die back, and flowering has not been recorded over four years, even though some plants have grown substantially.

To analyse the response of Slender Marsdenia to translocation in more detail, thirteen response categories were defined in terms of the pattern of change in plant height over three years, as shown in Table 5. These were derived by merging the seven monitoring events into a single sheet for each receival site and ascertaining the main syndromes of regrowth pattern and height change. The response syndromes of individuals at each site were tallied and expressed as a percentage of the site total.

Table 5: Definition of categories of plant response (response syndromes) over four years in Slender Marsdenia after translocation. Three main categories of response syndrome were exhibited – D, S and T, which were divided into sub-categories

Code	Response syndromes of transplanted individuals
D	**Dead (or appears to be dead)**
D1	Didn't reshoot
D2	Small shoot then died
D3	Reshot, reached small to medium height (<1.2 m) then died back to ground, some bell-shaped, some db-rs-db
D4	Reshot, grew tall (~2 m+) then died back to ground, possibly dead
S	**Alive but small, growing very slowly, or declining**
S1	Stayed small, most less than 10 cm tall (to 40 cm), little change in 4 years
S2	Continuously small (mostly <0.5 m), dieback to ground and reshot once or twice, still alive
S3	Declining or bell shaped (increase-decrease), to ~130cm at peak, not tiny, continuously alive
S4	Fluctuating – i.e. 'small-medium/tall-small'; or 'grew medium/tall then died back to small'
S5	Delayed response – no reshooting for 6-12 months, small (<1 m)
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

Initial plant size is one of the many factors that may determine an individuals' regrowth response and survival. For Slender Marsdenia, the size of each stem-individual including its rhizome was not recorded during transplanting as this would have meant separating the rhizome from soil. The direct transplanting method aimed to keep soil and rhizome as intact as possible to promote survival. Instead, initial plant size (including rhizome) was assumed to be roughly proportional to and proximated by plant height at the first monitoring event.

2.3 Results

2.3.1 Species Survival Summary

Transplant survival rates after four years for all threatened species excluding Koala Bells were 67-100% (Table 6). The survival rate of Koala Bells after four years was 43%, but this was due to most individuals exhibiting an annual or biennial life cycle (i.e. rapid growth, flowering and seeding, then dying off) after transplanting. Results are described in more detail in Table 6.

See Appendix 1 for photos of translocation sites and species in 2018.

Table 6: Species survival rates (expressed as a proportion of live individuals) four years after translocation (transplanting) on the WC2NH project.

Species/Receival Site	**No. of plants translocated**	**Survival (%)**				
		Aug 2015 (~6 mth)	**Feb 2016 (~1 Yr)**	**Jan 2017 (~2 Yrs)**	**Nov 2017 (~3 Yrs)**	**Nov 2018 (~4 Yrs)**
Slender Marsdenia (*Marsdenia longiloba*)						
Receival Site 1 - Cockburns Lane	27	93	93	75	63	59
Receival Site 2 (3) – Old Coast Rd	17	100	91	93	88	88
Receival Site 3 (5a) – Old Coast Rd	22	81	81	91	73	77
Receival Site 4 (5b) – Old Coast Rd	16	100	94	81	69	69
Receival Site 5 (7a) – Old Coast Rd	57	90	90	72	74	72
Receival Site 6 (8a) – Old Coast Rd	8	88	75	75	75	88
Receival Site 8 (8c) – Old Coast Rd	28	93	100	86	82	79
Total	175	92	91	80	74	74
Rusty Plum (*Niemeyera whitei*)						
Receival Site 1 - Cockburns Lane	7	100	100	86	86	86
Wooll's Tylophora (*Tylophora woollsii* – unconfirmed)						
Receival Site 6 (8a) – Old Coast Rd	6	100	100	100	83	67
Spider Orchid (*Dendrobium melaleucaphilum*)						
Receival Site 5 (7a) – Old Coast Rd	2	100	100	100	100	100
Floyds Grass (*Alexfloydia repens*)						
Receival Site 9a – Warrell Creek	54 clumps	100	94	Substantial cover	Substantial cover	Substantial cover
Receival Site 9b – Warrell Creek	61 clumps	Not planted yet	Not planted yet	98	93	70
Koala Bells (*Artanema fimbriatum*)						
Receival Site 7 (8b) – Old Coast Rd	16	75	63	25	13	6
Receival Site 9 – Warrell Creek	14	Not planted yet	Not planted yet	Not yet planted	57	86
Total	30	75	63	25	34	43

2.3.2 Slender Marsdenia (*Marsdenia longiloba*)

2.3.2.1 Summary

Combining the receival sites, the survival rate of Slender Marsdenia in year 4 had not changed since year 3, remaining at 74% (Table 6). Survivorship per site in year 4 ranged from 59% to 88%, which is almost the same as for year 3 (63% to 88%). Note that for some receival sites there has been an increase in survivorship between monitoring events. For example, survivorship at Receival Site 6 was 75% in November 2017 and 88% in November 2018. This is because Slender Marsdenia often dies back and appears to be dead but then reshoots and grows again.

Approximately 25% of transplants appeared to be dead in November 2018. Understanding why mortalities occur is important for improving translocation methods and assessing whether translocation is feasible for a species. This is discussed in more detail below.

2.4.2.2 Causes of Mortality

Possible causes of mortality identified in previous monitoring reports by Ecos Environmental included:

- Disturbance and damage to the stem and/or root system during transplanting.
- Interactions between plant and habitat, including environmental stress arising from lack of sunlight, water and soil nutrients, or inter-specific competition for scarce resources.
- Inherent growth processes (e.g. stem individuals genetically programmed to grow suddenly drawing on stored food reserves in the tuberous rhizome, but unable to maintain growth, or an imbalance between growth and resources available to sustain growth).
- Natural thinning due to factors that affect survival.
- Sensitivity to microsite/microhabitat heterogeneity.

With regard to the last point, within an area of generally suitable habitat, a likely factor determining whether a translocated individual survives or not is the microsite or point at which it happens to be planted (either deliberately or haphazardly). This is particularly the case for small plant species. Natural habitats generally have high microsite heterogeneity, which partly underlies the difficulty of translocating most small plant species. Some microsites may favour survival and growth more than others. Planting points for the WC2NH project were essentially random with respect to a variable microsite surface, although points with more shade, near rotting logs and away from tree trunks were preferred by some planters. Perhaps this was a mistake and points next to large trees and away from rotting logs would have been better. Regardless of slight biases in choice of site, planting points were random with respect to microsite patterning, so a degree of thinning or population decrease over time seems inevitable.

2.4.2.3 Height/Performance

Mean plant height of Slender Marsdenia for each receival site in year 4 ranged from 24 cm to 84 cm. Note that as mean height was calculated by averaging across all individuals including those with zero height (i.e. appeared to be dead), the mean height of live plants is under-estimated to a minor degree.

There has been a minor decrease in mean height since year 3 for receival sites 1, 2, 4, 5 and 6, but a slight increase for receival sites 3 and 7. No signs of habitat deterioration at the receival sites, or disease or herbivory on plants were observed, therefore, it appears that declines in mean plant height since year 3 (for some sites) were not caused by these factors.

Mean plant height for receival sites has not consistently increased or decreased throughout the monitoring program, rather it has fluctuated. For example, mean plant height for Receival Site 8 in June 2015 was 43.68 cm, it then increased to 69.57 cm in February 2016, decreased to 50.82 cm in January 2017, continued to decrease to 43.96 cm in November 2017 but then increased again to 62.21 cm in November 2018 (this monitoring event).

Monitoring of Slender Marsdenia for the WC2NH project and previously for the NH2U project revealed that the species has an unpredictable life history. Multiple reshooting and dieback events were recorded in a substantial number of plants during four years of monitoring. No one pattern of growth is observed at a site, rather individuals differ in their translocation response, with some growing larger, some declining and some remaining the same, and this varies from year to year.

Changes in mean plant height indicate how well Slender Marsdenia is generally performing at each site but this index can be misleading and does not consider the varying growth syndromes (patterns) that appear to be part of the species life cycle. For this reason a more detailed analysis of individual translocation response syndromes was carried out, the results of which are described below.

Table 7: Mean height (cm) ± standard error of Slender Marsdenia per receival site from the first monitoring in June 2015 to November 2018 (four years after translocation).

Receival site	n	June 2015 (6 months)	Feb 2016 (~1 yr)	Jan 2017 (~2 yrs)	Nov 2017 (~3 yrs)	Nov 2018 (~4 yrs)
Receival Site 1	27	26.51±6.48	39.0±10.43	39.26±10.60	31.07±10.30	24.37±9.54
Receival Site 2 (3)	11	25.64±10.09	60.82±15.50	67.27±13.57	97.09±14.23	84.76±12.73
Receival Site 3 (5a)	22	29.29±7.46	49.76±11.16	46.41±9.51	45.73±9.34	46.27±10.81
Receival Site 4 (5b)	16	38.69±11.44	47.00±14.84	29.44±9.45	31.88±10.67	29.44±11.52
Receival Site 5 (7a)	57	29.54±3.72	51.74±6.78	47.74±7.62	43.78±8.11	35.02±6.35
Receival Site 6 (8a)	8	55.13±22.24	53.00±17.92	60.57±17.55	84.79±18.35	82.13±19.12
Receival Site 8 (8c)	28	43.68±6.39	69.57±9.16	50.82±5.29	43.96±5.43	62.21±10.67

2.4.2.4 Response Syndromes of Transplanted Individuals

As described in the Monitoring and Data Analysis section of this report, responses of Slender Marsdenia individuals to transplanting after four years were placed into three main categories (dead, surviving but weak or declining, and thriving) and 13 sub-categories, as defined in Table 5).

Looking at the ‘dead’ category in Table 8 and Figure 4 we can see that for those individuals that appeared to be dead in spring 2018 (i) a small proportion died without reshooting (D1),

(ii) most either produced a small shoot then died (D2) or grew moderately then died (D3), and (iii) none grew vigorously/tall and then died (D4).

In the second category – alive but small or declining – there are five sub-categories. Out of the 68 individuals that were alive but small most fell into S1 (often less than 10 cm, little change in 4 years). S2 (small individuals that have died back and reshot once or more times) accounted for 17 individuals (Figure 4), followed by S3 (14 individuals), then S4 (8 individuals). No ‘S’ category individuals fell into S5 (delayed response – no reshooting for 6-12 months).

The third category includes the most vigorous plants, including the tallest and those with most leaves, which in spring 2018 accounted for 61 of the 175 translocated Slender Marsdenia individuals. Out of the 61 ‘T’ category individuals, nearly all (53) fell into T2 (moderate increase in height (0.5 – 1 m+) or constant height (1 m+). T1 accounted for 5 individuals and T3 accounted for 3 individuals. T4 (small for long time then grew large) did not include any individuals in spring 2018.

The overall picture is one of wide variation in individual response to transplanting. In other species such variation is generally related to initial plant size, microsite factors such as sun exposure and a range of other variables related to implementation, follow-up maintenance and other physiological and ecological factors. Slender Marsdenia is a particularly difficult species to interpret results for as many occurrences are apparently clonal (Shapcott *et al.* 2018) and clones are probably broken up during transplanting. Some transplants clearly had larger rhizomes than others, but it was difficult to record this trait consistently during transplanting of 175 individuals. Each individual was excavated in a roughly standardised volume of soil, but the size of the rhizome in that volume varied.

Table 8: Percentage of Slender Marsdenia individuals with specific regrowth response syndromes after translocation (transplanting) at each receival site.

			Receival site					
	Response syndromes of transplanted individuals	**1**	**2 (3)**	**3 (5a)**	**4 (5b)**	**5 (7a)**	**6 (8a)**	**8 (8c)**
D	**Dead (or appears to be dead)**							
D1	Didn’t reshoot	3.7	0	4.5	0	5.3	0	0
D2	Small shoot then died	18.5	11.8	9.1	18.8	10.5	0	3.6
D3	Reshot, reached small to medium height (<1.2 m) then died back to ground, some bell-shaped, some db-rs-db	18.5	0	4.5	12.5	8.8	12.5	10.7
D4	Reshot, grew tall (~2 m+) then died back to ground, possibly dead	0	0	4.5	0	3.5	0	7.1
	Sub-total	40.7	11.8	22.7	31.3	28.1	12.5	21.4
S	**Alive but small, growing very slowly, or declining**							
S1	Stayed small, most less than 10 cm tall (to 40 cm), little change in 4 years	11.1	17.64	9.1	43.8	19.3	0	10.7
S2	Continuously small (mostly <0.5 m), dieback to ground and reshot once or twice, still alive	14.8	0	13.6	6.3	10.5	12.5	7.1
S3	Declining or bell shaped (increase-decrease), to ~130cm at peak, not tiny, continuously alive	11.1	0	18.2	0	10.5	0	3.6
S4	Fluctuating – i.e. ‘small-medium/tall-small’; or ‘grew medium/tall then died back to small’	7.4	0	0	0	5.3	0	10.7
S5	Delayed response – no reshooting for 6-12 months, small (<1 m)	0	0	0	0	0	0	0

	Sub-total	40.7	17.64	40.9	50	46.4	12.5	32.1
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	0	0	0	1.8	12.5	7.1
T2	Thrived – moderate increase in height (0.5 – 1 m+), or constant height (1 m+)	11.1	70.6	31.8	18.8	24.6	50	35.7
T3	Died back to ground then reshot vigorously (>1 m)	0	0	4.5	0	0	12.5	3.6
T4	Small for 5 or 6 events then suddenly grew big	0	0	0	0	0	0	0
	Sub-total	14.8	70.6	36.4	18.8	26.3	75	46.4
	% Survivorship 4 yrs	59.3	88.2	77.3	68.8	71.9	87.5	78.6
	Total individuals	27	17	22	16	57	8	28

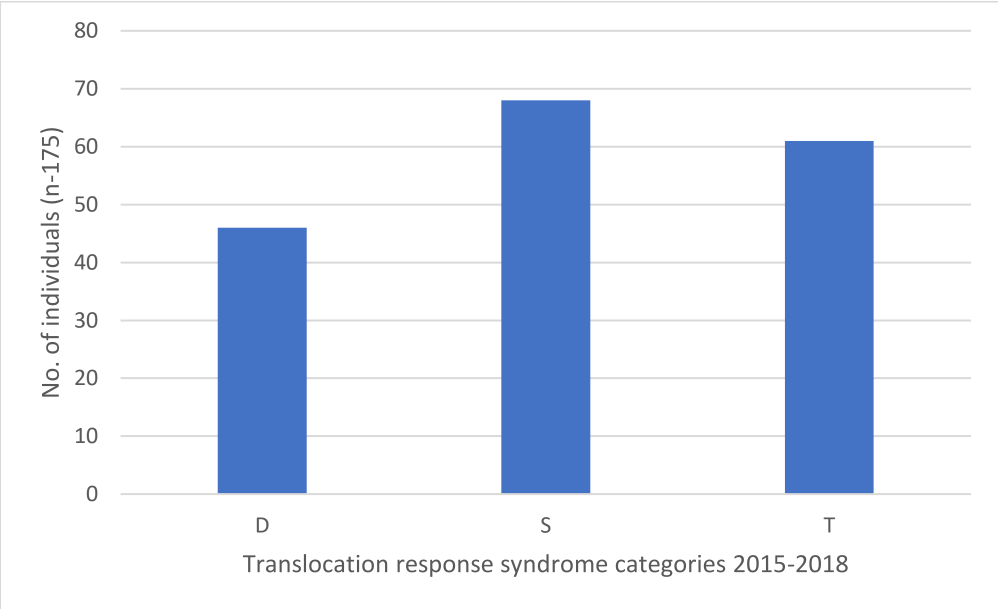

Figure 3: Slender Marsdenia translocation response syndromes across four years for seven receival sites. D = dead, S = surviving, T = thriving.

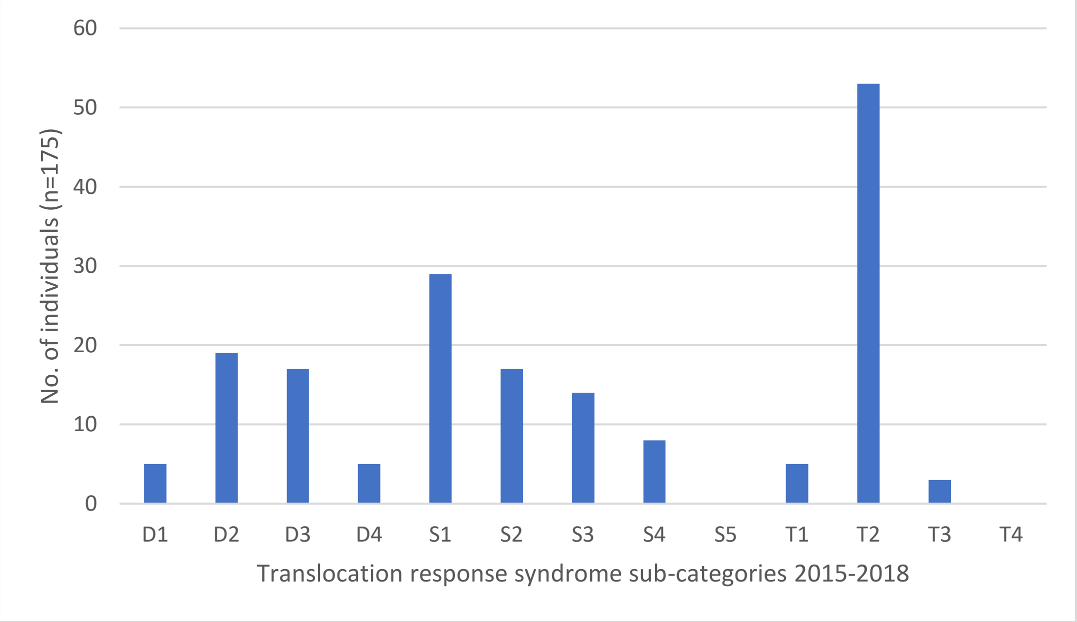

Figure 4: Slender Marsdenia translocation response syndromes across four years, data combined for seven receival sites (see Table 1 for receival sites). D = dead, S = surviving, T = thriving. See Table 5 for definition of each response syndrome sub-category.

2.4.3 Rusty Plum (*Niemeyera whitei*)

Six out of the seven translocated Rusty Plums at Receival Site 1 (Cockburns Lane) survived to year 4. All have continued to increase in height and foliage area since they were transplanted but it will probably be 5-10 years before the largest individuals reach reproductive maturity.

The single transplant mortality was caused by installation of a shade cloth shelter including a roof so the plant was completely enclosed. The shade cloth was high density and with additional shade from vegetation, light exclusion was probably ~80%. This together with increased humidity probably encouraged fungal rot which killed the whole plant, not just the leaves. The plant failed to reshoot after removal of the shade cloth roof.

At Receival Site 5, Rusty Plum seeds had germinated in 8 of the 14 chicken-wire cylinders that were direct-seeded with Rusty Plum seeds in 2017. A total of 11 seedlings were observed ranging from 8-18 cm. Three seeds were sown into each cylinder. A substantial number of seed rooted and failed to germinate, which is probably due to the poor quality of the seed. Few seeds could be found in 2017, Rusty Plum being an intermittent seeder, and most seeds were undersized due to dry conditions.

2.4.4 Wooll's Tylophora (*Tylophora woollsii* – unconfirmed)

At Receival Site 6, four out of six transplanted individuals that are possibly Woolls' Tylophora survived to year 4. These four plants are in good condition, ranging from 79-145 cm in height and new shoots were observed on three of the six plants.

2.4.5 Spider Orchid (Dendrobium melaleucaphilum)

The two translocated Spider Orchid plants survived to year 4 and are in good condition. Both plants flowered in spring 2015 six months after translocation, again in 2016 and 2017, and in 2018. One plant appeared to have flowered recently, most likely earlier in spring. None of the flowering events, however, produced seed pods, possibly due to a lack of pollinators. New pseudobulbs (stem units) were produced each year since translocation demonstrating active growth.

2.4.6 Floyds Grass (*Alexfloydia repens*)

At Receival Site 9 (Warrell Creek), survival and growth of the 54 clumps of Floyds Grass transplanted to Area 9a was 94% in spring 2018 which is equal to or better than in spring 2017 (Table 6). The clumps have spread out and coalesced so it is no longer possible to count individuals. Approximately 44% of the original clumps survived, mostly in the rows closest to Warrell Creek but these have spread out and probably cover one third to a half of the fenced translocation area. This is a considerably larger area than impacted by the highway.

Survival of the 61 clumps introduced to area 9b was about 70% in spring 2018. These have grown slower than in Area 9a as the site is somewhat drier, yet the translocation appears to be progressing successfully.

Removal of exotic ground layer vegetation and topsoil stripping proved to be an effective method of restoring relatively weed-free habitat for Floyds Grass to recolonise. Maintenance, however, was still necessary to remove low numbers of exotics and thin out native tree and shrub regeneration.

The low level of mortality recorded was probably due to water and heat stress as the receival sites were relatively exposed and long periods of hot dry weather have occurred during the monitoring program.

2.4.7 Koala Bells (*Artanema fimbriatum*)

The survival rate of Koala Bells at Receival Site 7 was 76% after six months, 63% after one year, 25% after two years, 13% after three years, and 6% after four years. Most transplants flowered and produced seed in year 1. A fairly rapid decline was recorded in year 2, similar to the pattern of survival recorded for this species on the NH2U translocation project. Only one plant has survived to year 4.

The survival of propagated Koala Bells at Receival Site 9b, however, has increased from 57% in spring 2017 to 86% in Spring 2018 due to recruitment. The small plants observed appeared to be seedling recruits. Ecos Environmental has translocated this species on other highway upgrade projects including NH2U, Oxley Highway (Pt Macquarie), but this is the first instance recorded of recruitment following translocation. Koala Bells is a short-lived ephemeral and like other such species prefers disturbed areas where there is abundant light and minimal competition from other plant species. These environmental conditions were likely created at Receival Site 9b when the topsoil was stripped, enabling introduced Koala Bells to recruit successfully.

Of the 12 individuals alive at Receival Site 9b in spring 2018, 10 were flowering, suggesting that recruitment may continue at this site.

Koala Bells generally flowers and sets seed in the first six months after transplanting in Spring or Summer, then it gradually dies back in Autumn and Winter. Most plants die completely but a few reshoot the following Spring in the second or even third year. This appears to be the species natural life cycle rather than a response induced by translocation. In the bush, Koala Bells can appear suddenly on disturbed sites such as roadsides, then disappear the following year. Some populations have been observed persisting for more than one year, so longevity can apparently vary depending on site conditions, but overall Koala Bells is a relatively short-lived species. Observations on translocated plants indicate that for plants that survive into the second year, regrowth occurs from adventitious shoots produced from persistent lateral roots.

Fertiliser addition during translocation appears to speed up the life cycle, causing plants to flower and seed prolifically then die out in the first year, presumably leaving behind dormant seed in the soil. Fertilisers were not applied to Koala Bells on WC2NH so this factor did not influence results.

Corrective action because of low survival rate is not appropriate or warranted, as Koala Bells is a naturally short-lived species. Most plants are annual or biennial, which is why they die out quickly. Translocation goals were achieved by plants growing to reproductive maturity and seeding their receival sites. If the right disturbance occurs in future, chances are it will reappear from dormant seed in the soil formed as a result of translocation. Note that Koala Bells is a nationally rare (ROTAP – Rare or Threatened Australian Plants) species, but not a listed threatened species under environmental legislation.

2.5 Performance Assessment

Performance criteria were met (Table 9) and therefore no corrective actions are required.

Table 9: Performance criteria for Threatened Translocation Areas monitoring.

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 4 (excluding Koala Bells but this species is a short-lived ephemeral that 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

2.6 Evaluation of Methods and Cost-effectiveness

The translocation methods applied for the WC2NH threatened flora translocation achieved relatively high survival rates for all species after four years (>60%) for all threatened species except the annual/biennial species Koala Bells (reasons explained above). The general approach to translocation was based on the ANPC guidelines for the translocation of threatened plants in Australia (ANPC 2004). Methods were developed for WC2NH taking into consideration the results of previous translocation projects involving the subject threatened species, including the NH2U, Bonville and S2W threatened flora translocation projects.

Methods were applied that aimed to achieve a satisfactory translocation outcome while keeping costs to a reasonable level. A full evaluation of the costs of the project would require an analysis of input to the threatened flora translocation project by Ecos Environmental, Geolink and Pacifico which is beyond the scope of this report.

2.7 Work Plan for Year 5 (December 2018 – December 2019)

Table 10: Work plan for Threatened Translocation Areas for the period of December 2018 – December 2019.

Task	**Time**
Monitoring	
Second yearly operation phase monitoring	November 2019 (to coincide with flowering of Slender Marsdenia and Rusty Plum)
Reporting	
Second yearly operation phase monitoring report	November-December 2019

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 on 7 and 8 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.

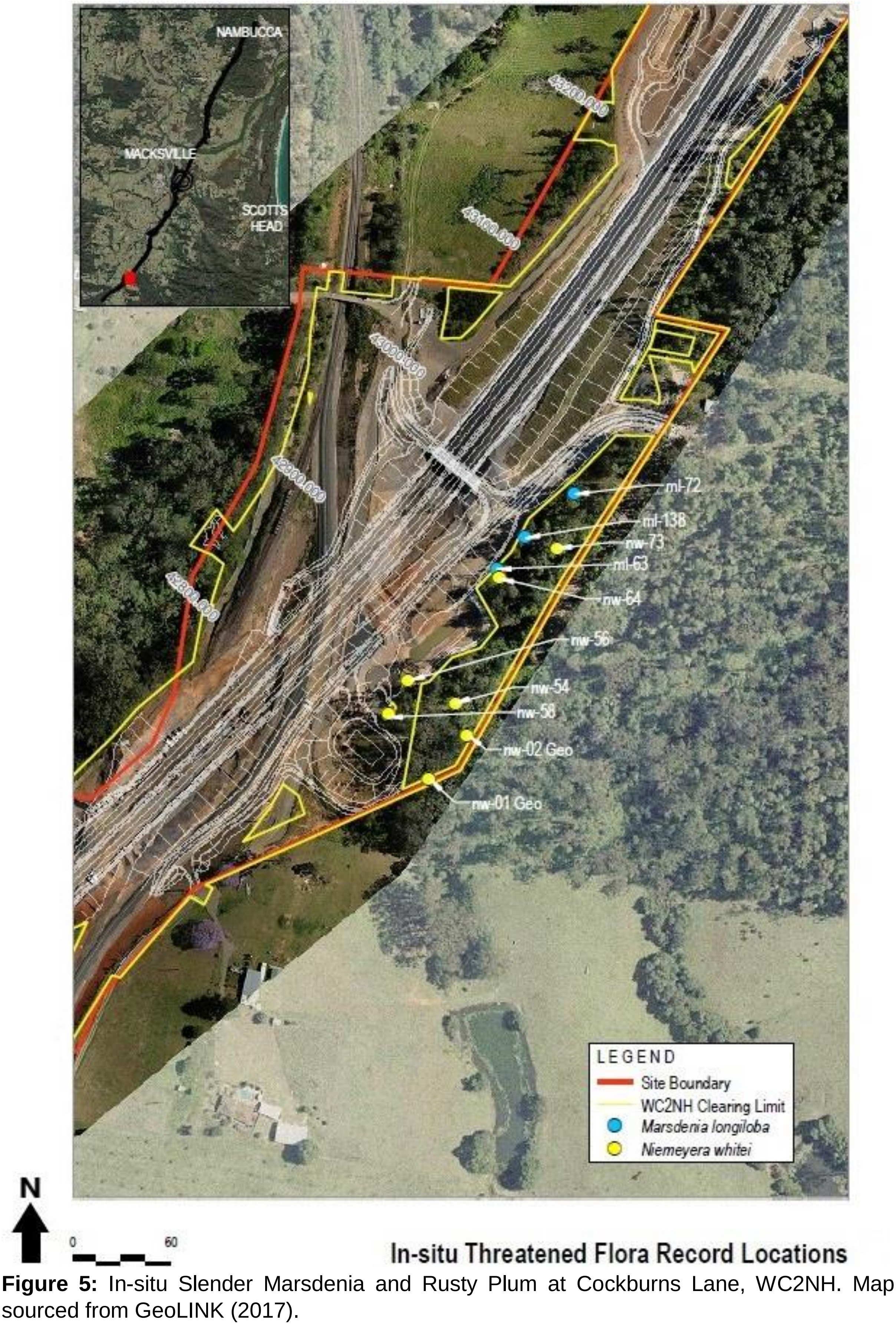

Figure 5: In-situ Slender Marsdenia and Rusty Plum at Cockburns Lane, WC2NH. Map sourced from GeoLINK (2017).

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).

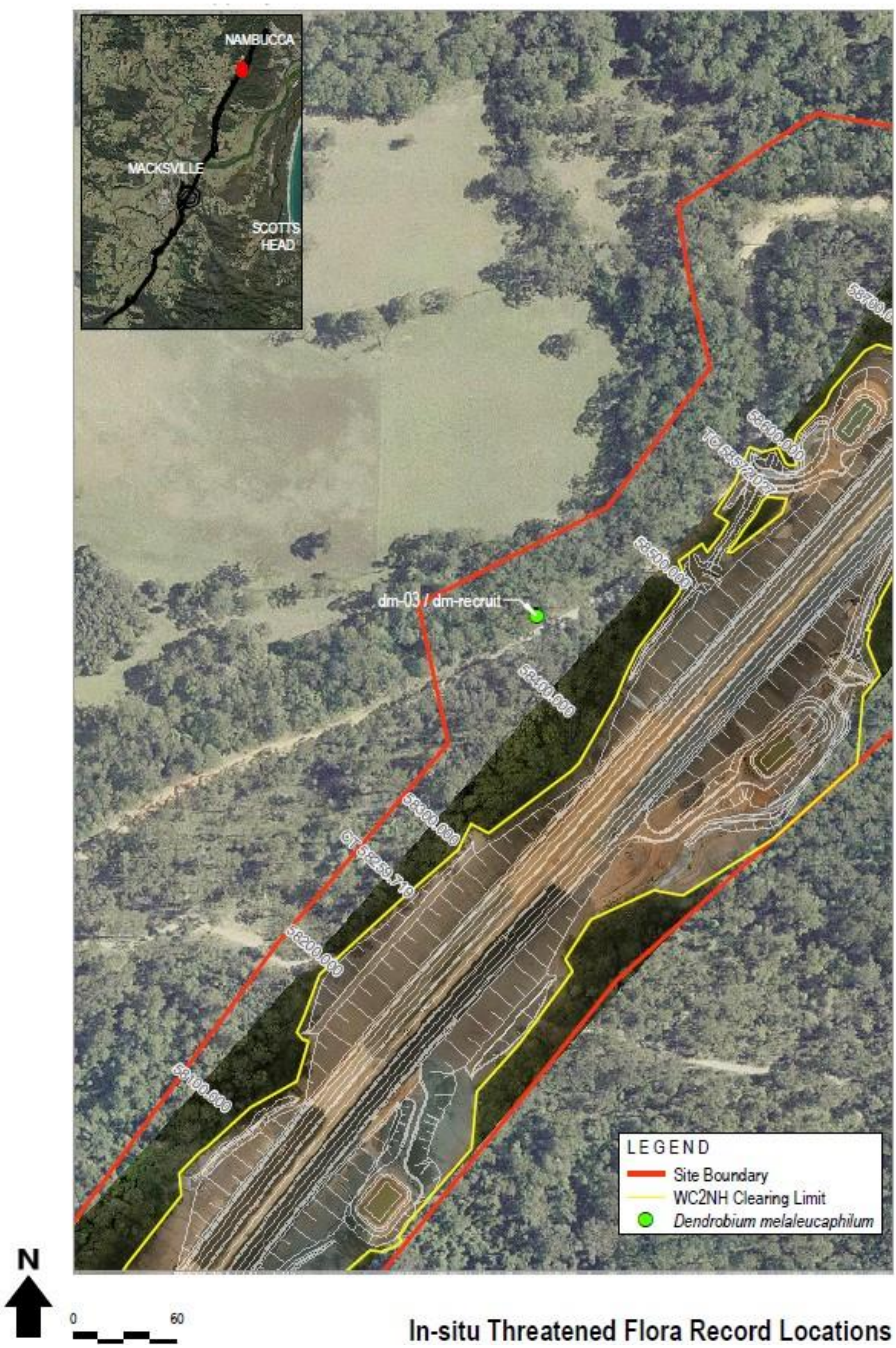

Figure 8: In-situ Spider Orchid, WC2NH. Map sourced from GeoLINK (2017).

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

3.2 Results

3.2.1 Maundia (Maundia triglochinoides)

The population of Maundia at the Nambucca Floodplain is in a patch about 50 m by 20 m, with the long edge running parallel to the highway. The plant community canopy height reaches 10-13 m and is dominated by *Melaleuca quinquenervia*. When Ecos Environmental visited the site in November 2018, the water depth was about 10 cm. Crown cover (%) of Maundia in the 50 m by 20 m patch was 40% (Table 11), which is an increase from spring 2017 when GeoLINK last monitored the population. In November 2018 Ecos Environmental also observed flowers on some plants, new growth on some plants and signs of recent recruitment. No evidence of disturbance to the population was observed.

See Appendix 2 for photos of the in-situ threatened plant species in November 2018.

3.2.2 Spider Orchid (Dendrobium melaleucaphilum)

The mature and recently recruited Spider Orchid plants were in healthy condition in November 2018. The mature plant appeared to have recently flowered – most likely earlier in spring that year – but no fruit were observed. The number of pseudobulbs of the mature plant had increased since spring 2017 (Table 12). The overall condition of the recruit remained the same since last year (condition score of 3).

3.2.3 Rusty Plum (*Niemeyera whitei*)

All seven Rusty Plum individuals in-situ at Cockburns Lane were in healthy condition in November 2018 (Table 13). Two individuals were fruiting – nw-73 and nw-64. Six fruits were observed on the former and 3 fruits were observed on the latter. These two individuals were flowering in spring 2017 but not fruit were observed (GeoLINK 2017).

No fruit were observed on the other 5 in-situ plants in November 2018 but they all appeared to be healthy and received a condition score of 4.

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 2018, suggesting that it is no longer suffering from edge effects.

The habitat condition at Cockburns Lane in November 2018 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 individuals 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.

The survival rate of the in-situ Slender Marsdenia was 62% at the finish of clearing (October 2015) and 60% at the end of years 1-3 (GeoLINK 2017). In November 2018, Slender

Marsdenia was actively growing (i.e. green stem and leaves) in all five in-situ locations, suggesting plants had died back in the previous years but were still alive as stem bulbs underground. 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 8 to 300 cm and their condition score ranged from 2 to 4 (Table 14).

In November 2018, the in-situ location consisted of a clonal patch of about 10 stems growing around the base of a large *Eucalyptus microcorys* tree. The largest stem was 100 cm and most stems had new growth. There were additional Slender Marsdenia plants immediately adjacent to this in-situ location which could have been included in GeoLINK's count of 23 stems in 2017. The number of stems appears to have increased at this location since 2015 but as no flowering or fruiting has been recorded, recruitment is mostly likely by asexual means (i.e. production of stems from underground rhizomes).

Two small stems about 2 m apart were recorded there in November 2018, both with new shoots. In 2015, stem height was 40 cm and increased to 50 cm in 2017. Die back appears to have occurred after 2017 as stem height was only 8 cm in November 2018.

Specimens ml-72, ml-138 and ml-63 occur at Cockburns Lane (same site as in-situ Rusty Plum). In November 2018, stem heights for ml-72, ml-138 and ml-63 were 40 cm, 90 cm and 300 cm, respectively. The height of ml-63 (300 cm) increased substantially since spring 2017 when it was 120 cm.

Table 11: In-situ threatened flora monitoring results for Maundia (*Maundia triglochinoides*). PC (pre-construction) 2015 and Spr (spring) 2017 data recorded by GeoLINK, Spr 2018 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
	PC 2015	Spr 2017	Spr 2018	PC 2015	Spr 2017	Spr 2018	PC 2015	Spr 2017	Spr 2018	PC 2015	Spr 2017	Spr 2018	PC 2015	Spr 2017	Spr 2018	
Nambucca Floodplain	10-20% (3)	10-20% (3)	40% (5)	N	N	Y	N	Y	Y	N	Y	Y	N	N	N	Canopy height 10-13 m with *Melaleuca quinquenervia* dominant species; ground stratum 100% crown cover; water depth 10 cm; few exotics.

Table 12: In-situ threatened flora monitoring results for Spider Orchid (*Dendrobium melaleucaphilum*). 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 #	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 2018)
	PC 2015	Spr 2017	Spr 2018	PC 2015	Spr 2017	Spr 2018	PC 2015	Spr 2017	Spr 2018	PC 2015	Spr 2017	Spr 2018	PC 2015	Spr 2017	Spr 2018	PC 2015	Spr 2017	Spr 2018			
3	30	40	35	2	4	5	6	20	50+	Y	Y	N	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.	Appears to have flowered prolifically recently
DM Recruit	-	10	12	-	3	3	-	-	4	-	Y	N	-	N	N	-	N	N		This new recruit was first observed during Spring 2016.	

Table 13: In-situ threatened flora monitoring results for Rusty Plum (*Niemeyera whitei*). 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
	PC 2015	Spr 2017	Spr 2018	PC 2015	Spr 2017	Spr 2018	PC 2015	Spr 2017	Spr 2018	PC 2015	Spr 2017	Spr 2018	PC 2015	Spr 2017	Spr 2018	PC 2015	Spr 2017	Spr 2018	
NW58	700	750	800	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	130	120	5	3	4	N	N	N	Y	Y	Y	N	N	N	N	N	N	
NW73	600	650	700	5	5	5	N	Y	Y	Y	Y	N	N	N	N	N	N	N	
NW54	400	500	600	5	5	4	N	N	N	Y	Y	N	N	N	N	N	N	N	
NW64	500	650	800	5	5	5	N	Y	Y	Y	Y	N	N	N	N	N	N	N	
NW01-Geo	-	450	450	-	5	4	-	N	N	-	Y	N	-	N	N	-	N	N	
NW02-Geo	-	500	500	-	5	4	-	N	N	-	Y	N	-	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)
	PC 2015	Spr 2017	Spr 2018	PC 2015	Spr 2017	Spr 2018	PC 2015	Spr 2017	Spr 2018	PC 2015	Spr 2017	Spr 2018	PC 2015	Spr 2017	Spr 2018	PC 2015	Spr 2017	Spr 2018			
ML93	5	5 - 60	100	3	1 - 4	2	N	N	N	N	Y	Y	N	Y	N	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 10 stems around base of Eucalyptus microcorys.
ML132	40	50	8	3	3	2	N	N	N	Y	Y	Y	N	Y	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.	Prostrate; another stem 2 m away, which was tagged with flagging tape
ML72	5	100	40	2	1	2	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.	
Ml138	5	230	90	2	4	3	N	N	N	N	Y	Y	N	N	N	N	N	N		Tall plant with mature leaves some yellowing.	

ML63	10	120	300	2	1	4	N	N	N	N	N	Y	N	N	N	N	N	N		Natural die back of the stem, possibly live stem bulb. No obvious signs of construction related impacts.	

3.3 Conclusion

The survival rate of in-situ plants at the end of Year 4 (spring 2018) was 100% for all four threatened species (Table15). For Slender Marsdenia, survival rate increased from previous years, indicating that plants appeared dead but stems later reshot from underground rhizomes.

One hundred percent of plants were in good condition (class 3 or >) for all species except Slender Marsdenia (40% in good condition). This species, however, regularly dies back and reshoots meaning the condition of plants (as defined by above ground characteristics) will fluctuate considerably.

No signs of construction-related impacts were observed in spring 2018 and 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 >)* – and therefore no corrective actions are required. 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.

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 4 - 2018
Spider Orchid (*Dendrobium melaleucaphilum*)	Yes - 100% survival 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 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 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 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.

On 7 and 8 November 2018, Andrew Benwell and Jeremy Benwell-Clarke of Ecos Environmental carried out the first yearly operation phase monitoring of the ten plots. 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.

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 2017 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 2018 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 – 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 2018.

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
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)	2	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)	0	2
4	Lantana	
Spring 15 (GeoLINK)	0	2
Autumn 16 (GeoLINK)	0	2
Spring 16 (GeoLINK)	0	2

Plot	Weed Level (% crown cover)	Microclimate Class
Spring 17 (GeoLINK)	0	2
Spring 18 (Ecos)	<5%	2
5	Lantana, Setaria	
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
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
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
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)	1	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)	3	2
10	Lantana, Billygoat Weed	
Spring 15 (GeoLINK)	<5%	4
Autumn 16 (GeoLINK)	<5%	4
Spring 16 (GeoLINK)	<5%	4
Spring 17 (GeoLINK)	<5%	4
Spring 18 (Ecos)	2	5

Table 18: Vegetation structure of ten Slender Marsdenia and Woolls' Tylophora habitat monitoring plots, WC2NH. Data recorded November 2018 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	Mid stratum Height to crown (m) min-mode-max		
Mid	*Cissus hypoglauca*	65			
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 ancophila*	10	28	28	30
Mid	*Schizomeria ovata*	10	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 pilularis*	10			
Upper			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

Stratum	Dominant species	Cover (% crown cover)	For the entire		
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	Lower stratum Height to crown (m) min mode max		
Lower	*Gahnia aspera*	15			
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					

Stratum	Dominant species	Cover (% crown cover)	For the entire		
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					
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, which most likely reflects observer variability rather than physical changes. Plot crown-cover of exotic species at the end of year 4 – which ranged from 0 to 3% – was far below the performance threshold of 25% and vegetation structured appeared to have remained the same since year 3. 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 4 is 0-3%
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 4 compared to year 3
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.

5 References

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Appendix 1: Photos of Threatened Flora Translocations, WC2NH, Nov 2018

Plate 1: Floyds Grass receival site (9), Area 1 (direct transplanted). Dense ground cover of Ottochloa and Floyds Grass in SE corner. November 2018

Plate 2: Floyds Grass receival site (9), Area 1. View over site looking south. November 2018

Plate 3: Floyds Grass receival site (9), Area 2 (population enhancement). Shade awning still in place due to greater sun exposure. November 2018

Plate 4: Floyds Grass receival site (9), Area 2. Close up of Floyds Grass patch. November 2018

Plate 5: Translocated Koala Bells in Floyds Grass receival site 9, Area 2. Plant no. 4. November 2018

Plate 6: Translocated Koala Bells in Floyds Grass receival site 9, Area 2. Plant no. 6. November 2018

Plate 7: Slender Marsdenia receival site 5a. Open highway corridor on right hand side.

Plate 8: Slender Marsdenia receival site 1 Cockburns Lane, plant no. 4. November 2018

Plate 9: Slender Marsdenia receival site 1 Cockburns Lane, plant no. 6. November 2018

Plate 10: Slender Marsdenia receival site 7a, plant no. 1. November 2018

Plate 11: Slender Marsdenia receival site 7a, plant no. 2. November 2018

Plate 12: Slender Marsdenia receival site 7a, plant no. 3. November 2018

Plate 13: Slender Marsdenia receival site 7a, plant no. 4. November 2018

Plate 14: Slender Marsdenia receival site 8a. Photo taken from track next to highway. Nov. 2018

Plate 15: Slender Marsdenia receival site 8a, plant no. 3. November 2018

Plate 16: Slender Marsdenia receival site 8a, plant no. 4. November 2018

Plate 17: Slender Marsdenia receival site 8a, plant no. 13. November 2018

Plate 18: Slender Marsdenia receival site 8c. November 2018

Plate 19: Slender Marsdenia receival site 8c, plant no. 3. November 2018

Plate 20: Slender Marsdenia receival site 8c, plant no. 21. November 2018

Plate 21: Slender Marsdenia receival site 8c, plant no. 22. November 2018

Plate 22: Rusty Plum seedlings at the direct seeding area adjacent to receival site 7a. Nov 2018

Plate 23: Spider Orchid receival site adjacent to receival site 7a, plant no. 1 November 2018

Plate 24: Translocated Rusty Plum, Receival Site 1 Cockburns Lane, plant no. 2, 1 November 2018

Plate 25: Translocated Rusty Plum, Receival Site 1 Cockburns Lane, close-up of stem regrowth off trunk of plant no. 2, 1 November 2018

Appendix 2: Photos of in-situ threatened plant species, WC2NH, November 2018

Plate 1. In-situ Slender Marsdenia, monitoring ID ml-132, November 2018.

Plate 2. In-situ Slender Marsdenia, monitoring ID ml-138, November 2018. Not that it is growing on *Rhodamnia rubescens*, which was recently listed as Critically Endangered under the BC Act 2016.

Plate 3. In-situ Rusty Plum, monitoring ID nw-732, November 2018.

Plate 4. Fruit of nw-732, November 2018.

Plate 5. In-situ Rusty Plum, monitoring ID nw-64, November 2018.

Plate 6. In-situ Spider Orchid, monitoring ID dm-03, November 2018.

Plate 7. Maundia population at Nambucca River Floodplain, November 2018.

Appendix 3: Photos of Slender Marsdenia and Woolls' Tylophora habitat condition monitoring plots, Nov 2018

Plate 1. Slender Marsdenia and Woolls' Tylophora habitat condition monitoring plot 1, south-west corner, November 2018.

Plate 2. Slender Marsdenia and Woolls' Tylophora habitat condition monitoring plot 2, south-west corner, November 2018.

Plate 3. Slender Marsdenia and Woolls' Tylophora habitat condition monitoring plot 3, north-east corner, November 2018.

Plate 4. Slender Marsdenia and Woolls' Tylophora habitat condition monitoring plot 4, north-east corner, November 2018.

Plate 5. Slender Marsdenia and Woolls' Tylophora habitat condition monitoring plot 5, south-west corner, November 2018.

Plate 6. Slender Marsdenia and Woolls' Tylophora habitat condition monitoring plot 6, south-west corner, November 2018.

Plate 7. Slender Marsdenia and Woolls' Tylophora habitat condition monitoring plot 7, south-west corner, November 2018.

Plate 8. Slender Marsdenia and Woolls' Tylophora habitat condition monitoring plot 9, north-east corner, November 2018.

Plate 9. Slender Marsdenia and Woolls' Tylophora habitat condition monitoring plot 10, south-west corner, November 2018.

Appendix 4: Vegetation structure of Slender Marsdenia and Woolls' Tylophora habitat monitoring quadrats Recorded BY GeoLINK (2017)

Quadrat	*Vegetation Structure (dominant species, height, cover)*			*Weed Level*	*Microclimate Class*
	Canopy	*Mid-storey*	*Ground cover*		
1	Flooded Gum, Swamp Turpentine – 25m	Red Ash, Brush Box, Swamp Turpentine, Rosewood – 3-8m	Gristle Fern, Water Vine, Mat-rush, Native Jasmine – 0.5m	Lantana	
Spring 15	5%	50%	40%	<5%	5
Autumn 16	5%	50%	40%	5%	5
Spring 16	5%	45%	45%	5%	5
Spring 17	5%	60%	45%	5%	5
2	Swamp Turpentine, Forest Oak, Tallowwood – 20m	Black Wattle, Red Ash, Brush Box, Rosewood – 3-6m	Gristle Fern, Palm Lily, Mat-rush, Native Jasmine – 0.5m	Lantana	
Spring 15	15%	60%	10%	<5%	5
Autumn 16	15%	65%	15%	5%	5
Spring 16	15%	65%	15%	10%	5
Spring 17	15%	65%	20%	10%	5
3	Swamp Turpentine, Flooded Gum, Ironbark – 22m	Rosewood, Red Ash, Black Wattle, Cabbage Palm – 2-10m	Gristle Fern, Mat-rush, Native Jasmine – 0.5m	Lantana	
Spring 15	5%	70%	10%	<5%	1
Autumn 16	5%	70%	10%	<5%	1
Spring 16	5%	70%	10%	<5%	1
Spring 17	10%	70%	30%	<5%	1
4	Flooded Gum, White Mahogany, Swamp Turpentine – 25m	Red Ash, Forest Oak, Cabbage Palm, Rosewood -3-8m	Water Vine, Palm Lily, Saw-sedge, Gristle Fern – 0.5m	No weeds	
Spring 15	5%	10%	30%	-	2
Autumn 16	5%	10%	30%	-	2
Spring 16	5%	10%	35%	-	2
Spring 17	5%	10%	45%	-	2
5	Ironbark, Brush Box, Tallowwood, Swamp Turpentine – 28m	Forest Oak, Swamp Turpentine, Cabbage Palm, Palm Lily – 3-8m	Mat-rush, Gristle Fern, Palm Lily. Regrowth shrub species Cheese Tree and Banana Bush – 0.5m	Lantana	
Spring 15	50%	15%	15%	<5%	5
Autumn 16	50%	20%	15%	<5%	5
Spring 16	50%	20%	15%	<5%	5
Spring 17	55%	25%	25%	<5%	5
6	White Mahogany, Brush Box, Paperbark – 20m	Black Wattle, Cabbage Palm, Palm Lily, Geebung – 3-8m	Mat-rush, Gristle Fern, Palm Lily <1m	Lantana	
Spring 15	50%	40%	30%	5%	4
Autumn 16	50%	40%	30%	5%	4
Spring 16	50%	40%	35%	5%	4
Spring 17	55%	50%	35%	5%	4
7	Tallowwood – 20m	Red Ash, Rosewood, Acacia sp, Leptospermum sp – 2-8m	Gristle Fern, Bracken Fern, Mat-rush – 0.5m	No weeds	
Spring 15	10%	25%	50%	-	1
Autumn 16	10%	25%	50%	-	1

Quadrat	Vegetation Structure (dominant species, height, cover)			Weed Level	Microclimate Class
	Canopy	Mid-storey	Ground cover		
Spring 16	10%	25%	50%	-	1
Spring 17	15%	25%	50%	-	1
8	Paperbark, Brush Box, White Mahogany – 18m	Cheese Tree, Rosewood, Geebung, Lilly Pilly – 2-8m	Gristle Fern, Mat-rush, Bracken Fern, Water Vine, Palm Lily – 0.5m	Lantana	1
Spring 15	40%	40%	25%	5%	1
Autumn 16	40%	40%	30%	5%	1
Spring 16	40%	40%	30%	7%	1
Spring 17	40%	40%	35%	5%	1
9	Tallowwood, Swamp Turpentine, Flooded Gum – 28m	Palm Lily, Paperbark, Cabbage Palm, Acacia sp., Cheese Tree – 2-8m	Saw-sedge, Jasmine, Gristle Fern, Mat-rush - <0.5m	Lantana, Broad-leaved Paspalum	
Spring 15	40%	30%	25%	5%	1
Autumn 16	40%	30%	25%	5%	1
Spring 16	40%	30%	30%	<5%	1
Spring 17	45%	30%	40%	<5%	1
10	Flooded Gum – 30m	Sandpaper Fig, Red Ash 6-8m	Jasmine, Bracken Fern – 0.5m (5%)	Lantana <5%	
Spring 15	5%	30%	5%	<5%	4
Autumn 16	5%	30%	10%	<5%	4
Spring 16	5%	30%	20%	<5%	4
Spring 17	10%	30%	25%	<5%	4