Warrell Creek to Nambucca Heads Upgrade of the Pacific Highway

Threatened Flora Translocation Project

Annual Monitoring Report – Year 3




Prepared for:

Pacifico
PO Box 254, Macksville, NSW 2447

Prepared by:

Dr Andrew Benwell
ECOS Environmental Pty Ltd
PO Box 641 Mullumbimby, NSW 2482
ph 0487050005; email: andrewbenwell@bigpond.com

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EXECUTIVE SUMMARY

This report documents the results of translocations of threatened plant species conducted for the Warrell Creek to Nambucca Heads (WC2NH) upgrade of the Pacific Highway after approximately 3 years (Feb 2015 to November 2017). Methods used during implementation are also described. The translocation project was implemented by Ecos Environmental for Pacifico (Acciona - Ferrovial joint venture) based on the Warrell Creek to Urunga Threatened Flora Management Plan (ECOS Environmental Ver. 4 (24/12/2014) and Ver. 5 (1/7/2016)). Five threatened species were translocated from the highway corridor to adjoining bushland: *Marsdenia longiloba* (Slender Marsdenia), *Tylophora woollsii* (Woolls' Tylophora), *Dendrobium melaleucaphilum* (Spider Orchid), *Niemeyera whitei* (Rusty Plum) and Floyds Grass (*Alexfloydia repens*). One nationally rare species, *Artanema fimbriata* (Koala Bells) was also translocated.

The translocation project aimed to establish populations of the impacted species in habitat adjacent to the highway corridor. To achieve this aim, the translocation program involved the following actions:

- salvage transplanting of impacted individuals from the construction footprint;
- enhancement of the size of the translocation population where possible by propagation and introduction, or direct seeding.
- restoration of good quality habitat to the receival sites.

Potential receival sites were assessed according to physical, biotic and logistical criteria set out in the Threatened Flora Management Plan. Nine receival sites spread out along the 19.6 km road corridor were selected that provided habitat assessed as suitable for each species, whilst minimising the distance plants were moved from the donor sites. Eight were located in the Road Reserve of the new highway and one on adjoining RMS property. Receival sites in the Road Reserve were selected with a buffer of forest ~20 metres wide to the edge of the cleared highway alignment and with State Forest on the other side to provide microclimatic protection.

Salvage of impacted plants was carried out by direct transplanting. Approximately three years after translocation, the survival rate of all species was >70% with the exception of Koala Bells (see Table 1 below). The overall survival rate of Slender Marsdenia, the main species requiring translocation was 74.4% (175 individuals translocated). This survival rate is in line with NH2U (67.9% - 2013-2016) and much higher than Bonville (45% and 25%, two sites, 2007-2010). Plants were transplanted directly to the new sites, watered-in and given follow-up watering, otherwise they received no further treatment. Fertilisers were not applied. Results supported the hypothesis that low survival for Bonville was due to the adverse effect of fertiliser addition and soil improvement. This effect appeared to be field interactions, as in pot cultivation, Slender Marsdenia grew strongly in response to fertiliser addition.

Spider Orchid flowered in spring each year, including Year 1 only 6 months after transplanting, but no seed pods were formed during the three years. Koala Bells started to flower a month after transplanting and set seed. Most plants died at the end of Year 1 and 2 due to its inherently short life cycle and a few persisted to Year 3. A different approach was used to prepare the receival site for Floyds Grass which was heavily infested with Broad-leaved Paspalum and other weeds. Ground layer vegetation and the top 10cm of soil containing most of the soil seedbank was stripped off with an excavator, which created largely weed free soil conditions for Floyds Grass to establish in. Nearly all Floyds Grass clumps survived after three years (94%) and continue to grow.

Assessment of the translocation outcomes after three years according to the performance criteria in Appendix 11 of the WC2U Threatened Flora Management Plan (Ver. 4 24/12/2014) found that all performance criteria had been met. (Corrective action not required for Koala Bells as the species has a naturally short life cycle; plants survived and grew to maturity, seeding the habitat.)

Table 1: Species transplant survival rate over approximately three years – Feb /2015 to Nov/2017. (details of monitoring results can be found in the Excel spreadsheet appended to this report).

Species/Receival Site	**No. plants**	**% survival**			
		Aug 2015 (~6 mth)	**Feb 2016 (~1 Yr)**	**Jan 2017 (~2 Yrs)**	**Nov 2017 (~3 Yrs)**
Slender Marsdenia (*Marsdenia longiloba*)					
Receival Site 1 - Cockburns Lane	27	93	93	75	63
Receival Site 2 (3) – Old Coast Rd	17	100	91	93	88
Receival Site 3 (5a) – Old Coast Rd	22	81	81	91	73
Receival Site 4 (5b) – Old Coast Rd	16	100	94	81	69
Receival Site 5 (7a) – Old Coast Rd	57	90	90	72	74
Receival Site 6 (8a) – Old Coast Rd	8	88	75	75	75
Receival Site 8 (8c) – Old Coast Rd	28	93	100	86	82
Total	175		91	82	74
Rusty Plum (*Niemeyera whitei*)					
Receival Site 1 - Cockburns Lane	7	100	100	88	88
Wooll's Tylophora (*Tylophora woollsii* – unconfirmed)					
Receival Site 6 (8a) – Old Coast Rd	6	100	100	100	83
Spider Orchid (*Dendrobium melaleucaphilum*)					
Receival Site 5 (7a) – Old Coast Rd	2	100	100	100	100
Floyds Grass (*Alexfloydia repens*)					
Receival Site 9 – Warrell Creek	54 clumps	100	94	94	94
Receival Site 9a – Warrell Creek	61 clumps			98	93
Koala Bells (*Artanema fimbriatum*)					
Receival Site 7 (8b) – Old Coast Rd	16	75	63	25	13

1 INTRODUCTION

1.1 Background

The Warrell Creek to Nambucca Heads (WC2NH) project is a 19.6 km section of the Pacific Highway upgrade on the NSW Mid North Coast. Construction began in early 2015 and completion is scheduled in 2018. Threatened plant species management for the project is set out in the Warrell Creek to Urunga Threatened Flora Management Plan (ECOS Environmental Ver. 4 (24/12/2014) and Ver. 5 (1/7/2016)). This plan covers the southern (WC2NH) and northern (NH2U) halves of the 55km Warrell Creek to Urunga upgrade, originally planned as a single project. The Warrell Creek to Urunga Threatened Flora Management Plan (TFMP) was prepared to meet the requirements of Condition of Consent B7 of the NSW Department of Planning's project approval in relation to management of flora listed under the NSW *Threatened Species Conservation Act* 1995. Referral and approval of the TFMP was also required for species listed under the Commonwealth *Environmental Planning and Biodiversity Conservation Act* 1999. This report addresses monitoring and reporting requirements in relation to the translocation component of the TFMP.

Five threatened and one nationally rare plant species were translocated from the construction footprint of the WC2NH project: -

Threatened

- Slender Marsdenia (*Marsdenia longiloba*) (TSC Act, EPBC Act) (Plate 1)
- Woolls' Tylophora (*Tylophora woollsii*) (TSC Act, EPBC Act) (Plate 2)
- Rusty Plum (*Niemeyera whitei*) (TSC Act) (Plate 3)
- Spider Orchid (*Dendrobium melaleucaphilum*) (TSC Act) (Plate 4)
- Floyds Grass (*Alexfloydia repens*) (TSC Act) (Plate 5)

Nationally Rare

- Koala Bells (*Artanema fimbriatum*) (Plate 6)

The translocation component of the TFMP was implemented by Ecos Environmental Pty Ltd for Pacifico (Acciona-Ferrovial joint venture), the principal contractor for the WC2NH project. This is the third annual monitoring report and documents implementation and results of the threatened species translocations from February 2015 to November 2017.

An additional threatened plant species, *Maundia triglochinoides* (TSC Act), was translocated by the principal contractor. Translocation of this species was not proposed in the TFMP (see TFMP Section 3.5.5), although the plan indicated that translocation by transplanting was likely to be successful, as subsequently demonstrated.

1.2 Translocation Strategy and Objectives

The translocation component of the TFMP was prepared according to the ANPC (2004) guidelines for planning threatened flora translocations. The overall translocation strategy was to endeavour to maintain population numbers of each species in the local area by salvaging threatened and rare species impacted by construction and re-establishing them in suitable habitat alongside the highway corridor. A propagation component would make up for 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; and

- Habitat restoration to ensure the receival sites provided good quality habitat.

The specific objectives of threatened flora translocation set out in the Warrell Creek to Urunga Threatened Flora Management Plan were as follows:-

- To salvage and re-establish impacted individuals of threatened (TSC/EPBC Act) species.
- To re-establish species at a relocation site in close proximity to the original site with closely matching habitat and long-term security of tenure.
- To enhance the size and genetic diversity of the translocated population by propagation and introduction of individuals additional to those salvaged from the road footprint.
- To maintain good quality habitat in the receival site(s).
- To preserve individuals of threatened species in situ wherever possible and limit transplanting to plants within the construction footprint and buffer.

1.3 Reporting Requirements

The reporting requirements for the Annual Translocation Monitoring Report are specified in Section 4.8.5 of the TFMP. The table below indicates the sections where reporting requirements are addressed in this report.

Reporting requirement	**Where addressed in the annual monitoring report?**
Background and description of the translocation project;	Section 1, 2 and 3
Implementation of the translocation project;	Section 3
A description of monitoring methods;	Section 3.8
An analysis of monitoring data on a species by species basis;	Section 4
An assessment of causes of plant mortality;	Section 4
A record of the plants transplanted and propagated;	Section 3 Digital Excel spreadsheet appended to report
A description of the population enhancement program;	Section 3
An assessment of the success or failure of the translocation based on criteria set out in the WC2U TFMP Ver.5 (Appendix 11 and Section 4.8.6);	Section 5
An evaluation of the methods and cost-effectiveness of the translocation project; and	Section 5
Work plan for the next twelve months.	Section 5

Plate 1: Slender Marsdenia (*Marsdenia longiloba*) produces umbels of white flowers in the leaf axils. It has similar leaves to Woolls' Tylophora and both species also have clear rather than milky sap, adding to the difficulty of telling non-flowering plants apart

Plate 2: Woolls' Tylophora (*Tylophora woollsii*) has purplish flowers arranged in a short cymose panicle, clearly different to Slender Marsdenia above.

Plate 3: Rusty Plum (*Niemeyeria whitei*) is a medium sized rainforest tree.

Plate 4: Spider Orchid (*Dendrobium melaleucaphilum*) produces large, vanilla scented flowers in August and September.

Plate 5: Floyds Grass (*Alexfloydia repens*) a rare mat-forming grass found along creeks between Coffs Harbour and Warrell Creek. Note small inflorescence in centre.

Plate 6: Koala Bells (*Artanema fimbriatum*). An annual or short-lived perennial herb found in grassy forest on coastal floodplains and edges of tracks.

2 RECEIVAL SITES

2.1 Site Selection

The type of habitat present at a receival site has a major bearing on whether a translocated species survives the introduction process and establishes to grow to maturity. The general approach in selecting a receival site is to pick one that resembles the donor site as closely as possible in terms of topography, soil and vegetation type. Vegetation condition can vary from undisturbed, mature vegetation to regenerating or cleared. Translocation can be successful in a range of different vegetation conditions but effects need to be carefully considered, for example, excessive sun exposure in a regenerating site, or high interspecific competition in a mature site. For the WC2NH project, receival sites were limited largely to forested habitat within the Road Reserve next to the new highway, as offsets were still being planned and parcels of residual RMS land were mostly cleared paddock that would have required extensive habitat restoration work. The Road Reserve includes all land between the property boundaries of the road corridor. Where the WC2NU corridor was cleared through Nambucca State Forest there was usually a strip of uncleared forest 20 to 40+ metres wide left within the Road Reserve, abutting State Forest on one or both sides. Small sections of forested road reserve adjoining private property were also present south of Warrell Creek.

Potential receival sites within the Road Reserve were identified by desktop review of aerial imagery overlaid with topography, vegetation type and the road design. Twenty potential sites were inspected and assessed according to selection criteria shown in Table 2. As Slender Marsdenia was impacted at several locations along the length of the WC2NH project, several receival sites were selected specifically for this species to maintain approximately the current distribution and to minimise distance individuals were translocated. A total of nine receival sites were finally selected, seven in the road reserve where the highway corridor crossed Nambucca State Forest. The other two were in the road reserve at the southern end of the project and on RMS land adjacent to the new highway bridge at Warrell Creek outside the project boundary.

Table 1: Translocation Receival Sites. The identifier in brackets is the original one used during site selection and subsequent monitoring.

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

Receival sites for Slender Marsdenia had moist open forest habitat with a light mesic understorey. The sites were in hilly terrain on lower slopes with a sheltered south to east aspect alongside the highway. Species composition, structure and soil type were very similar to the donor sites. The forest generally consisted of mature regrowth logged 30-50 years ago with a fairly open understorey structure, which the species seems to prefer. Canopy species included Grey Gum (*E. propinqua*), Ironbark (*E. siderophloia*), Tallowwood (*E. microcorys*), White Mahogany (*E. acmenoides*), Pink Bloodwood (*Corymbia intermedia*), Blackbutt *(E. pilularis*) and Turpentine (*Syncarpia glomulifera*), proportions varying from site to site. Woolls' Tylophora is also suited to this type of habitat.

The receival site for Floyds Grass was selected on RMS land adjoining the project boundary next to Warrell Creek. Habitat consisted of a narrow floodplain with alluvial soil supporting patchy, riparian forest regrowth with a weedy understorey of Broad-leaved Paspalum (*Paspalum mandiocanum*) and Lantana.

Koala Bells was translocated to a small area of Broad-leaved Paperbark alongside a track inside the Road Reserve. Propagated Koala Bells were planted into the Floyds Grass receival site.

Brief descriptions of the nine receival sites are provided below. Photos of the receival sites are included with the plates at the end of the report.

2.2 Receival Site 1

Receival Site 1 is located in the road reserve on the eastern side of the highway alignment adjacent to Cockburn's Lane at the southern end of the project. The road reserve is relatively narrow here and exposed to the west, although timbered on the eastern side, providing a reasonable level of microclimatic protection. The soil type is a red loam formed on a dark glassy rock which differs from the metasediment geology found along most of the alignment (ie the Nambucca Beds). Slender Marsdenia and Rusty Plum impacted at Cockburns Lane were translocated to Receival Site 1 which has the same red loam soil type. A buffer of forest and landscaping approximately 20m wide separates the receival site from the cleared road corridor.

2.3 Receival Site 2 (3)

(Note – the original numbering from the site selection process is shown in brackets).

Receival Site 2 is located north of the Nambucca River in a strip of moist open forest between Old Coast Road and the highway alignment. The site faces east and is situated on a mid-slope. A buffer of forest approximately 30m wide separates the translocation area from the cleared road corridor.

2.4 Receival Site 3 (5a)

Receival Site 3 is located on the western side of the alignment in a narrow strip of forested road reserve. As the site adjoins Nambucca State Forest on the western side, which extends upslope for more than 100 metres, the site is relatively protected. The site is situated on a lower slope and has an easterly aspect. A buffer of forest approximately 15m wide separates the translocation area from the cleared road corridor.

2.5 Receival Site 4 (5b)

Receival Site 4 is located about 100 metres north of site 3 on the other side of a gully which intersects the alignment at right angles (site 3 is on the southern side of the gully). A buffer of forest approximately 30m wide separates the translocation area from the cleared road corridor.

2.6 Receival Site 5 (7a)

Receival Site 5 is located further north between Old Coast Road and the highway alignment, adjacent to the turn-off to the Council waste recycling depot. This site has similar aspect and topographic position to site 3 and is well protected on the western side by a wide strip of Nambucca State Forest between Old Coast Road and the new highway.

2.7 Receival Site 6 (8a)

Receival Site 6 is located a few hundred metres south of where the alignment crosses Old Coast Road south of Nambucca Heads. The site is located in the Road Reserve in a narrow strip of forest next to an easement with a fiber-optic cable and water main, on the western side of the highway. The site aspect is east and topographic position lower slope. There is a forested buffer approximately 20 metres wide between the site and the highway. The site is well protected on the western side by Nambucca State Forest.

2.8 Receival Site 7 (8b)

Receival Site 7 selected for Koala Bells (*Artanema fimbriatum*) is located about 50 metres south of site 6 in a small area of Paperbark swamp forest next to a boundary access track for underground utilities, which generally meets the habitat requirements easement of Koala Bells. Although Koala Bells is not listed as a threatened species, it is rare and would probably qualify for listing if nominated. Translocation was undertaken more as a pre-cautionary measure and to extend translocation work with this species on other highway upgrade projects, which has produced puzzling results.

2.9 Receival Site 8 (8c)

Receival Site 8 is accessed by the same utilities easement as sites 6 and 7, and is located further south. The site is well protected on the western side by Nambucca State Forest. Site aspect is east and topographic position lower slope. A buffer of forest approximately 30m wide separates the translocation area from the cleared road corridor.

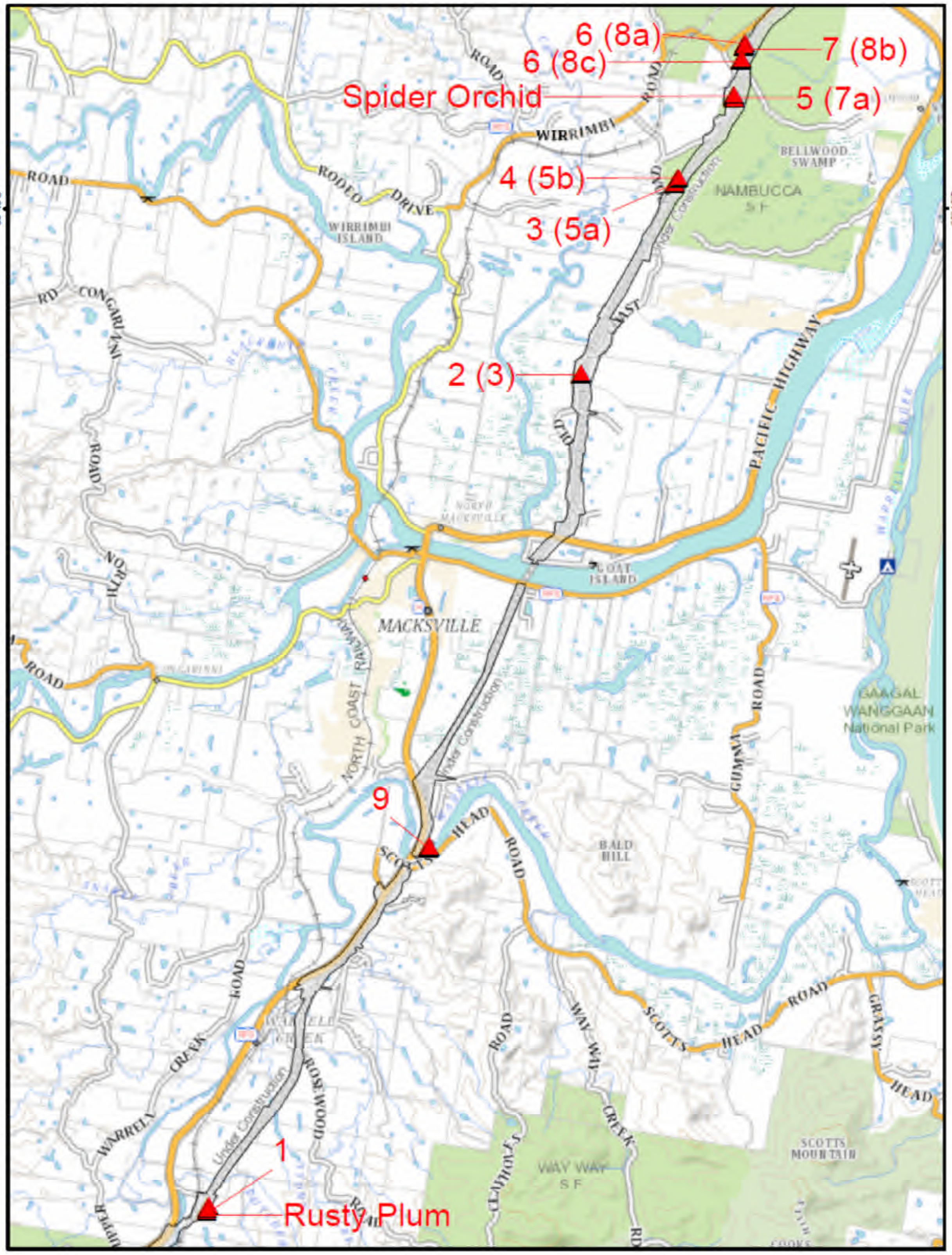
2.10 Receival Site 9

Receival Site 9 was selected for the Floyds Grass. The site is on alluvial soil next to Warrell Creek and is approximately 100 metres north of the donor/impact site at the new bridge site. Floyds Grass occurs in Swamp Oak (*Casuarina glauca*) swamp forest, or moist open forest dominated by Flooded Gum (*Eucalyptus grandis*), *Melaleuca* spp. and rainforest species. Both of these communities are usually situated on the banks of, or close to, coastal creeks and estuaries. Receival Site 9 supports the moist open forest type with rainforest trees. This type of habitat is extensive on the northern side of Warrell Creek, although overrun with Broad-leaved Paspalum (*Paspalum mandiocanum*). Two areas in Receival Site 9 were marked out for conducting the Floyds Grass translocation, each covering approximately 30 m x 20 m.

The site is on RMS land outside the project boundary and is part of an area identified in project documents for habitat restoration after completion of road construction.

Table 2: Site attributes of nine receival sites selected for translocation of threatened species on the WC2NH project

Receival Site/ Site Attributes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Physical									
slope aspect (S-south,E-east)	S	E	E	E	E	E	E	E	flat
slope angle (m-low to mod.)	M	m	m	M	M	m	m	m	flat
topographic position	Mid	mid	lower	Lower	lower	lower	lower	lower	plain
landform	Hills	hills	hills	Hills	Hills	hills	hills	hills	plain
geology (✓ matching donor site)	✓	✓	✓	✓	✓	✓	✓	✓	✓
soil (✓ matching donor site)	✓	✓	✓	✓	✓	✓	✓	✓	✓
proximity to donor site (✓ <1km)	✓	✓	✓	✓	✓	✓	✓	✓	✓
area of potential habitat available (✓ adequate)	✓	✓	✓	✓	✓	✓	✓	✓	✓
Vegetation									
plant community (✓ matching donor site)	✓	✓	✓	✓	✓	✓	✓	✓	✓
threatened species already present (p-possible)	P	p	p	p	p	p	p	p	n
invasive/difficult to control weeds present (y-yes; n-no)	N	n	n	n	n	n	n	n	y
Logistical									
accessibility (g-good; f-fair; p-poor)	G	f	f	f	f	g	g	g	g
available water source (y-yes; n-no; water cart)	N	n	n	n	n	n	n	n	n
distance to water source	Kms	kms	kms	kms	kms	kms	kms	kms	kms
likelihood of disturbance during construction (u-unlikely; p-possible)	u	u	u	u	u	u	u	u	u
Tenure/conservation									
land ownership/ protection mechanism	RMS	RMS	RMS	RMS	RMS	RMS	RMS	RMS	RMS
potential disturbance by future road widening (p – possible)	p	p	p	p	p	p	p	p	p
other project conservation uses (y-yes, forest habitat)	y	y	y	y	y	y	y	y	y



Receival Sites for the WC2NH Threatened Flora Translocation Project

3 TRANSLOCATION METHODS

3.1 Direct Transplanting

All 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.

3.2 Slender Marsdenia

3.2.1 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 40cm square and 20cm deep with a spade. Mapped points from the TFMP often included more than one stem at varying distance apart (e.g.10-50cm 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 (5m) along a row and therefore essentially random (ie planting location determined by distance and not a selective bias).

A total of 169 Slender Marsdenia plants (stem individuals) were salvaged and planted at seven receival sites (refer to Table 1) in February 2015. Additional plants were translocated in Year 2 due to a modification to the road design to construct north facing ramps at the southern end of Old Coast Road. Any individuals found that were not specified in the Management Plan were also salvaged. It is not unusual for Slender Marsdenia plants to be missed during surveys because of their sparse, well disguised growth form.

The transplants were watered in as soon as planted, then watered once every second day for a week and once a week for four weeks to keep the soil damp. Chicken wire cylinders were installed around each individual 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

3.2.2 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 WC2H 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).

3.2.3 Propagation of population enhancement plants

Propagation of Slender Marsdenia from pieces rhizome 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 Nov/17 (Plate 40).

Flowering of Slender Marsdenia occurs in November and ripe pods have been collected in December (only a single pod from two projects). 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 30cm 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 Dec/16.

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 production also occurs quite frequently. Given the difficulty of finding seed pods for propagation this was perplexing. However, the findings may represent the genetic imprint of recent, pre-European ecological conditions when cross-pollination and seed production were more frequent. It is possible that forestry, clearing and other impacts have disrupted this species ecology, so cross-pollination and seed set occur less frequently. 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 very hard 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.

3.3 Woolls' Tylophora

3.3.1 Species Identification

Woolls' Tylophora has not been positively identified on the WC2NH project. 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 have leaves similar to Woolls Tylophora, as evident in Plates 1 and 2. Typical Slender Marsdenia has a more elongated leaf, pinnate venation, cordate leaf base, paler green colour and is glabrous (without hairs). Woolls' Tylophora in Plate 2 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.

About 10 flowering vines were positively identified as Slender Marsdenia on the WC2NH footprint prior to clearing and translocation, but no flowering plants of Woolls Tylophora were found. If present it appears to be much rarer than Slender Marsdenia.

3.3.2 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.

3.4 Rusty Plum

3.4.1 Salvage Transplanting

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

All Rusty Plums were translocated at Cockburn's Lane at the southern end of the project, from the footprint to Receival Site 1 in the adjacent Road Reserve. Several Rusty Plums remained in-situ in the same area as Receival Site 1. 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.

3.4.2 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 seed were found in State Forest in November 2016. 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 7/12/2017. 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 (NH2U), 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 (Plate 11). The cylinders were tagged for monitoring and location recorded with a GPS.

3.5 Spider Orchid

3.5.1 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 out the stem or branch section supporting the orchid. These were tied onto the trunks of understory rainforest trees in a gully at Receival Site 5 (7a) (Plate 47). Apart from watering during transport, no additional watering or other treatments were applied.

3.5.2 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, it was proposed to propagate from seed. Both of the plants translocated on WC2NH 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.

3.6 Koala Bells

3.6.1 Salvage Transplanting

Koala Bells was transplanted by digging out plants in a block of soil 40 cm square and 20cm deep with a spade, pruning the tops back, then planting into a shaded site and watering. Receival Site 8b was the only site found in the road reserve with swamp forest similar to typical Koala Bells habitat. The edges of sed basins could also have been used, but this presents management difficulties. Follow-up watering was carried out. No fertilisers were applied.

3.6.2 Population Enhancement

Cuttings of Koala Bells were propagated in summer 2015/2016 at Ecos Environmental's nursery and grown-on in pots during 2016. The propagated plants grew rapidly in the nursery and flowered in summer-autumn 2016, died back over winter then reshot in spring/2016. The regrowth was less vigorous than the first year's growth and small adventitious shoots were also produced around the edge of the pots as also observed in some transplanted specimens in the field (NH2U). Twenty of these plants were introduced to the Floyds Grass receival site (Area 2) at Warrell Creek in January 2017. This site is on alluvial soil and has open ground layer habitat with little competition from other plants, which Koala Bells seems to prefer.

3.7 Floyds Grass

3.7.1 Topsoil Stripping

As the receival site for Floyds Grass next to Warrell Creek was heavily infested with Broad-leaved Paspalum (BLP), it was necessary to kill or remove this exotic grass before translocating Floyds Grass to the site. Killing BLP with herbicide would have left the soil seedbank to contend with. Follow-up spraying of weed germination from the soil seedbank was impractical, as it was impossible to spray small weed plants 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 10cm of soil was scrapped off and placed to the side of the site. The soil beneath the uppermost 10cm was slightly more clayey in texture, but had reasonable texture and drainage for young plant growth. Sed fencing was installed around the site to prevent run-off to Warrell Creek and to act as a fence to deter wallaby grazing.

3.7.2 Salvage Transplanting

Small clumps of Floyds Grass approximately 10cm square were dug up with a spade and planted at the receival site. 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 1m high and running N-S were erected to provide additional shade (Plate 45). These have now been removed from Area 1 (Plate 42).

3.7.3 Population Enhancement

To promote population establishment by increasing initial population size, approximately 100 additional Floyds Grass plants were propagated at Ecos Environmental's nursery and planted out in a second area at Receival Site 9 in March 2016. These plants were propagated from small pieces of runner that broke off during transplanting. As Area 2 was more exposed than Area 1 and had little shade, shade cloth fences installed to protect the young Floyds Grass plants also had a roof to protect from the overhead sun (Plate 45). Hand weeding to remove competing exotic and native species was carried out by Pacifico workers under the supervision of the plant ecologist, as in Area 1. 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 octanda* (Ink Weed), a large herbaceous shrub. Very little BLP germinated.

3.8 Monitoring and Data Analysis

Each individual was identified by a monitoring number (as well as the source identification code from the TFMP). Additional individuals from the same point location were indicated by an additional suffix on the source identification code – e.g. Ml146-7

Monitoring of plant growth and survival was required every 3 months during the first year and six months in the second year. As the spring monitoring session was missed in year 1, an additional monitoring session was carried out in the second year. Monitoring was conducted at the following dates:-

<u>Year 1</u>
February 2015 – start translocation
June 2015 – 3 months
August 2015 – 6 months
Missed – 9 months
February 2016 – 12 months
<u>Year 2</u>
June 2016 – 6 monthly
November 2016 (additional to make up for one missed session)
January 2017 – 6 monthly
<u>Year 3</u>
November 2017 – yearly

Data were recorded as per Section 3.8 of the WC2U TFMP. The main data fields recorded were as follows:-

> <u>Slender Marsdenia and other species except Spider Orchid:</u> Monitoring Number, Date, Line, Source Label, Species (Translocation Plan Label), Species (Current ID), Condition, Height (cm), New Shoots (Y/N), Comment, sig. growth (+) or sig. dieback (-), Waypoint, Coordinates
>
> <u>Spider Orchid:</u> Monitoring Number, Date, Source Label, Species, Number of pseudobulbs with leaves, Length of the longest pseudobulb, New growth, Condition, Waypoint, Coordinates

Field data were entered into an Excel file with separate sheets for each monitoring event. The latest digital file is appended to this report. Note – the gps coordinates of each translocated plant are provided in the sheets labelled Feb 2016.

In analysing the results, species performance and survival were evaluated primarily in terms of plant Condition, which is 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 different species, as indicated in Tables 3-5 below.

Species 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 in the case of Slender Marsdenia).

Table 3: 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/ active growth present or absent
3 good	plant > 75 cm tall, stem with leaves, new shoots/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 4: 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 Koala Bells)
3	vigorous re-shooting (>40 cm tall Koala Bells)
4	crown recovering, foliage healthy
5	growing actively, flowering or seeding recorded

Table 5: Condition scores applied to Spider Orchid

Score	**Condition**
0	Dead
1	pseudobulbs discoloured/grazed/withering, no new growth
2	pseudobulbs healthy in colour, not withering, no new growth
3	plant small, not many healthy pseudobulbs, new growth occurring
4	several healthy pseudobulbs present, new growth occurring
5	several good sized, healthy pseudobulbs, flowering or seeding recorded

As an individual only has to be alive to contribute to species survival, the 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, but in the case of Slender Marsdenia, a more nuanced response was evident, 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, plants often remain small or repeatedly grow and die back, and flowering has not been recorded over three years, even though some plants have grown substantially.

To analyse the response of Slender Marsdenia to translocation (ie transplanting) 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 6. These were derived by merging the seven monitoring events into a single sheet for each receival site (see Excel spreadsheet, 'Site 3 all', 'Site 7a all' etc tabs) and subjectively identifying the main syndromes of height change. The response syndromes of individuals at each site were tallied and expressed as a percentage of the site total.

Table 6: Definition of categories of plant response ('response syndromes') over three years in Slender Marsdenia after translocation (ie. transplanting).

Code	Response syndromes of transplanted individuals
D	**Died**
D1	Didn't reshoot
D2	Small shoot then died
D3	Reshot, small to medium (<1.2m) died back to ground; some bell-shaped pattern; some dieback-reshoot-dieback; dead or probably dead Nov/17
D4	Reshot, grew tall (~2m+) then died back to ground, probably dead
	Sub-total
S	**Alive but small, growing very slowly, or declining**
S1	Stayed small, most less than 10cm tall (to 40cm), little change in 3 years
S2	Small (mostly <0.5m), dieback to ground and reshot once or twice, still alive
S3	Declining or bell shaped (increase-decrease), to ~130cm at peak, not tiny, alive
S4	Large fluctuation – ie 'small-tall-small'; or 'grew large then died back to small'
S5	Delayed response – no reshooting for 6-12 months, small (<1m)
	Sub-total
T	**Thriving, plant continuing to grow, or maintaining size, healthy**
T1	Thriving– tall (1.5m+) , substantial increase in ht/no. of leaves, or ~maintained tall height (some decreased slightly Nov/17)
T2	Thriving – moderate increase in height (0.5 - 1m+); or constant height (1m+)
T3	Died back to ground then reshot vigorously (>1m)
T4	Small for 5 or 6 monitoring events then suddenly grew tall
	Sub-total

Initial plant size is one of the many factors that may affect 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 approximated by plant height at the first monitoring event. Regression analysis was used to test if there was a relationship between initial and final plant height in each receival site.

4 RESULTS

4.1 Species Survival Summary

Transplant survival rates after three years were 74-100% for the five threatened species (Table 7). The survival rate of Koala Bells was only 13% after three years, but this was due to most individuals exhibiting an annual or biennial life cycle (ie rapid growth, flowering and seeding, then dying off) after transplanting. Results are described in more detail for each species below.

Table 7: Species survival rates three years after translocation (transplanting) on the WC2NH project.

Species/Receival Site	**No. plants**	**% survival**			
		Aug 2015 (~6 mth)	**Feb 2016 (~1 Yr)**	**Jan 2017 (~2 Yrs)**	**Nov 2017 (~3 Yrs)**
Slender Marsdenia (*Marsdenia longiloba*)					
Receival Site 1 - Cockburns Lane	27	93	93	75	63
Receival Site 2 (3) – Old Coast Rd	17	100	91	93	88
Receival Site 3 (5a) – Old Coast Rd	22	81	81	91	73
Receival Site 4 (5b) – Old Coast Rd	16	100	94	81	69
Receival Site 5 (7a) – Old Coast Rd	57	90	90	72	74
Receival Site 6 (8a) – Old Coast Rd	8	88	75	75	75
Receival Site 8 (8c) – Old Coast Rd	28	93	100	86	82
Total	175		91	82	74
Rusty Plum (*Niemeyera whitei*)					
Receival Site 1 - Cockburns Lane	7	100	100	88	88
Wooll's Tylophora (*Tylophora woollsii* – unconfirmed)					
Receival Site 6 (8a) – Old Coast Rd	6	100	100	100	83
Spider Orchid (*Dendrobium melaleucaphilum*)					
Receival Site 5 (7a) – Old Coast Rd	2	100	100	100	100
Floyds Grass (*Alexfloydia repens*)					
Receival Site 9 – Warrell Creek	54 clumps	100	94	94	94
Receival Site 9a – Warrell Creek	61 clumps			98	93
Koala Bells (*Artanema fimbriatum*)					
Receival Site 7 (8b) – Old Coast Rd	16	75	63	25	13

4.2 Slender Marsdenia (*Marsdenia longiloba*)

4.2.1 Summary

Combining the receival sites, the survival rate of Slender Marsdenia after three years was 74.4%. Survivorship per site varied from 63% to 88%, down from 72% to 93% in Year 2 (Table 7). Most individuals translocated to Site 5b turned out to be *Marsdenia liisae* (see Plate 27).

Mean plant height stayed about the same between Years 2 and 3 in four receival sites and increased in two sites (Table 8 – sites 2 and 6). (Note - as mean height was averaged across all individuals including those with zero height, the mean height of live plants is under-estimated to a minor degree.) There was very little evidence of insect grazing, no disease was recorded, leaf discolouration (e.g. pale green, yellow, blotchy) was relatively rare and generally preceded leaf fall, and no flowering or seed production were recorded.

Table 8: Mean height (cm) of Slender Marsdenia per receival site from the first monitoring in June 2015 to November 2017 three years after translocation.

Receival site	n	June 2015 (6 months)	Feb 2016 (~1 yr)	Jan 2017 (~2 yrs)	Nov 2017 (~3 yrs)
Receival Site 1	27	26.51±6.48	39.0±10.43	39.26±10.60	31.07
Receival Site 2 (3)	11	25.64±10.09	60.82±15.50	67.27±13.57	97.09
Receival Site 3 (5a)	22	29.29±7.46	49.76±11.16	46.41±9.51	45.73
Receival Site 4 (5b)	16	38.69±11.44	47.00±14.84	29.44±9.45	31.88
Receival Site 5 (7a)	57	29.54±3.72	51.74±6.78	47.74±7.62	43.78
Receival Site 6 (8a)	8	55.13±22.24	53.00±17.92	60.57±17.55	84.79
Receival Site 8 (8b)	28	43.68±6.39	69.57±9.16	50.82±5.29	43.96

The survival rate of 104 Slender Marsdenia transplants on the NH2U project was 67.9% after three years (2013-2016), slightly less than WC2NH.

The survival rate of Slender Marsdenia transplants on the Bonville project was 45% (Site 1) and 25% (Site 2) after three years (2007-2010). The low survival rate was attributed to the adverse effect of added fertiliser, which appears to be supported by results of the fertiliser experiment conducted for NH2U up to 2016. (Monitoring from 2017 has been conducted by another consultant.)

Approximately 25% of transplants died in the first 3 years at WC2NH. There was wide variation in the response syndrome of transplanted individuals, which is analysed in more detail below. Understanding why mortalities occur and why individual's exhibit different patterns of regrowth and survival is important for improving translocation methods and assessing whether translocation/transplanting is feasible for a species.

4.2.2 Causes of mortality

Possible causes of mortality identified in previous monitoring reports 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, soil nutrients; or inter-specific competition for scarce resources.

- Inherent growth processes (e.g. stem individuals genetically programed to grow suddenly drawing on stored food reserves in the tuberous rhizome, but unable to maintain growth; 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 central 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 were essentially random with respect to a variable microsite surface, although points with more shade, near rotting logs and away from tree trunks etc 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 microsite patterning, so a degree of thinning or population decrease over time seems inevitable.

4.2.3 Response syndromes of transplanted individuals

As described in the methods section, responses of Slender Marsdenia individuals to transplanting after three years were placed into three main categories (dead, surviving but weak or declining, and thriving) and 13 sub-categories, as defined in Table 6 and 9.

Looking at the ‘dead’ category in more detail in Table 9 it can see that: (i) a small proportion did not reshoot at all (D1); (ii) a small proportion produced a small shoot then died (D2); and (iii) most grew weakly then died (D3).

In the second major category – alive but small or declining – there are five sub-categories. Most individuals fall into S1 (often less than 10cm, little change in 3 years). S2 includes small individuals that shot, died off, then reshot again, sometimes twice in three years. They accounted for 18% of individuals in Receival Site 1. Overall, the second category accounted for about half of surviving plants.

The third category includes the most vigorous plants, including the tallest and those with most leaves, which account for roughly the other half of surviving plants. They accounted for 22% to 77% of individuals in the different receival sites. The most vigorous plants were in the T1 category, which varied from a low of 7% in Receival Site 8c to 64% in Receival Site 8a.

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 clonal 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 176 individuals. Each individual was excavated in a roughly standardised volume of soil, but the size of the rhizome in that volume varied.

Table 9: Percentage of transplanted individuals with specific response syndromes in each receival site. Data not shown for Receival Site 4 (5b) as transplants are now known to be mostly Marsdenia liisae.

		Receival Sites						
	Response syndromes of transplanted individuals	**1**	**2 (3)**	**3 (5a)**	**4 (5b)**	**5 (7a)**	**6 (8a)**	**8 (8c)**
D	**Dead**				**liisae**			
D1	Didn't reshoot	7.4	0	4.8		5.3	7.1	0.0
D2	Small shoot then died	11.1	9.1	0.0		1.8	0.0	0.0
D3	Reshot, reached small to medium ht (<1.2m) then died back to ground; some bell-shaped; some db-rs-db;	22.2	9.1	19.0		17.5	14.3	14.8
D4	Reshot, grew tall (~2m+) then died back to ground, possibly dead	0.0	0.0	0.0		0.0	0.0	3.7
	Sub-total	40.7	18.2	23.8		24.6	21.4	18.5
S	**Alive but small, growing very slowly, or declining**							
S1	Stayed small, most less than 10cm tall (to 40cm), little change in 3 years	18.5	9.1	9.5		26.3	0.0	14.8
S2	Small (mostly <0.5m), dieback to ground and reshot once or twice, still alive	18.5	0.0	9.5		3.5	0.0	14.8
S3	Declining or bell shaped (increase-decrease), to ~130cm at peak, not tiny, alive	0.0	0.0	19.0		12.3	0.0	11.1
S4	Large fluctuation – ie 'small-tall-small'; or 'grew large then died back to small'	0.0	0.0	0.0		3.5	0.0	3.7
S5	Delayed response – no reshooting for 6-12 months, small (<1m)	0.0	0.0	9.5		0.0	0.0	0.0
	Sub-total	37	9.1	47.5		45.6	0.0	44.4
T	**Thriving, plant tall, continuing to grow, or maintaining size, healthy**							
T1	Thrived– tall (1.5m+) , substantial increase in ht/no. of leaves, or ~maintained tall height (some decreased slightly Nov/17)	11.1	54.5	9.5		21.1	64.3	7.4
T2	Thrived – moderate increase in height (0.5 - 1m+); or constant height (1m+)	11.1	18.2	19.0		5.3	14.3	29.6
T3	Died back to ground then reshot vigorously (>1m)	0.0	0.0	0.0		1.8	0.0	0.0
T4	Small for 5 or 6 events then suddenly grew big	0.0	0.0	0.0		1.8	0.0	0.0
	Sub-total	22.2	72.7	28.5		30	78.6	37

	% Survivorship 3 yrs	63	88	73		74	75	82
	Total individuals	27	11	21	12	57	14	27

1. The regrowth response of individuals after transplanting was highly variable. The commonest responses recorded over three years were:

- D1+D2 (5-15%) – either did not reshoot or produced small shoot then died
- D3 (10-20%) - reshot but probably dead; reached small to medium height (0.5 – 1m+) then died back to the ground.
- S1 (10-25%) – reshot, stayed small mostly <20cm tall, little change in 3 years.
- S2 (5-15%) – reshot, died back to the ground, reshot again, sometimes twice over seven monitoring events.
- T1 (10-60%) – tall (>1.5m), substantial increase in height/number of leaves
- T2 (10-25%) – med. (<1.5m) moderate increase in height/number of leaves.

2. Initial plant size (including rhizome), which is one of the many factors that may affect an individuals' regrowth response, was approximated by plant height at the first monitoring event. Regression of plant height at the first and final monitoring showed that in receival sites with a high frequency of thriving individuals (ie. Nos. 2 (3) and 8 (8a)) there was an inverse relationship between initial and final height that approached statistical significance (e.g. 8a: P=0.076). At sites with a higher proportion of dead or declining individuals there was no relationship between initial and final height (e.g. 7a: P = 0.234).

3. Compared to the other receival sites, sites 2 (3) and 8 (8a) both have a less sheltered microclimate and tend to be more exposed to wind and/or morning sun. This suggests that sites closer to the moist open forest ecotone rather thin inside moist open forest may favour growth and survival.

4. Physically separating stems that form part of a clone during transplanting may affect performance. In a typical Slender Marsdenia patch there are usually a higher number of small shoots, some medium sized shoots and perhaps one or two tall stems that grow into the forest mid-stratum. The genetic study indicated a high level of clonality in localised patches, but it is not known to what extent stems are connected underground. Rhizomes over a metre long were found during transplanting on NH2U. The function of small stems that remain small for several years may be to channel food reserves to growth of a central flowering stem, rather than potentially forming separate plants. Little success was achieved attempting to propagate from rhizome pieces, suggesting the tuberous rhizomes are not designed for vegetative reproduction, but more for food and possibly water storage. The root system of Slender Marsdenia is poorly understood, but appears to be made of tuberous rhizomes, which send up occasional plant stems, and sections with fibrous roots.

6. The analysis of transplanting response syndromes shows that the pattern of regeneration of Slender Marsdenia individuals after salvage translocation is highly complex. It is difficult to relate individual survival to any particular factor, unlike other species where survival can be linked with initial plant size, habitat/micro-habitat variables, level of damage during transplanting, and post-transplanting maintenance.

4.3 Rusty Plum (*Niemeyera whitei*)

Seven out of eight individuals survived after 3 years. All continued to increase in height and foliage area. It will probably be at least another three years before the largest transplants reach reproductive maturity.

<u>Causes of mortality</u>
The single 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.

4.4 Wooll’s Tylophora (*Tylophora woollsii* – unconfirmed)

Five out of six possible Woolls’ Tylophora in Receival Site 6 were alive after 3 years and are in reasonable condition.

<u>Causes of mortality</u>
See Slender Marsdenia above.

4.5 Spider Orchid (*Dendrobium melaleucaphilum*)

The two translocated Spider Orchid plants survived after three years and are in good condition. Both plants flowered in spring 2015 six months after translocation and again in 2016 and 2017. No seed pods have been produced possibly due to a lack of pollinators. New pseudobulbs (stem units) were produced each year since translocation demonstrating active growth.

<u>Causes of mortality</u>
No morality recorded.

4.6 Floyds Grass (*Alexfloydia repens*)

The survival rate of 54 clumps of Floyds Grass translocated to Area 1 in Receival Site 9 remained at 94% after three years. Growth and expansion of the translocated clumps continued in the lower (creek side) half of Area 1, but was checked by vigorous growth of the competing native species *Ottochloa gracillima* in the upper half of Area 1. The survival rate of propagated plants introduced to Area 2 was the same as Area 1, although growth rate was slower, possibly as this site is more exposed.

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

<u>Causes of mortality</u>
The low level of mortality recorded was probably due to water and heat stress as the receival sites were relatively exposed and there were long periods of hot dry weather during the last three years.

4.7 Koala Bells (*Artanema fimbriatum*)

The survival rate of Koala Bells in Receival Site 7 was 76% after six months, 63% after one year and 13% after three 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 a few plants survived to Year 3 (also similar to NH2U, Area 2).

<u>Causes of mortality</u>
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 year or even third year. This appears to be the plant's 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, 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 habitat. 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 – Koala Bells is a nationally rare (ROTAP) species, but not a listed threatened species under environmental legislation.)

4.8 Maundia (*Maundia triglochinoides*)

Maundia, an aquatic plant found in freshwater swamps and streams of the North Coast is listed as Vulnerable under the TSC Act. This species was originally included in the TFMP but was taken out on the advice of RMS, as it was not translocated on the Frederickton to Eungai (F2E) project. Translocation on F2E did not seem to be warranted as the species had built up a large population which extended well beyond the F2E corridor, but also because a previous attempt to translocate Maudia by the Royal Botanic Gardens (Sydney) by propagation of seedlings and planting had failed (Ecos Environmental 2012).

Smaller occurrences of Maundia were present within the WC2NH corridor and larger stands just outside the alignment. A trial translocation of Maundia from the Williamson's Creek bridge site south of Warrell Creek was implemented by Pacifico following discussions with Ecos Environmental on the practicality of translocating this species. As Maundia grows from a network of rhizomes in the bottom mud, it was considered feasible to translocate this species by scooping up the plant with its rhizomes using an excavator bucket and depositing it in suitable wetland habitat. If the leaves were damaged the plant would most likely regrow from its rhizomes.

Pacifico initially translocated Maundia to a site downstream of the Williamson's Creek bridge site. The clumps survived and grew, but it became necessary to move them again. This time they were transplanted to a nearby sedimentation basin where the water level was managed to maintain a suitable depth for Maundia. The plants thrived while being held in the sedimentation basin and after completion of the creek realignment, Maundia was translocated back to the new creek course using the same direct transplanting method. Five patches of Maundia have been established over a distance of approximately 30 metres at the bridge and plants are growing well (Plate 7). The results show that Maundia can be translocated with a high degree of success by direct transplanting of plants with their rhizomes and mud substrate.

Plate 7: Clumps of Maundia (the sword-leaved aquatic plant) reinstated along Williamson's Creek two years after salvaging Maundia from the creek prior to construction of a new bridge and stabilisation of the creek banks.

4.9 Habitat Restoration

4.9.1 Site 9 - Floyds Grass

Habitat restoration was required mainly for the Floyds Grass site which was originally covered by dense Broad-leaved Paspalum (BLP). Although the topsoil seedbank was removed, some weed growth has occurred from seed blown onto the site, carried on boots etc, or deeply buried seed, particularly *Phytolacca octandra* (Ink Weed) in Year 1. Both exotic and native species regenerating from seed tend to reduce the growth of Floyds Grass by competing for space, light and nutrients. Fortunately, the level of weed regeneration was low after removing ground layer vegetation and the top 10cm of soil, so that it has been practical to weed out competing exotic and native species to maintain Floyds Grass expansion.

No maintenance was carried out in first six months after introduction (to February 2016). After six months the most abundant weeds in terms of crown cover were Ink Weed (*Phytolacca octandra*) and Tobacco Bush (*Solanum mauritanicum*). Ink Weed had grown 1-1.5 metres tall and covered most of the site, but survival of Floyds Grass clumps was unaffected as it can grow in the shade or full sun. Other common native 'weeds' included the grass *Ottochloa gracillima* and herb *Commelina cyanea*. These species germinated at low density but grew rapidly. Ottochloa is difficult to weed out as it produces runners that root at nodes and its leaves look very similar to Floyds Grass. Red Ash (*Alphitonia excelsa*) and *Acacia floribunda* also germinated across the site at low density and have been thinned out with other native species. Seedlings of the above species germinated from seed buried deeper than 10cm in soil. Very little Broad-leaved Paspalum germinated indicating that nearly all of its seedbank was in the surface layer.

Four half days of hand weeding by two people were carried out in Years 2 and 3 to control regrowth and remove weeds.

Swamp Oak (*Casuarina glauca*) were planted over the site three months after introduction. These were heavily grazed by wallabies, killing most of them. The site has now been fenced to keep wallabies out. Wallabies did not graze Floyds Grass.

The same topsoil stripping method could be used to rehabilitate the rest of this area, which has apparently been identified by RMS for ecological restoration after the completion of construction.

4.9.2 Site 1 (Rusty Plum and Slender Marsdenia)

Receival Site 1 was moderately infested with Lantana. This has been removed by hand, requiring half a day once a year. Some weed spraying of BLP near the transplanted Rusty Plums was also carried out.

5 ASSESSMENT

5.1 Introduction

This section assesses the outcomes of the WC2NH translocation project after three years according to performance criteria in Section 4.8.6 and Appendix 11 of the Warrell Creek to Urunga Threatened Flora Management Plan Ver. 5 (1/7//2016) (TFMP).

5.2 Performance Assessment

Table 8: Assessment of outcomes of the threatened flora translocation project after three years according to performance criteria in TFMP.

Project Phase	Were Performance Criteria Met?
Pre-construction phase (Appendix 11, Table 1)	
• Salvage translocation (transplanting) of all directly impacted threatened flora completed according to the TFMP, Sections 4.5, 4.6 & 4.7.	Yes - all directly impacted individuals were translocated, including all tagged individuals and additional individual found during pre-translocation surveys and while transplanting
• No loss or damage to threatened flora occurs prior to translocation being implemented.	Yes - no loss or damage prior to translocation
Construction phase (Appendix 11, Table 2)	
• All translocation actions required during the construction phase are implemented including monitoring and preparation of the annual monitoring report.	Yes – maintenance, monitoring and reporting implemented. The monitoring schedule was changed from four times in Year 1 and twice in Year 2 to three times in both years in Ver. 5 of the TFMP.
• Annual monitoring report provides full description of management plan implementation and results, as per the required contents in Section 4.8.5, and an evaluation of outcomes according to criteria listed in Section 4.8.6 of the TFMP.	Yes - annual reports including detailed descriptions of plan implementation, results and an evaluation of outcomes according to criteria in the TFMP were prepared.
Summary (Appendix 11, Table 4)	
1. All recorded directly impacted individuals are 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 greater than 60%
3. At the end of the monitoring program at least 50% of surviving individuals have a Condition Class of 3.	not applicable yet

5.3 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 three years (>70%) for all threatened species except the annual/biennial species Koala Bells. 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.

5.4 Work Plan for Year 4 (February 2018 – February 2019)

Task	**Time**
Monitoring	
Monitoring (once a year)	November 2018 (to coincide with flowering of Slender Marsdenia and Rusty Plum)
Population enhancement	
Seed collection Rusty Plum (provisional if results of 2017 direct seeding are poor) and direct seed into same receival site using same methods	November 2018
Maintenance	
Weeding, maintain shade fences – Floyds Grass site	May 2018, November 2018
Reporting	
Supply monitoring summary	November 2018
Prepare Year-4 annual monitoring report	January 2019

6 REFERENCES

ANPC (2004). Guidelines for the Translocation of Threatened Plants in Australia. 2nd Edition. Australian Network for Plant Conservation.

ECOS Environmental (2013). Bonville Threatened Flora Translocation Project - Final Monitoring Report (No. 5). Report prepared for Lend Lease Infrastructure.

ECOS Environmental (2012 ver.5) Pacific Highway Upgrade Frederickton to Eungai *Maundia triglochinoides* Field Survey and Assessment. Report to Lewis Ecological Surveys.

ECOS Environmental (2014 ver.4 24/12/2014). Warrell Creek to Urunga Upgrade of the Pacific Highway Threatened Flora Management Plan. Report to Roads and Maritime Services.

ECOS Environmental (2014 ver. 5 1/7/2016). Warrell Creek to Urunga Upgrade of the Pacific Highway Threatened Flora Management Plan. Report to Roads and Maritime Services.

ECOS Environmental (2016). Nambucca Heads to Urunga Threatened Flora Translocation Project – Annual Monitoring Report Year-3. Report prepared for Lend Lease Infrastructure.

Primack, R. B. (1996). Lessons from ecological theory: dispersal, establishment and population structure. In D.A. Falk, C.I. Millar and M. Olwell (eds) Restoring Biodiversity pp. 208-234. Island Press, Washington.

Shapcott, A, Lamont, R, O'Connor, K, James, H and Benwell, A. (2016). How is genetic variability in the endangered rainforest vine *Marsdenia longiloba* (Benth:Slender Marsdenia) distributed at different geographic scales? Botanical Journal of the Linnaen Society.

APPENDIX 1: Plates 8 to 48. Photo record of WC2NH threatened flora translocation project in Year 3, ended November 2017.

Rusty Plum (*Niemeyera whitei*) translocation

Plate 8: Rusty Plum (Niemeyera whitei) No. 5, three years after transplanting. New branches have reshot from near top of bare trunk cut down to about 1 metre high.

Plate 9: Rusty Plum (Niemeyera whitei) No. 6, three years after transplanting

Plate 10: Rusty Plum (Niemeyera whitei) No. 7, three years after transplanting

Plate 11: Rusty Plum seeds were directed seeded into wire enclosures at Receival Site 5 (7a) in Nov/17. This measure addressed the population enhancement requirement of the Management Plan for Rusty Plum, which aimed to replace possible translocation losses and maintain population number at the pre-construction level.

Koala Bells (*Artanema fimbriatum*) translocation

Plate 12: Koala Bells (Artanema fimbriatum) No. 10, three years after transplanting. A tree has fallen on the edge of the wire guard but the plant has reshot in and outside the cage. Only two plants were still alive after 3 years. Most plants responded as annuals, flowering and dying in the first year.

Plate 13: Propagated Koala Bells (Artanema fimbriatum) six months after planting out in the Floyds Grass translocation area (Area 2).

Slender Marsdenia (*Marsdenia longiloba*) translocation – Receival Site 1

Plate 14: Slender Marsdenia (*Marsdenia longiloba*). Site 1 (Cockburns Lane) No.11. The height of this plant recorded over 3 years starting 2015 was 5 (cm), 5, 5, 0, 0, 2, 4, an example of how little above ground growth can occur over a long period of time in this species.

Plate 15: Site 1, No. 13. This plant started as an old pruned stem when transplanted. It shot a new stem off the old one and maintained growth. Height over 3 years starting 2015 was 124 (cm), 133, 144, 137, 12, 170, 205.

Plate 16: Slender Marsdenia. Site 1, No.14. This plant had produce a second small shoot at the Nov/17 monitoring. The height of this plant recorded over 3 years starting 2015 was 26 (cm), 20, 9, 0, 10, 10, 4. After appearing to die off it shot again.

Plate17: Site 1, No. 23. This plant maintained size but only a small number of leaves and these were often yellowish. Plant height over 3 years starting 2015 was 119(cm), 120, 49, 15, 62, 76, 102.

Plate 18: Slender Marsdenia. Site 1, No.25. The height of this plant recorded over 3 years starting 2015 was 10 (cm), 10, 25, 4, 3, 3, 3. About 20% of plants remained small like this over 3 years in Site 1 – Response Syndrome S1.

Plate 19: Slender Marsdenia. Site 1, No.9. The height of this plant recorded over 3 years starting 2015 was 52 (cm), 41, 32, 6, 0, 0, 4. After dying off this plant had reshot in Nov/17. Response Syndrome S2.

Slender Marsdenia (*Marsdenia longiloba*) – Receival Site 2 (3)

Plate 20: Slender Marsdenia. Site 2 (3), No.3. The height of this plant over 3 years starting 2015 was 7 (cm), 7, 72, 87, 85, 88, 181, an example of Response Syndrome T1.

Plate 21: Slender Marsdenia. Site 2 (3), No. new 3. The height of this plant over 3 years starting 2015 was 7 (cm), 7, 72, 87, 85, 88, 181, an example of Response Syndrome T1.

Plate 22: Receival Site 2 (3). Habitat – moist open forest with fern and leaf litter ground layer, mature forest regrowth. This site was more open than most other sites, less protected from the cleared road corridor and more exposed to wind, yet the translocated plants performed well.

Slender Marsdenia (*Marsdenia longiloba*) – Receival Site 3 (5a)

Plate 23: Slender Marsdenia. Site 3 (5a), No. 1. The height of this plant over 3 years starting 2015 was 46 (cm), 44, 45, 45, 45, 46, 72. This plant was either leafless or had only 1-3 leaves over 3 years.

Plate 24: Slender Marsdenia. Site 3 (5a), No. 6. Plant height over 3 years starting 2015 was 25 (cm), 25, 125, 130, 118, 70, 147. This is an example of Response Syndrome T1 'large, thriving'.

Plate 25: Slender Marsdenia. Site 3 (5a), No. 16. Plant height over 3 years starting 2015 was 64 (cm), 64, 124, 140, 64, 78, 28. This is an example of Response Syndrome S3 'bell-shaped'.

Plate 26: Receival Site 3 (5a). Habitat – moist open forest with leaf litter and fern ground layer in mature forest regrowth.

Slender Marsdenia (*Marsdenia longiloba*) – Receival Site 4 (5b)

Plate 27: Most *Marsdenia* plants transplanted to Receival Site 4 (5b) appear to be *Marsdenia liisae* (Large-flowered *Marsdenia*), which has larger leaves than *M. longiloba*. This wasn't clear at the time of transplanting. *M. liisae* is a rare species (ROTAP) but not listed as threatened.

Plate 28: Receival Site 4 (5b) habitat – moist open forest with fern and leaf litter ground layer.

Plate 29: Receival Site 4 (5b), No. 16. This was an important individual for translocation and research on the ecology of *Marsdenia longiloba*. It was the only plant found with seed pods (2 in total), one of which was collected before the start of construction of WC2NH. Seedlings propagated from the pod were introduced to the NH2U translocation area for *M. longiloba*, which started two years earlier. This plant also had flowers allowing positive species identification and it was used as one of the marker plants for the *M. longiloba* genetic study (Shapcott et al. 2016), which investigated genetic variation across the species' range from the Mid North Coast to South East Qld. After transplanting successfully it was damaged by an animal colliding with its cage and then reshot again. Plant height over 3 years starting 2015 was 145 (cm), 145, 221, 110, 110, 119, 132.

Slender Marsdenia (*Marsdenia longiloba*) – Receival Site 5 (7a)

Plate 30: Receival Site 5 (7a) No. 3. Plant with actively growing shoot and 19 leaves in Nov/17. Plant height over 3 years starting 2015 was 48 (cm), 46 118, 110, 130, 132, 130.

Plate 31: Receival Site 5 (7a) No. 34. Plant height over 3 years starting 2015 was 45 (cm), 45 124, 115, 112, 34, 35

Plate 32: Receival Site 5 (7a) No. 17. A second shoot appeared in Year 2. Plant height over 3 years starting 2015 was 27 (cm), 22, 13, 3, 10, 10, 10. This is an example of Response Syndrome S1 'stayed small'.

Plate 33: Receival Site 5 (7a) habitat – moist open forest regrowth with fern and leaf litter ground layer. Highway embankment in the background, wire cages at each *M. longiloba* transplant in the foreground.

Slender Marsdenia (*Marsdenia longiloba*) – Receival Site 6 (8a)

Plate 34: Receival Site 6 (8a) No. 3. Plant height over 3 years starting 2015 was 5 (cm), 5, 66, 97, 150, 135, 175. This is an example of Response Syndrome T1 'large, thriving'.

Plate 35: Receival Site 6 (8a) habitat – moist open forest with fern and leaf litter ground layer.

Slender Marsdenia (*Marsdenia longiloba*) – Receival Site 8 (8c)

Plate 36: Receival Site 8 (8c) No. 6. Plant height over 3 years starting 2015 was 21 (cm), 15, 18, 4, 6, 6, 10. This is an example of Response Syndrome S1 'stayed small'.

Plate 37: Receival Site 8 (8c) No. 7. Plant height over 3 years starting 2015 was 55 (cm), 53, 40, 0, 7, 10, 13. This is an example of Response Syndrome S2 'small, died off, reshot again'

Plate 38: Receival Site 8 (8c) No. 24. Plant height over 3 years starting 2015 was 10 (cm), 13, 106, 94, 108, 102, 112. This is an example of Response Syndrome S2 'medium, increased height'

Plate 39: Receival Site 6 (8c) habitat – moist open forest regrowth with fern and leaf litter ground layer.

Plate 40: Planting propagated Slender Marsdenia plants for population enhancement in Nov/17 next to Receival Site 5 (7a). Only a small number of population enhancement plants were propagated (12) due the low strike rate of rhizome cuttings (<5%) and absence of seed.

Floyds Grass (*Alexfloydia repens*) translocation

Plate 41: Floyds Grass (*Alexfloydia repens*) Receival Site 9, Area 1. Floyds Grass spreads by runners and now covers most of the receival site closest to Warrell Ck, which started as bare ground after topsoil and ground layer plant removal. Sapling regrowth was removed during maintenance in Nov/17 to reduce competition and shading. Markers show where initial plants were introduced.

Plate 42: Overall shot of Area 1 above. Floyds Grass dominates the left hand side closest to Warrell Creek and the native creeping grass Ottochloa gracillima dominates the right hand side. Nov/17, 2.5 years after transplanting.

Plate 43: Floyds Grass, Receival Site 9, Area 1. Close-up of Floyds Grass clump.

Plate 44: Floyds Grass, Receival Site 9, Area 1. The majority of clumps were producing flowers and seeds in Nov/17 although they were relatively sparse.

Plate 45: Floyds Grass, Receival Site 9, Area 2. Propagated, population enhancement plants were introduced this site following the same weed and topsoil removal treatment. The shade cloth rows with an awning are for shade as there is no tree shade to the west. Nov/17, 1.5 years after planting.

Plate 46: Floyds Grass, Receival Site 9, Area 2. Floyds Grass pots were planted in pairs at each tagged point. Clumps grew slower than in Area 1, apparently due to slightly poorer soil (deeper excavation by different operator) and less shade. The site was hand weeded, herbicide was only used in dense Broad-leaved Paspalum around the receival site.

Spider Orchid (*Dendrobium melaleucaphilum*) translocation

Plate 47: Large Spider Orchid clump relocated with its supporting branch to the trunk of a tree in the gully next to Receival Site 5 (7a). The branch with orchid has been tied onto the trunk resulting in minimal disturbance to the orchid and it epiphytic roots.

Plate 48: Close up of Spider Orchid showing leaves at the apex of the pseudobulbs, and just visible, the short dead inflorescence axes projecting at the tip. These are the remains from flowering in August-September/17. No pods were formed probably indicating an absence of insect pollinators, or insufficient food reserves although this seems unlikely considering the health of the plants.