Warrell Creek to Nambucca Heads Upgrade of the Pacific Highway

Threatened Flora Translocation Project

Annual Monitoring Report – Year 1

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EXECUTIVE SUMMARY

This report presents the results of threatened plant species translocations undertaken for the Warrell Creek to Nambucca Heads (WC2NH) upgrade of the Pacific Highway after one year (Feb 2015 to Feb 2016). The translocation project was implemented by Ecos Environmental for Pacifico (Acciona and Ferrovial joint venture), according to the Warrell Creek to Urunga Threatened Flora Management Plan (ECOS Environmental 2013 Ver.1). 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*), and one nationally rare species: *Artanema fimbriata* (Koala Bells).

The overall aim of the translocation project is to establish viable populations of the impacted species in habitat adjacent to the highway corridor. To achieve this aim the translocation program has three components:

- salvage transplanting of impacted individuals from the construction footprint;
- population enhancement by introduction of additional plants propagated from locally collected seed, to increase the initial population size and promote establishment of a viable long-term population; and
- restoration of good quality habitat in the receival sites where required.

Potential receival sites were assessed according to the physical, biotic and logistical criteria in the management plan. Nine receival sites were selected spread out along the road corridor to provide appropriate habitat for each species, minimise the distance plants were moved and maintain a more natural distribution. Eight of these were in the road reserve and one on adjoining RMS land. Although the road reserve can be narrow, it was possible to select receival sites with a buffer of forest ~20 metres wide on the highway side and with State Forest on the other side, together providing adequate microclimatic protection.

The survival rate of all threatened species was high in the first year (see Table below). The overall survival rate of Slender Marsdenia, the main species requiring translocation was 90.7% (169 individuals translocated). Plants were transplanted directly to the new sites, watered in and given follow-up watering. No other treatments were applied such as fertilisers. This survival rate is slightly higher than the equivalent treatment on the NH2U project (87.6% after 12 months).

Koala Bells and Spider Orchid flowered in the first year and Koala Bells set seed. A novel approach was used to prepare the receival site for Floyds Grass, which was weed infested, by stripping off the ground layer vegetation and the top 10cm of soil which contains most of the soil seedbank, creating bare conditions with much lower weed potential for the Floyds Grass to become established. Nearly all Floyds Grass clumps survived and are growing, 30% o have sent out runners of more than 1m up to a maximum of 1.6m long in just over six months.

Assessment of the outcomes of the translocation project in Year 1 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.

Table: Summary of species survival rates for the WC2NH translocation project during Year-1, to February 2016

Species/Receival Site	Number of plants		% survival	
		June 2015 (~3 mths)	Aug 2015 (~6 mths)	Feb 2016 (~12 mths)
Slender Marsdenia (*Marsdenia longiloba*)				
Receival Site 1 - Cockburns Lane	27	93	93	93
Receival Site 2 (3) – Old Coast Rd	11	100	100	91
Receival Site 3 (5a) – Old Coast Rd	22	81	81	81
Receival Site 4 (5b) – Old Coast Rd	16	100	100	94
Receival Site 5 (7a) – Old Coast Rd	57	93	90	90
Receival Site 6 (8a) – Old Coast Rd	8	88	88	75
Receival Site 8 (8c) – Old Coast Rd	28	100	93	100
Total	169			91
Rusty Plum (*Niemeyera whitei*)				
Receival Site 1 - Cockburns Lane	7	100	100	100
Wooll's Tylophora (*Tylophora woollsii* – unconfirmed)				
Receival Site 6 (8a) – Old Coast Rd	6	100	100	100
Spider Orchid (*Dendrobium melaleucaphilum*)				
Receival Site 5 (7a) – Old Coast Rd	2	100	100	100
Floyds Grass (*Alexfloydia repens*)				
Receival Site 9 – Warrell Creek	54 clumps	-	100	94
Koala Bells (*Artanema fimbriatum*)				
Receival Site 7 (8b) – Old Coast Rd	16	80	75	63

1 INTRODUCTION

1.1 Purpose

This report documents the implementation and results of threatened flora translocations conducted for the Warrell Creek to Nambucca Heads (WC2NH) upgrade of the Pacific Highway, a 23.6 km section on the NSW Mid North Coast. The translocations were carried out by Ecos Environmental for Pacifico (Acciona and Ferrovial joint venture), the principal contractor for the WC2NH project. (WC2NH is the southern half of the Warrell Creek to Urunga section of the Pacific Highway upgrade which is being built in two stages.) The translocation works were implemented according to the Warrell Creek to Urunga Threatened Flora Management Plan (ECOS Environmental Ver. 4; 24/12/2014), as required by condition B7 of the project approval in relation to flora listed in the NSW *Threatened Species Conservation Act* 1995. Referral and approval was also required in relation to threatened plant species listed in the Commonwealth *Environmental Planning and Biodiversity Conservation Act* 1999, as indicated below.

Translocations were conducted for five threatened and one nationally rare plant species: -

Threatened
- Slender Marsdenia (*Marsdenia longiloba*) (TSC Act, EPBC Act)
- Woolls' Tylophora (*Tylophora woollsii*) (TSC Act, EPBC Act).
- Rusty Plum (*Niemeyera whitei*) (TSC Act)
- Floyds Grass (*Alexfloydia repens*) (TSC Act)
- Spider Orchid (*Dendrobium melaleucaphilum*) (TSC Act)

Nationally Rare
- Koala Bells (*Artanema fimbriatum*)

A further threatened species *Maundia triglochinoides* (TSC Act) was translocated on the initiative of the principal contractor although this was not required by the WC2U TFMP.

This is the first annual monitoring report and describes the implementation and results of the flora translocation project between February 2015 and February 2016.

1.2 Strategy and Objectives

The overall strategy of the WC2NH translocation project was to salvage individuals of threatened and rare species impacted by the highway upgrade and use these individuals plus additional propagated plants to re-establish viable populations in suitable habitat adjacent to the highway corridor. To achieve this aim the translocation program had three components:
- salvage transplanting of impacted individuals from the construction footprint;
- population enhancement by introduction of additional plants propagated from locally collected seed, to increase the initial population size and promote establishment of a viable long-term population; and
- restoration of good quality habitat in the receival sites where required.

The objectives of the translocation project as set out in the Warrell Creek to Urunga Threatened Flora Management Plan (ECOS Environmental 2013Ver.1) 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 to the relocation site(s).
- To preserve individuals of threatened species in situ wherever possible and limit transplanting to plants within the highway footprint and construction buffer.

1.3 Reporting Requirements

The reporting requirements for the WC2NH annual translocation monitoring report were set out in the WC2U Threatened Flora Management Plan Ver. 4 (24/12/2014), Section 4.8.5. The table below indicates the section(s) where the reporting requirements are addressed in this annual 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 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.4 (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*) has white flowers arranged in umbels. Leaves are similar to Woolls' Tylophora, both have clear sap.

Plate 2: Woolls' Tylophora (*Tylophora woollsii*) has purplish flowers arranged in a short cymose panicle.

Plate 3: Rusty Plum (*Niemeyeria whitei*)

Plate 4: Spider Orchid (*Dendrobium melaleucaphilum*)

Plate 5: Floyds Grass (*Alexfloydia repens*)

Plate 6: Koala Bells (*Artanema fimbriatum*).

2 RECEIVAL SITES

2.1 Site Selection

As there were no areas of offset land designated at the start of the WC2NU project and most areas of RMS residual land along the road corridor were cleared, the selection of translocation receival sites for the WC2NU project was limited mainly to forested parts of the road reserve alongside the new highway. The road reserve consists of all the land between the road property boundaries on both side of the highway, including the highway pavement as well as strips of forested or grassed land of variable width up to the road property boundaries. Where the WC2NU corridor crosses Nambucca State Forest, a narrow strip of uncleared forest from 20 to 40 metres wide generally remained within the road reserve next to State Forest after clearing. Smaller sections of forested road reserve adjoining private property were also available south of Warrell Creek.

Twenty potential translocation receival sites were identified by a desktop review of topography and vegetation mapping. Field inspections were conducted to assess their suitability. Each site was assessed according to the selection criteria in the TFMP (Section 4.3.3 – see Table 2 below). In terms of number of individuals the main species requiring translocation was Slender Marsdenia. As this threatened species was recorded at several points along the alignment, several receival sites were selected to reduce the distance individuals were moved. Nine receival sites were selected, seven of these in the road reserve where the highway corridor crosses Nambucca State Forest. The other two sites were in the road reserve at the far southern end of the project and on RMS land adjacent to the new highway bridge at Warrell Creek.

Table 1: Translocation Receival Sites.

Receival Site	Species
1	Slender Marsdenia, Rusty Plum
2	Slender Marsdenia
3	Slender Marsdenia
4	Slender Marsdenia
5	Slender Marsdenia
6	Slender Marsdenia, Woolls' Tylophora(?)
7	Koala Bells
8	Slender Marsdenia
9	Floyds Grass

Donor and receival sites were similar in vegetation structure, which generally consisted of mature forest regrowth, having been selectively logged 30-50 years ago. The plant species composition and habitat of the donor and receival sites were also similar. All Slender Marsdenia and Woolls' Tylophora receival sites were located in moist open forest on lower to mid hill slopes with an east to southeast aspect. Dominant/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*), the proportions varying from site to site.

A site with floodplain soil adjacent to a coastal creek was selected for Floyds Grass. The only site found with this type of soil had disturbed, weed infested vegetation, which required habitat restoration. A gully floor site with seasonally waterlogged soil was selected for Koala Bells.

Photos of the receival sites are presented at the end of the report. Brief descriptions of the nine receival sites are provided below.

2.2 Receival Site 1

Receival site 1 is located in the road reserve on the eastern side of the alignment adjacent to Cockburn's Lane at the southern end of the project. The road reserve is relatively narrow at this point and exposed to the west, although timbered on the eastern side which provides microclimatic protection. The soil type is a red loam formed on a black, glassy rock (hornfels?) which differs from the geology along the rest of the alignment. Impacted Slender Marsdenia and Rusty Plum found at Cockburns Lane on this soil type were translocated to an adjacent receival site with the same soil type rather than moving them to the Nambucca State Forest section further north which is on different geology. A buffer of forest approximately 20m wide separates the translocation area from the cleared road corridor.

2.3 Receival Site 2 (3)

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

Receival site 2 is located north of the Nambucca River in a strip of forest between Old Coast Road and the highway alignment. The site faces east and is located 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 aspect is east and the topographic position lower-slope. 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 being 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 a 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 just south of Nambucca Heads. The site is located in the road reserve in a narrow strip of forest between an easement for fiber-optic cable and water pipeline and the road reserve boundary, again on the western side of the

highway. The site aspect is east and topographic position lower slope. There is a forested buffer approximately 15 metres wide between the site and highway, although this is divided by the easement. The site is well protected on the western side by Nambucca State Forest.

2.8 Receival Site 7 (8b)

Receival site 7 is located about 50 metres south of site 6 where there is a patch of swamp forest on the flat gully floor. This was the only site found with swamp forest vegetation similar to the type of habitat preferred by Koala Bells. Being in a narrow section of the road reserve and close to a utilities easement the site was not ideal, but was the best that could be found within the road reserve. (Note – Koala Bells (*Artanema fimbriatum*) is not a listed threatened species, although is it generally regarded as rare and would probably qualify for listing if nominated. It was not essential to translocate this species, but was undertaken as a pre-cautionary measure. Koala Bells has been translocated on other highway upgrade projects because of its rarity.)

2.9 Receival Site 8 (8c)

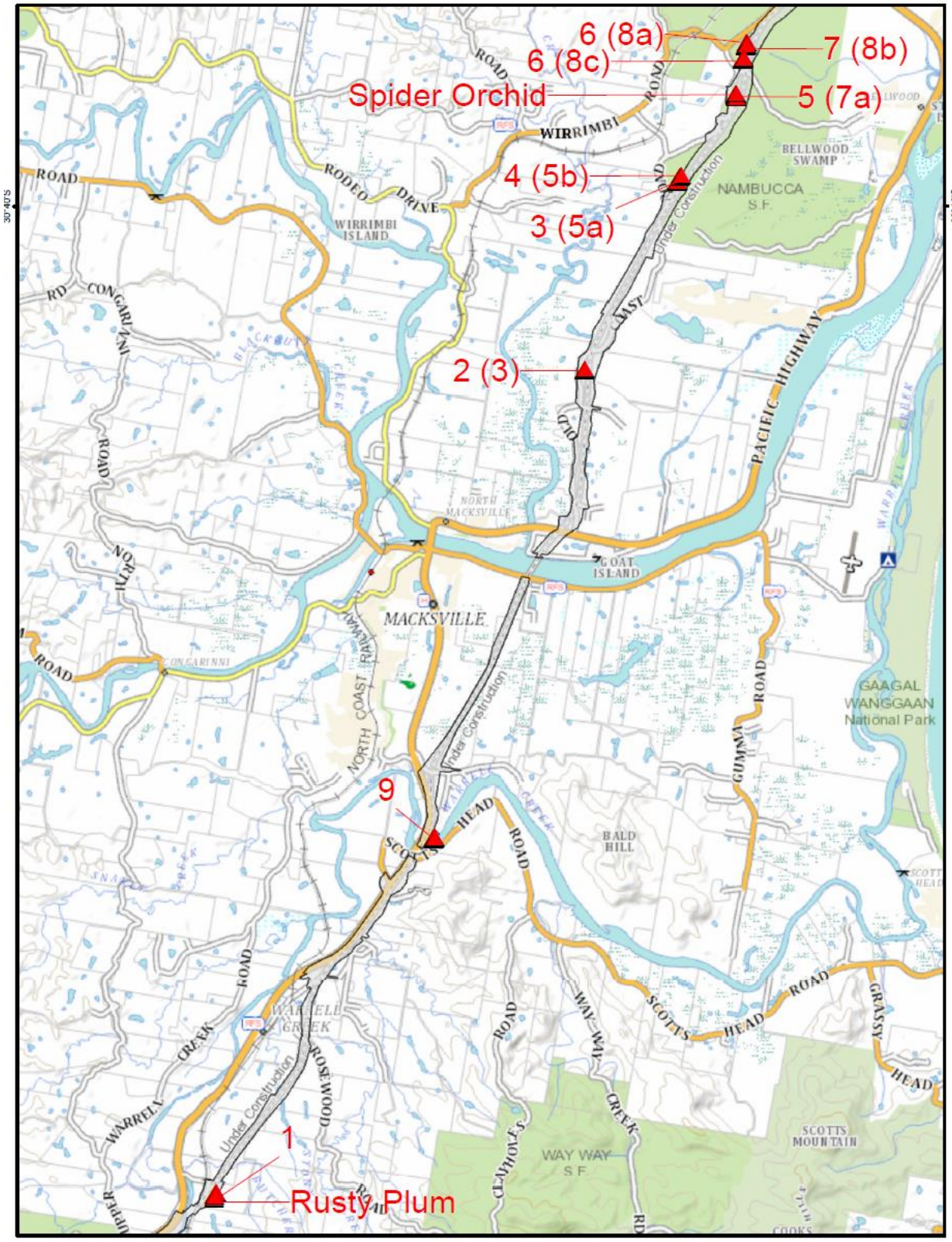
Receival site 8 is located further south along the same utilities easement as sites 6 and 7. The site is well protected on the western side by Nambucca State Forest. The site aspect is east and topographic position lower slope. A buffer of forest approximately 30m wide separates the translocation area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

2.10 Receival Site 9

Receival site 9 selected for Floyds Grass is approximately 100 metres north of the donor site on the northern bank of Warrell Creek. Floyds Grass inhabits floodplain forest generally within 30 metres of coastal creeks. This may include swamp sclerophyll forest dominated by Swamp Sheoak (*Casuarina glauca*) or moist open forest dominated by Flooded Gum, paperbarks and rainforest species. This type of habitat was only present along the alignment at Warrell Creek near the impacted population. Potential habitat for Floyds Grass in this area is more extensive, but the habitat is degraded and overrun with exotic Broad-leaved Paspalum (*Paspalum mandiocanum*), which prevents Floyds Grass from spreading away from the water's edge. Suitable soil for Floyds Grass extends north of the bridge site for more than 100 metres between the eastern side of the alignment and Warrell Creek. A receival site was selected in this area covering 30 m x 20 m with some tree shade to protect transplanted Floyds Grass. The site is located on RMS land just outside the WC2NH project boundary and has been identified for ecological restoration after completion of road construction.

Table 2: Site attributes of the 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 (Y = matching donor site)	Y	Y	Y	Y	Y	Y	Y	Y	Y
soil (Y = matching donor site)	Y	Y	Y	Y	Y	Y	Y	Y	Y
proximity to donor site (Y = <1km)	Y	Y	Y	Y	Y	Y	Y	Y	Y
area of potential habitat available (Y = adequate)	Y	Y	Y	Y	Y	Y	Y	Y	Y
Vegetation									
plant community (Y = matching donor site)	Y	Y	Y	Y	Y	Y	Y	Y	Y
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



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Source: Receival Sites: Ecos Environmental 2015; Road Design detail and corridor: RMS 2014; Background topographic map: NSW Land & Property Information 2015

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File: WC2NH-SOUTHERN-RECEIVAL-SITES-OVERVIEW-160224

0 1 2 Kilometers

A4 Scale 1:60,000

Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator

Receival Sites

WC2NH road corridor

Receival Sites for the WC2NH Threatened Flora Translocation Project

3 TRANSLOCATION METHODS

3.1 General

Salvage transplanting of all species except Floyds Grass was carried out in February 2015 prior to the start of vegetation clearing. Floyds Grass was translocated in July 2015. The possibility of frost damage to Floyds Grass by transplanting in winter was considered minimal as the site was next to a large coastal creek and there was added protection from trees. All species were translocated using the direct transplanting method whereby plants are excavated and planted into a receival site as quickly as possible and pruned and watered to minimise transpiration stress.

Positions were selected for planting out of direct sunlight, or shade screen erected if transplants were exposed to full sun. As the number of transplanted Slender Marsdenia was substantial, plants were set out in rows at roughly equal spacing to assist with relocation and monitoring. Individuals were planted 3-4 meters apart in rows about 5 metres apart. No fertilisers were applied. Rusty Plum was mulched with cane mulch and leaf litter was spread over the soil for other species.

Floyds Grass was given liquid seaweed and fish emulsion fertiliser twice in Year 1 to promote growth as the same treatment was applied at Bonville with good results. As the soil surface at the Floyds Grass site was initially bare (see below) the site was lightly mulched with cane mulch to minimise erosion and soil compaction.

More information on the translocation methods applied for each species is provided below.

3.2 Slender Marsdenia

3.2.1 Salvage Transplanting

Transplanting of Slender Marsdenia was carried out by tracing the stem to the ground and digging out the root system and attached stem to a depth of about 20cm with a spade. Usually there were several small stems at each mapped point and all of these plants were salvaged, each representing one individual. The plants were introduced to a pre-marked receival site and planted in rows. As vegetation clearing had not begun, the project boundary and clearing limit were marked accurately by surveyors to ensure plants were not placed outside the road reserve or in the clearing corridor.

A total of 169 Slender Marsdenia were salvaged and planted into the receival sites. This was about twice the number given in the TFMP, which is typical of cryptic and difficult to survey species such as Slender Marsdenia. All additional plants found during pre-translocation surveys and transplanting work were salvaged. Plants and soil were kept damp during transplanting and watered immediately after planting to saturate the soil. After planting, watering was carried out once every second day for a week then once a week for four weeks.

Chicken wire cylinders were installed around each individual to prevent any damage by grazing and bandicoot digging, to provide a climbing frame and to make relocation and monitoring easier. Flagging tape was attached to the base of each stem just above the ground to assist with relocation if the plant died back. Flagging tape with the individuals monitoring number and source identification code as per the TFMP was attached to each cage. Multiple individuals from the same mapped flora point were indicated by an additional suffix on the source identification code – e.g. Ml46-7

3.2.2 Propagation of population enhancement plants

Seed propagation was shown to be an effective method of propagating Slender Marsdenia on the NH2U translocation project (Ecos Environmental 2016). The strike rate of cutting-grown plants on the NH2U project was low (15% or less) and the plants lacked vigour. Propagation from seed was therefore the preferred method of propagation of Slender Marsdenia for population enhancement on the WC2NH project.

The author was on leave in December 2015 and unable to carry out seed collection. Previously, Slender Marsdenia has been recorded in flower bud in October, flowering in November and with ripe pods in December (NH2U and S2W projects). It appears that pods form quite rapidly after flowering. To collect seed in 2016, large plants of Slender Marsdenia known to occur at locations at Nambucca Heads to Urunga, Sapphire to Woolgoolga, Nambucca State Forest, genetic study locations and the Slender Marsdenia Offset Site in Boambee State Forest will be inspected in December for seed pod formation. As plants at these locations have already been tagged, searching for seed pods should be much more efficient than having to search forest to find plants first. Checking all these locations at the same time in December when Slender Marsdenia is known to produce pods has a reasonable chance of success.

Once seed is collected, plants can be propagated and ready for planting out in about 8 months, as on the NH2U project.

3.3 Woolls' Tylophora

3.3.1 Species Identification

Woolls' Tylophora may be present on the WC2NH section, but it has not been positively identified from flowering specimens. Plants identified in the TFMP as this species may actually be Slender Marsdenia. This implies that Slender Marsdenia also can't be distinguished from Woolls' Tylophora without flowers. However, there is a range of variation in the shape of Slender Marsdenia leaves. The overlap between the two species is represented by the leaf shape and colour shown in Plate 2, a flowering specimen of Woolls' Tylophora from the Bonville project. Plants confidently identified as Slender Marsdenia have leaves with a more elongated shape, pinnate venation, leaf base tending to cordate, often paler green and almost totally glabrous (without hairs). Woolls' Tylophora has a broader leaf with purplish tinges, tending to 3-veined at base and sparsely hairy. A potted Woolls' Tylophora from the Bonville project flowered in late August, whereas Slender Marsdenia has been recorded flowering mainly in November.

About 10 Slender Marsdenia plants have been found with flowers on the WC2U section allowing positive identification of this species, but no Woolls' Tylophora have been found in flower. As both species are listed as threatened, any plant identified as one or other of these species required translocation anyway.

3.3.2 Salvage Transplanting

Woolls' Tylophora was transplanted using the same methods applied to Slender Marsdenia. Both species have a similar growth form.

Plants identified in the TFMP as possibly Woolls' Tylophra were translocated to Receival Site 8a, which also contains Slender Marsdenia.

3.3.3 Propagation of population enhancement plants

A possible *Tylophora woollsii* plant with one pod was found in the Boambee State Forest Offset Site in April 2015 during other survey work.

3.4 Rusty Plum

3.4.1 Salvage Transplanting

Rusty Plum trees and saplings were dug out using an excavator. A trench was dug around larger trees to a depth of about 1 metre to form a soil-root ball about 1 metre in diameter. This was undercut and the tree leaned to the side for pruning. The trunk was cut back removing all foliage then the tree and root-ball lifted out of the ground with a sling to avoid bark scrapping. Rusty Plums were salvaged from the population at Cockburns Lane at the southern end of the project and planted into Receival Site 1 located in the road reserve adjacent to the donor site. The plants were watered in and follow-up watering carried out during the first month. Sugar cane mulch was spread around each plant and hessian barriers were erected for additional shade as the site was exposed to the afternoon sun.

3.4.2 Population Enhancement

Rusty Plum seed collected is schedule for November 2016, the month when seed matures Approximately 30 Rusty Plums will be propagated and introduced to the road reserve near Receival Site 1.

3.5 Spider Orchid

3.5.1 Salvage Transplanting

Two large Spider Orchid plants were salvaged from the WC2NH highway corridor where they were growing on Prickly Paperbark *Melaleuca stypheloides* trees. The orchid was translocated by cutting out the section of paperbark stem supporting the orchid plant. This host stem was tied onto the trunk of a rainforest tree in the gully at Receival Site 7a. Apart from watering during transport, no watering was applied.

3.5.2 Population Enhancement

The TFMP aims to propagate additional Spider Orchid plants for population enhancement. As there would not be enough wild plants for propagation by vegetative division without depleting populations, it was proposed to propagate plants from seed. This species was also translocated for the NH2U project where seed collection has been unsuccessful to date. Further monitoring for flowering and seed production will be carried in 2016 for both NH2U and WC2NH. If seed pods are found, propagation and population enhancement will be carried out.

3.6 Koala Bells

3.6.1 Salvage Transplanting

Koala Bells plants were dug up with a spade and planted into Receival Site 8b in the road reserve. The site is not ideal for this species, as described above, but the best that could be found in the road reserve. The plants were watered in and follow-up watering carried out. No fertilisers were applied.

3.6.2 Population Enhancement and Experimentation

Seed of Koala Bells was collected from translocated plants in January 2016 for propagation and population enhancement. To test the effect of propagation medium on the plant's performance in the field, it is proposed to grow one batch of plants in a organic soil medium without addition of fertiliser and one batch in standard nursery soil mix with added artificial fertiliser, then compare their growth after planting out.

A damp site in the road reserve or on adjoining RMS land would be required for a receival site.

3.7 Floyds Grass

3.7.1 Site Preparation

As the receival site for Floyds Grass at Warrell Creek was heavily infested with exotic Broad-leaved Paspalum (BLP) it was necessary to remove this grass and the soil seedbank before translocating Floyds Grass to the site. Spraying the site with herbicide to kill BLP would still leave the soil seedbank to contend with, which on disturbed sites usually results in prolific weed germination. Follow-up spraying of weeds would be difficult without damaging Floyds Grass which sends out long runners that are hard to see.

The only feasible way of establishing Floyds Grass on such a weedy site was to strip off the BLP and then the topsoil seedbank. As the site was on a floodplain with relatively deep soil, a sufficient depth of reasonable quality soil would likely remain after the stripping process.

Preparation of the site for translocation of Floyds Grass was carried out with an excavator as follows. Firstly, BLP was scrapped off with the excavator bucket. After exposing the topsoil, the top 10cm was scrapped off and stockpiled with the grass to the side of the site and later flattened out. The topsoil beneath the uppermost 10cm was slightly more clayey in texture, but still had reasonable soil texture and drainage. Sed fence was installed around the site to prevent run-off of sediment to Warrell Creek.

3.7.2 Salvage Transplanting

Floyds Grass was dug up with a spade and planted at the receival site in clumps approximately 10cm square. The clumps were watered in and sugar cane mulch (weed free) spread lightly over the site to prevent raindrop compaction. Follow-up watering was carried out. One application of 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 23).

3.7.3 Population Enhancement

To increase population size and promote long-term population viability, approximately 100 Floyds Grass plants have been propagated for introduction to the receival site. The plants were propagated from small, detached pieces of rhizome collected during transplanting and grown in a nursery soil mix. These plants will be

introduced to a similar sized area as the transplanted area and prepared using the same method, in March 2016.

3.8 Monitoring and Data Processing

Each individual was identified by a source identification code as per the TFMP and a monitoring number. Different individuals from the same donor point site were indicated by an additional suffix on the source identification code – e.g. Ml46-7

Monitoring of transplants was conducted every 3 months during the first year.

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

> Slender Marsdenia and other species except Spider Orchid: 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
>
> Spider Orchid: Monitoring Number, Date, Source Label, Species, Number of pseudobulbs with leaves, Length of the longest pseudobulb, New growth, Condition, Waypoint, Coordinates

All field data can be found in the Excel file appended to this report. Note – the gps coordinates of each translocated individual are provided in the spreadsheets labelled Feb 2016.

The key attribute for evaluating species health and survival was Condition, which was scored on a scale of 0 to 5. The scores were defined slightly differently for different species, as indicated in Tables 3-5 below.

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

Means species height was calculated for all plants including those with zero height (ie plants that had died back to the ground – condition class 1), not just surviving plants (condition class 2 to 5)

Table 3: Condition scores applied to Slender Marsdenia and Woolls' Tylophora

Score	Condition
0	dead
1	stem died back to ground, no leaves or green stem, live stem stub may be present
2	stem with leaves, no active growth; green leafless stem; active growth but <75cm tall
3	stem with leaves, active growth – ie current new shoot growth stem with leaves and plant >75cm tall
4	plant > 1.5m tall with lots of leaves, mature or nearing maturity
5	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

4 RESULTS

4.1 Summary

One year after the start of translocation project all species had a high survival rate with the exception of Koala Bells (Table 6). Survival rates were similar to the NH2U project where the same species were translocated, with the exception of Floyd Grass.

Table 6: Summary of species survival rates after one year, to February 2016

Species/Receival Site	Number of plants	% survival		
		June 2015	**Aug 2015**	**Feb 2016**
Slender Marsdenia (*Marsdenia longiloba*)				
Receival Site 1 - Cockburns Lane	27	93	93	93
Receival Site 2 (3) – Old Coast Rd	11	100	100	91
Receival Site 3 (5a) – Old Coast Rd	22	81	81	81
Receival Site 4 (5b) – Old Coast Rd	16	100	100	94
Receival Site 5 (7a) – Old Coast Rd	57	93	90	90
Receival Site 6 (8a) – Old Coast Rd	8	88	88	75
Receival Site 8 (8c) – Old Coast Rd	28	100	93	100
Total	169			91
Rusty Plum (*Niemeyera whitei*)				
Receival Site 1 - Cockburns Lane	7	100	100	100
Wooll's Tylophora (*Tylophora woollsii* – unconfirmed)				
Receival Site 6 (8a) – Old Coast Rd	6	100	100	100
Spider Orchid (*Dendrobium melaleucaphilum*)				
Receival Site 5 (7a) – Old Coast Rd	2	100	100	100
Floyds Grass (*Alexfloydia repens*)				
Receival Site 9 – Warrell Creek	54 clumps	-	100	94
Koala Bells (*Artanema fimbriatum*)				
Receival Site 7 (8b) – Old Coast Rd	16	80	75	63

4.2 Slender Marsdenia (*Marsdenia longiloba*)

Combing results for the seven receival sites with Slender Marsdenia (169 individuals) the survival rate after 12 months was 90.7%. Survivorship per site varied from 75% to 100% (Table 6).

Height and active shoot growth data indicated general growth and increase in plant size during the first year. In the last six months to February 2016, the mean height of Slender Marsdenia increased in all except one receival site where it remained about constant (-4% change, Table 7). The increase in mean height in six months was generally more than 50%, to a mean height of about 55cm. At the Feb/16 monitoring, 37.3% of plants showed active shoot growth.

Causes of mortality

Mortality levels were fairly low for Slender Marsdenia in Year 1 (~10% overall). There were no obvious reasons for the mortality of plants that died. Mortality was most likely related to the degree of damage to root systems during transplanting. Post-transplanting infection of cut root surfaces may also have been a factor in plant death. Some stem shoots once separated from a parent root system may have had very few roots to take up water so these plants died. Unfortunately it was not possible to score each plant for this type of information without slowing the whole translocation procedure down.

Table 7: Mean height (cm) of Slender Marsdenia transplants 6 and 12 months after translocation (± standard error) and the percentage change in height during this period.

Receival site	n	June 2015 (6 months)	Feb 2016 (12 months)	% height change
Receival Site 1 - Cockburns Lane	27	26.51±6.48	39.0±10.43	47
Receival Site 2 – Old Coast Rd	11	25.64±10.09	60.82±15.50	137
Receival Site 3 – Old Coast Rd	22	29.29±7.46	49.76±11.16	70
Receival Site 4 – Old Coast Rd	16	38.69±11.44	47.00±14.84	21
Receival Site 5 – Old Coast Rd	57	29.54±3.72	51.74±6.78	75
Receival Site 6 – Old Coast Rd	8	55.13±22.24	53.00±17.92	-4
Receival Site 8 – Old Coast Rd	28	43.68±6.39	69.57±9.16	59
Total	169			

4.3 Rusty Plum (*Niemeyera whitei*)

All seven transplants survived after 12 months and there was a substantial amount of new shoot growth on larger individuals. Small plants showed little shoot growth. Mulching with sugar cane mulch stimulated reshooting and produced healthier foliage compared with individuals that did not receive mulch (a few were not mulched until later in the year)

Causes of mortality

No mortality recorded. One small individual enclosed by workers in a shade cloth box lost its leaves probably from lack of light. The shade cloth roof has been removed and the plant should reshoot as the bark was still alive.

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

Six possible Woolls' Tylophora in Receival Site 6 were all still alive after 12 months and in reasonable condition.

Causes of mortality

See Slender Marsdenia above.

4.5 Spider Orchid (*Dendrobium melaleucaphilum*)

The two translocated Spider Orchid plants survived after 12 months. Both flowered in spring 2015 approximately 9 months are transplanting. This demonstrates the effectiveness of the minimal disturbance transplanting method. Active shoot (pseudobulb) growth was present on one plant in Feb/2016.

Causes of mortality
No morality recorded.

4.6 Floyds Grass (*Alexfloydia repens*)

The survival rate of 94 clumps of Floyds Grass translocated to Receival Site 9 was 94% after 6 months. Nearly all surviving plants had runners of varying length; 32% had runners greater than 1m long, up to a maximum of 1.6m.

The results showed that Floyds Grass will grow rapidly on a bare site stripped of other ground layer plant cover and with only a light litter layer. The same response was on the Bonville project where Floyds Grass was translocated to a site where dense Lantana rather than BLP was cleared away (Ecos Environmental 2013). The growth of Floyds Grass tends to be checked by other ground covers such as the native grass Ottochloa, especially if they are well established. If competition if reduced by weeding, Floyds Grass will develop into a thick grass mat which resists invasion by other species (also see Sec. 4.9.1).

Causes of mortality
The few transplanted clumps that died were all at the northern end of the receival site where there was minimal shade from the large tree in the centre of the site. These plants were probably subject to greater sun exposure that the rest of the site.

4.7 Koala Bells (*Artanema fimbriatum*)

The survival rate of 16 Koala Bells in receival site 7 was 80% after three months and 63% after 12 months. Seed capsules were maturing on 44% of plants in Feb/2016.

Causes of mortality
The mortality of Koala Bells on the WC2NH project did not exceed the performance threshold in the TFMP, but almost 40% of plants died or appear to have died in Year 1. Koala Bells has been translocated before and transplants generally flower and seed in the first six months if transplanted in summer and then gradually die out. It is unclear if this is just the plant's natural life cycle or if they die out due to some factor related to translocation. At least some naturally occurring plants have been observed persisting for several years. Wild plants can die back in winter and reshoot in spring.

Fertiliser addition during translocation (e.g. NH2U) may speed up the life cycle so plants die out after seeding prolifically in the first year, leaving behind dormant seed in the soil. However, no fertilizer was added on the WC2NH project. The receival site was not ideal for Koala Bells and a possible reason for some of the mortality recorded. A larger site with better soil and more micro-sites to choose planting points from would have been better.

4.8 Maundia (*Maundia triglochinoides*)

Maundia a sedge-like plant found in freshwater swamps and streams is listed as Vulnerable under the TSC Act. This species was originally included in the WC2U TFMP but was taken out as it was not considered to warrant translocation on the Fredrickton to Eungai project. Large stands of Maundia occurred within and adjacent to the F2E project, although the species was rare in the same area in earlier environmental studies conducted during the millennium drought. Smaller occurrences were present within the WC2NH corridor and large stands just outside the alignment.

Pacifico undertook translocation of Maundia from the Crouches Creek bridge site south of Warrell Creek 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 relatively easy to translocate by scooping up the plant with its rhizomes with an excavator bucket and depositing them in suitable wetland habitat. If the leaves were damaged they would regrow from the rhizomes. Previous attempts at translocating the species by the Royal Botanic Gardens in Sydney using plants propagated from seed were unsuccessful (Ecos Environmental 2012).

Pacifico initially translocated Maundia to a site downstream of the Crouches 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 have thrived and will be held at the sedimentation basin until the bridge works are completed when they will be reintroduced back into Crouches Creek in the road reserve.

4.9 Habitat Restoration

4.9.1 Site 9 - Floyds Grass

Habitat restoration was required mainly for the Floyds Grass site, initially overgrown with Broad-leaved Paspalum. Although the topsoil seedbank was removed, some weed growth was inevitable from seed blown into the site, carried on boots etc, or seed buried more deeply in the soil. Both exotic and native species regenerating from seed would reduce the growth of Floyds Grass by competing for space, light and nutrients. Fortunately, the level of seedling regeneration was low as a result of moving the top 10cm of soil and it was practical to weed out competing exotic and native species to maintain a high Floyds Grass growth rate.

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 caused little if any damage to Floyds Grass which can grow in the shade or full sun. Other common species included the native grass *Ottochloa gracillima* and herb *Commelina cyanea*. These species germinated at low density but grow rapidly. Ottochloa is difficult to weed out as it produces runners that root at nodes and its leave look very similar to Floyds Grass. Red Ash (*Alphitonia excelsa*) and *Acacia floribunda* also germinated a low density across the site and were removed with other native species. Most seedlings of the above species probably germinated from seed buried deeper than 10cm in soil, possibly by ants. Only a small amount of Broad-leaved Paspalum germinated from seed indicating that nearly all of its seedbank had been removed.

Two days of hand weeding by two people were carried out in February 2016 to remove six months of weed and native species regeneration. Ink Weed and Tobacco Bush were removed in a couple of hours by hand pulling. Removal of the native grass Ottochloa and other native herbs took longer. These species would have been left if the aim was simply to regenerate native bush, but as Ottochloa competes strongly with Floyds Grass it was best to remove it to allow Floyds Grass to become established.

Swamp Oak (*Casuarina glauca*) in six inch pots were planted over the site three months after introduction. These were heavily grazed by wallabies, killing about a

third. The site has now been fenced with chicken wire and star pickets to keep wallabies out. They did not graze Floyds Grass.

The pattern of vegetation regrowth after removal of BLP and the topsoil seedbank to a depth of 10cm was of interest as it indicated how the same methods, which is relatively inexpensive and fast (stripping with an excavator), could be used to rehabilitate native vegetation in the area between the highway and Warrell infested with BLP. This has apparently been identified for ecological restoration.

4.9.2 Site 1 (Rusty Plum and Slender Marsdenia)

Receival Site 1 was moderately infested with Lantana. This was removed by hand, requiring half a day by one person. 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 Year 1 of the WC2NH translocation project according to performance criteria listed in Section 4.8.6 and Appendix 11 of the WC2U Threatened Flora Management Plan Ver. 4 24/12//2014.

5.2 Performance Assessment

Table 8: Assessment of performance of the threatened flora translocation project based on criteria in WC2 TFMP ver.4 (24/12/2014)

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 WC2U TFMP, Sections 4.5, 4.6 & 4.7.	Yes - all directly impacted threatened flora 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. There was change of the monitoring schedule from 4 times in Year 1 and twice in Year 2 to 3 times in Year 1 and 3 times in Year 2. This will enable recording of possible flowering of Slender Marsdenia in November 2016.
• Annual monitoring report provides full description of management plan implementation and results, as per the required contents in Section 4.7.7, and an evaluation of outcomes according to criteria listed in Section 4.7.8 of the WC2U TFMP. (Note – the above Section numbers are for NH2U; the section numbers for WC2NH should be 4.8.5 and 4.8.6)	Yes - annual report includes detailed description of management plan implementation and results and an evaluation of outcomes according to criteria in WCU TFMP ver. 4 24/12/201
Summary (Appendix 11, Table 4)	
1. All recorded directly impacted individuals are translocated.	Yes

Project Phase	Were Performance Criteria Met?
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 – all translocated species achieved a survived 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 in Year 1. 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 and learning from the results of the previous translocations of the subject threatened species, including the results of the NH2U, Bonville and S2W threatened flora translocations.

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 the Next Twelve Months (March 2016 – March 2017)

Task	Time
Monitoring	
Monitoring (3, 6 and 12 months)	May 2016, November 2016, February 2017
Population enhancement	
Plant out Floyds Grass	March 2016
Seed collection Rusty Plum	November 2016
Seed collection Slender Marsdenia and Woolls Tylophra – if possible	December 2016 possibly into 2017 if pods not ripe
Seed collection Spider Orchid – if possible; combine with NH2U	November - December 2016
Maintenance	
Watering – Floyds Grass population enhancement after planting	March 2016
Weeding – Floyds Grass site, to coincide with monitoring	May 2016, November 2016, February 2017
Reporting	
Supply 3 and 6 month data with summary of results	May, November 2016
Prepare Year-2 annual monitoring report	February-March 2017

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 (2016). Nambucca Heads to Urunga Threatened Flora Translocation Project – Annual Monitoring Report Year-2. Report prepared for Lend Lease Infrastructure.

Plate 7: Receival Site 1. Moist open forest with Turpentine. Wire cages contain transplanted Slender Marsdenia. Feb/2016

Plate 8: Receival Site 1. Slender Marsdenia with active shoot growth, growing out of top of cage. No.4 (monitoring number); ML68-4 (source/donor code). Feb/2016

Plate 9: Receival Site 1. Rusty Plum with healthy new shoot growth from transplanted stump. Feb/2016

Plate 10: Receival Site 2 between Old Coast Road and highway alignment, construction in background. Moist open forest, easterly aspect, mid slope. Feb/2016

Plate 11: Receival Site 3. Exposed to the east by highway alignment, in background. A buffer of forest ~15m wide separates receival area from construction. Feb/2016

Plate 12: Receival Site 3. Slender Marsdenia with active shoot growth growing out of top of cage. No. 7; ML 141-2. Feb/2016

Plate 13: Receival Site 4. No. 16; Ml-42. This transplanted Slender Marsdenia is the only plant pods have been found on the WC2U road corridor, one pod was produced two years in succession. The seed from one pod was used for propagating for the NH2U project. This plant was also a reference plant for the Slender Marsdenia genetic study as it was positively identified from flowers.

The plant was leafless after pruning when planted into the receival site. In Feb/2016 a shoot had grown from the 2mm diameter stem from a point 100cm above the ground to a total height of 221cm.

Plate 14: Receival Site 5 between Old Coast Rd and the highway alignment in the background. Moist open forest, easterly aspect, on a lower slope. Feb/2016

Plate 15: Receival Site 5. Slender Marsdenia with active shoot growth growing out of top of cage. Dust on leaves from earthwork caused no apparent damage. No. 29; Ml 147-1. Feb/2016

Plate 16: Receival Site 5. Spider Orchid translocated to the gully at Receival Site 5. The trunk section of the host tree supporting the orchid was cut out and tied to the trunk of a suitable rainforest tree, which the orchid roots may eventually grow on to.

Plate 17: Receival Site 6. Utilities easement and highway corridor in the background.

Plate 18: Receival Site 7. This low lying site on the edge of a utilities easement was used to translocate Koala Bells.

Plate 19: Receival Site 7. Koala Bells with seed capsules Feb/2016, one year after translocation.

Plate 20: Receival Site 8. Moist open forest with a ferny ground layer, easterly aspect, lower slope, highway alignment in background.

Plate 21: Receival Site 8. Slender Marsdenia dying back, terminal stem section 20cm long has died back and leaves yellowing. Plant no.17; Ml9-4. Feb/2016.

Plate 22: Receival Site 9. Floyds Grass translocation area in background, see light brown shade cloth, about 10 metres from Warrell Creek. Highway in foreground.

Plate 23: Receival Site 9. Floyds Grass translocation area with shade cloth screen to protect plants from hot afternoon sun, Warrell Creek in background. Feb/2016.

Plate 24: Receival Site 9. Floyds Grass site before translocation covered in Broad-leaved Paspalum. This exotic grass and the topsoil seedbank was scrapped off with an excavator to a depth of 10cm before introducing Floyds Grass.

Plate 25: Receival Site 9. Patches of Floyds Grass forming 6 months after planting 5cmx5cm clumps of grass translocated from the Warrell Creek bridge site 200m south. Feb/2016.

Plate 26: Receival Site 9. Floyds Grass clump no. 9. The initial clump has thickened up and sent out runners over a metre long. The other flagging tape is a planted Swamp Oak *Casuarina glauca*. These were heavily grazed so a fence was installed in Feb/2016.

Plate 27: Receival Site 9. Floyds Grass runners such as this one should spread right over the site and thicken up into a dense matt of grass. Note how the site is bare of other plant cover after weeding out seedlings of other native as well as exotic species in Feb/2016.