Pacific Highway Upgrade - Nambucca Heads to Urunga Operational Phase Threatened Flora Monitoring Year 1 Annual Report

Prepared for NSW Roads and Maritime Services

Peter Richards

December 2017

This report, **Pacific Highway Upgrade Nambucca Heads to Urunga Operational Phase - Threatened Flora Monitoring Year 1 Annual Report**, was prepared for NSW Roads and Maritime Services in accordance with the NSW *Environmental Planning and Assessment Act* 1979, the NSW *Threatened Species Conservation Act* 1995 (now the NSW *Biodiversity Conservation Act* 2016) and the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999.

The author of this report is Peter Richards, Consultant Ecologist, whose qualifications are B.Sc. (UNE).

Any opinion expressed in this report is the professional, objective opinion of the author.

December 2017

Title Page Images

Top: Slender Marsdenia *Marsdenia longiloba* in flower. Translocated plant in Sector A, Translocation Area 1.
Bottom: Red Bopple Nut *Hicksbeachia pinnatifolia* in flower. Translocated plant in Sector H, Translocation Area 1.

Images taken by Peter Richards, October - November 2017.

TABLES

FIGURES

GLOSSARY

TERM	MEANING
ANPC	Australian Network for Plant Conservation
BC Act	NSW *Biodiversity Conservation Act* 2016
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999
EP&A Act	NSW *Environmental Planning and Assessment Act* 1979
In-situ	Latin term meaning 'in the original place'. In this report, refers to threatened plants that are being protected where they were found
LGA	Local Government Area
MCoA	Ministers Conditions of Approval
NH2U	Nambucca Heads to Urunga Pacific Highway Upgrade Project
NSW EPA	NSW Environment Protection Authority
NSW OEH	NSW Office of Environment and Heritage
RMS	NSW Roads and Maritime Services
TA	Translocation Area
TFMP	Threatened Flora Management Plan (Ecos Environmental 2013)
TSC Act	NSW *Threatened Species Conservation Act* 1995

INTRODUCTION

The Nambucca Heads to Urunga Pacific Highway Upgrade Project (NH2U) is a 22-km-long section of the Pacific Highway upgrade on the Mid North Coast of NSW. The NH2U project comprises the northern half of the Warrell Creek to Urunga section of the Pacific Highway upgrade, which is being built in two stages. Mitigation measures employed during the construction of NH2U included *in-situ* protection, or translocation, and monitoring, of populations of the following eight threatened or rare plant species:

Spider Orchid *Dendrobium melaleucaphilum* (Endangered, TSC/BC Act)

Red Bopple Nut *Hicksbeachia pinnatifolia* (Vulnerable, TSC/BC Act & EPBC Act)

Slender Marsdenia *Marsdenia longiloba* (Endangered, TSC/BC Act; Vulnerable, EPBC Act)

Rusty Plum *Niemeyera whitei* (Vulnerable, TSC/BC Act)

Woolls's Tylophora *Tylophora woollsii* (Endangered, TSC/BC Act & EPBC Act).

Koala Bells *Artanema fimbriatum* (unlisted, nationally rare)

Gully Ironbark, Nambucca Ironbark *Eucalyptus ancophila* (unlisted, local endemic species)

Ford's Goodenia *Goodenia fordiana* (unlisted, nationally rare)

In-situ flora populations

One component of the mitigation measures employed on the NH2U project involved the protection and monitoring of *in situ* plants of Spider Orchid, Slender Marsdenia and Gully Ironbark that remain within the NH2U road reserve and were not directly impacted by the project. Baseline data collection, and construction phase monitoring, has been undertaken on 76 Spider Orchid plants, five Slender Marsdenia plants and a single Gully Ironbark (Ecos Environmental 2014, 2016, 2017) which are located at various points in the road reserve along the NH2U route (Figure 1).

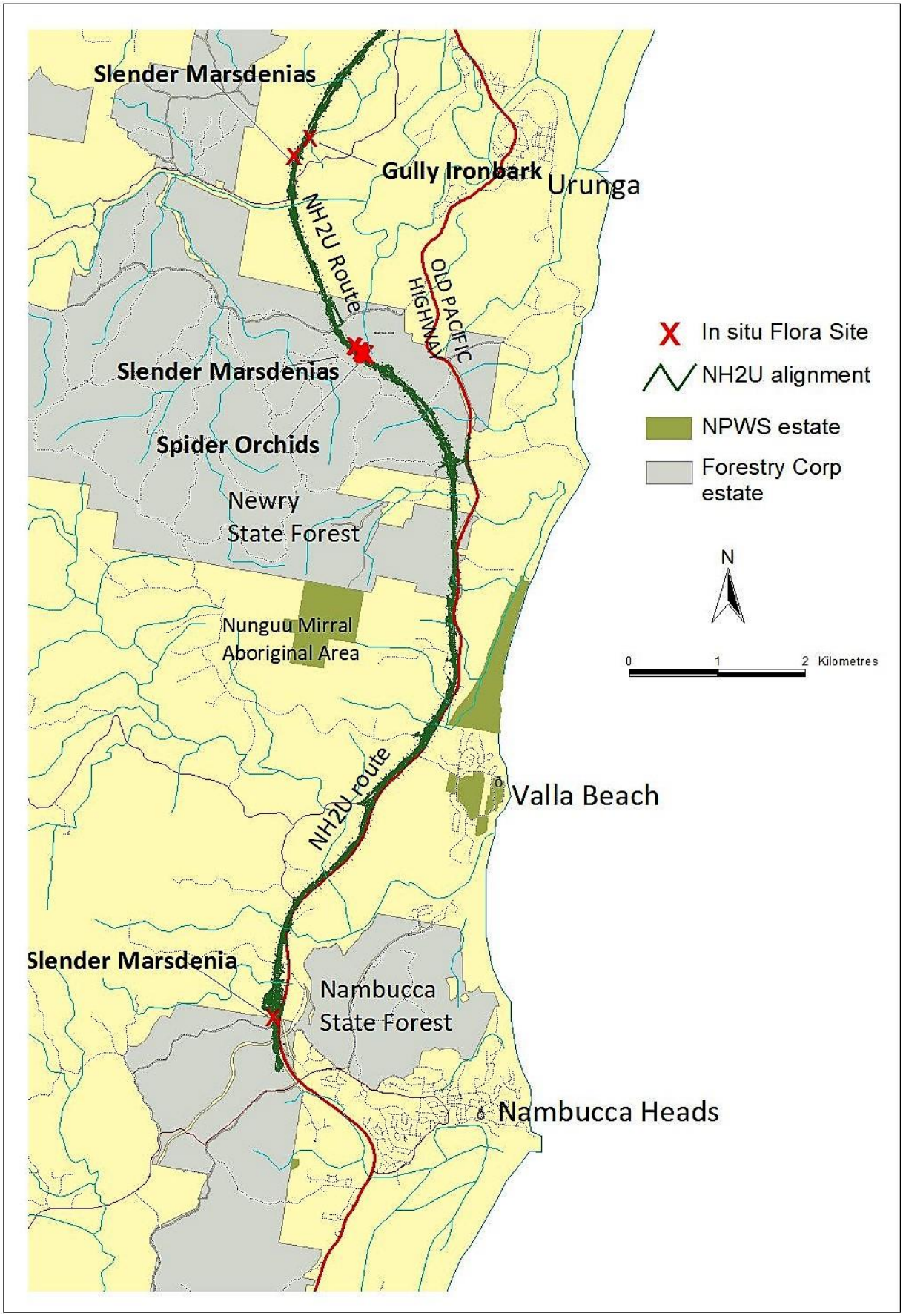

Figure 1: Location of NH2U in-situ threatened or rare flora monitoring sites.

Translocated Flora Species

Where threatened or rare plants were recorded within the NH2U construction footprint and direct impact was unavoidable, a program was developed to guide the translocation and monitoring of Spider Orchid, Red Bopple Nut, Slender Marsdenia, Rusty Plum, Woolls's Tylophora, Koala Bells and Ford's Goodenia from the construction footprint into one of two recipient sites (Translocation Areas, TA1 and TA2) that adjoin the NH2U footprint and are owned and managed by RMS (Figure 2).

The translocations were conducted according to the Warrell Creek to Urunga Threatened Flora Management Plan (TFMP, Ecos Environmental 2013), which was prepared as a condition of approval by the NSW Department of Planning and the Commonwealth Department of Environment.

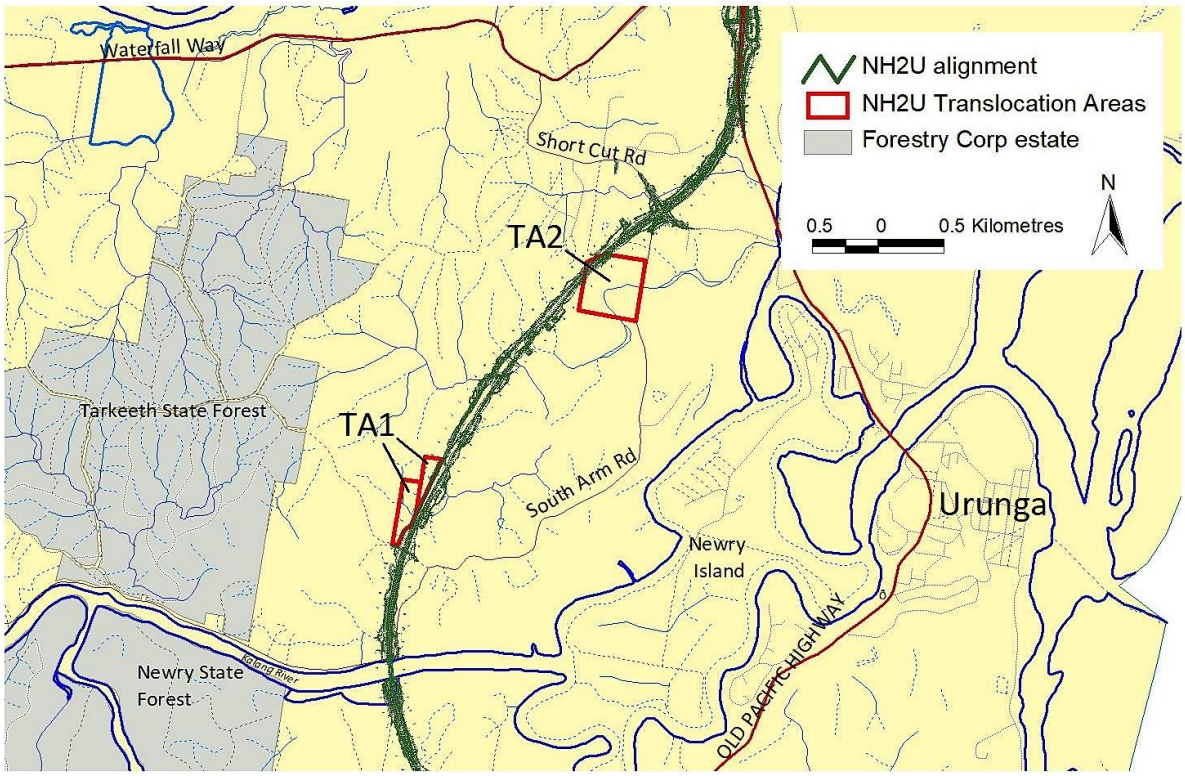

Figure 2: Location of NH2U Translocation Areas (TA1 and TA2).

Translocation methods and planting layout

A thorough, detailed description of the actual salvage and translocation methodology is provided in Ecos Environmental (2013, 2014a, 2016a, 2016b). The summary provided below is also drawn from these Ecos Environmental reports, and explains the source of plant material (transplanted from construction footprint or propagated off-site), whether a slow-release fertiliser was applied, and the location within TA1 or TA2 of the transplants or enhancement plantings.

Translocation Area 1

TA1 was divided into ten sectors (A to J, Figure 3) each receiving one species and different introduction treatments, as described below:

- Transplanted from construction footprint with no addition of fertiliser.

  Sector A Slender Marsdenia

  Sector B Woolls's Tylophora

- Transplanted from construction footprint with no fertiliser except initial watering with seaweed solution.

  Sector C Ford's Goodenia

Sector D Koala Bells

Sector E Rusty Plum

- Propagated vegetatively and planted in experimental grids with and without addition of slow-release fertiliser.

Sector F Slender Marsdenia

Sector G Woolls's Tylophora

Sector I Woolls's Tylophora

- Propagated from seed and planted in an experimental grid with and without addition of slow-release fertiliser.

Sector J Slender Marsdenia

- Transplanted from construction footprint with no fertiliser except initial watering with seaweed solution.

Sector H Red Bopple Nut

Translocation Area 2

TA2 consists of two sectors, for the Spider Orchid and Koala Bells (Figure 4).

- Spider Orchid transplanted from construction footprint, no fertiliser addition – Sector A
- Koala Bells population enhancement, no fertiliser addition – Sector B

Individuals were planted at a regular spacing, with rows about 10m apart and individual plants about 5 metres apart along rows. Where a sector was on a hill slope, grid lines were laid out parallel with the slope contour. This facilitated comparison of species performance in relation to slope position.

Monitoring, to date, has been undertaken for a total of 681 translocated plants (Ecos Environmental 2014, 2016, 2016a) as detailed in Table 1 below.

Table 1:Number and location of translocated plants and enhancement plantings at NH2U Translocation Areas.

Translocation Area (TA)	Species	Sector / Method	Number of plants
TA1	Slender Marsdenia	Sector A – transplants	104
		Sector F – population enhancement (veg) & fertilizer experiment	90
		Sector J – population enhancement (seed) & fertilizer experiment	103
	Woolls's Tylophora	Sector B – transplants	42
		Sector G – population enhancement (veg) & fertilizer experiment	87
		Sector I – population enhancement (veg)	51
	Rusty Plum	Sector E – transplants and population enhancement (seed)	3 trees 40 seeds
	Red Bopple Nut	Sector H - transplant	1
	Koala Bells	Sector D - transplants	35
	Ford's Goodenia	Sector C – transplants	5 patches
TA2	Spider Orchid	Sector A - transplants	55
	Koala Bells	Sector B - population enhancement (veg)	69

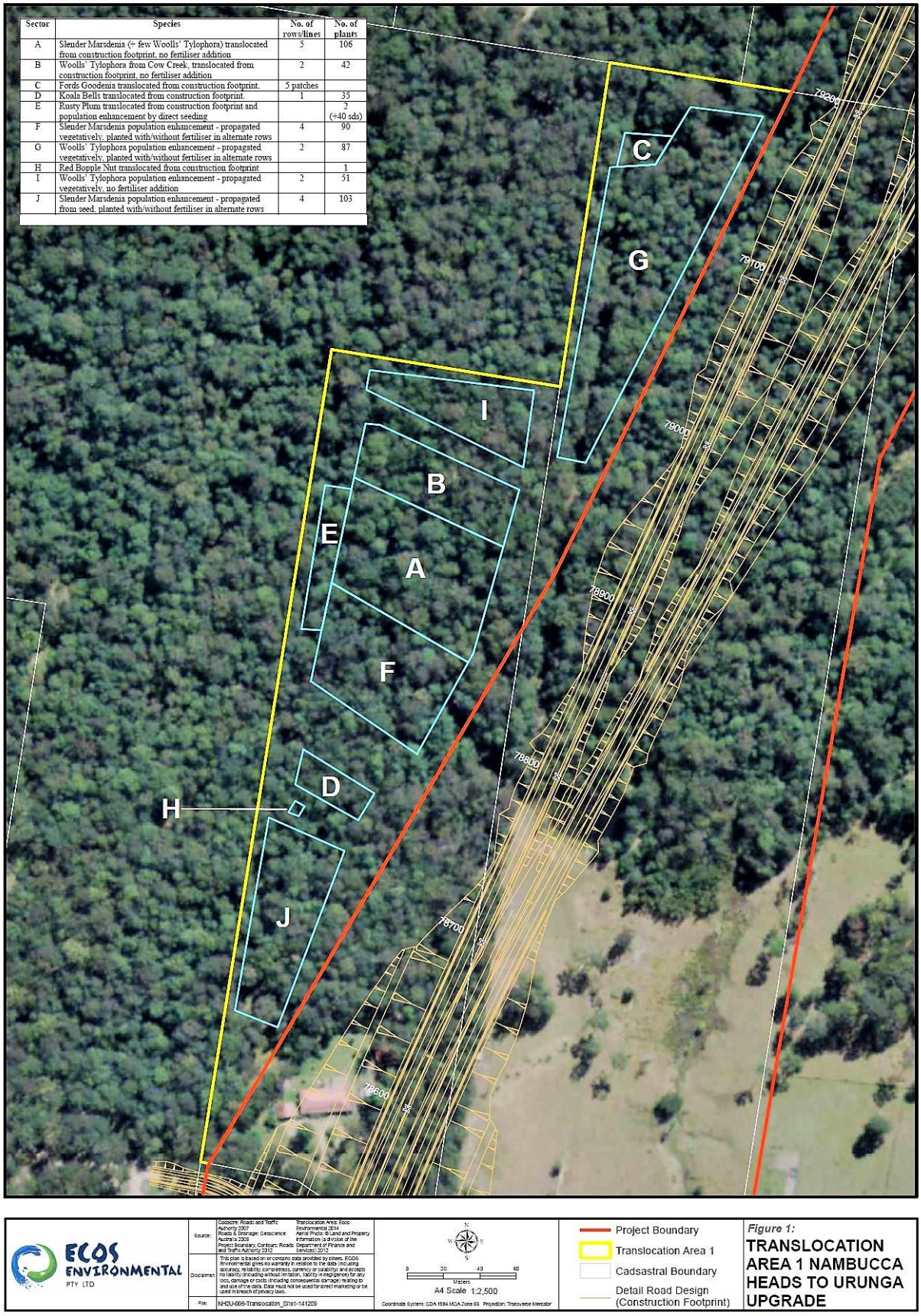

Figure 3: Translocation Area 1 (TA1) showing sectors supporting different species and treatments (from Ecos Environmental 2016a).

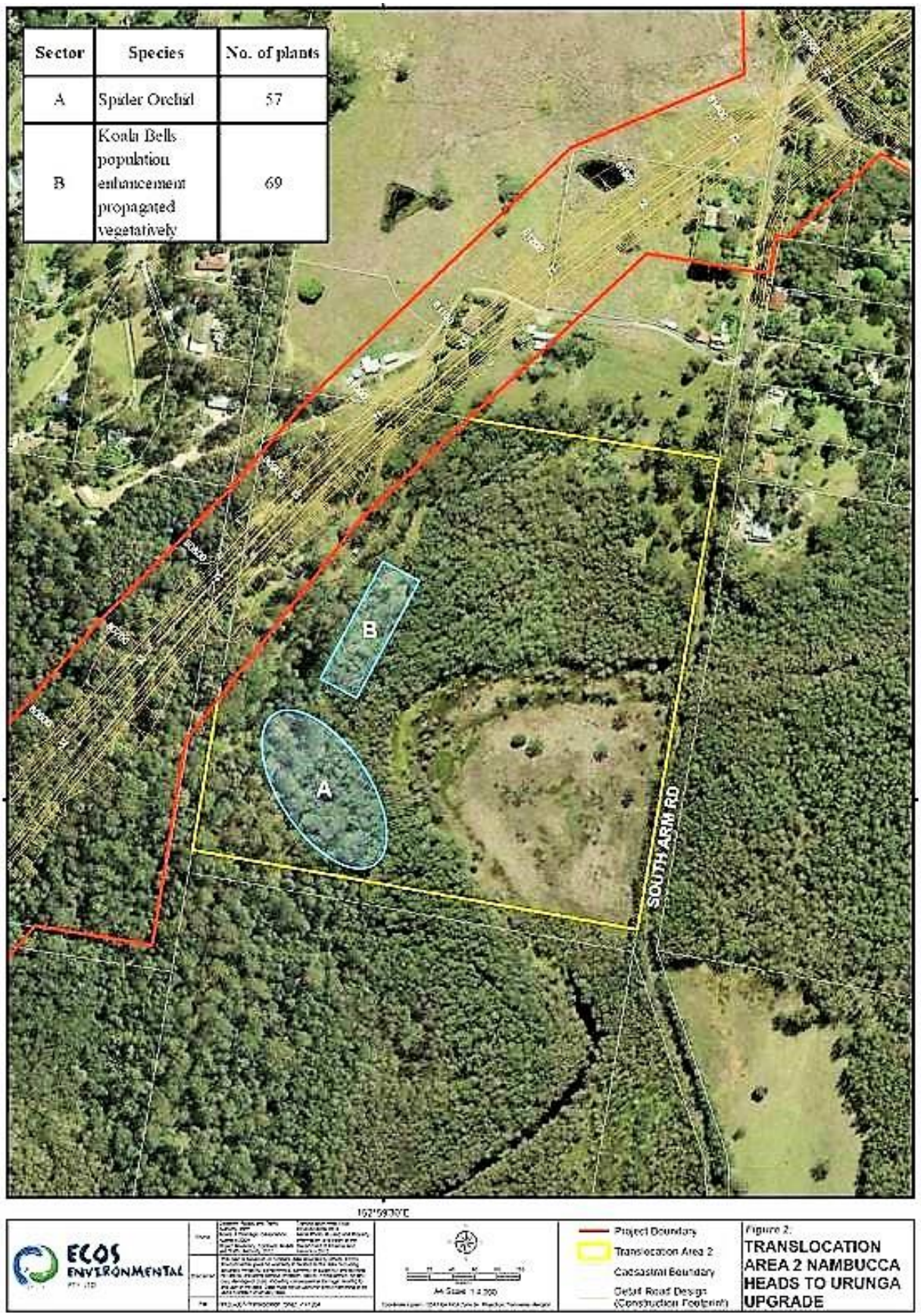

Figure 4: Translocation Area 2 (TA2) showing sectors supporting different species and treatments (from Ecos Environmental 2016a).

Objectives of translocation

The objectives of the translocation project set out in the TFMP are:

- To salvage and re-establish impacted individuals of threatened (TSC/EPBC Act) species.
- To re-establish species at a recipient site near 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 translocation to plants within the highway footprint and construction buffer.

In accordance with the Ministers' Conditions of Approval (MCoA) for the TFMP, an annual monitoring report is to be prepared which addresses the monitoring goals, provides an evaluation of the effectiveness of the mitigation measures against performance indicators, documents any corrective actions implemented, and identifies recommendations for any adaptive management.

Upon completion of the construction phase of the NH2U upgrade, responsibility for operational management passed to the NSW Roads and Maritime Services (RMS). This report describes the results of Year 1 (operational phase) monitoring of *in situ* and translocated flora for the NH2U upgrade. It should be noted that, upon completion of construction phase monitoring of translocated plants, monitoring of those species not listed as threatened under the TSC (BC) Act or the EPBC Act (Koala Bells and Ford's Goodenia) has been discontinued.

MONITORING METHODS

Monitoring of all in-situ and translocated plants was undertaken over October and November 2017.

The following description of the NH2U flora monitoring methodology is adapted from Ecos Environmental (2014 to 2017). During the NH2U construction phase, monitoring of transplants was conducted every 3 months in Year 1, every 6 months in Year 2 and annually in Year 3. Population enhancement individuals were monitored twice in Year 1 thence at the same time as transplanted individuals. Ongoing monitoring during the NH2U operational phase is to be undertaken annually for a minimum five years.

Each transplanted and propagated plant was given a unique identification number which was written on flagging tape and attached to the plant itself, or to its protective wire cage. Transplants were re-located in the field using a hand-held GPS to navigate to a set of coordinates that had been recorded when the plants were introduced to the sites (in some cases coordinates were not available – in such cases a thorough search of the relevant sector was undertaken by the author, and each transplant found had locality coordinates recorded with a GPS unit). Data were recorded as per Section 3.8 of the TFMP, and listed in Table 2 below.

Table 2: Monitoring data recorded for each translocated species.

Data Recorded	Slender Marsdenia	Woolls's Tylophora	Rusty Plum	Red Bopple Nut	Spider Orchid
Monitoring Number	y	y	y	y	y
Date	y	y	y	y	y
Line	y	y	-	-	-
Source Label	y	y	y	-	y
Translocation Label	y	y	y	y	y
Species - Current ID	y	y	-	-	-
Condition Class	y	y	y	y	y
No. leaves	y	y	-	-	
Height (cm)	y	y	y	y	
New Shoots – New Active Growth (Y/N)	y	y	y	y	y
Comment	y	y	y	y	y
No. of pseudobulbs with leaves	-	-	-	-	y
Length of the longest pseudobulb	-	-	-	-	y
Waypoint	y	y	y	y	y
Coordinates	y	y	y	y	y

Condition Class Scores

The key attribute for evaluating species survival and performance was Condition Class, which was scored on a scale of 0 to 5. The scores were defined differently according to plant type, as detailed below in Table 3, Table 4 and Table 5.

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

Score	Condition
0	dead
1	stem died back to ground, no leaves or green stem, live stem stub may be present
2	plant < 75 cm tall; stem with leaves, with or without new shoots (active growth), or green leafless stem
3	plant > 75 cm tall, stem with leaves, with or without new shoots (active growth), if green leafless stem <1m or leaves discoloured score as 2
4	plant > 1.5m tall with > 15 leaves, mature or nearing maturity
5	plant flowering or seeding

Table 4: Condition scores applied to Rusty Plum and Red Bopple Nut.

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

Data Analysis

Monitoring data were stored and processed in Excel™ spreadsheets.

Species survival rate was calculated as:

(no. of individuals in condition classes 2+3+4+5/total no. plants) X 100

Species 'thrival' rate (a term used by Ecos Environmental to describe the general trend in vigour of plants in individual sectors or subject to different treatments) was calculated as:

(number of individuals in condition classes 3+4+5/total no. plants) X 100

The thrival rate provides, according to Ecos Environmental (2016a) a better indication of the percentage of plants likely to reach reproductive maturity. Mean plant 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 plants in condition classes 2 to 5).

RESULTS - *IN-SITU* FLORA MONITORING

APPENDIX 1: **Monitoring Results – all *in situ* flora March 201** provides full details of the results of the NH2U Year 1 October 2017 monitoring of all *in situ* flora. A summary of these results is provided below.

Spider Orchid

The rate of survival of Spider Orchid decreased to 88% compared to the previous survey in February 2017. Several host plants could not be found, and some individual orchids had died, bringing the total number of losses or mortalities over four years to nine plants from the original 76. Some orchid plants bore old inflorescence axes, indicating that they had flowered earlier in the spring of 2017. No seed pods were recorded during the current survey.

Some of the attributes summarised in Table 6 below suggest a general decline in plant condition:

- Survival rate decreased, and
- Mean length of the longest pseudobulb per plant decreased.

However, other measured attributes (Table 6) indicate an improvement in plant condition:

- Mean number of pseudobulbs with leaves per plant increased.
- Percentage of plants showing an increase in number of pseudobulbs with leaves increased compared to last survey.
- The number of plants showing new shoot growth increased markedly.

This apparent anomaly in results may be due to two reasons. Firstly, because this is the author's first survey of the NH2U threatened flora sites, it is likely that plants that were not re-located during this survey are still present and alive, and may well be re-located next season. Secondly, the method employed to measure pseudobulb length may differ to that used by Ecos Environmental. It was

noticed that pseudobulb measurements taken during this current survey were generally shorter than those recorded by Ecos Environmental.

Considering the above factors, the overall trend in the *in-situ* Spider Orchid population indicates an improvement in plant condition, with a median condition class score of 3. This result is surprising, as the past year was characterised by long periods of below average rainfall, including a very severe winter-spring drought during which almost no rain was recorded between the end of June and the end of August 2017.

Table 6: Summary of monitoring results for in-situ Spider Orchids.

Attribute	Dec 2014	Feb 2016	Feb 2017	Oct 2017
No. plant points (host stems with orchids)	41	41	41	36
Total number of living orchid plants (n)	76	75	72	67
% survival	100%	98.7%	96.1%	88%
Median condition class of plants				3
Mean length of longest pseudobulb	5.27±0.86	6.46±0.85	5.92±0.34	4.2±4.1
Mean number of pseudobulbs with leaves per plant	2.46±0.43	2.92±0.19	2.46±0.19	3.4±1.8
% of plants with active new shoot growth	4.8%	15.2%	2.5%	60%
Change in number of pseudobulbs with leaves per plant relative to the year before (*note – Oct 2017 result includes plants not found*)		dead – 1%; decrease – 10%; increase – 59%; same – 29%	dead – 2.4%; decrease – 24.4%; increase – 24.4%; same – 48.7%	Dead / not found – 14%; decrease – 21%; increase – 41%; same – 24%

Slender Marsdenia

Of the five in-situ *Slender Marsdenia plants being monitored, two had died back, and the remaining sites sites supported relatively healthy plants, with a median condition class of 2. Sites UTW3 and UTW4 each had three each had three plants recorded close to the flagged survey point. It is uncertain if all plants were present during present during past surveys, or if new plants have recruited into the sites, as only single plants had been previously been previously recorded at these sites. Nonetheless, all plants were recorded as being in reasonable health (health (*

Figure 5).

Figure 5: In-situ Slender Marsdenia at site UTW4 in Oct 2017.

Gully Ironbark

The very large Gully Ironbark, which occurs on a drainage line in the NH2U road reserve directly opposite TA1, was observed to be in good health, with new growth on some limbs. As this specimen is a very old tree, the crown inevitably displays some signs of senescence (Figure 6).

Figure 6: The very large, old Gully Ironbark opposite TA1. Note numerous old Yellow-bellied Glider feeding scars on the trunk.

RESULTS - TRANSLOCATED FLORA MONITORING

Full details of the results of the current season's monitoring of all translocated threatened plants, including all data collected in the field, is provided as an Excel™ workbook which accompanies this report.

Ecos Environmental (2016a) reported the results of a comparison of the performance of fertilised *versus* non-fertilised Slender Marsdenia and Woolls's Tylophora transplants, and survival and mean plant height between transplants that had been planted along different contour lines in each sector (ie, a habitat preference trial). No significant difference in condition, height or survival between fertilised and non-fertilised plants was recorded, nor was any significant difference detected in the performance of transplants grown along different contour lines, from years 1 to 3. Considering these findings by Ecos Environmental, the fertiliser and habitat experiments will not be assessed or reported on in this and future monitoring reports, as 1) the fertiliser applied to plants would, by now, be depleted, and 2) results to date indicate that the transplants are located within habitat of uniform quality for the two subject vine species.

Slender Marsdenia

Slender Marsdenia was planted in three sectors in TA1:

- Sector A - Directly transplanted from construction footprint with no fertiliser.
- Sector F - Propagated vegetatively and introduced with and without fertiliser.
- Sector J - Propagated from seed and introduced with and without fertiliser.

Sector A

Survival rate for all plants in Sector A was 40% after four years, a significant decrease on the previous year (69%) and probably attributable to the extremely dry winter-spring conditions of 2017. Mean plant height decreased slightly, but not significantly, from 39.9cm to 36.3cm. 62 plants had died back (58.5%), and two plants could not be found and have possibly been lost under tree-fall debris. These results are summarised in Table 7 below.

After four years the 'thrival rate' of Slender Marsdenia in Sector A was 21% (22 plants out of 106 with a Condition Class score of 3, 4 or 5), which compares favourably to previous results. 16 of these plants were more than one metre in height. Two plants, Nos. 30b and 54, were in flower at the time of survey (title page, top image). The percentage of plants with active shoot growth in October 2017 was 35%.

Table 7: Slender Marsdenia in TA1 Sector A - mean height in centimetres and percent survival of transplants.

All plants n = 106	Mar 2014	Dec 2014	Jan 2016	Nov 2016	Oct 2017
Mean height (cm)	36.25	36.25	42.38	39.97	36.3
Survival %	90.5	87.6	71.2	67.9	40

Sector F

The survival rate of all plants in Sector F was 61.1%, a small decrease on the previous survey but significantly higher than the Sector A transplant survival rate. Mean plant height was 52.4cm, a small decrease on the previous survey (Table 8).

The thrival rate after 4 years was 33.3%, higher than the Sector A transplants and comparable to the Sector J seedlings (see below). 21 plants with a condition class score of 3 or more were more than one metre in height. No plants were in bud, or flowering, at the time of the current survey.

Table 8: Slender Marsdenia in TA1 Sector F - mean height in centimetres and percent survival of transplants.

All plants n = 90	Jul 2014	Jan 2016	Nov 2016	Oct 2017
Mean height (cm)	21.04	68.50	55.89	52.44
Survival %	83.63	77.1	66.75	61.1

Sector J

Propagated seedlings of Slender Marsdenia were planted in Sector J in August 2014. Previous monitoring reports described the faster early growth of seedlings compared to transplanted individuals (Ecos Environmental 2014a). Results from the current survey reveal a significant decrease in survival rate (from 82.5% to 54.39%) and mean plant height (64.19cm to 54.61cm) since the last monitoring survey (Table 9).

After 4 years the thrival rate of Slender Marsdenia in Sector J was 32.04%, about 50% better than the thrival rate of transplants in Sector A (21%). 28 of these plants were more than one metre in height and the tallest plant was 3 metres. No plants were in flower.

Table 9: Slender Marsdenia in TA1 Sector J - mean height in centimetres and percent survival of transplants.

All plants n = 103	Dec 2014	Jan 2016	Nov 2016	Oct 2017
Mean height (cm)	46.75	69.15	64.19	54.61
Survival %	92.2	86.4	82.5	54.39

Woolls's Tylophora

The Tylophora from Cow Creek (tentatively identified by the National Herbarium of NSW as Woolls's Tylophora *T. woollsii*, and treated as such pending confirmation of identity) was translocated to TA1 into:

- Sector B - Directly transplanted from the construction footprint with no fertiliser.
- Sector G - Propagated vegetatively and introduced with and without fertiliser.
- Sector I - Propagated vegetatively and introduced without fertiliser.

Sector B

Mean survival rate for all plants in Sector B for the current survey was 14.29% (6 plants of 42), a significant decrease from the previous year and showing a continuing trend of decline in condition of plants in this sector. Mean plant height also decreased significantly to 4.88cm (Table 10).

The strongest indicator of the poor state of plants in this sector is the current thrival rate of 0%. No plants were assessed as condition class 3 or better, down from 3 plants recorded as such during the previous survey. As suggested by Ecos Environmental (2016a), the recipient site is on a hill crest and is much drier and more exposed than other sectors. Numerous plants of Milky Silkpod *Parsonsia dorrigoensis*, a distantly-related vine species, were observed in Sector B, indicating different habitat conditions to those normally equated with the presence of Woolls's Tylophora and Slender Marsdenia.

Table 10: Woolls's Tylophora in TA1 Sector B - mean height in centimetres and percent survival of transplants.

All plants n = 42	Mar 2014	Dec 2014	Jan 2016	Nov 2016	Oct 2017
Mean height (cm)	76.31	38.84	34.07	11.73	4.88
Survival %	90.5	80	73.8	31	14.29

Sector G

Mean survival rate for all plants in Sector G was 26.1%, a significant decrease from the previous survey, and mirroring the decline recorded in plants in Sector B. Mean plant height also decreased to 18.81cm (Table 11). The better survival rate in this sector probably reflects the less exposed position of Sector G compared to Sector B.

Thrival rate was better in Sector G compared to Sector B, but still poor, with 12 plants (13.64%) in condition class 3 or better. Of those 12 plants, 4 were more than one metre high. All living plants with aerial stems in this sector were noted as looking very similar, in the author's opinion, to *Tylophora paniculata* rather than *T. woollsii*.

Table 11: Woolls's Tylophora in TA1 Sector G - mean height in centimetres and percent survival of transplants.

All plants n = 88	Aug 2014	Jan 2016	Nov 2016	Oct 2017
Mean height (cm)	49.98	43.04	32.6	18.81
Survival %	95.4	56.3	48.3	26.1

Sector I

Mean survival rate for all plants in Sector I was 15.7%, a decrease from the previous survey, and following the trend of continual decline over time displayed by all Woolls's Tylophora transplants in TA1. Mean height also decreased to 12.94cm, down from 16.14cm recorded in the previous survey (Table 12).

Thrival rate for plants in Sector I was 9.8% (5 plants of 51, three of which were over a metre high). Again, all plants with aerial stems were noted during the current survey as looking more like *T. paniculata* than *T. woollsii*.

Table 12: Woolls's Tylophora in TA1 Sector I - mean height in centimetres and percent survival of transplants.

All plants n = 51	Dec 2014	Jan 2016	Nov 2016	Nov 2017
Mean height (cm)	70.41	36.68	16.14	12.94
Survival %	86.3	47.7	21.6	15.7

Identity of Tylophora transplants in TA1

During this current monitoring program, the author corresponded with Dr Andrew Benwell of Ecos Environmental, who undertook the NH2U flora translocation project, designed and instigated the monitoring program, and wrote all the Ecos Environmental reports cited herein. Dr Benwell advised (pers. comm. Oct 2017) that he retained some material of the Cow Creek Woolls's Tylophora plants in pots. These plants had recently flowered and are in fact *Tylophora paniculata*, a reasonably common species which is not listed as rare or threatened. This finding confirms the author's field observations of the transplants in Sectors G and I.

This outcome means that ongoing monitoring of Sectors G and I is probably no longer warranted. Sector B, on the other hand, should continue to be monitored as the identity of transplanted vines there is not clear.

Rusty Plum

Translocated Rusty Plums

Two small Rusty Plum trees (4-8m high) were transplanted into Sector E in TA1. One tree had split and was separated into two pieces (plants 1 and 2) before planting. The other tree (plant 3) was pruned back to remove most of the branch system before being transplanted.

The current survey revealed a survival rate of 67%. Plant 1 bore a healthy, basal stem shoot which had doubled in size from the previous survey in November 2016. Plant 2 appeared to be dead, and Plant 3 was in excellent health with a flush of new growth (Figure 7).

Figure 7: Rusty Plum transplanted tree No. 3 in good health with new growth.

Rusty Plum enhancement plantings

Ecos Environmental (2016a) noted that most of the 40 Rusty Plum seeds planted directly into 20 points within Sector E of TA1 had germinated, but no protective wire cages were installed, resulting in heavy losses to browsing by wallabies and possums. Ten of the direct seeded points (50%) had live Rusty Plum seedlings in January 2016. This number had decreased to six (30%) by Nov 2016. During the current survey, only three points with Rusty Plum seedlings were recorded, a survival rate of 15%.

This decline in seedling numbers serves to highlight the importance of installing protective cages around seedlings. The author's experience with monitoring both direct-seeded and seedling Rusty Plums in a receival site as part of the Sapphire to Woolgoolga Pacific Highway Upgrade (Richards 2016) showed that, with protective cages in place, survival after 5 years was 51% and 65% respectively.

Red Bopple Nut

A single Red Bopple Nut tree was transplanted to Sector H in TA1. The tree was recorded in excellent condition during the current survey. It bore numerous inflorescences (title page, bottom image), although no fruit-set was observed at the time of the survey.

Spider Orchid

Six of the original Spider Orchid transplants were stolen from TA2 just after translocation had occurred, leaving 60 plants at the recipient site (Ecos Environmental 2016a). The rate of survival of transplanted Spider Orchids, based on the results of the current monitoring survey, indicates a decline to 78.3% survival, compared to previous survey results which reported over 90% survival (Table 13). This figure may underestimate actual survival, as 10 plants were not able to be re-located in October 2017. The recipient site was flooded after heavy rains when the current survey took place, making access difficult. It is therefore probable that some of the plants listed as missing will be re-located during the next survey.

Apart from the apparent decline in survival rate, other results showed an improvement in the population, including a small increase in the mean number of pseudobulbs with leaves per plant, and a significant jump in the number of plants bearing new shoots. Offsetting these increases, however, was a decline in mean length of the longest pseudobulb. As mentioned previously, in the results of the *in-situ* Spider Orchid monitoring, it appears that this may be due to differing methods of measuring pseudobulb length between report authors.

Median condition class of the translocated Spider Orchids was 2, which is the same as the previous survey. Several old inflorescence axes were observed during the current survey, but no evidence of fruit production was recorded.

Table 13: Summary of monitoring results for Spider Orchid transplants at TA2.

Attribute	Mar 2014	Dec 2014	Jan 2016	Nov 2016	Oct 2017
Mean length of the longest pseudobulb (cm)	8.22	8.22	8.56	8.56	6.55
Mean number of pseudobulbs with leaves	1.95	1.73	2.40	2.40	2.43
Number of plants with new shoots (pseudobulbs)	1	6	10	10	15
Survival (%, n=60)	96.4	92.7	94.6	94.6	78.3

DISCUSSION

In accordance with the MCoA of the NH2U TFMP (Ecos Environmental 2013), each annual monitoring report must include an assessment of the success or failure of protective measures for *in-situ* threatened flora, and an assessment of the success or failure of the threatened flora translocation program (salvage translocation and population enhancement measures). These assessments are provided below. The MCoA also requires a recommended work plan for the next 12 months. This, too, is provided below.

Evaluation of *in-situ* Flora Management

The following performance indicators are used to evaluate the success of protective measures for *in-situ* threatened flora:

a) The survival rate of *in-situ* threatened flora at the finish of clearing is 100%. No accidental damage occurs during clearing;
b) The survival rate of *in-situ* threatened flora at the end of years 1-3 of the monitoring program is at least 80% and at least 70% at the end of years 4-8;
c) Of plants surviving at the end of each year, at least 75% are in good condition – i.e. they have healthy foliage, no sign of die-back or disease and exhibit new shoot growth (Condition Class 3 or better).

Table 14 below summarises how the above performance indicators have been met to date.

Table 14: Evaluation of performance indicators for in-situ flora.

Species	100% survival rate at the finish of clearing. No accidental damage during clearing	80% survival rate at the end of years 1-3 and at least 70% at the end of years 4-8	At least 75% of surviving plants are in good condition at each year end (Condition Class 3 or higher)	Performance indicators met?
Spider Orchid	Y	Y (98.7% and 88%)	N (64%)	2 of 3
Slender Marsdenia	Y	Y (100% and 100%)	N (20%)	2 of 3
Gully Ironbark	Y	Y	Y	3 of 3

Spider Orchid

The current level of survival of *in-situ* Spider Orchids is the only performance indicator that has not been met to date. As noted previously, this may well be because not all surviving plants were located by the author during the current survey, as he is yet to become familiar with the sites and the location of all monitored plants. It is probable that surviving plants which were overlooked this season will be re-located in the next survey.

Slender Marsdenia

Note that in the above Table 14, a question mark precedes the survival rate for Slender Marsdenia in the current survey. This is because the aerial stems of plants that have been assigned a Condition Class of 1 have died back. These plants cannot be considered to have died, as a dormant but living subterranean rhizome usually persists. Slender Marsdenia generally displays a seasonal growth pattern of stem dieback and resprouting, with stems dying back in response to the winter-spring drought experienced in this region. Resprouting may occur annually or it may not occur for several years, after which a new shoot can arise from the dormant stem base or rhizome. Taking this characteristic into account, survival of *in-situ* Slender Marsdenia plants to date is 100%. However, general condition class is low, possibly because of the severe drought over winter and spring of 2017.

Evaluation of Flora Translocation Program

The following performance indicators are used to evaluate the success of the threatened species translocations (salvage translocation and population enhancement):

a) All directly impacted individuals of threatened species were salvaged and relocated to the receival sites.
b) At least 60% of transplant and enhancement individuals are surviving after the first year, 50% after five years and 40% after eight years.
c) At the end of the monitoring program (8 years), at least 50% of surviving individuals have a Condition Class of 3 or higher.

Table 15 below summarises how the above performance indicators have been met to date.

Table 15: Evaluation of performance indicators for translocated flora.

Species	All directly impacted individuals of threatened species were salvaged and relocated to the receival site(s).	At least 60% of transplant and enhancement individuals are surviving after the first year, 50% after five years and 40% after eight years	At the end of the monitoring program (8 years), at least 50% of surviving individuals have a Condition Class of 3 or higher.	Performance indicators met?
Slender Marsdenia	Y	Y, n/a, n/a	n/a	2 of 3 to date
Woolls's Tylophora	Y	Y, n/a, n/a	n/a	2 of 3 to date
Rusty Plum	Y	Y, n/a, n/a	n/a	2 of 3 to date
Red Bopple Nut	Y	Y, n/a, n/a	n/a	2 of 3 to date
Spider Orchid	Y	Y, n/a, n/a	n/a	2 of 3 to date

It is clear from Table 15 above that the performance indicators are designed to provide an assessment of translocation success mainly for the latter half of the program (years 5 to 8). Because of this, little can be gleaned from this current assessment, apart from some specific comments below.

Slender Marsdenia

The current (Year 4) mean survival rate of all Slender Marsdenia plants stands at 51.8%. Based on the author's knowledge of other translocations of this species, this is a comparatively good result. However, successful achievement of the performance indicators for this species is most likely as dependant on climatic factors as much as anything else. Should the region experience a severe winter-spring drought like the 2017 episode, then the survival rate of Slender Marsdenia transplants would be expected to decline as more plants die back in response to dry conditions. On the other hand, should milder conditions prevail then significantly more Slender Marsdenia plants might be expected to produce aerial shoots and be in better overall condition.

Woolls's Tylophora

The current (Year 4) mean survival rate of all Woolls's Tylophora (now known to be mostly *T. paniculata*) stands at 18.7%, with a correspondingly low median condition class score of 1. If this low survival and condition persists, then the translocation of this species will have failed all survival and condition class performance indicators. It is of interest to note the poor translocation performance of what has turned out to be a quite common species.

Rusty Plum

Because all Rusty Plum transplants and half the Rusty Plum enhancement plantings survived through Year 1, at present Rusty Plum meets relevant performance criteria. As at Year 4, Rusty Plum transplant survival is 67%, which, if maintained, will meet ongoing performance criteria. However, the enhancement planting survival rate is currently only 15%, which equates to failure of performance criteria for Year 5, should these rates continue. This failure in performance of Rusty Plum is largely due to easily preventable browsing of enhancement plantings by wildlife. Replenishing the enhancement plantings via direct seeding and installation of tree protectors would most likely reinstate the success of the Rusty Plum plantings.

Spider Orchid

The current (Year 4) survival rate of 78.3% is probably an underestimate of the actual rate of survival of Spider Orchid plants at TA2, as explained above. Overall, the translocation of Spider Orchid plants has been successful, and it is expected that performance indicators will be met in the future for this species.

RECOMMENDED 12 MONTH WORK PLAN.

The following actions are recommended here with the aim of achieving the principle objectives and performance indicators of the TFMP for *in-situ* and translocated flora.

1. Discontinue monitoring of *Tylophora paniculata* plants in Sectors G and I in TA1.
2. Direct seed additional Rusty Plum seeds to replace those lost through browsing by wildlife. It is recommended that an additional 40 Rusty Plum seeds be direct-seeded into Sector E in TA1. The heavy mortality reported for Rusty Plum enhancement plantings should be rectified to ensure that performance indicators for this species are met in the future.
3. Install protective cages on all new and surviving Rusty Plum enhancement plantings. Robust, plastic mesh tree guards, 1 metre high and about 50cm wide, were installed on Rusty Plum seedlings at a translocation site for the Sapphire to Woolgoolga Highway Upgrade (Richards 2016). These guards had an immediately beneficial effect on the seedlings, with immediate cessation of browsing and a corresponding improvement in plant condition.

REFERENCES

ECOS Environmental. 2013. Warrell Creek to Urunga Upgrade Threatened Flora Management Plan. Report prepared for NSW Roads and Maritime Services, Grafton.

ECOS Environmental. 2014. Nambucca Heads to Urunga Pacific Highway Upgrade - Monitoring of In-situ Roadside Threatened Plants - Summary for Year 1 (December 2013 to December 2014). Report prepared for Lend Lease Infrastructure.

ECOS Environmental Pty Ltd. 2014a. Nambucca Heads to Urunga Upgrade of the Pacific Highway Threatened Flora Translocation Project - Annual Monitoring Report Year 1 December 2014. Report prepared for Lend Lease Infrastructure.

ECOS Environmental Pty Ltd. 2016. Nambucca Heads to Urunga Upgrade of the Pacific Highway Monitoring of In-situ Roadside Threatened Plants - Summary for Year 2 (December 2014 to February 2016). Report prepared for Lend Lease Infrastructure.

ECOS Environmental Pty Ltd. 2016a. Nambucca Heads to Urunga Upgrade of the Pacific Highway Threatened Flora Translocation Project - Annual Monitoring Report (Year 2) February 2016. Report prepared for Lend Lease Infrastructure.

ECOS Environmental Pty Ltd. 2016b. Nambucca Heads to Urunga Upgrade of the Pacific Highway Threatened Flora Translocation Project - Annual Monitoring Report (Year 3) December 2016. Report prepared for Lend Lease Infrastructure.

ECOS Environmental Pty Ltd. 2017. Nambucca Heads to Urunga Pacific Highway Upgrade - Monitoring of In-situ Roadside Threatened Plants - Year 3 (December 2014 to February 2017) Results

Richards, P. 2016. Pacific Highway Sapphire to Woolgoolga Upgrade Threatened Flora Monitoring Annual Report 5. Final report prepared for NSW Roads and Maritime Services.

APPENDIX 1: Monitoring Results – all *in situ* flora March 2017

Spider Orchid

Monitoring No.	Date	Number of plants	Condition Class	Number of pseudobulbs	No. of pseudobulbs with leaves	No. of pseudobulbs with leaves previous survey	Length of the longest pseudobulb overall (cm)	New growth	Comment	pb change Feb 2017 to Oct 2017
so-59	16/10/2017	1	1	3	1	1	1	n	On Grey Gum sapling. Will vanish when bark shed.	same
so-61	16/10/2017	2	2	8	1	1	1.5	n		same
	16/10/2017		2	4	1	1	1	n		same
A	16/10/2017	0	0			2		o	Not found	-
so-39	16/10/2017	2	1	4	0	4	10	n	Both look dead, but pb still green on L plant	decrease
	16/10/2017		1	3	0	4	3	n		decrease
so-41	16/10/2017	4	3	8	4	3	19	y	Top of host stem with 2 plants on it has broken off	increase
	16/10/2017		3	9	4	3	16	y		increase
	16/10/2017		3	4	2	2	1.5	n		same
	16/10/2017		3	8	6	4	2.5	n		increase
so-40	16/10/2017	2	3	14	11	10	6.5	y	3 plants present, lowest 2 monitored	increase
	16/10/2017		3	8	7	6	3	y		increase
so-69	16/10/2017	3	3	6	4	2	2.5	y		increase
	16/10/2017		3	9	3	2	4	y		increase
	16/10/2017		3	6	5	2	1.5	y		increase
so-70	16/10/2017	1	1	8	1	2	2	y		decrease
B	16/10/2017	2	3	9	4	3	2.5	y		increase
	16/10/2017		3	5	3	3	1.5	y		same
C	16/10/2017	1	2	5	3	1	1.5	n		increase
D	16/10/2017	0	0			0		o	dead	-
so-71	16/10/2017	4	0					o	dead	-
	16/10/2017		1	2	2	1	1	y		decrease
	16/10/2017		1	2	2	1	1	y		decrease
	16/10/2017		1	3	2	1	1	y		decrease

Monitoring No.	Date	Number of plants	Condition Class	Number of pseudobulbs	No. of pseudobulbs with leaves	No. of pseudobulbs with leaves previous survey	Length of the longest pseudobulb overall (cm)	New growth	Comment	pb change Feb 2017 to Oct 2017
so-72	16/10/2017	6	2	5 (largest)	4	3	4.5	n		increase
	16/10/2017		2					n		-
	16/10/2017		1					n		-
	16/10/2017		2					n		-
	16/10/2017		2					n		-
	16/10/2017		3					y		-
F	16/10/2017	3	3	10	3	3	4.5	y		same
	16/10/2017		3	5	3	4	5	n		decrease
	16/10/2017		3	4	4	4	19	n		same
G	16/10/2017	1	3	5	2	2	1.5	y		same
H	16/10/2017	2	2	4	1	5	1.5	y		decrease
	16/10/2017		3	8	2	2	5	n		same
M	16/10/2017	0	0					o	not found	-
N	16/10/2017	1	3	5	4	3	4	y	host tree has snapped below orchid	increase
so-27	16/10/2017	3	2	7	3	1	2	y		increase
	16/10/2017		2	8	6	1	1	y		increase
	16/10/2017		2	4	2	4	1	y		decrease
so-26	16/10/2017	1	3	6	5	4	2.5	y	3 plants on tree	increase
so-22	16/10/2017	1	2	14	8	6	1	y	many tiny Pbs at base with leaves	increase
O	16/10/2017	2	3	5	5	3	1	y	1 plant either side of flagging. 1 more plant further up.	increase
	16/10/2017		3	6	6	5	6	y		increase
P	16/10/2017	1	3	5	4	2	2	y	1 other plant high up on tree	increase
Q	16/10/2017	1	3	8	6	7	1.5	y		decrease
so-21	16/10/2017	1	3	8	1	4	8	y	One new Pb, but in poor health	decrease
R	16/10/2017	2	2	5	5	4	2	n	Both plants just hanging on by roots to loose bark	increase
	16/10/2017		2	4	3	3	3	n		same
so-19	16/10/2017	0	0					o	not found	-
so-17	16/10/2017	0	0					o	not found	-
so-16	16/10/2017	1	2	3	2	3	4	n	On broken stem	decrease
so-15	16/10/2017	3	3	5	1	4	1	y		decrease

Monitoring No.	Date	Number of plants	Condition Class	Number of pseudobulbs	No. of pseudobulbs with leaves	No. of pseudobulbs with leaves previous survey	Length of the longest pseudobulb overall (cm)	New growth	Comment	pb change Feb 2017 to Oct 2017
	16/10/2017		3	5	3	3	2.5	n		same
	16/10/2017		2	6	5	2	1	n		increase
S	16/10/2017	3	3	7	3	3	3	n		same
	16/10/2017		2	4	3	3	1	n		same
	16/10/2017		3	5	4	3	1.5	n		increase
so-14	16/10/2017	1	3	7	3	2,2	5	y	One plant gone. Top of host stem snapped off.	increase
so-12	16/10/2017	2	3	4	4	2	1	y		increase
	16/10/2017		1	6	0	5	1	y		decrease
so-10	16/10/2017	1	3	9	5	3	3	y		increase
so-11	16/10/2017	2	3	5	4	4	3	y		same
	16/10/2017		3		5	5	3	y		same
so-6	16/10/2017	2	3	3	3	2	1.5	y		increase
	16/10/2017		3	5	3	3	5	y		same
so-5	16/10/2017	1	3	8	3	1	3	y		increase
so-4	16/10/2017	1	3	6	3	5	1.5	y		decrease
so-7	16/10/2017	2	3	4	3	2	1.5	y		increase
	16/10/2017		3	6	3	1	1.5	y		increase
so-8	16/10/2017	3	3	7	2	5	2	y		decrease
	16/10/2017		3	7	4	4	3	y		same
	16/10/2017		3	6	3	3	2	y		same
so-9	16/10/2017	2	3	7	3	1	1	y	tiny plants	increase
	16/10/2017		2	3	2	1	1	y		increase

Note: where more than one plant occurs, the lowest plant is recorded first and the highest plant last. If score is the same for all plants, then only one score is recorded. Some scores are given only for the largest of multiple plants.

Slender Marsdenia and Gully Ironbark

Label	Species	Chainage	Date	Condition Class	Height (m)	New shoots	Comment
ML 119	Slender Marsdenia	62100	11/10/2017	1			Died back. Only dead stems found along barbed wire fence.
ML 2010-1	Slender Marsdenia	75000	11/10/2017	2	0.4	Y	Plant 1m downhill from flagged shrub. Good health.
ML 2010-3	Slender Marsdenia	75000	11/10/2017	1			Died back.
UTW3	Slender Marsdenia	78450	11/10/2017	2	.2; .8; .1	Y; N; N	3 plants in an uphill to downhill line. All scrambling in litter
UTW4	Slender Marsdenia	78450	11/10/2017	3	.8; .7; .1	Y; Y; N	
EA	Gully Ironbark	78850	11/10/2017	3		Y	OK