Woolgoolga to Ballina Pacific Highway upgrade

Threatened Flora Translocation Project (Section 1-11)

Annual Monitoring Report (2019)

NSW GOVERNMENT

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Woolgoolga to Ballina Threatened Flora Translocation Project (Sections 1-11)

Annual Monitoring Report 2019

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Executive Summary

This annual monitoring report describes the implementation and results of threatened flora translocations on Sections 1-11 of the Woolgoolga to Ballina (W2B) upgrade of the Pacific Highway, a 155 km section of new highway under construction on the North Coast of NSW. Results are presented for Sections 1-2 & Early Works Soft Soil Treatment Areas (EWSSTA) after four years and for Sections 3-11 after three years, these two components of the translocation work starting a year apart.

A total of 21 plant species were translocated on the W2B highway project, including 18 threatened species, one rare species and two vines that host threatened species of butterfly and moth, as follows:-

Threatened Species

- Yellow-flowered King of the Fairies (*Oberonia complanata*)
- Slender Screw Fern (*Lindsaea incisa*)
- Singleton Mint Bush (*Prostanthera cineolifera*)
- Weeping Paperbark (*Melaleuca irbyana*)
- Tall Knotweed (*Persicaria elatior*)
- Four-tailed Grevillea (*Grevillea quadricauda*)
- Stinking Cryptocarya (*Cryptocarya foetida*)
- Rusty Green-leaved Rose Walnut (*Endiandra muelleri ssp. bracteata*)
- Red Lilly Pilly (*Syzygium hodgkinsoniae*)
- White Laceflower (*Archidendron hendersonii*)
- Rough-shelled Bush Nut (*Macadamia tetraphylla*)
- Hairy Joint Grass (*Arthraxon hispidus*)
- Square-fruited Ironbark (*Eucalyptus tetrapleura*)
- Hairy Melichrus (*Melichrus hirsutus*)
- Lindernia (*Lindernia alsinoides*)
- Rotala (*Rotala tripartita*)
- Square-stemmed Spike Rush (*Eleocharis tetraquetra*)
- Moonee Quassia (*Quassi*a sp. Moonee)

Rare Species

- *Lepidosperma* sp. Coaldate

Hosts of Threatened Invertebrates

- Richmond Bird Wing Vine (*Aristolochia pravevenosa*)
- Pink Underwing Moth Vine (*Carronia multisepala*)

Species were translocated using four main methods:

- Salvage transplanting.
- Introduction of plants propagated from cuttings.
- Introduction of plants propagated from seed.
- Introduction of plants propagated from the soil seedbank.

Most species were translocated using a combination of these methods. Species were translocated to seven receival sites on Section 1-2 & Early Works Soft Soil Treatment Areas and thirteen on Sections 3-1. Monitoring was conducted quarterly in the first year, biannually in the second year and once a year thereafter. Results have been evaluated according to the aims and targets set out in the Translocation Strategy (RMS 2015 a & b). Target numbers for each species varied from less than 10 to 1500 or more, depending on the numbers of individuals impacted and the general aim of maintaining no net loss to local threatened species populations.

After three years, aims and targets were met for all 16 species translocated on Sections 3-11 with the exception of Lindernia. On Sections 1-2 & EWSSTA, after four years, most species fell below target and failed to meet project aims, including Moonee Quassia, Oberonia, Lindernia, Square-stemmed Spike Rush, Lepidosperma sp. Coaldale, Hairy Joint Grass, Tall Knotweed and Eucalyptus tetrapleura. Possible reasons for outcomes are discussed in the report.

1.0 INTRODUCTION

This monitoring report describes the results of threatened flora translocations carried out on Sections 1-11 of the Woolgoolga to Ballina (W2B) upgrade of the Pacific Highway, a 155 km section of dual carriageway under construction on the North Coast of NSW (Figure 1).

Threatened flora translocations for the W2B project were implemented in two stages, as follows:

- *Landmark Ecological Services and Bushland Restoration Services* conducted translocations for Sections 1-2 and EWSSTA in 2015-2016. Implementation for these sections was based on RMS (2015a). *Flora Translocation Strategy Pacific Highway Upgrade Sections 1-2 Woolgoolga to Ballina Pacific Highway upgrade – April 2015.* The translocation strategy was modified to include Early Works Soft Soil Treatment Areas.

- *Ecos Environmental* conducted translocations on Sections 3-11 in 2016-2017. Implementation for these sections was based on RMS (2015b) - *Flora Translocation Strategy Pacific Highway Upgrade Sections 3-11 excluding Early Works Soft Soil Treatment Areas Woolgoolga to Ballina – Ver. 2 Nov. 2015.* The translocations planned for this section also required modification to include several unexpected finds, which were translocated in 2017, as described below.

'Strategy' or 'Translocation Strategy' refers to RMS (2015a) and RMS (2015b).

A total of 21 plant species were translocated on Sections 1-11 of the W2B project, including 18 threatened species, one rare species (not scheduled) and two species of vine that are hosts of threatened butterfly and moth species during their larval stage (Table 1).

Translocations on Sections 1-2 & Early Works Soft Soil Treatment Areas (EWSSTA) started in 2015, a year earlier than Sections 3-11. Results for the first two years were described in reports by Landmark Ecological Services (2016, 2017). Results for the third year were included in Ecos Environmental (2018) and results for the fourth year are presented in this report.

Translocation results on Sections 3-11 for Years 1 and 2, starting 2016, were described in Ecos Environmental (2017, 2018). Unexpected finds translocated on Sections 3-11 in 2017 were included in the 2018 report. This report includes results of all translocations on Sections 3-11 after three years, up to July 2019.

According to the strategy:
"*Monitoring of the translocations would be conducted during and after construction for a minimum of 3 years* (i.e. 3 years before, 3 years after), *a total of approximately 5 years*." (p. 44).

The report contents are arranged as follows: Following the Introduction, Part 2 presents an overview of methods applied during the threatened species translocation program, including selection of receival sites, a brief summary of techniques used for salvage and propagation, and monitoring methods. Part 3 is a species by species description of the translocation implementation and results. Part 4 assesses the translocation results in terms of aims, objectives and targets set out in the Translocation Strategy. Part 5 identifies any corrective measures considered necessary to improve outcomes and achieve the translocation project aims. A photo record of the progress of the translocation project is included.

Table 1: Species translocated during the first round of translocations for Sections 1-2 and EWSSTA starting in 2015 and the second round of translocations for Sections 3-11 starting in 2016

Threatened Species	**EPBC Act status**	**BC Act status**	**Sec.1-2 & EWSSTA 2015**	**Sec.3-11 2016**
Four-tailed Grevillea (*Grevillea quadricauda*)	V	V		√
Hairy Joint Grass (*Arthraxon hispidus*)	V	V	√	√
Hairy Melichrus (*Melichrus hirsutus*)	E	E		√
Lindernia (*Lindernia alsinoides*)	-	E	√	√
Moonee Quassia (*Quassia* sp. 'Moonee')	E	E	√	
Red Lilly Pilly (*Syzygium hodgkinsoniae*)	V	V		√
Rotala (*Rotala tripartita*)	-	E		√
Rough-shelled Bush Nut (*Macadamia tetraphylla*)	V	V		√
Rusty Green-leaved Rose Walnut (*Endiandra muelleri ssp. bracteata*)	-	E	√	√
Singleton Mint Bush (*Prostanthera cineolifera*)	V	V		√
Slender Screw Fern (*Lindsaea incisa*)	-	E	√	√
Square-fruited Ironbark (*Eucalyptus tetrapleura*)	V	V	√	
Square-stemmed Spike Rush (*Eleocharis tetraquetra*)	-	E	√	
Stinking Cryptocarya (*Cryptocarya foetida*)	V	V		√
Tall Knotweed (*Persicaria elatior*)	V	V	√	√
Weeping Paperbark (*Melaleuca irbyana*)	-	E		√
White Laceflower (*Archidendron hendersonii*)	-	V		√
Yellow-flowered King of the Fairies (*Oberonia complanata*)	-	E		√
Rare Species				
Lepidosperma sp. 'Coaldale'	na	na	√	
Host Species for Threatened Insects				
*Richmond Bird Wing Vine (*Aristolochia pravevenosa*)	-	-		√
Pink Underwing Moth Vine (*Carronia multisepala*)	E			√

*Listed as threatened in Qld, not in NSW or the Commonwealth

2.0 METHODS

2.1 Aims and Objectives

The aims of the translocation project as defined by the Translocation Strategy were to:

- Create self-sustaining populations.
- Maintain or enhance existing demographic function and genetic variability.
- Generate increased knowledge of threatened plant species.
- Achieve no net loss to local populations being impacted by the project.
- Make the best possible use of all plant material with potential conservation value.

Objectives addressing the above aims include:

- Plants improve in condition so that flowering fruiting and regeneration is successful.
- Relevant project results and observations documented.
- Original number of individuals re-established.
- Available cutting material and seed harvested, and plants transplanted to the best extent practical.
- Create or augment small sub-populations with diffuse connectivity to metapopulations conserving existing genetic variability.
- Maintain or create a self-sustaining population (or augment an existing patch).

2.2 Translocation Targets

The 'translocation target' is the number of individuals that require translocation to compensate for individuals lost during clearing for highway construction. Translocation targets were identified in the Translocation Strategy (RMS 2015 a & b) based on the number of individuals, or area covered by a species, recorded during surveys of the construction footprint. The aim of translocation is to maintain populations at pre-construction levels by salvage transplanting and introduction of propagated plants.

Translocation can contribute towards achieving conservation aims and mitigating some of the impacts of development on threatened plant species. However, it is recognised that translocation is often experimental for a given species and outcomes cannot be guaranteed. Therefore translocation is not considered a mitigation measure under the EPBC Act and plants to be translocated are still considered as impacted for the purposes of offsetting, for example.

Translocation targets for Sections 3-11 and Sections 1-2 & Early Works Areas are listed in Tables 2 and 3 below. Adjustments to numbers in the Strategy were necessary for some species due to unexpected finds, which increased the number of plants being cleared (Table 2). There were also instances where fewer plants were found on the construction footprint than indicated in the Strategy, including *Cryptocarya foetida,* 28 individuals instead of 41. In this case, the clearing footprint had apparently been reduced to avoid some individuals and some plants had been misidentified (*C. microneura*, not *C. foetida*) .

2.2.1 Sections 3-11

The Translocation Strategy for Sections 3-11 (RMS 2015b) identified twelve threatened species requiring translocation. Additional threatened plant species were found during pre-clearing surveys (i.e. unexpected finds) and incorporated into the translocation program, including two species of vine that host threatened invertebrate species, taking the total to 18 species (Table 2).

Table 2: Threatened species translocated for the W2B project on Sections 3-11 and the translocation targets for each species, including unexpected finds.

Species	**Translocation Target (RMS 2015a)**	**Unexpected Finds**	**Total number removed/ translocated**
Threatened Species – Translocation Strategy			
Yellow-flower King of the Fairies (*Oberonia complanata*)	18 (+11) clumps*	35 clumps	53 clumps
Slender Screw Fern (*Lindsaea incisa*)	6350 fronds (0.370ha)	4350 fronds (~0.3ha)	10700 fronds (0.670 ha)
Singleton Mint Bush (*Prostanthera cineolifera*)	609 (0.424ha)	35**	644 (0.43)
Weeping Paperbark (*Melaleuca irbyana*)	1721 (2.761 ha)	1	1721
Tall Knotweed (*Persicaria elatior*)	20	350	370
Four-tailed Grevillea (*Grevillea quadricauda*)	3	15	18
Stinking Cryptocarya (*Cryptocarya foetida*)	41		28
Rusty Green-leaved Rose Walnut (*Endiandra muelleri ssp. bracteata*)	3		3
Red Lilly Pilly (*Syzygium hodgkinsoniae*)	6		6
White Laceflower (*Archidendron hendersonii*)	1		1
Rough-shelled Bush Nut (*Macadamia tetraphylla*)	10		10
Hairy Joint Grass (*Arthraxon hispidus*)	348 (1.3ha)	1000 (~0.1)	1348 (1.4ha)
Threatened Species - Unexpected Finds			
Square-fruited Ironbark (*Eucalyptus tetrapleura*)		5	5
Hairy Melichrus (*Melichrus hirsutus*)		1	1
Lindernia (*Lindernia alsinoides*)		30	30
Rotala (*Rotala tripartita*)		10***	10
Species Associated with Threatened Insects	Other		
Richmond Bird Wing Vine (*Aristolochia pravevenosa*)	3		3
Pink Underwing Moth Vine (*Carronia multisepala*)	5		5

* 18 translocated during early works soft soil areas in 2015 went to a nursery but appear to have died; 11 more were translocated in 2016 by Ecos Environmental as described below. **Pacific Complete pers. comm. July 2018. *** plants previously included from a second donor site, but as they disappeared before clearing they have been omitted.

2.2.2 Sections 1-2 & Early Works Areas

The Translocation Strategy for Sections 1-2 & Early Works Soft Soil Treatment Areas (RMS 2015a) identified nine threatened species requiring translocation, including Rusty Rose Walnut (Table 3). Attempts to protect in situ a single individual of the latter species at the Maclean interchange were unsuccessful (ie. accidently cleared) and the tree has now been included in the translocation targets for Sections 1-2 & EWSSTA. However, further translocation work on

this species to address the loss at Maclean interchange will be done in accordance with the Geolink 2019 Green-leaved Rose Walnut Rehabilitation Plan and will be reported on separately

Table 3: Translocation targets for threatened species on Sections 1-2 & EWSSTA as per Table 3 in RMS 2015a (Translocation Strategy) and Table 6 in Landmark Ecological Services 2017 (2017 monitoring report).

Species	**Translocation Target (RMS 2015a) as no. or no./area**	**Early Works Soft Soil Areas No. of plants**	**Total number removed/ translocated**
Threatened Species – Translocation Strategy			
Hairy Joint Grass (*Arthraxon hispidus*)	2	38	40
Lindernia (*Lindernia alsinoides*)	1811		1811
Moonee Quassia (*Quassia* sp. 'Moonee')	73 (0.086 ha)		73 (0.086 ha)
Yellow-flower King of Fairies (*Oberonia complanata*)		18*	18
Slender Screw Fern (*Lindsaea incisa*)	2820 fronds (0.013ha)		2820 fronds (0.013ha)
Square-fruited Ironbark (*Eucalyptus tetrapleura*)	823 (20.285ha)		823 (20.285ha)
Square-stemmed Spike Rush (*Eleocharis tetraquetra*)	253 (0.815ha)		253 (0.815ha)
Tall Knotweed (*Persicaria elatior*)		37 (44)	37 (44)
Rusty Green-leaved Rose Walnut (*Endiandra muelleri ssp. bracteata*)		1	1
Lepidosperma sp. 'Coaldale'		35	35

* 18 translocated during early works in 2015 went to a nursery but appear to have died; 11 more were translocated in 2016 by Ecos Environmental as described below.

2.3 Receival Sites

Translocation results are largely determined by how well the habitat at the receival site matches the habitat requirements of the species being translocated and/or the habitat profile of the donor site. The selection of receival sites usually involves finding a receival site that matches the donor site as closely as possible in its habitat attributes. Several abiotic and biotic factors need to be carefully considered including geology, soil type, topographic position, aspect, hydrology, vegetation structure, floristics and successional stage (e.g. mature, regrowth, patchy regrowth or cleared). Other factors such as access and water availability, and security of tenure also constrain the selection of receival sites.

The receival sites chosen for Sections 3-11 and Sections 1-2 & EWSSTA are listed in Tables 4 and 5 below. Most are described in the Strategy, although new sites were also selected. Prior to commencing the translocations, the receival sites were inspected to assess their suitability in terms of soil type, topography, vegetation and other environmental and logistical factors likely to affect species survival and establishment. This assessment was summarised in Ecos Environmental (2016) "W2B Flora Translocation Project - Site Selection and Validation Report". Thirteen receival sites were finally selected on Sections 3-11. The seven used for Section 1-2 & Early Works Areas (see Figs 2 and 3) had already been selected and the translocations started.

Table 4: Receival sites for species translocated on Sections 3-11. See Figure 2 below.

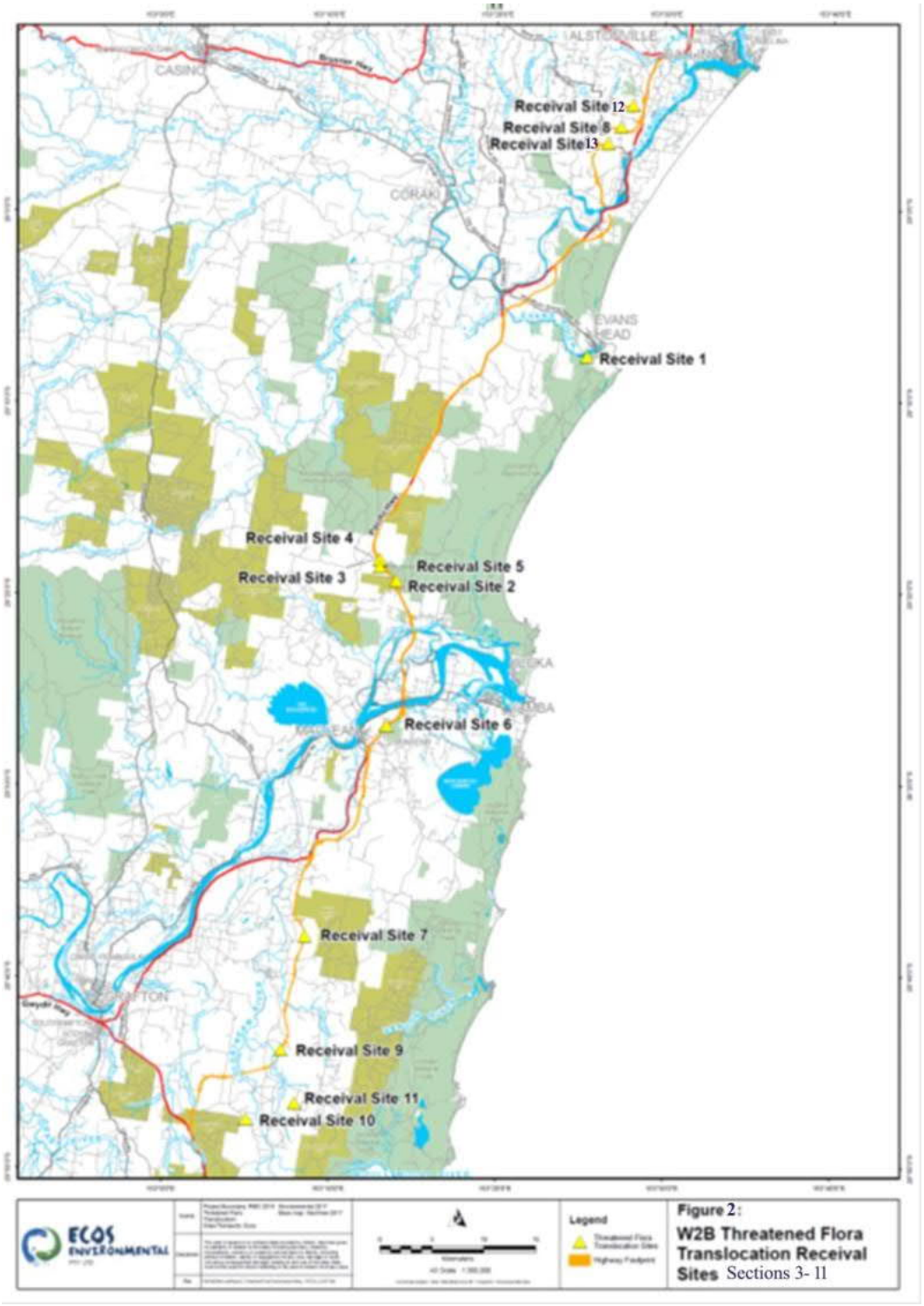
Species	**Receival Site**
Sections 3-11	
Yellow-flowered King of the Fairies (*Oberonia complanata*)	Site 1 - Bundjalung National Park (Evans Head) Site 13 - Lumleys Lane South
Slender Screw Fern (*Lindsaea incisa*)	Site 2 - Bundjalung National Park (Mororo Rd)
Singleton Mint Bush (*Prostanthera cineolifera*)	Site 3 - Tabbimoble Triangle, RMS property at Tabbimoble Ck as per Strategy
Weeping Paperbark (*Melaleuca irbyana*)	Site 3 - Tabbimoble Triangle Site 4 and 5 - RMS offset property at Tabbimoble Ck.
Tall Knotweed (*Persicaria elatior*)	Site 6 - Yaegl Nature Reserve (centre-north)
Four-tailed Grevillea (*Grevillea quadricauda*)	Site 7 - Within project boundary Quarry Rd (Sec.3)
Stinking Cryptocarya (*Cryptocarya foetida*)	Site 8 - Lumley's Lane; Site - 12 Coolgardie Rd
Rusty Green-leaved Rose Walnut (*Endiandra muelleri ssp. bracteata*)	Site 8 - Lumley's Lane; Site - 12 Coolgardie Rd
Red Lilly Pilly (*Syzygium hodgkinsoniae*)	Site 8 - Lumley's Lane; Site - 12 Coolgardie Rd
White Laceflower (*Archidendron hendersonii*)	Site 8 - Lumley's Lane; Site - 12 Coolgardie Rd
Rough-shelled Bush Nut (*Macadamia tetraphylla*)	Site 8 - Lumley's Lane*; Site - 12 Coolgardie Rd
Hairy Joint Grass - Section 10 (*Arthraxon hispidus*)	Site 8 - Lumley's Lane
Hairy Joint Grass - Section 3 (*Arthraxon hispidus*)	Site 9 - Within project boundary at Mitchells Rd (Sec.3)
Species Additional to Translocation Strategy	
Richmond Bird Wing Vine (*Aristolochia pravevenosa*)	Site 12 - Coolgardie Rd
Carronia (*Carronia multisepala*)	Site 12 - Coolgardie Rd
Lindernia (*Lindernia alsinoides*)	Site 9 - Within road reserve at Mitchells Rd (Sec.3)
Square-fruited Ironbark (*Eucalyptus tetrapleura*)	Site 10 - Offset land, Sunnyside Rd
Weeping Paperbark (*Melaleuca irbyana*)	Site 10 - Offset land, Sunnyside Rd
Hairy Melichrus (*Melichrus hirsutus*)	Site 11 - Offset land, Pillar Valley (Mahogany Drive)

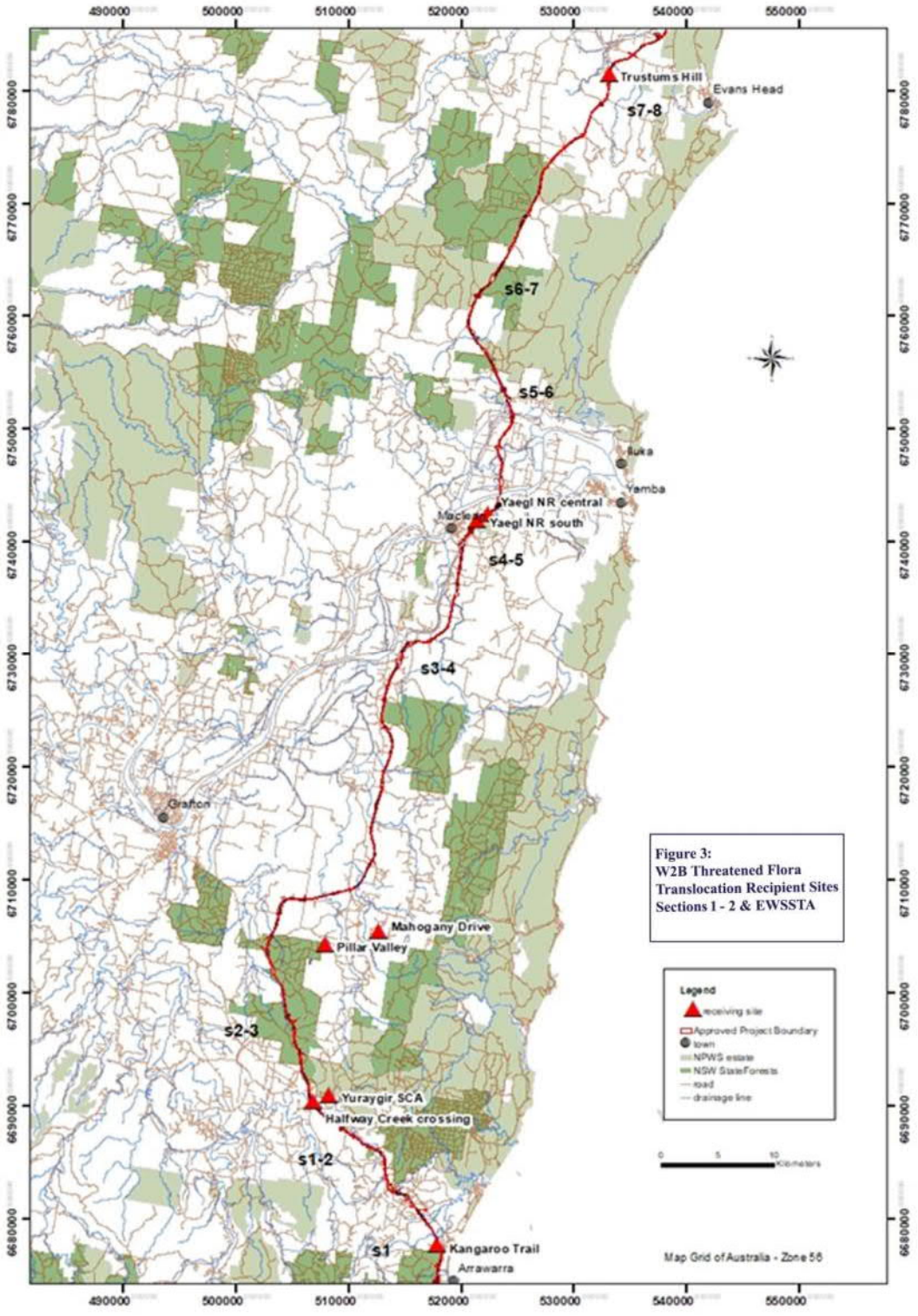
* More individuals of Rough-shelled Bush are still being propagated to introduce to Lumleys Lane, as well as those already introduced to Coolgardie Rd.

Table 5: Receival sites for species translocated on Sections 1-2 & EWSSTA. See Figure 3 below.

Species	**Receival Site**
Sections 1-2 and EWSSTA	
Hairy Joint Grass (*Arthraxon hispidus*)	Kangaroo Trail, Trustrums Hill
Lindernia (*Lindernia alsinoides*)	Kangaroo Trail, Halfway Ck Crossing, Yuragir NP
Moonee Quassia (*Quassia* sp. 'Moonee')	Dirty Creek Road Reserve
Slender Screw Fern (*Lindsaea incisa*)	Kangaroo Trail

Species	**Receival Site**
Square-fruited Ironbark (*Eucalyptus tetrapleura*)	Pillar Valley
Square-stemmed Spike Rush (*Eleocharis tetraquetra*)	Halfway Ck Crossing
Tall Knotweed (*Persicaria elatior*)	Yaegl NR
Lepidosperma sp. 'Coaldale'	Mahogany Drive

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Evans Head
s7-8
s6-7
s5-6
Iluka
Yamba
Yaegl NR central
Yaegl NR south
s4-5
s3-4
Grafton
Mahogany Drive
Pillar Valley
s2-3
Yuraygir SCA
Halfway Creek crossing
s1-2
s1
Kangaroo Trail
Arrawarra
Figure 3:
W2B Threatened Flora
Translocation Recipient Sites
Sections 1 - 2 & EWSSTA
Legend
receiving site
Approved Project Boundary
town
NPWS estate
NSW StateForests
road
drainage line
0
5
10
Kilometers
Map Grid of Australia - Zone 56

2.4 Translocation Methods

Four main techniques were employed to translocate species:
(i) Salvage transplanting of impacted plants from the road alignment.
(ii) Introduction of plants propagated from cuttings of impacted plants.
(iii) Introduction of plants propagated from seed of impacted plants, or from the local population.
(iv) Introduction of plants propagated from the soil seedbank under impacted plants.

Different combinations of methods were applied for different species, as shown in Table 6. Summing the instances of each translocation method in Table 6, the main translocation method applied was transplanting (18), followed by seed propagation (8), cutting propagation (5) and soil seedbank propagation (3). More than one method was applied to several species, often as a back-up in case another method failed, or fell below target. The main translocation techniques used for the W2B project are briefly described below. More detail is provided in the sections on each species below.

2.4.1 Transplanting

The direct transplanting method was used to salvage plants growing on the construction footprint. This entails digging the plant up with stems and roots partly intact, pruning the plant to readjust the ratio of stem and root system, transport and planting into the receival site as quickly as possible and saturation watering. This approach has a number of advantages over other techniques (e.g. gradual trenching, root pruning etc), which have been described in previous reports. Transplanting on this project was limited to plants small enough to be transplanted manually – i.e. up to tall sapling size.

Direct transplanting of large individuals using an excavator has been successful in the past, particularly with rainforest species (e.g. the Brunswick Heads to Yelgun and Tintenbar to Ewingsdale projects), but the Translocation Brief for W2B project generally required translocation by propagation from seed and cuttings.

Transplanting has advantages such as ensuring that locally adapted (selected) genotypes are preserved and usually achieves a high survival rate, but propagation may be more appropriate (i.e. cost-effective) in situations where large numbers of mature individuals require replacement, as in the case of Weeping Paperbark and Singleton Mint Bush on the W2B project.

2.4.2 Seed and Cutting Propagation

Most species translocated on Sections 3-11 by Ecos Environmental were propagated from seed, because on previous translocation projects, cutting propagation had often resulted in a very low strike rate, or plants with a weak root system requiring a long period in the nursery before planting out (e.g. 2 years), although there are exceptions (Ecos Environmental 2011a). Cutting propagation was used only when a seed source was not available, for example, for Richmond Bird Wing Vine (*Aristolochia praevenosa*). As it turned out, this species propagated well from hardwood stem cuttings.

Propagation was not attempted for the fern *Lindsaea incisa* and the orchid *Oberonia complanata*, as previous transplanting was successful with these or related species (Ecos Environmental 2016 and 2011b), and specialised techniques were required for propagation.

Propagation methods were successful for most species and any problems arose after planting out. *Quassia* sp. Moonee on Sections 1-2 was main exception. Propagation of this species from cuttings was attempted but unsuccessful. Seed propagation and salvage transplanting were not attempted so translocation of this species had to be counted as a fail.

Horticultural factors play a key role in the success or failure of translocations, including choice of translocation technique, propagation method, soil media, fertilisers, growing-on period and hardening off, as well as follow-up maintenance and plant care. Ideally, horticultural methods

should be based on previous results but often this information is not available, which underlines the experimental nature of much threatened plant translocation work and the importance of monitoring and documenting translocation methods and results.

2.4.3 Soil Seedbank Propagation

The soil seedbank was used to propagate Singleton Mint Bush, Four-tailed Grevillea and Tall Knotweed. Topsoil was collected under mature plants assuming it would contain dormant seed of the target species. To break seed dormancy in the first two species above, which occur in fire-prone vegetation, the topsoil was spread on sheets of roofing iron and dry leaf litter burnt on top to mimic the effect of bushfire (see Sec. 3.4.1). This propagation method was applied as seed and cuttings were either of poor quality or not available, but it proved to be both practical and cost-effective. Applying the same approach without fire, mud was collected under old Tall Knotweed plants and spread in plots at the receival site.

Table 6: Translocation methods applied to impacted threatened species on (i) Sections 3-11 and (ii) Sections 1-2 & EWSSTA of the W2B project. Four methods were applied to species. Totals for each method are indicated at the bottom of the table.

(i) Sections 3-11

Species	**Transplant**	**Propagate Seed**	**Propagate Cuttings**	**Propagate Soil seedbank**
Yellow-flowered King of the Fairies (*Oberonia complanata*)	+	-	-	-
Slender Screw Fern (*Lindsaea incisa*)	+	-	-	-
Singleton Mint Bush (*Prostanthera cineolifera*)	-	-	+	+
Weeping Paperbark (*Melaleuca irbyana*)	-	+	-	-
Tall Knotweed (*Persicaria elatior*)	+	-	-	+
Four-tailed Grevillea (*Grevillea quadricauda*)	+	+	-	+
Stinking Cryptocarya (*Cryptocarya foetida*)	+	+	-	-
Rusty Rose Green Walnut (*Endiandra muelleri ssp. bracteata*)	+	+	-	-
Red Lilly Pilly (*Syzygium hodgkinsoniae*)	+	+	-	-
White Laceflower (*Archidendron hendersonii*)	+	+	-	-
Rough-shelled Bush Nut (*Macadamia tetraphylla*)	-	+	-	-
Hairy Joint Grass - Section 10 (*Arthraxon hispidus*)	+	-	-	-
Hairy Joint Grass - Mitchell Rd Sect 3 (*Arthraxon hispidus*)	+	-	-	-
Additional Species				
Square-fruited Ironbark (*Eucalyptus tetrapleura*)	+	-	-	-
Hairy Melichrus (*Melichrus hirsutus*)	+	-	-	-
Lindernia (*Lindernia alsinoides*)	+	-	-	-

Species	Transplant	Propagate Seed	Propagate Cuttings	Propagate Soil seedbank
Richmond Bird Wing Vine (*Aristolochia pravevenosa*)	-	-	+	-
Carronia (*Carronia multisepala*)	-	-	+	-

(ii) Sections 1-2 & EWSSTA

Species	Transplant	Propagate Seed	Propagate Cuttings	Propagate Soil seedbank
Hairy Joint Grass (*Arthraxon hispidus*)	+	-	-	-
Lindernia (*Lindernia alsinoides*)	-	-	+	-
Moonee Quassia (*Quassia* sp. 'Moonee')	-	-	+	-
Slender Screw Fern (*Lindsaea incisa*)	+	-	-	-
Square-fruited Ironbark (*Eucalyptus tetrapleura*)	-	+	-	-
Square-stemmed Spike Rush (*Eleocharis tetraquetra*)	+	-	-	-
Tall Knotweed (*Persicaria elatior*)	+	-	-	-
*Lepidosperm*a sp. 'Coaldale'	+	-	-	-
Total instances (i) and (ii)	18	8	5	3

2.5 Experimentation

Experiments were incorporated into the translocation program for three species to examine how various factors affect species performance during translocation. Most of these experiments were carried out on Singleton Mint Bush (*Prostanthera cineolifera*). Questions investigated are indicated in the table below. Details are provided in the sections on each species below.

Translocated Species	Experiment
Slender Screw Fern (*Lindsaea incisa*)	How does microtopography affect species performance?
Singleton Mint Bush (*Prostanthera cineolifera*)	How does fire intensity affect seed germination from the soil seedbank? How does soil texture affect species performance? How does propagation type (seedlings vs cuttings) affect species performance? How does fertiliser addition affect species performance?
Weeping Paperbark (*Melaleuca irbyana*)	How does fertiliser addition affect species performance?

2.6 Monitoring

Monitoring was conducted once every three months in Year-1, 6-monthly in Year-2 and annually from Year 3 onwards, as required by the Translocation Strategy (RMS 2015a and b).

Monitoring for the present report was carried out in July 2019, representing Years 3 or 2 (unexpected finds) for Sections 3-11 and Year 4 for Sections 1-2.

The following data were recorded at each monitoring event for each tagged plant or plot:- the number or abundance of individuals (e.g. counts or percent crown-cover), plant condition, presence/absence of new shoot growth, flowering, recruitment, evidence of disease or grazing, soil moisture/recent rainfall, water depth if flooded and exotic species. Plant condition was recorded on a scale of 0 to 5 where '0' is dead and '5' is reproductively mature.

2.7 Data Entry and Analysis

The results recorded at each monitoring event were entered in the following Excel spreadsheets: "W2B Translocation Monitoring Sections 3-11 – Years 1 -3, to July 2019" and "W2B Translocation Monitoring Sections 1-2 and EWSSTA – Year 4, to July 2019", as appended to this report

ANOVA was carried on the results of the Singleton Mint Bush experiments. Summary statistics and graphs were relied on to interpret trends over time for other species.

Singleton Mint Bush

Data from the Singleton Mint Bush Experiment 2 was checked for a normal distribution using the *ks.test* function in R version 3.6.1 (R Core Team 2009). The data was found to be normally distributed (p-value = 0.7192). Normally distributed data is an assumption for parametric tests such as analysis of variance (ANOVA). A three-way ANOVA was performed on the data with the following factors and factor levels – plot (A and B), mode of propagation (seedlings and cuttings) and added fertilizer (fertilizer and no fertilizer). The three-way ANOVA found a significant interaction effect between plot and added fertilizer (p-value = 0.0193, see results section for further details) and so post-hoc testing was carried out using the *TukeyHSD* function in R version 3.6.1 (R Core Team 2009) to find out which factor levels were different to which. The data was analysed following the methods described in Dytham (2011).

2.8 Maintenance

In plant translocation work, biotic and abiotic factors that cause high rates of mortality in a natural plant community are usually manipulated to some degree to give the introduced/translocated plants a better chance of survival and ultimately establishing a self-sustaining population. This can be achieved by a wide range of horticultural interventions such as watering, mulching, shading, spraying or poisoning to control competing plants, fencing to exclude grazers and use of fertilisers, which come under general heading of maintenance.

Maintenance activities carried out during the last 12 months (spring 2018 to winter 2019) are shown in Table 7. These varied according to species and receival sites, and included watering during long dry spells, mulching, checking and repair of fences, removing sapling competition, application of slow release fertiliser, clearing of leaf litter from small species such as Slender Screw Fern, renewing monitoring tags and implementation of habitat restoration at the two rainforest species receival sites (Lumleys Lane and Coolgardie Rd).

Table 7: Maintenance activities carried out between June 2018 and July 2019

Maintenance Activities 2018-2019 **Receival Sites**	Watering	Weed control	Mulching/fertiliser	Fence repair/exclude grazers	Renew monitoring tags	Grub saplings/reduce natives	Biomass reduction	Clear leaves	Rainforest restoration
Site 1 - Bundjalung National Park (Evans Head) Oberonia									
Site 2 - Bundjalung National Park (Mororo Rd) Slender Screw Fern	+				+	+		+	
Site 3 - Tabbimoble Triangle Singleton Mint Bush, Weeping Paperbark	+			+					
Site 4 and 5 - RMS offset property at Tabbimoble Ck. Weeping Paperbark, Rotala				+	+	+			
Site 6 - Yaegl Nature Reserve (centre-north) Tall Knotweed		+			+				
Site 7 - Within project boundary Quarry Rd (Sec.3) Grevillea quadricauda				+					
Site 8 - Lumley's Lane Rainforest species'; Hairy Joint Grass	+	+	+	+	+		+		+
Site 9 - Within project boundary at Mitchells Rd (Sec.3) Hairy Joint Grass; Lindernia				+	+				
Site 10 - Offset land, Sunnyside Rd Eucalyptus tetrapleura									
Site 11 - Offset land, Pillar Valley (Mahogany Drive) Hairy Melichrus				+					
Site 12 - Coolgardie Rd Rainforest species	+	+	+	+	+				+
Site 13 - Lumleys Lane South Oberonia									
Sites on Section 1-2 and Early Work Areas		+			+		+		

3.0 IMPLEMENTATION AND RESULTS (SECTIONS 1-11)

3.1 Weather Conditions

The start of translocation work on Sections 1-2 & EWSSTA in July 2015 coincided with average rainfall between July and December 2015, except for October which was drier than average. Between January and May 2016 (the rainy season in a typical year), monthly rainfall was well below average (Figure 4). However, as even below average rainfall during the rainy season is enough to maintain adequate soil moisture, below average rainfall in summer-autumn 2016 did not result in particularly stressful soil moisture conditions.

The start of translocation work on Sections 3-11 in August 2016 coincided with the dry season. Between September 2016 and February 2017 rainfall was well below average (see Figure 4) and temperatures were also above average, necessitating additional watering of most of the receival sites to avoid wilting and minimise mortality. The Far North Coast of NSW recorded its highest maximum daily temperature on record on 11/2/2017 (mid to high 40s), causing leaf damage, wilting and some mortality among the translocated species. The seasonal drought ended abruptly at the end of February 2017 with heavy rain and flash flooding. Between 27/2/17 and 31/3/17, 800-1000 mm of rain fell from Ballina to Maclean causing flash floods and prolonged flooding of the receival sites located on Sections 3-11 and similar effects on Sections 1-2. Wet conditions persisted to the end of June 2017.

Between June 2017 and June 2018, the usually dry period from late winter to early spring was very dry and a bushfire occurred at one of the receival sites on Sections 1-2 (Mahogany Drive, Pillar Valley). This was followed by above average rainfall in late spring 2017 and average rainfall through to June 2018. Unlike the previous year (2016/2017) there were no heavy rainfall events and flash flooding.

Last year (June 2018 to July 2019), rainfall in spring in 2018 was above average then from early summer 2018 to autumn 2019 rainfall was below average for five consecutive months. Rainfall for January 2019 was close to zero, very unusual for that time of year.

Overall, the weather pattern between mid-2015 and mid-2019, was notable for three lengthy periods of below average rainfall (each with more than three consecutive months of below average rainfall) and one period of exceptionally high rainfall in autumn 2017. The rest of the four year period had fairly average rainfall although higher than average for occasional single months. Exceptionally high temperatures were recorded in summer early 2017.

Weather extremes, including long periods of below average rainfall and flood events are typical causes of plant mortality during translocation projects and their impact needs to be managed where possible to reduce this.

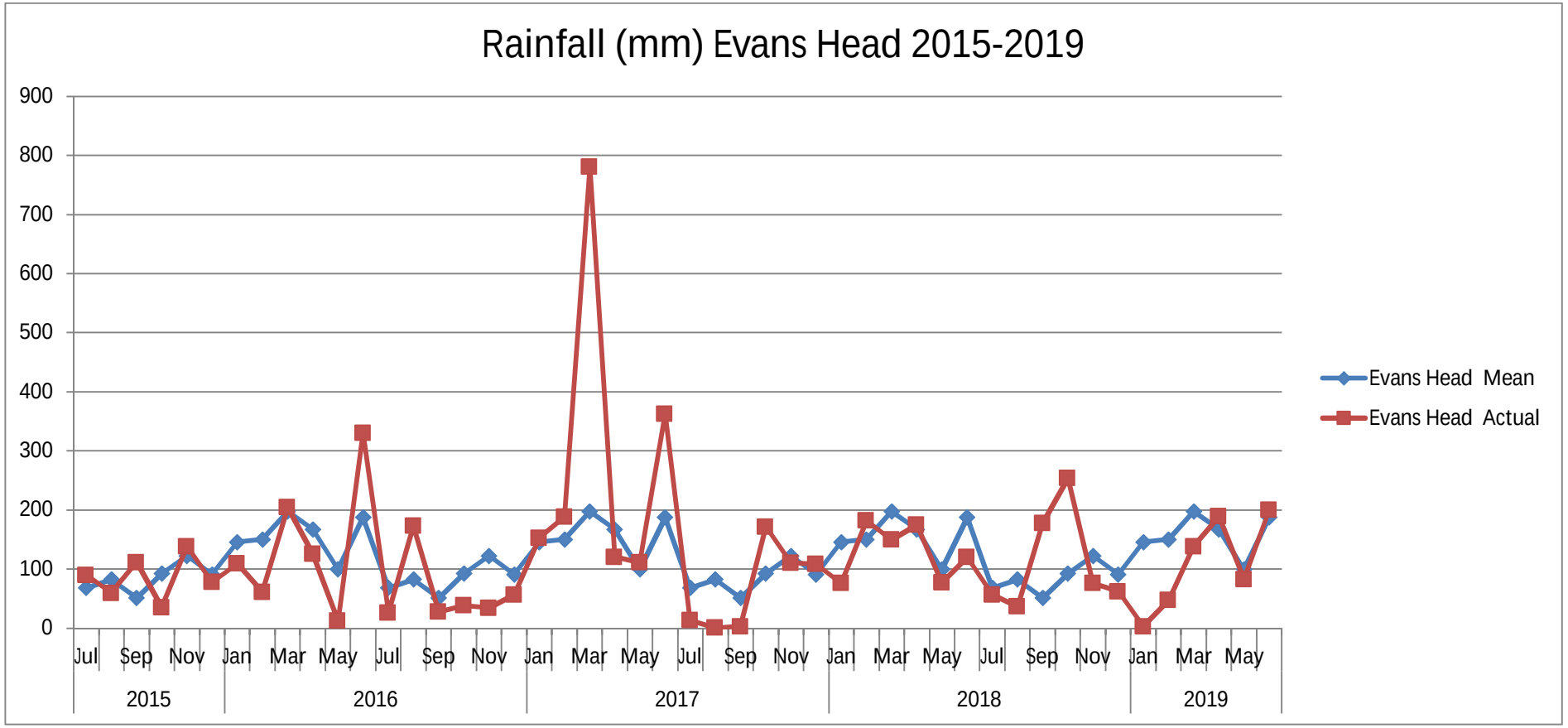

Figure 4: Daily and monthly rainfall in 2016-2019 recorded at Evans Head Bombing Range, representative of the W2B alignment.

3.2 Slender Screw Fern (*Lindsaea incisa*)

3.2.1 Translocation Method – Sections 3-11 (2016-19)

First translocation 2016

The first translocation of Slender Screw Fern on Sections 3-11 comprised the plants identified in the Translocation Strategy (RMS 2015b). A second translocation was necessary for additional plants found during pre-clearing surveys.

For the first translocation, a total of 127 trays (or ~6350 fronds) were transplanted to Receival Site 1 (Area 1) in Bundjalung National Park (Table 8) in September 2016. Sods containing fronds and rhizomes were dug out to a depth of 6-8cm, placed in 40cm x 40cm plastic trays, watered and transported to the receival site about 0.5 km away. The trays of fern were planted in plots the size of the tray about 2 m apart in five lines, each at slightly higher elevation along a very gently sloping (~1 degree) valley bottom. The aim of this layout was to examine how small differences in elevation affected survival and growth.

Each plot received one tray of *L.incisa* and five patches were each planted with five trays. The overall planting layout was as follows:
Area 1
- Line A – 25 trays/plots
- Line B – 44 trays/plots
- Line C – 15 trays/plots
- Line D – 18 trays/plots
- Patches 1– 5 (5 trays/patch)

Total trays/plots = 127. Total number of fronds based on an av. of ~50 per tray = 6350.

The fronds of *L.incisa* grow from a network of thin, brown, horizontal rhizomes, so it is not possible to estimate the number of genetic individuals (genets). It is possible that patches of fronds are actually single clones, or ramets equivalent to a single genetic individual.

The plots were watered regularly to keep soil moist and no fertilisers or other soil additives were applied. The plastic trays, which have with an open grid base, were inverted over the plants to provide protection from animal grazing and digging, and to define the plots for monitoring. They also proved useful for catching heavy litter fall during late spring-early summer and preventing the build-up of leaf litter that tended to smother *L. incisa*. Leaves were cleared from the trays every few months. To prevent wilting additional watering was necessary up to the end of February 2017 due to hot, dry weather.

Second translocation 2017 (unexpected finds)

The second translocation of Slender Screw Fern on Sections 3-11 was carried out after previously unrecorded plants were found during pre-clearing flora surveys on the opposite side of the highway. The second batch was translocated one year later in September 2017.

The same receival site in Bundjalung National Park was used to relocate the additional plants. Planting sites were selected above the level of flash floods, which occurred in autumn 2017. About half the plants were planted on the opposite side of the swale to the first batch, about 30-40 m south (Area 2). Topography and vegetation type in Area 2 were similar to Area 1, but the soil type and understory were different. The soil consisted of a pale grey (higher content of fine sand) clay loam rather than the dark brown, humic clay loam in Area 1. The understory was dominated by Common Tea Tree (*Leptospermum polygalifolium*), which was scarce in Area 1.

The overall planting layout for the second translocation was as follows:
Area 2
Line A – 29 trays/plots
Line B – 30 trays/plots
Patches = 7
Area 1
Patches =16

Total fronds=~4350 (25 fronds/tray)

The pre-clearing survey estimated 8500 fronds of Slender Screw Fern in the unexpected find area. Transplanting the fern, we estimated 4350 fronds based on an average of 25 fronds per tray. The density of fronds in the unexpected find area was noticeably less than the first area, as it was drier, more exposed and less swampy. We considered that 4350 fronds was a more accurate estimate of the total number of fern fronds in the unexpected find area.

3.2.2 Results

First translocation (2016- 2019)

After three years, to July 2019, the mean percent crown-cover of *L. incisa* on Lines A to D was 25.0% to 40.9%, and the patches had a mean percent crown-cover of 36.0% (Table 8). In terms of the number of plots with at least some *L. incisa* fronds, the survival rate of the first translocation after three years was 100%,

The translocated population underwent large swings in crown-cover over three years due to flood and drought disturbances. In Feb/2019 after a long, dry period last summer, nearly all fern fronds in the plots and patches had died off. Although monitoring was not due until about June, monitoring data were recorded to capture the dramatic decrease in crown-cover. It was unclear if the plants were dead, or would reshoot again when rain fell. Another site inspection in May after several falls of rain found that the fern had reshot vigorously. After having no fern fronds in Feb, some of the patches had near 100% cover of healthy, new fern fronds.

L. incisa also recovered from damage caused by flooding. In autumn-winter 2017, toward the end of the first year, three flash floods occurred in quick succession. Most fronds died from being flattened and then lying in water for an extended period, but the rhizomes apparently survived and *L. incisa* regrew to pre-disturbance crown-cover in about a year.

Mean cover-abundance was highest on Line C, indicating that factors associated with elevation were more suitable for *L. incisa* (Line A was the lowest and Line D the highest). The same result was recorded last year. Differences in microhabitat associated with elevation are probably related to subtle gradients of soil moisture and species composition/competition. A similar response to small differences in elevation was recorded during the translocation of *L. incisa* for the Sapphire to Woolgoolga Pacific Highway upgrade project (Ecos Environmental 2011b).

Second translocation 2017 (unexpected finds)

The second translocation was implemented after the flash floods in autumn 2017, but before the summer drought of 2018/2019. Both the first and second batches of plants recorded the same dieback response to the drought, with almost total dieback of plots and patches, then rapid recovery after rain. Survivorship and mean-crown-cover were lower on Line A, which appears to be related to differences in soil, hydrology and species composition, particularly the grey soil and abundance of Common Tea Tree (see Sec. 3.2.1). The patches in Area 2 were located well away from the stand of Common Tea Tree, which may account for the better performance of the patches. Results for the second translocation are shown in Figure 6 and Table 8.

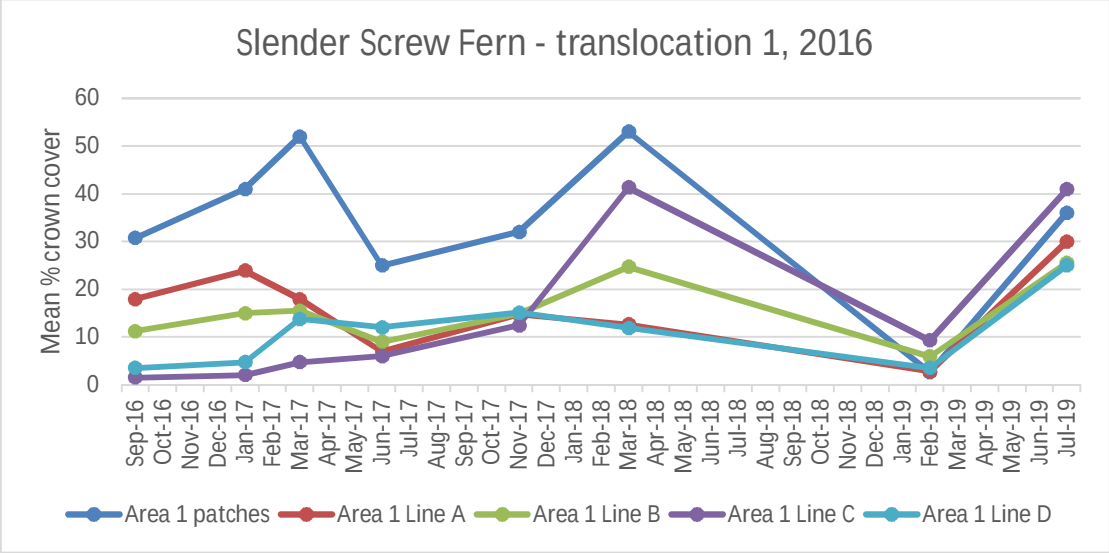

Figure 5: Results of the first Slender Screw Fern translocations on Section 3-11 showing changes in means percent crown cover over three years (approx.). The two declines in crown-cover relate to extreme weather events, the first to flash flooding and the second to unseasonal drought.

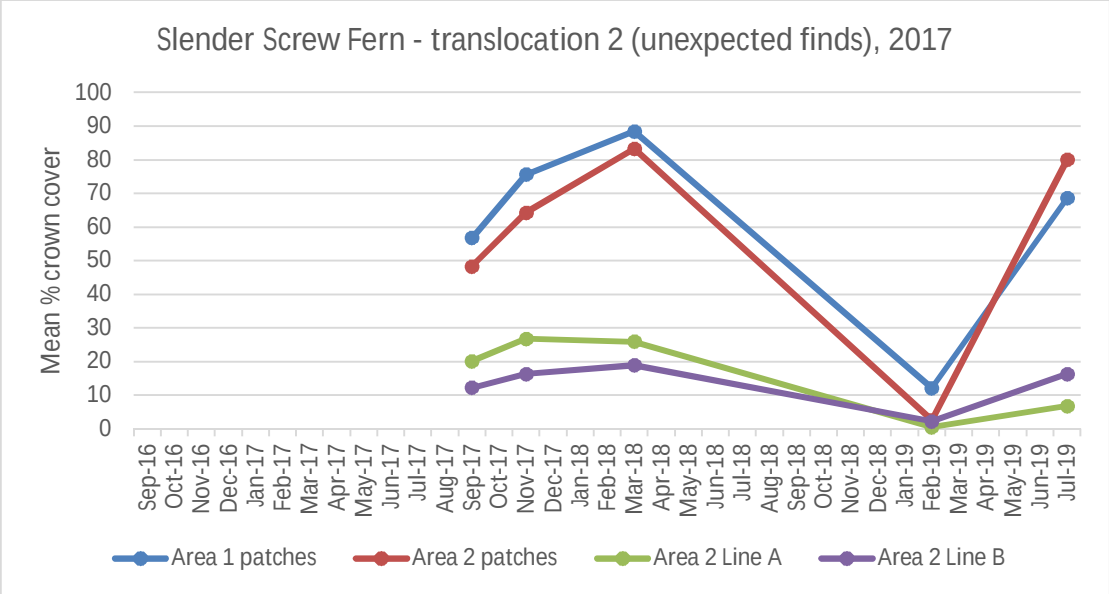

Figure 6: Results of the second Slender Screw Fern translocations on Section 3-11 (unexpected finds) showing changes in means percent crown cover over two years (approx.). The major decline in crown-cover relates to the drought of summer 2018/2019, also seen in the graph above.

3.2.3 Methods and Results – Section 1-2 & EWSSTA (2015-18)

Results of the Slender Screw Fern translocation on Sections 1-2 & EWSSTA over the first two years were reported by Landmark Ecological Services (2016, 2017). Only 3 of the original 45 slabs transplanted (equivalent to plots) survived after 2.5 years. Near 100% of 17 additional potted plants introduced in autumn 2017 were surviving after one year (Table 8). The second planting consisted of plants grown in a nursery. High mortality in the initial translocation was attributed to kangaroo grazing and flash flooding.

Monitoring over the last two years by Ecos Environmental found that out of 57 tagged points (representing planted *L. incisa*), 35.1% had surviving *L. incisa* plants in 2018 and 15.8% in July 2019. Most of the surviving plants were healthy and there was some lateral expansion of clumps. The main threat was smothering by the exotic grass Broad-leaved Paspalum (*Paspalum mandiocanum*).

3.3 Yellow-flowered Oberonia (*Oberonia complanata*)

3.3.1 Translocation Method

The 18 impacted plants requiring translocation identified in the Strategy (RMS 2015a) were salvaged from the donor site on the Woodburn-Evans Head Rd during early works in 2015 and sent to a nursery for growing-on, but all apparently died.

A further 11 plants were translocated from the same donor site by Ecos Environmental in August 2016. These plants were growing on a dead Casuarina tree in an advanced state of decay and about to collapse. As the orchid plants were unlikely to survive once the tree collapsed (and the tree was now also exposed on the edge of clearing), 11 clumps of orchid on the dead tree were salvaged and relocated to the receival site in Bundjalung National Park near Evans Head.

Rather than prising the orchid away from the tree, as described in the Strategy, a hand saw and chisel were used to remove sections of dead bark supporting the orchid so there was minimal disturbance to its roots. The pieces of bark supporting orchid plants were then transported to the receival site and attached to a suitable tree with ribbon or wire.

To propagate more orchid plants, twenty small seedlings growing on bark at the base of a mature plant were separated and placed in small pots of ground up casuarina bark. They survived for up to 3 months, but gradually succumbed to a fungal wilt, probably due to dampness of the potting medium. The few that produced growth arched downward as if growing on a vertical face. This orchid should have been attached to a vertical surface in a fully aerated and drained position rather than planting them upright in pots of damp bark fines.

More plants of this species were found during pre-clearing surveys in 2017. These were growing on a *Melaleuca linariifolia* tree south of Lumleys Lane. A total of 14 small branch sections containing approximately 35 orchid clumps were removed from the tree and attached to trees in the adjoining swamp sclerophyll forest about 30 metres away in August 2017.

3.3.2 Results

Only one of the 11 plants translocated in 2016 died after relocation to the receival site. This was apparently caused by the orchid coming into contact with moist moss packed behind the piece of dead bark, again showing how this species does not tolerate moisture around its surface roots for any length of time. All the other plants were still in good condition in July 2019. The clumps of orchid plants continued to flower and produce seed without any apparent interruption.

For the second translocation of unexpected finds in 2017, south of Lumleys Lane, out of the fourteen branchlets supporting approximately 35 clumps of plants, all survived to July 2019 and the majority of clumps continued to produce flowers and seeds.

3.4 Singleton Mint Bush (*Prostanthera cineolifera*)

3.4.1 Translocation Method

Singleton Mint Bush is a tall shrub with an 'obligate seeder' life cycle, similar to many other Australian plants. A typical obligate seeder regenerates only from seed, is fast growing and short-lived (<20yrs), has a relatively high reproductive output and persists by means of dormant seed stored in the soil. Seed germination is triggered by bushfires, although some seed can germinate if fire is absent for a long time. Obligate seeder shrubs also have a characteristic growth-form, most being single-stemmed and lacking a woody rootstock, as seen in many other Australian native shrubs.

In August 2016, the Tabbimoble Ck population of Singleton Mint Bush consisted of tall, straggly, over-mature, senescent plants with a few recent recruits on the edge. Most were collapsing as they neared the end of their life-span. Cuttings and seed were of poor quality, or not available until later in the year. (Better cuttings were taken during early works from a few young plants growing on the banks of the creek.) As clearing of the alignment was scheduled to begin in one or two months, it was decided to trial a different method of propagation using the soil seedbank and fire.

Topsoil was collected to a depth of 1-3 cm from under *P. cineolifera* plants growing on the highway footprint. Fire was applied to the collected soil with the aim of triggering seed germination, which would hopefully include Singleton Mint Bush. To understand better how fire could be used for propagation by stimulating seed germination, an experiment was designed to compare seed germination in response to high and low intensity fire, and without any fire (control). The high fire intensity treatment consisted of covering the soil with a 10 cm layer of dry leaves and twigs. For the low fire intensity treatment the thickness of fuel was halved to 5 cm.

At Ecos Environmental's nursery, the soil was divided into two batches, spread on sheets of roofing iron to a depth of 6-8 cm and covered with dry leaves and twigs to depths of 10 cm and 5 cm. To simulate bushfire, the litter was ignited at one corner and allowed to burn across the soil, heating the topsoil and releasing of combustion compounds that help to trigger germination of dormant seed. After cooling down the topsoil was placed into 40 cm x 40 cm x 6 cm plastic trays and germinated under sprinklers in the nursery. Trays of untreated soil were included to examine the seed germination response without fire treatment.

The trays were examined regularly and germination recorded. Singleton Mint Bush seedlings started to germinate after about 4 weeks but identification was not confirmed for two months as the first leaves were a different shape from the adult and had no smell. After three months, 10 trays were selected at random from the high and low fire intensity and control treatments and counts made of the number of seedlings of each species, including unknowns. To identify unknowns the trays were grown-on for several more months, some started to flower. Seedling density and species diversity were much higher in the high fire intensity treatment and lowest in the control (no germination of Singleton Mint Bush).

After recording the results of the fire treatments, seedlings of *P. cineolifera* were pricked out potted into native tubes in October 2016. Standard nursery potting mix for natives was used and Seasol liquid fertiliser applied at intervals as the potting mix had no added fertiliser. There were no disease problems and only minor grazing by caterpillars in the nursery. Tubestock were >30 cm high and hardened off before planting out. A series of plantings were carried out at the 'Tabbimoble Triangle' receival site over 11 months in 2017 – firstly in March, followed by three additional plantings in April and November (see Table 8).

The receival site is about 80 metres long (N-S) by 60 metres wide (E-W) Vegetation structure varies from open forest in the south to woodland in the north. A soil texture gradient extends across the site with increasing sand content and better drainage towards Tabbimoble Creek at the southern end, and increased clay content and poorer drainage to the north. Tabbimoble Creek carries sand eroded from sandstone hills upstream and during floods the sand spills out on the edge of the clay soil floodplain. The site was fenced to exclude wallabies and kangaroos.

First Planting

In the first planting (23/3/2017) 600 tubestock were planted across the whole receival site at roughly even spacing (a few metres apart). An inspection three weeks after planting found that most tubestock in the northern half to two-thirds of the site were dead or dying from a wilt disease (probably a root fungus), whereas most plants in the southern half to one third of the site were still healthy. As soil texture across the site became sandier towards the creek, this indicated that *P. cineolifera* was sensitive to a root disease associated with soil texture and more likely to establish on soil with a higher sand content closer to Tabbimoble Creek.

Experiment 1 (effect of soil texture gradient and tubestock age)

To clarify the effect of variation in soil texture within the site on the performance of planted tubestock (apparent from the first planting), and to discount possible effects due to flash flooding and pre-planting herbicide, the following experiment was designed and planted on 12/4/2017. Five transects (T1-T5) were laid out at different positions relative to the north-south soil texture gradient within the fenced site. Transects were placed at approx. right angles to the soil texture gradient so soil texture along a transect would be roughly the same. Three 2 m x 2 m plots were placed 10-20 m apart along each transect. The plots were divided into quarters and each quarter planted with four tubestock (16 plants per plot).

Two months after the start of the experiment, plants on the two transects furthest from the creek at the northern end of the site (T1 and T2) were showing the same wilt symptoms as the first planting, whereas plants in transect plots closest to the creek (T5) and in the side gully (T3) were healthy. For the transect in an intermediate position (T4), about half the plants were healthy and half were wilting. All seedlings on T2 subsequently died in the first 6 months of Experiment 1 (Oct/2017).

The seedlings in the first planting and Experiment 1 were 6 months old when introduced. Although consistent with general guidelines for planting-out native seedlings (i.e. >30cm tall), they were relatively young, so we were curious to see if planting older seedlings, which were available, would affect survival rate. To test whether older seedlings would perform any better, 12 month old seedlings were planted in Nov/2017 into two of the three plots on T2 where all the 6 month old tubestock had died. The same planting layout was used with 16 tubestock per plot.

Experiment 2 (effect of seedlings vs cuttings and fertiliser)

Cuttings of *P. cineolifera* were propagated during the early works period in 2015-2016 from a few young plants growing on the creek bank. These were transferred to Ecos Environmental's nursery where they were put in larger tubes and grown on for later planting out.

A second experiment was carried out to examine if there was any difference in the performance of plants propagated from seed and cuttings. The effect of fertiliser was included in the experiment by planting half with 12-month slow release fertiliser and half without. Seedlings in this experiment were 12 months old and the cuttings 18 months old when planted. A sandier area closer to Tabbimoble Creek was used for the experiment.

3.4.2 Results

First planting of Singleton Mint Bush

Survivorship was ~35% (two thirds dead or dying) after three months (June 2016). The main cause appeared to be a root disease making plants to wilt. Being the rainy season, soil moisture was high. This disease could have been Phytophthora which is indigenous to soils in the North Coast region, but seldom causes disease under natural conditions. Plants that survived the initial die-off were monitored. Mean height was 31.3 cm in November 2017, 91.4 cm in July 2018 and 121.1 cm in July 2019. Survivorship after 3 years was 84.3% (i.e. after the initial period of high mortality). The tallest plant in July 2019 was 268 cm, 2 years after planting out, 3 years after sowing seed. This is a fast rate of growth and reflects the species' obligate seeder type of life history.

Experiment 1 (effect of soil texture and seedling age)

Survivorship on five transect after two years varied from 0% to 77.1% depending on the position of transects relative to the soil texture gradient. Nearly all plants died on Transect 1 and 2 furthest from the creek. Survivorship increased toward the creek as the topsoil became sandier (Table 7). These results were already evident after one year (Table 7) and the surviving seedlings have continued to increase in height. A ribbon test was carried out to examine soil texture but it would good to have some better data on soil particle size composition to round out the experiment.

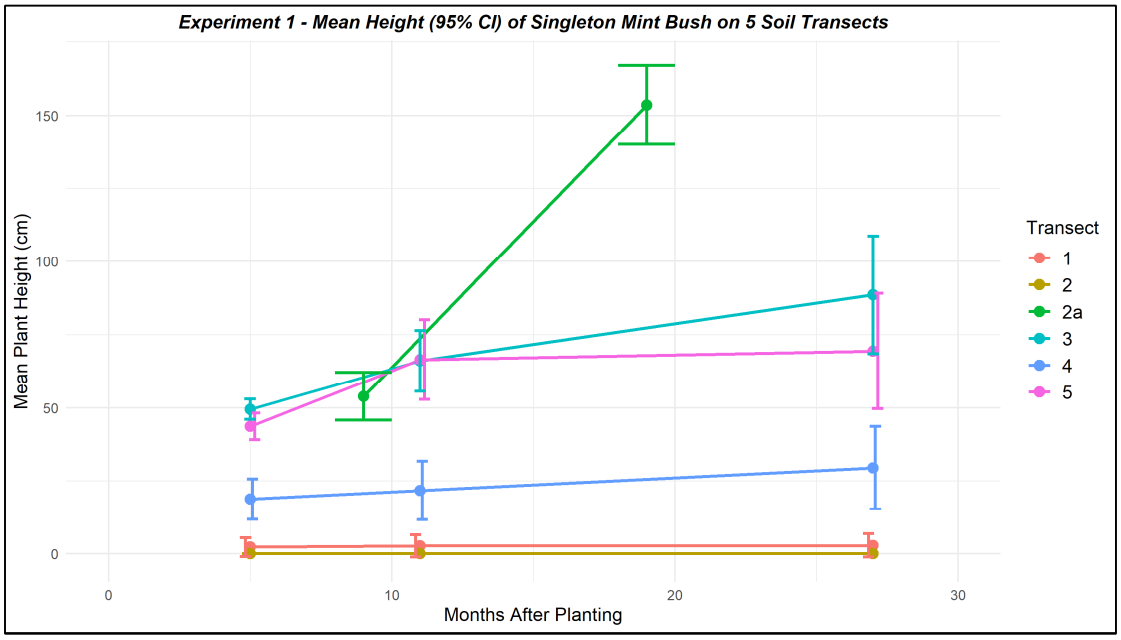

Figure 7: Mean height (cm) of Singleton Mint Bush on five transects located in a receival site 80m wide with variable soil texture/sand content. Mean height was higher on T3 and T5 which were on parts of the site with higher sand content. Mean height was substantially higher on T2a with 12-month old seedling tubestock after all the 6-month old tubestock on this transect had died. . (Note - mean plant height was calculated by scoring plants that were dead as zeros, which effectively weights the mean by survivorship. No plants died in Transect 2a.)

The most surprising result came from the two plots on T2 replanted with older tubestock after the 6-month old tubestock had died (Figure 7, T2a). The survival of the 12-month old seedlings after two years (approx.) was 100% and they grew rapidly, compared with zero survival for the 6-month old tubestock. This showed that as well as soil texture/sand content, the age of tubestock (a horticultural factor) has a major effect on the performance of this species during translocation. Possible mechanisms for the effect could be (i) seedlings develop disease resistance as they grow older, (ii) changes occur in the microflora of sterilised soil as the soil

medium ages and is recolonised by soil biota (fungi, bacteria, protozoans etc). Exposure to soil biota may condition the root system of seedlings so they are better able to resist pathogenic microorganisms when introduced to the wild. This effect may be due to both the age of seedlings and the age of the soil medium (since it was sterilised).

Experiment 2

Experiment 2 was designed as a factorial experiment with three factors: propagation mode (seedlings vs cuttings), fertiliser addition (12 month slow release applied/not applied) and block. As the six plots were contiguous, plots 1-3 were placed in Block 1 and plots 4-6 in Block 2, as surrogates for a potential systematic gradient in environmental factors across the six plots that could have affected the results (e.g. greater or less shade, competition etc.).

The results of the three-way ANOVA are shown below where the three factors are 'plot' (= block), 'S.C' (seedlings vs cuttings) and 'F.NF' (fert/no fert). The other terms are interaction factors.

Test for normality

```
> ks.test(data3$height, "pnorm", mean=mean(data3$height), sd=sqrt(var(data3$height)))

        One-sample Kolmogorov-Smirnov test

data:  data3$height
D = 0.081928, p-value = 0.7192
alternative hypothesis: two-sided
```

Three-way ANOVA

```
> model<-(aov(height~plot*S.C*F.NF))
> summary(model)
             Df Sum Sq Mean Sq F value   Pr(>F)
plot          1   2913    2913   1.472   0.2295
S.C           1  34148   34148  17.251 9.89e-05 ***
F.NF          1   3413    3413   1.724   0.1939
plot:S.C      1    356     356   0.180   0.6731
plot:F.NF     1  11396   11396   5.757   0.0193 *
S.C:F.NF      1    171     171   0.086   0.7697
plot:S.C:F.NF 1    817     817   0.413   0.5229
Residuals    64 126687    1979
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Post-hoc testing. Summary of the data is also given below to show which groups have larger/smaller means.

```
> TukeyHSD(model, "plot:F.NF")
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = height ~ plot * S.C * F.NF)

$`plot:F.NF`
                diff         lwr       upr     p adj
b:F-a:F   -34.54167 -76.0350500  6.951717 0.1353669
a:NF-a:F  -12.08333 -53.5767166 29.410050 0.8684791
b:NF-a:F    6.75000 -41.1624320 54.662432 0.9823287
a:NF-b:F   22.45833 -11.4208723 56.337539 0.3075971
b:NF-b:F   41.29167  -0.2017166 82.785050 0.0515879
b:NF-a:NF  18.83333 -22.6600500 60.326717 0.6307917

> data3_summary
  plot F.NF  N   height       sd        se       ci
1    a    F 12 141.5000 47.87389 13.820001 30.41762
2    a   NF 24 129.4167 44.50297  9.084131 18.79196
3    b    F 24 106.9583 49.03369 10.008960 20.70511
4    b   NF 12 148.2500 57.30005 16.541099 36.40671
```

The three-way ANOVA table above found that fertiliser addition and block had no significant effect, while propagation mode strongly affected plant height after 20 months. The mean height

of seedlings was about 45cm taller than cuttings. The seedlings grew more erect and much leafier than the cuttings, a difficult trait to measure without drying and weighing the whole plant.

Lack of any effect from fertiliser could have been due to residual fertiliser applied when tubestock were in the nursery. However, a similar comparison of fertiliser and no fertiliser carried out with Weeping Paperbark seedlings found that fertiliser roughly doubled the rate of growth, when fertiliser was also applied to tubestock in in the nursery. There was also a curious interaction between block and fertiliser (see term 'plot:F.NF', where plot=block).

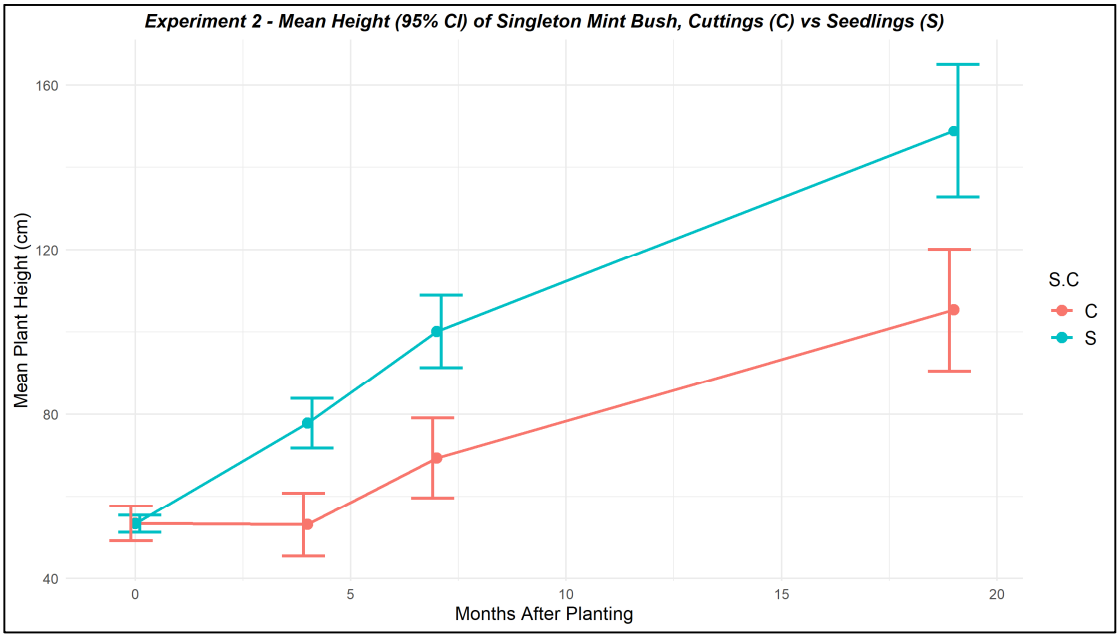

Figure 8: Comparison of the mean height of Singleton Mint Bush propagated from seed and cuttings over 20 months (approx.2 years). Significant difference in mean height are indicated where the 95% confidence limit bars are non-overlapping. After 20 months the seedlings were about 45 cm higher than cuttings.

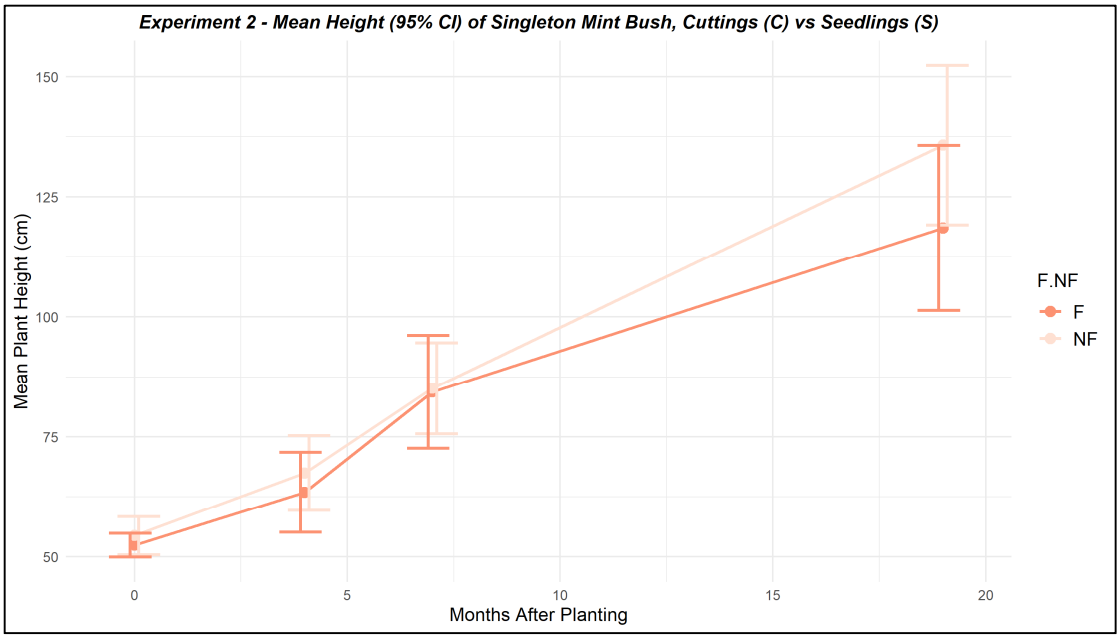

Figure 9: Effect of fertiliser and no fertiliser treatments on mean height of Singleton Mint Bush over 20 months. No significant difference indicated by overlapping 95% confidence limit bars.

3.5 Weeping Paperbark (*Melaleuca irbyana*)

3.5.1 Translocation Method

Seed capsules were collected from a cross section of trees at the New Italy donor population in August 2016 (see Excel spreadsheet). Following germination, the seedlings were grown in native tubes in a commercial, sterilised soil mix for natives and dilute Seasol liquid fertiliser was applied three times. When introduced the tubestock were 6-months old, 35-45 cm high and hardened-off. The whole process of propagation from seed took 8 months to complete.

Weeping Paperbark was introduced to two receival sites: RMS offset land south of Tabbimoble Creek and 'Tabbimoble Triangle' on the northern side of Tabbimoble Creek, also RMS property. At the first site two planting areas were marked out in grassy, open woodland dominated by Forest Red Gum, Swamp Oak, Paperbark and Swamp Box. Planting areas were fenced to exclude domestic and native grazing animals. Both areas are on a floodplain with heavy clay soil, which is typical of Weeping Paperbark habitat. The areas were relatively open with low tree density allowing for better tubestock establishment, although sapling regrowth will need to be controlled during the establishment period.

Tubestock were planted on the offset land south of Tabbimoble Ck in March/17 and at the Tabbimoble Triangle in July/17. Tubestock were planted with 12 month slow release fertiliser. To assess how fertiliser affected performance, two plots of plants received no fertiliser. Tubestock in the Tabbimoble Triangle were planted without fertiliser, but when it became clear that fertiliser was stimulating growth, fertiliser was applied at this site also.

More tubestock were planted in April 2018 in the northern part of the Tabbimoble Triangle to replace losses and increase numbers to around the target of 1700.

3.5.2 Survival and Growth

Mean plant height roughly doubled over the last 12 months to July 2019. Addition of slow release fertiliser resulted in a doubling of mean plant height to 211.0 cm - see Table below.

Mean height of seedlings (cm) over three years:

	no Fert	Fert
Mar-17	31.4	42.3
Apr-18	68.9	109.3
Jul-19	108.9	211.0

The total or net number of plants surviving in July 2019 was approximately 1400 or within 80% of the target of 1700.

3.6 Tall Knotweed (*Persicaria elatior*)

3.6.1 Staging

Tall Knotweed was translocated in 2015 for Sections 1-2 & Early Works and in 2016-2017 for Sections 3-11. Donor and receival sites for all the translocations were located in the same area of low lying swamp and swamp sclerophyll forest between the Maclean interchange and the Harwood Bridge. Results of the first round of (Early Works) translocation were described in two monitoring reports (Landmark Ecological Services 2016, 2017). Results of the second round of translocation were described in Ecos Environmental (2017 and 2018). This report describes the result of all translocations of this species.

3.6.2 Translocation Method – Second Round (2016-19)

Translocation work confirmed that Tall Knotweed is an annual (rarely biennial) species and that to persist as above ground plants in an area, recruitment (meaning germination and establishment from seed) has to occur each year. It is possible the species can also persist for short or long periods as dormant seed in the soil or mud seedbank.

Seedlings appeared after the first translocation in Yaegl Nature Reserve during Early Works but failed to grow, indicating that conditions at the receival site used inside the paperbark forest may not be suitable for Tall Knotweed. Usually this species is found in more open habitat with fewer trees. For the second round of translocations carried out by Ecos Environmental in 2016/2017, another receival site in Yaegl Nature Reserve was selected a few hundred metres north in a more open habitat on the edge of paperbark forest. A total of 335 plants were introduced to the site in three translocations. All plants came from the same swampy area north of Goodwood St at the Maclean interchange construction area. Translocation methods evolved as more plants were found during pre-clearing surveys and added to the translocation effort. The three translocations were carried out using slightly different methods according to the age and size of Tall Knotweed plants being salvaged and environmental conditions at the time, as indicated in the table below.

Translocations 1-3	Number
(1) old plants and soil seedbank (Aug/16)	7 old plants and soil seedbank (26 plots)
(2) young plants (0.5-0.7m tall) (Nov/16)	27 clumps of plants/~48 individuals.
(3) salvaged field seedlings, grown-on in nursery until mature, plant-out (Feb/17)	300 tubestock, mature plants in flower/seed

For the first translocation in August 2016, old Tall Knotweed plants (from the previous year's cohort) and soil seedbank were translocated to the new receival site in Yaegal Nature Reserve. Seven old Tall Knotweed plants were transplanted (one per plot) and 20 plots were seeded with soil seedbank collected around the old plants. The old plants were relocated to shallow standing water at the receival site. Several bins of muddy substrate were collected assuming they would contain Tall Knotweed seed. The mud was spread in 1m x 1m cleared plots on the margin of paperbark forest where the paperbark trees were widely spaced and the ground layer consisted of grasses and sedges. More than half the plots were in shallow standing water 1-10cm deep and were dug over with a spade to reduce sedge and grass competition (mainly *Eleocharis acuta* and *Paspalum distichum*). The mud seedbank plots were placed at slightly different elevations in the Couch Grass zone (higher – no standing water) and the Water Couch zone (lower – shallow standing water) along about 150 metres of swamp edge. The plots were tagged for monitoring.

In November 2016 more Tall Knotweed plants were found during pre-clearing surveys and translocated to the receival site. These plants had grown from seed and were 0.5-0.7m tall. The plants were dug up and transported to the receival site in Yaegl National Park where they were planted further into the swamp as conditions were drying out. Twenty-seven clumps containing approximately 48 plants were transplanted and tagged for monitoring.

While conducting the second translocation in Nov/16, several hundred recently germinated seedlings of Tall Knotweed were also collected and grown in pots at the nursery. Tall Knotweed is very fast growing and had to be pruned back twice while at the nursery to keep the plants less than a meter high. Planting had to be delayed until February/17 due to unseasonal, hot, dry conditions. Three hundred tubestock were planted in fifteen 4m x 4m plots, 20 plants per plot in mid-February on anticipation of rain, which came as a flood one week later. All plants were flowering and seeding when planted.

3.6.3 Results - Second Round (2016-19)

Translocation 1- transplanted old plants and soil (mud) seedbank
The old plants survived for ~about 2 months, producing a small amount of seed, then died off as the swamp dried out.

Tall Knotweed seedling recruitment was recorded in some of the mud seedbank plots, but sparsely. It occurred mainly in cleared plots in the Couch Grass (*Cynodon dactylon*) zone which is slightly higher than the Water Couch (*Paspalum distichum*) zone. Tall Knotweed seedlings were identified by their sticky, scented first true leaves.

Most seedlings died during the following dry spring- early summer period, some persisted in slightly damper microsites where they grew to maturity and set seed. A few plants grew into the second year (like the old plants salvaged in August 2016).

29% of the 27 plots in Translocation 1 had Tall Knotweed plants in autumn 2018. 18.5% of plots had seedlings and one or two live or recently dead medium sized plants in July 2019.

Translocation 2 – transplanted young plants (0.5-0.7m)
Most of these plants moved in Nov/16 survived and reached reproductive maturity. The site dried out in the first few months after transplanting and additional watering was necessary to prevent die-off. Although the plants were fairly large, flowering and seeding did not start until the wet season (Feb/17). A few plants were still alive at the end of June 2017. These had grown to a large size by producing branches and roots underwater. They appeared to be growing as floating aquatic plants with little attachment to substrate and were still producing flowers and seed.

A total 23 plants were counted at 8 of the 27 labelled plant points March 2018. In July 2019, there were no seedlings or evidence of dead plants. The surface soil was dry.

Translocation 2 - changing numbers of Tall Knotweed over three years:

Date	**No. of plants**
30-07-19	0
02-03-18	23
03-07-17	3
04-04-17	48
Start date Nov/16	

Translocation 3 - field seedling grown-on in nursery then introduced
Translocation 3 plots were located along the boundary between low lying paperbark forest and open pasture on slightly higher ground, where soil type, low competition from paperbark or casuarina trees, and open unshaded conditions were considered most suitable for Tall Knotweed seedling establishment and growth.

The 15 plots planted with tubestock were flooded about a week after introduction at the end of February 2017. More than half the 1m tall plants were fully submerged and died (at least some leaves must remain above water for plants to survive). All plants were in flower and producing seed when planted out so the plots were probably seeded. By June 2017, 87% of plots still had

at least three live plants and where the water had receded recently germinated seedlings were recorded. The seedlings were 5-10cm tall and being grazed by kangaroos.

In March 2018, 87% of the plots had mature Tall Knotweed plants again. Several plots had high densities and a crown-cover of Tall Knotweed (>50%, 100% in one plot). These plants had all recruited naturally from seed produced by the plants introduced in February 2017.

Weeding was carried out in autumn 2018 to stimulate seedling recruitment and maintain population levels at or above target. However, on-going recruitment from year to year in this annual species will depend on soil conditions not becoming too dry during the spring-early summer period, when dry conditions are not uncommon and appear to result in high seedling mortality in this species.

Life History Observations

Monitoring showed that Tall Knotweed is an annual plant and capable of exceptionally fast growth. In a few months it can grow from seed to a height well over a metre and start flowering, given suitable conditions. Field germination of Tall Knotweed seed can occur virtually all year round if seed is present and conditions are favourable. Germination requires a damp substrate exposed to air. There was no evidence that Tall Knotweed seed can germinate under water even though mature, seeding plants often grow in standing water. Seed germination occurred when the water receded, leaving damp ground. Observations indicated that seed can germinate within a few months of being shed from the parent plant, depending on the water level. Tall Knotweed seed does not appear to have a dormancy mechanism requiring an 'after-ripening' period, rather seed dormancy is temporarily enforced by environmental conditions such as standing water, dry soil and possibly low temperature.

Survival of seedlings recruited in autumn or winter requires that the substrate remains moist during the dry season, up the start of the next rainy season. Sites that appear to be suitable for Tall Knotweed in the wet season may dry out in spring-summer so that seedlings die. It is also possible for seed to germinate in summer and grow rapidly before flooding rains, so remain above water. Open habitat conditions with low competition from trees and herbaceous understory plants appear to be necessary for Tall Knotweed to thrive. Cattle grazing that reduces biomass in swampy areas during winter is often favourable for Tall Knotweed.

3.6.4 Translocation Method and Results – First Round (2015-2018)

Two receival sites in Yaegl Nature Reserve were used for the first round of translocation in Sept-Nov/2015. Nearly all of the plants were translocated to the Yaegl South site. The habitat consisted of young paperbark swamp forest with a sparse ground cover of swamp grass and sedges. Tall Knotweed plants were relocated by direct transplanting in September and November 2015. Fifty five plants were planted in several plots about 10-20 metres inside the edge of the swamp forest. From the stem diameter of dead plants observed in Aug/2016 they were about 50-100cm tall and they were pruned at introduction.

Only three were alive in Autumn 2016 so it appears that conditions were unfavourable at the receival site. Some were already flowering when transplanted in Nov/15 and some seeding of the receival site occurred. Seedlings were observed later at several of the marked planting points in spring 2016, but they did not establish and grow. This was due partly to the dry spring-early summer period in 2016-2017 and also the relatively high density of paperbark (*Melaleuca quinquenervia*) trees at the receival site. This tree is very competitive species producing a dense mat of surface roots that can inhibit the growth of herbaceous understorey plants. No Tall Knotweed plants were recorded at the receival site in April 2018, approx. three years after translocation.

As another cohort of Tall Knotweed failed to establish after introduction in 2015, habitat at this receival site appears to be unsuitable for the species. It remains to be seen whether the receival site used by Ecos Environmental further north will prove to be any more effective, as monitoring continues.

3.7 Four-tailed Grevillea (*Grevillea quadricauda*)

3.7.1 Translocation Method

Grevillea quadricauda is a shrub with a single-stemmed growth form typically found in 'obligate seeder' species. Generally, adult specimens of seeder species are not suited to direct transplanting, as they do not regenerate well after root disturbance and pruning, unlike resprouter species which can generally recover from damage to their stem and/or root systems. This is because resprouter species have dormant buds beneath the bark on stems, branches and roots, and they store food reserves that enable these buds to grow new shoots, leaves and roots if damaged by disturbance.

As adult seeder species often transplant poorly, salvage was limited to small, juvenile plants <30 cm in height. These were grown-on in pots in the nursery before planting out. Large pots were used so there was less disturbance of the root system during transplanting. The plants were grown in soil from the donor site and care taken not to over-water. Fifteen plants were grown in pots for six months to a size suitable for planting out.

An attempt was made to propagate more plants using the soil seedbank method applied to Singleton Mint Bush and by seed collection. Very little seed was found and the soil seedbank method yielded few seedlings. One reason for this may be that *G. quadricauda* produces a winged seed that disperses away from parent plant so that little seed is found under bushes, unlike Singleton Mint Bush.

3.7.2 Results

The juvenile plants transplanted to pots grew rapidly in the infertile sandy soil used from the donor site. They continued to grow rapidly after planting out despite competition from plants in the intact plant community at the receival site. No fertiliser was applied except a few pellets of organic fertiliser in the nursery. All plants were in in flower in March/17, three months after planting out.

In the last 12 months to July 2019, mean height increased about 50% to 155.9cm and mean plant width was 146.2 cm. No mortalities occurred and most plants had some flowers or fruit.

Survivorship and mean height of translocated Grevillea quadricauda:

	Surviv %	Mean Height (cm)
Jul-19	93.3	155.9
Mar-18	93.3	115.8
Mar-17	100	60.8

3.8 Stinking Cryptocarya (*Cryptocarya foetida*)

3.8.1 Translocation Method

The target for *Cryptocarya foetida* was revised down from 41 to 28 individuals based on the number found on the footprint during transplanting. Twenty-four (24) sapling sized individuals (1-4m tall) were transplanted manually. Some individuals were apparently misidentified and were actually *C. microneura* or *C. triplinervis*. All came from the Randles Creek area adjacent to Coolgardie Rd. Four trees were too large to transplant and were cleared.

Two receival sites were used for this species. Transplanting was first carried out to offset land at Lumleys Lane referred to as BOS 22 in the Translocation Strategy. Habitat consisted of cleared pasture and hillside rainforest regrowth dominated by broad-leaved privet and camphor laurel. An area next to the only dam was selected as the receival site, as a local water source is a key requirement for cost-effective translocation (trucking water for translocated plants is

logistically more complicated and expensive). Most of the hillside forest was very rocky, so open pasture immediately below the forest closer to the dam was selected as the receival site. The soil type consisted of a heavy yellow clay with minimal topsoil, formed on metasediment, not ideal but acceptable.

Sapling sized individuals were translocated by direct transplanting. Most of the 24 saplings were dug out with an intact soil-root ball. Pruning was carried out to reduce foliage area. Conditions at the receival site were exposed with few existing trees and little shade except around the forest edge. After transplanting, saplings were mulched and fertilised and watered regularly to maintain high soil moisture.

Additional plants were propagated from seed and introduced to a second rainforest species receival site at Coolgardie Road, as described below.

3.8.2 Results

The transplants at Lumleys Lane started to reshoot four weeks after transplanting. Short leafy shoots grew from dormant buds on the main stem and pruned branches. No root suckers or basal stem shoots were produced. Regrowth was slow and organic pelleted fertiliser and Seasol were applied to stimulate growth. By January 2017, ~6 months after transplanting, 62.5% (15/24) of the transplants had reshot and were alive. Two more had reshot, but died soon after. Although regeneration was slow, it appeared to be progressing satisfactorily until two extremely hot days in Feb/2017 which caused leaf scorching, tissue damage and die-off of half the transplants. One day was the hottest on record for most of the Far North Coast.

At the end of Year-1, survival rate had decreased to 26.9%. Basal reshooting occurred in two individuals that died back after the heat event. In July 2019, the survival rate after 3 years was unchanged at 26.9%, no further mortalities occurred in the last 12 months.

In contrast to the low survival rate of *Cryptocarya foetida* at the Lumley's Lane, several common rainforest species and two other threatened species transplanted to the site, survived and grew reasonably well. Both donor and receival sites had heavy clay soil, although the donor site on Randles Creek (North of Coolgardie Rd) included a narrow strip of alluvium, close to the creek. Very few saplings or regrowth trees of *C. foetida* have been observed in similar habitat on the Blackwall Range during other survey work, which indicates that hill slopes similar to the receival site represent marginal habitat for *C. foetida*.

For this reason, a second receival site with a soil type more closely matching the donor site was established north of Coolgardie Rd, in an island of natural vegetation retained within a wide section of the road reserve (project boundary). This site is on Randles Creek and adjoins the donor site. Work on the second rainforest species translocation site began in late 2017 and early 2018. Propagated plants of threatened rainforest species, including *C. foetida*, were introduced to this site.

Twenty eight (28) *C. foetida* propagated from seed were introduced to the site in Feb/18. By June/18, there were no mortalities and plants showed a small amount of new shoot growth. Additional watering was carried out during dry periods.

By July 2019, 18 months after planting out, survival was 89.3%. Mean height of the seedlings was 42.9 cm (zeros/mortalities included).

3.9 Rusty Green-leaved Rose Walnut (*Endiandra muelleri ssp. bracteata*)

3.9.1 Translocation Method

Three saplings were transplanted directly to the receival site and three juveniles were transplanted to pots for growing-on at the nursery.

Saplings were dug out manually as described for *C. foetida.*

Approximately 30 plants were propagated from seed collected in Aug-Sept/16. Nineteen plants approximately 15 months old were planted in Feb/18.

Work has just been started to propagate and introduce this species at the Maclean interchange where one tree inside the project boundary was accidently cleared this year. Plants will be propagated from seed collected from the Maclean or Wardell areas and introduced to a receival site about 20 metres from the original site. This work is being done in accordance with the Green-leaved Rose Walnut Remediation Plan and will be reported on separately.

3.9.2 Results

Only one of the three transplanted saplings reshot. This individual survived after three years. The three juveniles in pots all survived and grew very slowly.

No losses of 19 seed propagated plants occurred to June/2018. A small amount of new shoot growth was recorded on most plants.

No losses of 19 seed propagated plants occurred in the 12 months to July/2019. Mean height increased from 26.7cm to 35.7cm (Table 8).

3.10 Red Lilly Pilly (Syzygium hodgkinsoniae)

3.10.1 Translocation Method

A total of 42 Red Lilly Pilly have been translocated to the rainforest receival sites at Lumleys Lane and Coolgardie Road

Six juveniles were salvaged from under a large tree located on the clearing footprint north of Lumleys Lane in Oct/2016. These plants were grown on in pots for approx. 12 months before planting out with propagated tubestock in Rainforest Restoration Area No. 2 (Coolgardie Rd) in Dec/2017.

About 50 Red Lilly Pilly were propagated from seed collected in August 2016. Twelve were planted out in Rainforest Restoration Area No. 1 (Lumleys Lane) on 1/6/2017 and the remainder grown on for another six months. Thirty were subsequently introduced to Rainforest Restoration Area No. 2 (Coolgardie Rd) in December 2017, including the small potted transplants. 1.2m chicken wire tree guards were installed to prevent grazing by wallabies and 12 month slow release fertiliser applied.

3.10.2 Results

Rainforest Translocation Area 1

Mean height of first planting of propagated plants (12):

Date	Mean Height (cm)
Jul-19	
Jun-18	58.9
Mar-18	58.4
Planted out June-17	

Rainforest Translocation Area 2

Mean height of second planting of propagated plants and transplants (30):

Date	Mean Height (cm)	%Survival
Jul-19	23.0	50%
Jun-18	47.3	
Planted out Dec-17		

3.11 White Laceflower (*Archidendron hendersonii*)

3.11.1 Translocation Method

Two saplings were transplanted directly to the receival site at Lumleys Lane and six juveniles were transplanted to pots for growing-on at the nursery. Saplings were dug out manually as described for *C. foetida.*

3.11.2 Results

Translocation Area 1 (Lumleys Lane) - All transplants survived and are in good condition. Mean height of the two plants in Area 1 nearly doubled between June 2017 and June 2018.

Translocation Area 2 (Lumleys Lane) - In the last 12 months to July 2019, mean height increased from 92.5 cm to 152.7 cm. All plants survived.

Mean height of translocated White Laceflower at rainforest translocation areas 1 & 2:

	Mean Height (cm) Rainforest Translocation Area 1	Mean Height (cm) Rainforest Translocation Area 2
Jul-19		152.7
Jun-18	134	92.5
Jun-17	72	nursery
transplanted Oct-16		

3.12 Rough-shelled Bush Nut (*Macadamia tetraphylla*)

3.12.1 Translocation Method

Rough-shelled Bush Nut is being translocated by seed propagation. Seeds were collected on the Blackwall Range adjacent to the highway footprint and from a group of six trees with a densely coppice growth form growing in a paddock at the end of Whytes Rd, Pimlico. These

trees have the same unusual (unique?) growth form of old trees cleared from the footprint at Coolgardie Road, therefore are likely to preserve the same genotype as the cleared trees. Approximately 50 seeds were collected and five individuals were planted in Feb/18.

3.12.2 Results

After 18 months to July 2019, the five introduced plants were in good condition. Mean height increased from 31.2 cm to 55.2 cm in the last 12 months. Two additional plant propagated from local plants were introduced taking the total to 7.

Rainforest Translocation Area 2 (Coolgardie Rd)

Mean height of first planting of propagated plants:

Date	Mean Height (cm)
Jul-19	55.2
Jun-18	31.2
Planted out June-17	

3.13 Square-fruited Ironbark (*Eucalyptus tetrapleura*)

3.13.1 Translocation Method

Eight saplings were transplanted from the crown land site to the Sunnyside Rd offset property in Oct/16.

79 tubestock propagated from seed were planted at Sunnyside Rd in autumn 2017.

3.13.2 Results

Two of the eight transplants died over two years.

There was 10% mortality of the planted tubestock between 2017-2019 and mean height in autumn 2018 was 45.3cm.

Effects of frost were evidence in July 2019. New tip growth had been burnt off on most plants.

3.14 Hairy Melichrus (*Melichrus hirsutus*)

One individual was transplanted and divided into two plants. After three years, survivorship 100%. Flowering occurred each year in winter from June 2017 to July 2019.

3.15 Hairy Joint Grass (*Arthraxon hispidus*)

3.15.1 Translocation Method

On Sections 3-11. Hairy Joint Grass (HJG) was translocated in 2016 and on Sections 1-2 & EWSSTA's in 2015. All translocations were carried out by direct transplanting of sods containing plants or sods thought to contain seed.

On Sections 3-11, populations were translocated on Section 10 (Coolgardie Rd – Lumleys Lane) and Section 3 (Mitchell Rd). Plants on Section 10 were transplanted to a receival site at Lumleys Lane and those on Section 3 went into the adjoining road reserve. Fifty trays of plants from the Coolgardie Rd south and Lumley's Lane west donor sites were planted into 43 plots

at Lumley's Lane receival site, approximately 50 plants per plot (43 x 50 = 2150 plants), in Nov/16. Approximately 1000 plants were translocated to 20 plots at Mitchell Rd in Sept/16. The plants consisted of seedlings.

There were also two translocations of Hairy Joint Grass on Sections 1-2 & EWSSTA, one at Kangaroo Trail on Section 1 in Sept/15 and one at Trustrums Hill in July-Aug/15.Trustrum's Hill had two planting sites – Site 1, a low-lying area with 3 plots and Site 2 on higher ground with eight plots (Table 8)

3.15.2 Results

Sections 3-11

Plants in both translocations on Sections 3-11 grew to maturity and seeded in 2016-2017 and again in 2017-2018. Biomass reduction was carried out in June each year to create low, open conditions favourable for HJG seed germination and seedling establishment. HJG is an annual grass so a new cohort of seedlings must germinate each year for a population to be maintained at a location. In paddock grassland used for cattle grazing, biomass reduction either by grazing or slashing, and mulch removal if the mulch is thick, is necessary for a population to persist at a location. A small proportion of the seed produced each year appears to have a prolonged dormancy mechanism but most seed in populations adapted to agricultural grazing land appears to be is non-dormant (Ecos Environmental 2015).

Sections 1-2 & EWSSTA

On Sections 1-2 & EWSSTA, where there were also two translocations, both appear to have failed to establish a persistent population at the respective receival sites (Table 8). The 2017 monitoring report by LES stated "no plants observed" in autumn 2016 or autumn 2017 at the Kangaroo Trail receival site. However, on monitoring the site in autumn 2018, Ecos Environmental recorded 11 clumps of HJG in seed and some of these were near tags with 'A.h.' on them (*Arthraxon hispidus*). The origin of the HJG plants when none were recorded the previous two years (after translocation in Sept/15) is unclear. Perhaps they were accidently introduced in soil on people's boots.

At the Trustrums Hill receival site, two areas received slabs in July-Aug/15 during the species annual short dormancy or early germination phase. A total of 25 slabs were planted into 3 plots at Site 1 and 8 plots at Site 2. The slabs transplanted on July-Aug/15 had no plants but were thought to contain seed. Based on our research, in July-August, HJG seed should have already germinated and been present as small seedlings. HJG seedlings are distinctive by the width of the first leaf which is much broader than other grasses.

The 2017 monitoring report by LES stated that In the first area (Site 1), one plant was observed by bush regenerators in February 2016, and none were observed during monitoring in autumn 2016 and autumn 2017 (Table 8) when the slabs were overgrown by dense Setaria grass. Attempts were made to clear biomass, but no further plants were recorded. In the other area with eight plots, dead plants were recorded in autumn 2016 and 2017 indicating that HJG plants had recruited from seed in this area, but no dead plants were observed in June 2018. This area located on slightly higher ground had dense ground fern. Overall, the translocation of HJG at Trustrums Hill appears to have been unsuccessful in maintaining a population of HJG in the translocation areas, as biomass reduction was not carried out, or applied at the wrong time of year. The hydrological regime in low lying Site 1 may have been too wet for HJG, which can grow on the edge of wetlands, but not in standing water for any length of time.

No evidence of HJG plants were observed at Trustrums Hill in July 2019.

HJG is not a difficult species to translocate. All that is required is an understanding of the species' habitat requirements and life history/cycle, and how to manipulate site conditions to maintain favourable conditions for seed germination each year, which typically occurs in late winter when soil conditions are still damp.

3.16 Lindernia (Lindernia alsinoides)

3.16.1 Translocation Methods

The habitat requirements of Lindernia are clearer after monitoring its survival at the four receival sites where translocation was attempted. The natural habitat of Lindernia appears to consist of lower slope seepage areas (springs) and drainage lines in sandstone terrain. The seepage zones are more-or-less perennial and consequently often have peat soil overlying sand. At Mitchell Rd (Section 3-11) the peat was 20-30cm deep. Vegetation growing on the seepage at this site consisted of wetland sedges and herbs, and sphagnum moss, under an open woodland canopy of trees including Swamp Mahogany (*Eucalyptus robusta*) and *Melaleuca spp*.

Three receival sites were selected for Lindernia on Sections 1-2 & EWSSTA. Translocation methods applied on Sections 1-2 & EWSSTA included (i) transplanting sods/clumps of plants, (ii) removal of soil slabs thought to contain seed and (iii) introduction of plants propagated from cuttings. None of these methods were successful, which appears to be due to unsuitable habitat at the receival sites, or possibly horticultural factors. Large numbers of propagated plants were introduced to two receival sites (Kangaroo Trail and Halfway Ck Crossing) but very few survived by July 2019. At Kangaroo Trail, a planting of 350 nursery plants in Jan/16 died out in six months. A second large planting was carried out in autumn 2017 (428 plants Table 7), but nearly all plants died again after 12 months. The site was fenced to exclude kangaroo grazing but this was clearly not the cause of plant death as the same result occurred. Soil texture at both sites had a clay-silt texture rather than peat on sand that appears to be required by Lindernia

Translocation of Lindernia on Sections 3-11 consisted of unexpected finds and was limited to transplanting. As clearing was scheduled to take place the same week, there was little time to search for receival sites. Thirty spade sized sods (20-30 cm thick) of Lindernia plants growing in black peat over sand were transplanted in Dec 2016. The receival site was located on the opposite side of the highway to the donor site, on the same drainage line downstream. Run-off from earthworks deposited thick iron leachate at the receival site in autumn 2017, blanketing the translocated plants. They appeared to die, but in July 2019, water quality was much improved, and it is possible some plants may regenerate from seed or runners in the transplanted sods.

3.16.2 Results

Survivorship:

Mitchell Road – all plants in 30 sods appeared dead after two years (June/18). Seedling regeneration of various herbs was present in July 2019, but species were not in flower and could not be identified.

Halfway Ck Crossing – 12 out of 500 propagated plants survived after one year (June/18). Six plants surviving July 2019.

Kangaroo Trail – one plant out of 428 propagated plants survived after two years to July 2019.

Yuraygir SCA – no plants since spring 2016 (Table 8).

The Lindernia translocations although failing to establish compensatory stands or populations, were useful in clarifying the narrow habitat niche of this species. If carried out again, translocation would have a better chance of success as the habitat requirements of the species are better understood.

3.17 Rotala (Rotala tripartita)

3.17.1 Translocation Method

Approximately 10 plants growing in a linear drainage depression on the eastern side of the highway were salvaged in Sept/17 and grown-on in pots at Ecos Environmental's nursery for planting out closer to the wet season. Habitat at the donor site consisted of a linear wetland depression in a cleared paddock, which held shallow standing water for most of the rainy season (Dec-June) and dried out for a month or two during spring. Rotala appears to require low herbaceous, marshland vegetation growing in shallow, permanent water or wet soil.

No matching wetland habitat was found at potential receival sites, so similar habitat was engineered at a site on the Tabbimoble Creek floodplain about 0.5 km to the south. Two pond depressions were dug with an excavator on a floodway in open woodland on heavy clay soil. This aimed to create a permanent pond or damp area suitable for Rotala. Before introducing Rotala plants, the ponds were filled with water by pumping from a nearby creek. Natural run-off would then be relied on to maintain suitable hydrological conditions.

Rotala is a stoloniferous herb and can be propagated by cuttings or division. About 50 plants were propagated using this method from plants salvaged from the donor site. These were planted into the receival site in the pots, by digging in the pots, so the plants could be moved around to adjust their position with minimal damage to the plants. Suitable hydrological conditions are critical for the survival of wetland plants that grow in shallow water or on the edge of wetlands. More than half the plants were lost by planting them too high and two adjustments to pot position were made. Plants were moved down closer to the water as the water level dropped. Organic fertiliser pellets were added to pots to simulate growth. Plantings at the two ponds were fenced in March/18 due to disturbance by wild pigs.

3.17.2 Results

Survivorship was 90% after approximately 6 months (Feb to July/18). Stolons grew up to 10cm beyond some pots taking root in the damp substrate. After 18 months to July 2019, survivorship has fallen to 37.8% or 17 plants.

Surviving plants were still above the translocation target of 10 plants, but the ponds do not appear to be deep enough to maintain a sufficient area of permanent standing water or wet substrate for Rotala to persist at the site. There is too much shade at one of the two ponds in winter due to nearby trees.

3.18 Lepidosperma sp. Coaldale

3.18.1 Translocation Method

Lepidosperma sp. Coaldale is a sedge about 1 m high with still upright, cylindrical leaves and a short, woody rhizome. Habitat at the donor site at Wells Crossing consisted of open woodland dominated by Scribbly Gum with a dense shrub understorey (Leptospermum, Banksia, Xanthorrhoea), growing on shallow sandy soil overlying sandstone. The site was on a lower slope next to a swampy drainage line, on shallow soil overlying sandstone rock.

During early works, thirty five Lepidosperma sp. Coaldale were transplanted to pots in August 2015 and kept at a nursery before planting out at a receival site on RMS offset land at Pillar Valley (Mahogany Drive) in Spring 2016 (Table 8). This site has broadly similar habitat to the donor site at Wells Crossing, including sandstone geology and lower slope position, although there are differences in habitat including species composition, soil depth and soil hydrology. The Pillar Valley is in open forest (not woodland) and the soil is a deep sand (not shallow sandy

soil over rock). Thirty five individuals were planted in Spring/2016 in four plots located on two drainage lines. A year later in August 2017 the offset land was burnt by a fire, including the translocation plots. The plastic monitoring tags were burnt in the fire and have been replaced.

3.18.2 Results

Survivorship in June/2018, approximately three years after salvage from the construction footprint was 43%. Some of the plots were becoming overgrown with Common Ground Fern (*Calochlaena dubia*), which overtops and smothers Lepidosperma sp. Coaldale.

Survivorship in July/2019, approximately four years after salvage was 20%.

3.19 Richmond Bird Wing Vine (*Aristolochia pravevenosa*)

Propagated from 1-2 cm thick hardwood stem cuttings collected in Oct/16. Eleven plants introduced to the Coolgardie Rd rainforest species translocation area in Oct/17

Survivorship to July/2019 was 100%. Mean height decreased from 107.4 cm to 89.6 cm over the last 12 months

3.20 Carronia (Carronia multisepala)

Propagated from stem cuttings collected Nov/17. Six plants introduced to the Coolgardie Rd rainforest species translocation area in June/18. Survival was 83.3% after 12 months to July 2019. Very little growth has occurred.

3.21 Summary of Translocation Monitoring

Table 8: Results of threatened flora translocations on W2B sections 3-11 after three years (2016-2019).

S - survivorship %; CC - mean % crown-cover; Ht - mean height (cm); ~1 year, ~2 years - time since transplanting/introduction, or time since seed germination.

Species	Receival Site	Method/Start Date	No. of Plants Translocated (Transplanted/Propagated)	Survival %/Cover-abundance/ No. of plants June/2017	Survival %/Cover-abundance/ No. of plants March-June/2018	Survival %/Cover-abundance/ No. of plants July/2019
Yellow-flowered Oberonia (*Oberonia complanata*)	Bundjalung NP Gumma Gurra	Transplanted Aug/2016	Transplanted - 11	~1 year S = 91% (10/11)	~2 years S = 91%	~3 years S = 91%
Unexpected finds	Lumleys Lane Sth	Transplanted Aug/2017	Transplanted – 12 branches with 35 clumps	n/a	~1 year S = 100%	~2 years S = 100%
Slender Screw Fern (*Lindsaea incisa*)	Bundjalung NP Area 1	Transplanted Sept (most), Nov, Dec 2016	Transplanted: Line A – 25 trays/plots Line B – 44 trays/plots Line C – 15 trays/plots Line D – 18 trays/plots Patches = 5 (5 trays/plot) @ 50 fronds/tray Total fronds=~6350	~1 year Line A – S=100%; CC=17.9% Line B – S=100%; CC=15.5% Line C – S=100%; CC=4.7% Line D – S=89%; CC=13.8% patches – S=100%; CC=52%	~2 years Line A –S=100%; CC=12.6% Line B – S=100%; CC=24.7% Line C – S=100%; CC=41.3% Line D – S=100%; CC=11.9% patches – S=100%; CC=53%	~2 years Line A –S=100%; CC=30% Line B – S=100%; CC=25.5% Line C – S=100%; CC=40.9% Line D – S=100%; CC=25% patches – S=100%; CC=36%
Unexpected finds	Bundjalung NP Area 2	Transplanted Sept, Oct 2017	Transplanted: Line A – 29 trays/plots Line B – 30 trays/plots Patches Area 1 =16 Patches Area 2 = 7 @ 25 fronds/tray Total fronds=~4350	n/a	~1 year Line A – S=100%; CC=25.9% Line B – S=100%; CC=18.9% patches–S=100%; CC=88.4% &83.3%	~1 year Line A – S=97%; CC=6.8% Line B – S=94%; CC=16.3% patches–S=100%; CC=68.5% &80%
Singleton Mint Bush (*Prostanthera cineolifera*)	Tabbimoble Triangle	Soil seedbank collected Aug/2016 1st tubestock planted 23/3/2017 when seedlings ~6 month old	Propagated (soil seedbank) Number planted: 1 - 700 tubestock 2 - experiment 1 & tubestock (300) 3 - experiment 2 & tubestock (200)	~3 months 1st planting ~35% survival 1st planting mean ht 31.4cm	~2 years Total number surviving - 584 1st planting mean ht 91.4cm	~3 years Total number surviving - 520 1st planting mean ht 121.1cm
Experiment 1 (effect of soil texture gradient and fertiliser on survival and growth)	Tabbimoble Triangle	Soil seedbank collected Aug/2016 Exp.1 planted 12/4/2017 when seedlings ~6 month old	5 transects at different locations relative to soil texture gradient, 3 plots per transect, 2 treatments per plot (Fert and No Fert), 8 plants per treatment. 16 plants/plot Total 240 plants in experiment	~3 months Start height 35-45cm T1 – 97.9% wilted T2 – 91.7% wilted T3 – 4.2% wilted T4 – 62.5% wilted T5 – 14.8% wilted T2 all dead Sept/2017	~ 1 year Meant Ht of plants (cm) zeros included T1 T2 T3 T4 T5 NF 5.5 0 61.1 18.1 77.2 F 0 0 77.5 25.3 55.8	~ 2 years Mean Ht of plants (cm) zeros included T1 T2 T3 T4 T5 NF 5.7 0 84.4 19.8 79.6 F 0 0 91.8 39.2 59.3 Survival 4% 0% 77.1% 31.3% 58.3% (NF+F)

Species	**Receival Site**	**Method/Start Date**	**No. of Plants Translocated (Transplanted/Propagated)**	**Survival %/Cover-abundance/ No. of plants June/2017**	**Survival %/Cover-abundance/ No. of plants March-June/2018**	**Survival %/Cover-abundance/ No. of plants July/2019**
Experiment 1 (effect of seedling age – two plots on T2 replanted)	Tabbimoble Triangle	Experiment.planted 17/11/2017 with ~12 month of seedlings old	Two plots from Experiment 1 (T2-5 and T2-6) replanted with 12 mth old sdlgs, each plot quarter with four seedlings. 16 plants/plot Total 32 plants in experiment	n/a	~6 months T2-5 mean ht = 52.3 cm T2-6 mean ht = 55.8 cm Survivorship – 100%	~18 months T2-5 mean ht = 141.6 cm T2-6 mean ht = 165.5 cm Survivorship – 100%
Experiment 2 (effect of propagation type – cutting vs.seedling - and fertiliser on survival and growth)	Tabbimoble Triangle	Soil seedbank collected Aug/2016; cuttings collected 2015 Exp.2 planted 9 & 17/11/2017 Seedlings ~12 months old; cuttings ~18 mths	Six plots, each plot divided into quarters, two quarters with seedlings, two with cuttings, half plots with Fert, half No fert. 12 plants/plot Total 72 plants in experiment	n/a	~6 months Seedlings Cuttings NF Ht=95.6cm Ht=74.6cm F Ht=104.7cm Ht=64.1cm Survival 95-100%	~20 months Seedlings Cuttings NF Ht=155.2cm Ht=116.1cm F Ht=142.4cm Ht=94.5cm Survival 94.5%
Weeping Paperbark (*Melaleuca irbyana*)	Tabbimoble Offset Land Tabbimoble Triangle	Seed propagation, seed collected Aug/2016	Propagated (seed) No..planted (different sites): 1. 700 tubestock 2. 500 tubestock 3. 500 tubestock	1. S ~80% 2. S ~80% 3 – recently planted	~2 years Total number of plants approx. 1500	~3 years Total number of plants approx. 1500
Fert vs No Fert comparison	Tabbimoble Offset Land Tabbimoble Triangle	Seed propagation, seed collected Aug/2016	No fert – 2 plots of 9 Fert – 1 plot of 18			~3 years No fert mean ht = 121.2 cm Fert mean ht = 211.0 cm
Tall Knotweed translocation 1 (old plants and soil seedbank)	Yaegl Nature Reserve Centre-north	Old plants (7) transplanted & soil seedbank collected Aug/Sept 2016	Transplants (7) & soil seedbank (SSB) applied to 27 plots.	% of plots with Tall Knotweed: Oct/16 - 51.9%, Jan/17 - 29.6%, April/17 - 22..2%, June/17 – 0%	~ 2 years 29.6% of plots with at least one mature Tall Knotweed. Total number of plants ~12	~ 3 years 18.5% of plots with live sdlgs or recently dead mature Tall Knotweed. Total number of plants ~ 37
Tall Knotweed translocation 2 (transplant young plants (0.5-0.7m)	Yaegl Nature Reserve Centre-north	Young plants transplanted Nov/2016	Transplants - 27 clumps/plots 48 plants	% of plots with Tall Knotweed April/17 - 66.7% June/17 – 11.1%	~ 1.5 years 30% of plots with at least one mature Tall Knotweed. Total number of plants ~24	~ 2.5 years No plots with Tall Knotweed – there was some when inspected in March/19 Total number of plants = 0
Tall Knotweed translocation 3 (salvage field seedlings grow-on in nursery, introduce)	Yaegl Nature Reserve Centre-north	Field seedlings collected Nov/16, grown in pots in nursery introduced Feb/17	300 plants - 15 plots with 20 plants per plot	~4 months % of plots with Tall Knotweed: April/17 – 100% June/17 – 86.6%	~1 year 87% of plots with mature Tall Knotweed plants, several with a crown-cover of Tall Knotweed >50%. These plants were recruited naturally from seed produced by plants introduced in Feb/17. Total number of plants 300+	~2 years 33% of plots with live sdlgs or recently dead mature Tall Knotweed. Total number of plants ~ 33 (mainly dead matures)
Four-tailed Grevillea (*Grevillea quadricauda*)	Road Reserve south of Quarry Rd, Section 3	Transplanted - juvenile plants transplanted to pots Aug-Sept/16 and grown in nursery for ~6 months. Soil seedbank collected Aug-Sept/16	15 potted plants introduced to receival site I n March/17.	~ 1 year 85% survived transplanting to pots; 100% survived after planting out. Mean ht – 60.8cm	~ 2 years Survivorship - 93% Mean height – 115.8cm Total number of plants 14	~ 3 years Survivorship - 93% Mean height – 155.9cm Mean width – 146.2cm Total number of plants 14

Species	Receival Site	Method/Start Date	No. of Plants Translocated (Transplanted/Propagated)	Survival %/Cover-abundance/ No. of plants June/2017	Survival %/Cover-abundance/ No. of plants March-June/2018	Survival %/Cover-abundance/ No. of plants July/2019
Stinking Cryptocarya (*Cryptocarya foetida*)	Lumleys Lane	Transplanted Sept-Oct/16	Transplanted – 24 saplings	Jan/17 - 62.5% survived Mar/17 - 26.9% June/17 – 26.9%	~ 2 years Survivorship – 26.9% Total number of plants 7	~ 3 years Survivorship – 25% Total number of plants 6
	Coolgardie Rd	Propagated - seed collected Aug-Sept/16 Planted Feb/18	28 plants in 5 inch pots	n/a	~6 months Mean Ht – 35.6cm Survivorship – 100% Total number of plants 28	~18 months Mean Ht – 42.9cm Survivorship – 89.3% Total number of plants 25
Rusty Rose Green Walnut (*Endiandra muelleri ssp. bracteata*)	Lumleys Lane	Transplanted Sept-Oct/16	Transplanted – 3 saplings; (3 seedlings to pots)	Jan/17 - 33.3% survived Mar/17 - 33.3% June/17 – 33.3%	~ 2 years Survivorship – 33.3% Total number of plants 1	~ 3 years Survivorship – 33.3% Total number of plants 1
Propagated		Propagated - seed collected Aug-Sept/16 Planted Feb/18	19 plants in 5 inch pots	n/a	~6 months Mean Ht – 26.7cm Survivorship – 100% Total number of plants 19	~18 months Mean Ht – 42.9cm Survivorship – 100% Total number of plants 19
Red Lilly Pilly (*Syzygium hodgkinsoniae*)	Lumleys Lane	Transplanted and propagated - juveniles transplanted to pots (6) Oct/16; seed collected Aug-Sept/16. Planted June/17	12 propagated plants (supertubes)	n/a	~ 1 year Mean Ht – 57.5cm Survivorship – 100% Total number of plants 12	~ 2 years Mean Ht – 59.5cm Survivorship – 100% Total number of plants 12
	Coolgardie Rd	Propagated - seed collected Aug-Sept/16.Planted Feb/18	30 propagated plants including transplants (supertubes)	n/a	~ 6 mths Mean Ht – 47.3cm Survivorship – 100% Total number of plants 30	~ 18 mths Mean Ht – 23cm (zeros included) Survivorship – 46.7% Total number of plants 14
White Laceflower (*Archidendron hendersonii*)	Lumleys Lane	Transplanted Oct/16 Saplings directly transplanted, juveniles to pots	2 saplings transplanted; (6 seedlings to pots)	~ 1 year 100% survival transplants and pots	~ 2 years Survivorship – 100% Total number of plants 2	~ 3 years Survivorship – 100% Total number of plants 2
	Coolgardie Rd		6 potted juveniles (6) introduced Feb/18	n/a	~ 6 mths Mean Ht – 92.5cm Survivorship – 100% Total number of plants 6	~ 18 mths Mean Ht – 152.7cm Survivorship – 100% Total number of plants 6
Rough-shelled Bush Nut (*Macadamia tetraphylla*)	Coolgardie Rd	Propagation - seed collected Jan–Feb/2017	Most seed eaten by rats during propagation; 5 plants introduced in Feb/18	n/a	~ 6 mths Mean Ht – 31.2cm Survivorship – 100% Total number of plants 5	~ 18 mths Mean Ht – 55.2cm Survivorship – 100% Total number of plants 5
Square-fruited Ironbark (*Eucalyptus tetrapleura*)	Sunnyside Rd Offset property, Glenugie	Transplanted Oct/2016	Transplanted – 8	~ 1 year Survivorship – 75% Total number of plants 6	~ 2 years Survivorship – 75% Total number of plants 6	~ 3 years Survivorship – 75% Total number of plants 6
Hairy Melichrus (*Melichrus hirsutus*)	Mahogany Dv Offset property, Pillar Valley	Transplanted Oct/2016	Transplanted – 1 (divided into 2 plants)	~ 1 year Survivorship – 100% Total number of plants 2	~ 2 years Survivorship – 100% Total number of plants 2	~ 3 years Survivorship – 100% Total number of plants 2

Species	Receival Site	Method/Start Date	No. of Plants Translocated (Transplanted/Propagated)	Survival %/Cover-abundance/ No. of plants June/2017	Survival %/Cover-abundance/ No. of plants March-June/2018	Survival %/Cover-abundance/ No. of plants July/2019
Hairy Joint Grass (*Arthraxon hispidus*) Section 3	Mitchell Rd, Section 3	Placed in trays Sept/2016, planted out in Dec/2016	Transplanted – 20 trays/plots (~1000 plants)	~ 1 year Survivorship – 100% Total number of plants ~1000	~ 2 years Survivorship – 100% Total number of plants ~1000	~ 3 years Survivorship – 100% Total number of plants ~1000
	Lumleys Lane, Section 10	Transplanted Nov/2016	Transplanted - 43 trays/plots (~2150 plants)	~ 1 year Survivorship – HJG at 100% of plots, Total number of plants ~1000	~ 2 years Survivorship – HJG at 100% of plots Total number of plants ~2000	~ 3 years Survivorship – HJG at 100% of plots Total number of plants ~2000
Lindernia (*Lindernia alsinoides*)	Mitchell Rd	Transplanted Dec/2016	Transplanted - 5 plots containing 30 sods	~6 months April/17 – 50% of sods June/17 – 0%	~1.5 years Survivorship – 3% of sods	~2.5 years Survivorship – ? Need to monitor in summer
Rotala (*Rotala semipatita*)	Tabbimoble Offset land	Transplanted to pots Sept/2017. Pots planted out in Feb/18	About 10 plants salvaged and propagated by division to yield about 70 plants. After adjustments, final planting of 50 plants	n/a	~6 months Survivorship – 90% Total number of plants 45	~18 months Survivorship – 37.8% Total number of plants 17
Richmond Bird Wing Vine (*Aristolochia pravevenosa*)	Coolgardie Rd	Propagated - cuttings collected Oct, Nov/2016, Planted Oct/2017	Propagated - 11 in 6 inch pots	100%	~ 1 year Mean Ht – 107.4cm Survivorship – 100% Total number of plants 11	~ 2 year Mean Ht – 89.6cm Survivorship – 100% Total number of plants 11
Pink Underwing Moth Vine (*Carronia multisepala*)	Coolgardie Rd	Propagated - cuttings collected in June/2017; Planted June/18	6 planted out June/18	n/a	n/a	~ 1 year Mean Ht – 8.3cm Survivorship – 83.3% Total number of plants 5

Table 9: Results of threatened flora translocations on W2B Sections 1-2 & EWSSTA after four years (2015-2019)

Species	Receival Site	Methods/Start Date	No. of plants translocated	Autumn 2016	Spring 2016	Autumn 2017	Autumn 2018	July 2019
SECTION 1								
Lindernia	1. Yuraygir SCA	Slabs/clumps (15/8/15)	22 clumps/plants	6 clumps/plants (flowers on 2 plants, seed capsules on 1) (9 mths)	3 clumps/plants	no plants observed	~ 3 years Survivorship – 0 Total no plants – 0	~ 4 years Survivorship – 0 Total no plants – 0
	2. Halfway Creek crossing	Soil slabs stored (31/8/15)	8 slabs	no plants observed (9 mths)	no plants observed (1 yr)	no plants observed (1.5 yr)	~ 3 years Survivorship – 0 Total no plants – 0	~ 4 years Survivorship – 0 Total no plants – 0
	2. Halfway Creek crossing	Nursery plants		n/a, not yet planted out	n/a, not yet planted out	~ 500 plants newly planted	~ 1 year Survivorship – 2% Total no plants – 12	~ 2 years Survivorship – 1% Total no plants – 6
	3. Kangaroo Trail	Nursery plants 28/1/16	350	30 (3 mths) (flowers on 17 plants, seed capsules on 11)	1 (6 mths)	no plants observed (1 yr)	~ 3 years Survivorship – 0 Total no plants – 0	~ 4 years Survivorship – 0 Total no plants – 0
	3. Kangaroo Trail	Nursery plants 30/5/17	428			428 plants newly planted (30/5/17) 1-50 monitored	~ 1 year Survivorship – 0.2% Total no plants – 1	~ 2 years Survivorship – 0% Total no plants – 0
Slender screw-fern	3. Kangaroo Trail	Slabs/planting pts (10/9/2015)	45 slabs	17 (8 mths)	10 (1 yr)	4 (1.5yr) (+17 more planted May/17) = 21	~ 1 or 3 years Survivorship – 35.1%? Total no plants – 20 Total no of tags - 57	~ 2 or 4 years Survivorship – 15.8% Total no plants – 9 Total no of tags - 57
Hairy joint-grass	3. Kangaroo Trail	Slabs - stored soil (10/9/2015)	8 slabs	no plants observed	no plants observed	no plants observed	~ 3 years Survivorship – 0 Total no plants – 0	~ 4 years Survivorship – 0 Total no plants – 0
Square-stemmed spikerush	2. Halfway Creek Crossing	Soil slabs stored (31/8/2015)	75 slabs/clumps on 3 transects	no plants observed	no plants observed	no plants observed	~ 3 years Survivorship – 0 Total no plants – 0	~ 4 years Survivorship – 0 Total no plants – 0
Moonee Quassia	(Dirty Creek road reserve)	Nursery cuttings		No strike				
SECTION 2						A		
Lepidosperma "Coaldale"	4. Mahogany Drive	Nursery, plants		n/a, not yet planted out	35 planted out	20 (didn't look under ferns?)	~ 2 years Survivorship – 42.9% Total no plants – 15	~ 3 years Survivorship – 31.4% Total no plants – 11
Square-fruited ironbark	5. Pillar Valley	Nursery, seed		80 plants in nursery	80 plants in nursery	79 planted	~ 1 year Survivorship – 95% Total no plants – 75	~ 2 year Survivorship – 92% Total no plants – 71
SOFT SOILS								
Tall Knotweed summary	6. Yaegl NR (south 8 plots and central 2 plots and 4 controls)	Slabs/clumps/ plants (9/9/15, 29/11/15)	55 south (44?) 2 central	3	1 + 4 seedlings observed but did not establish.	All plants died back, including controls Occasional seedlings (cotyledon stage) present.	~ 3 years Survivorship – 0 Total no plants – 0	~ 4 years Survivorship – 0 Total no plants – 0

Species	Receival Site	Methods/Start Date	No. of plants translocated	Autumn 2016	Spring 2016	Autumn 2017	Autumn 2018	July 2019
Green-leaved rose-walnut	(Maclean Interchange road reserve?)	Single small root-pruned for translocation		Uncertain if translocation is required	Translocation not required			2019 – tree dead – translocation required; seed collection and propagation underway
Hairy joint-grass	Trustrums Hill road reserve Site 1	Slabs/plants (29/7/15, 6/8/15)	25 slabs in total (Sites 1 and 2) Site 1 - 3 plots	Though one plant was observed by bush regenerators in February, none was observed during monitoring	Non observed, biomass high	Non observed (biomass under management)	~ 3 years Survivorship – 0 Total no plants – 0	~ 4 years Survivorship – 0 Total no plants – 0
	Trustrums Hill road reserve Site 2	Slabs/plants (29/7/15, 6/8/15)	Site 2 – 8 plots		Dead transplants observed, no retained seed observed, probably shed	Dead material still present. (Live material not expected in autumn.)	~ 3 years Survivorship – 0 Total no plants – 0	~ 4 years Survivorship – 0 Total no plants – 0

4.0 Assessment of Translocation Outcomes

4.1 Translocation Results Summary

Translocation results on Sections 3-11 met short-term project aims and objectives for all 16 species translocated except Lindernia (Table 9).

Translocation results on Sections 1-2 & EWSSTA failed to meet project aims and objectives for most species. Only one or two species may meet translocation aims and objectives (Table 11). Translocations were unsuccessful or below target for Moonee Quassia, Lindernia, Square-stemmed Spike Rush, Hairy Joint Grass and Tall Knotweed. Monitoring tags for Lepidosperma sp. The assumption that seedbanks are in place for some species (e.g. Lindernia), even though there are no live plants, is doubtful given poor growth response after translocation. Monitoring tags for Lepidosperma sp. Coaldale were destroyed by a bushfire and replaced, but some plants may have been missed so it is unclear how many are currently surviving.

The short-fall in Square-fruited Ironbark currently with about 80 individuals introduced to the receival site and a target of 800, is being addressed with propagation of another 950 individuals, scheduled for introduction in the second half of 2020.

For Square-stemmed Spike Rush translocations undertaken as best possible, however, DPIE (Save Our Species) has approached TfNSW regarding a proposal for the collection of Seed (and vegetative material, if necessary) from multiple populations within two active SoS sites located in the Clarence Valley. TfNSW have agreed in principal to fund the proposal, with SOS implementing all aspects of the work. Consultation has been undertaken with NPWS who have provided written agreement to the translocation site within Bongil Bongil NP

Table 10: W2B Sections 3-11 - overall results after 3 Years. Each species translocation to each receival site is treated as a separate translocation. Targets are according to RMS (2015b) or number found within footprint during translocation. If these differ the original RMS target is shown in brackets. The second last column (Net Number Abundance July 2019) gives the total number or amount alive in July 2019 (i.e. after mortalities). Satisfactory/ Failure/ Equivocal is an overall assessment of the translocations in meeting targets.

Species	Receival Site	Method	Target	Number surviving July 2019	Satisfactory Failure Equivocal
Yellow-flowered King of the Fairies	Bundjalung Nat Pk (Evans Hd)	Transplanted	(18) 11	10	S
Unexpected finds	Lumleys Lane Sth	Transplanted	35	35	S
Slender Screw Fern	Bundjalung Nat Pk Area 1 (Mororo Rd)	Transplanted	6350 fronds/ 127 trays	survivorship (trays) 100%; mean crown-cover 25% - 40.9%	S
Unexpected finds	Bundjalung Nat Pk Area 2 (Mororo Rd)	Transplanted	4350 fronds/ 174 trays	Survivorship (trays) 95%; mean crown-cover 6.8% - 68.5%	S
Singleton Mint Bush	Tabbimoble Triangle	Soil seedbank	609	520	S
Weeping Paperbark	Offset property Tabbimoble Ck.	Seed	1700	1500	S
	Tabbimoble Triangle	Seed			S

Species	**Receival Site**	**Method**	**Target**	**Number surviving July 2019**	**Satisfactory Failure Equivocal**
Tall Knotweed (incl. unexpected finds)	Yaegl Nat. Res. (centre-north)	Transplanted Soil Seedbank	(20) 350 (most seedlings)	70 (incl. recently dead matures); copious amounts of seed produced in the first two years by this annual species	S
Four-tailed Grevillea	Quarry Rd (Sec.3)	Seed	(3) 15	14	S
Stinking Cryptocarya	Lumley's Lane	Transplanted	(41) 24	7	F (overall S)
	Coolgardie Rd	Seed		25	S
Rusty Green-leaved Rose Walnut	Lumley's Lane	Transplanted	(3) 6	1	F (overall S)
	Coolgardie Rd	Seed		19	S
Red Lilly Pilly	Lumley's Lane	Seed	6	12	S
	Coolgardie Rd	Seed Transplanted		12	S
White Laceflower	Lumley's Lane	Transplanted	(1) 8	2	S
	Coolgardie Rd	Transplanted		6	S
Rough-shelled Bush Nut	Coolgardie Rd	Seed	10	5	F
Hairy Joint Grass - Section 10	Lumley's Lane	Transplanted	348 (1.3ha)	41 plots (persistence 100%; no.~2000)	S
Hairy Joint Grass - Section 3	Mitchells Rd	Transplanted	1000	20 plots (persistence 100%; no.~1000)	S
Species Unexpected and Additional to the Translocation Strategy			Target= no. impacted		
Richmond Bird Wing Vine	Coolgardie Rd	Cuttings	5	11	S
Lindernia	Mitchells Rd (Sec.3)	Transplanted	30	0 ?	F
Square-fruited Ironbark	Offset land, Sunnyside Rd	Transplanted	8	6	S
Weeping Paperbark	Offset land, Sunnyside Rd	Transplanted	1	1	S
Hairy Melichrus	Offset land, Pillar Valley (Mahogany Drive)	Transplanted	1	2	S
Rotala	Offset land Tabbimoble Ck	Transplanted Division	20	17	S

Table 11: W2B Sections Sections 1-2 and EWSSTA - overall results after 4 Years. Each species translocation to each receival site is treated as a separate translocation. Targets are according to RMS (2015b) The second last column gives the total number or amount alive in July 2019. The last column (Satisfactory/ Failure/ Equivocal) is an overall assessment of the translocations in meeting targets.

Species	**Receival Site**	**Method**	**Target**	**Number surviving July 2019**	**Satisfactory Failure Equivocal**
Hairy Joint Grass	Kangaroo Trail	Transpl/Soil Seed	2	3	S
	Trustrums Hill	Transpl/Soil Seed	38	dead (annual) plants in 2 out of 11 plots	F
Lindernia	Kangaroo Trail	Cuttings	1811	0	F
	Halfway Ck Crossing	Cuttings		6	F
	Yuragir NP	Transpl/Soil Seed		0	F
Moonee Quassia	Dirty Creek Road Reserve	Cuttings	73	0	F
Slender Screw Fern	Kangaroo Trail	Transplanted	2820 45 slabs	9 (tagged points with plants)	F
Square-fruited Ironbark	Pillar Valley	Pillar Valley	823	71	E
Square-stemmed Spike Rush	Halfway Ck Crossing	Halfway Ck Crossing	253	0	F
Tall Knotweed	Yaegl NR	Yaegl NR	37	0 Seedbank?	E
Lepidosperma sp. 'Coaldale'	Mahogany Drive	Mahogany Drive	35	11	E

4.2 Performance Criteria

A key aim of both Translocation Strategies is 'no net loss' to the size and condition of local threatened flora populations as a result of construction of the W2B project.

This appears to have been stated more as an ideal goal, as the Short-term Criteria in the Strategy (p. 46) allow for a loss of 30% of individuals after one year and 40% after five years.

The Performance Criteria in Tables 12 and 13 from the two Strategy documents are also inconsistent in this regard, as one part will state the aim of no net loss and another part gives the threshold as 70%, 80%, 50% etc,

In assessing the performance of each species, we endeavoured to apply the general criteria on p. 46. If the year was between year 1 and 5, the allowable loss would be between 30% and 40%.

A range of measures were implemented to support this aim including construction-related mitigation measures, offsetting and translocation. Translocation aims to minimise loss to local threatened species populations by salvage transplanting, propagation and introduction of additional individuals to maintain local population numbers, and by restoring and maintaining habitat conditions suited to establishing self-sustaining populations of the subject species.

An assessment of how well the translocation project has so far met the Performance Criterial, Aims and Objectives set out in the Translocation Strategies is presented in Tables 12 and 13 below, which follows the format specified in the Strategies.

Note that an assessment of translocation outcomes in more succinct format is presented above in Section 4.1 Translocation Results Summary, Tables 10 and 1, in terms of an overall Satisfactory, Failure or Equivocal rating, with respect to achieving the target number, and the 30-40% threshold.

Table 12: Evaluation of Translocation Outcomes on Sections 3-11 (year 2) as per Table 6 of the Translocation Strategy (RMS 2015b)

Evaluation – Sections 3-11

		Four-tailed Grevillea	Green-leaved Rose Walnut	Hairy Joint-grass	Red Lilly Pilly	Rough-Shelled Bush Nut	Singleton Mintbush
1	Aim	Maintain or improve the functioning and condition of existing populations	Maintain or enhance existing demographic function and genetic variability	Create a self-sustaining population (Kangaroo Trail) or augment existing populations (Coolgardie-Wardell sites)	Maintain or enhance existing demographic function and genetic variability	Maintain or enhance existing demographic function and genetic variability	Maintain a self-sustaining population adjacent to and in the vicinity of the Tabbimobile Creek donor population.
1	Objectives	Plants improve in condition so that flowering fruiting and regeneration is successful.	Create or augment small sub-populations with diffuse connectivity to meta population in the Coolgardie-Wardell area conserving existing genetic variability	Plants complete their lifecycle and regenerate successfully	Create or augment small sub-populations with diffuse connectivity to meta population in the Coolgardie-Wardell area conserving existing genetic variability	Create or augment small sub-populations with diffuse connectivity to meta population in the Coolgardie-Wardell area conserving existing genetic variability	Translocated plants complete their lifecycle and regenerate successfully
1	Performance criteria	Threats identified and addressed. New growth documented on 80% of existing plants flowers and fruit observed by Year 3. Improvement maintained to Year 5.	Clumps of plants established numerically sufficient to replace or augment the number of affected individuals or sub-populations. Progeny from all translocated individuals is established by Year 3 and maintained to Year 5.	At least 50 plants germinate and set seed each year	Clumps of plants established numerically sufficient to replace or augment the number of affected individuals or sub-populations. Progeny from all translocated individuals is established by Year 3 and maintained through to Year 5.	Clumps of plants established numerically sufficient to replace or augment the number of affected individuals or sub-populations. Progeny from all translocated individuals is established.	At least 30 plants establish and set seed each year from Year 3
1	Threshold	New growth on <50% of existing plants no flowers nor fruit by Year 3. Improvement not maintained to Year 5.*	Less than 80% of no of original clumps or individuals are established. Less than 80% of impacted plants represented by established progeny.*	Less than 30 plants germinate and set seed in any one year*	Less than 80% of no of original clumps or individuals are established. Less than 80% of impacted plants represented by established progeny.*	Less than 80% of no of original clumps or individuals are established. Less than 80% of impacted plants represented by established progeny.*	Less than 20 plants establish and set seed in any one year from Year 2*
1	Corrective action	Re-assess threats and address. Consider augmentation from seed propagated plants from alternative donor sites.	Augment with nursery stock from (likely cutting grown) back up stock.	Undertake searches for suitable local donor populations (in case of isolated southern occurrence) or source from receiving site populations. Collect seed nursery propagate or clump transplant. Re-evaluate site moisture gradients to best target suitable planting sites.	Augment with nursery stock from (likely cutting grown) back up stock.	Augment with nursery stock from (likely cutting grown) back up stock.	Augment with nursery back up stock and if required collect additional seed and cuttings from seed; nursery propagate and plant out.

		Four-tailed Grevillea	Green-leaved Rose Walnut	Hairy Joint-grass	Red Lilly Pilly	Rough-Shelled Bush Nut	Singleton Mintbush
	Evaluation and actions	Performance criteria met. Salvaged plants in good condition, more than tripled in size since introduction, flowering. Large mature plants after 3 years, seeding. Adjacent population enhanced.	Performance criteria met. Population numbers and genetic diversity maintained by salvage from footprint and propagation. Above target, plants increasing in height. Adjacent population enhanced.	Performance criteria met. Existing population augmented. Species life cycle completed Years 1 -3. Dependent on biomass reduction. Adjacent population declined so translocation area helping to maintain species	Performance criteria met. Additional plants have been propagated from seed. Total number introduced well above target, survival rate low but above target. Adjacent population enhanced.	Performance criteria met. 7 seedlings propagated, target 10, growth satisfactory. Established new sub-population at Coolgardie Road adjacent to donor site.	Performance criteria met. Large number of seedlings propagated and introduced. Local population enhanced adjacent to donor site.
2	Aim	Increased knowledge of the threatened plant species	Increased knowledge of the threatened plant species	Increased knowledge of the threatened plant species	Increased knowledge of the threatened plant species	Increased knowledge of the threatened plant species	Increased knowledge of the threatened plant species
2	Objectives	Relevant project results and observations documented.	Relevant project results and observations documented.	Relevant project results and observations documented.	Relevant project results and observations documented.	Relevant project results and observations documented.	Relevant project results and observations documented.
2	Performance criteria	Reporting to Include e.g. threat identification and amelioration detail of growth and seeding periods and results of nursery tasks.	Reporting to Include observations of new growth on translocated trees results of nursery tasks. progress of seedling establishment as relevant.	Reporting to Include e.g. detail of growth and seeding periods and results of nursery tasks.	Reporting to Include observations of new growth on translocated trees results of nursery tasks. progress of seedling establishment as relevant.	Reporting to Include observations of new growth on translocated trees results of nursery tasks. progress of seedling establishment as relevant.	Reporting to Include e.g. detail of growth and seeding periods and results of nursery tasks.
2	Threshold	Reporting incomplete	Reporting incomplete	Reporting incomplete	Reporting incomplete	Reporting incomplete	Reporting incomplete
2	Corrective action	Project manager to address with sub-contractors	Project manager to address with sub-contractors	Project manager to address with sub-contractors	Project manager to address with sub-contractors	Project manager to address with sub-contractors	Project manager to address with sub-contractors
2	Evaluation and actions	Performance criteria met. Knowledge of species life cycle and translocation potential increased – e.g. obligate seeder, low seed output, low soil seedbank, young plants can be transplanted, capable of rapid growth in infertile soil	Performance criteria met. Knowledge of species life cycle and translocation potential increased – e.g. species fairly resilient – able to re-establish and increase slowly in cleared/ degraded by seed recruitment.	Performance criteria met. Knowledge of species increased – e.g. species life cycle re-confirmed as annual. Sensitive to dominance by tall exotic grasses. Co-exists with native Foxtail Grass	Performance criteria met. Knowledge of species life cycle and translocation potential increased. Limited translocation potential using propagation	Performance criteria met. Knowledge of species life cycle and translocation potential increased	Performance criteria met. Three experiments and general observation increase knowledge of species life cycle and translocation potential
3	Aim	Achieve no net loss in local plant populations being impacted by the project	Achieve no net loss in local plant populations being impacted by the project	Achieve no net loss in local plant populations being impacted by the project	Achieve no net loss in local plant populations being impacted by the project	Achieve no net loss in local plant populations being impacted by the project	Achieve no net loss in local plant populations being impacted by the project

		Four-tailed Grevillea	Green-leaved Rose Walnut	Hairy Joint-grass	Red Lilly Pilly	Rough-Shelled Bush Nut	Singleton Mintbush
3	Objectives	Original number of individuals and area re-established	Equivalent original number of individuals re-established. following guidelines for replacement of mature trees by seedlings/cuttings i.e ten seedlings established for any mature trees lost five seedlings established for any saplings lost.	Original number of individuals and area re-established	Equivalent original number of individuals re-established. following guidelines for replacement of mature trees by seedlings/cuttings i.e ten seedlings established for any mature trees lost five seedlings established for any saplings lost.	Equivalent original number of individuals re-established. following guidelines for replacement of mature trees by seedlings/cuttings i.e ten seedlings established for any mature trees lost five seedlings established for any saplings lost.	Original number of individuals re-established
3	Performance criteria	Compare with donor site. 70% of original number of plants established in Year 1 increasing to 100% minimum by Year 5	Compare with donor site. 70% of original number of plants established in Year 2 increasing to 100% minimum by Year 5	Compare with donor site. 70% of original cover of plants established over an area equivalent to original in Year 1 increasing to 100% cover by Year 5	Compare with donor site. 70% of original number of plants established in Year 2 increasing to 100% minimum by Year 5	Compare with donor site. 70% of original number of plants established in Year 2 increasing to 100% minimum by Year 5	Compare with donor site. 70% of original number of plants established in Year 2 increasing to 100% minimum by Year 5
3	Threshold	>50% of original number of plants established in Year 1 or similar levels below target in subsequent years*	>50% of original number of plants established in Year 2 or similar levels below target in subsequent years*	>50% of original cover of plants established over an area equivalent to original in Year 1 or similar levels below target in subsequent years*	>50% of original number of plants established in Year 2 or similar levels below target in subsequent years*	>50% of original number of plants established in Year 2 or similar levels below target in subsequent years*	>50% of original number of plants established in Year 2 or similar levels below target in subsequent year*
3	Corrective action	Evaluate options for sourcing more propagation material from neighbouring patches collect additional seed following guidelines for sampling	Replace with nursery back up stock. Evaluate options for sourcing more propagation material from neighbouring patches collect additional seed following guidelines for sampling	Undertake searches for suitable local donor populations collect seed nursery propagate or clump transplant.	Replace with nursery back up stock. Evaluate options for sourcing more propagation material from neighbouring patches collect additional seed following guidelines for sampling	Replace with nursery back up stock. Evaluate options for sourcing more propagation material from neighbouring patches collect additional seed following guidelines for sampling	Replace with nursery back up stock. Evaluate options for sourcing more propagation material from neighbouring patches collect additional seed/cuttings following guidelines for sampling
3	Evaluation and actions	Performance criteria met. Translocated number currently equal to or greater than target/impact number.	Performance criteria met. Total number translocated is above target.	Performance criteria met. Translocated number currently equal to or greater than target/impact number.	Performance criteria met. Total number translocated is above target (although high mortality of propagated seedlings).	Performance criteria met. Translocated number currently 70% of target number.	Performance criteria met. Translocated number currently equal to or greater than target/impact number.
4	Aim	Make the best possible use of all plant material with potential conservation value	Make the best possible use of all plant material with potential conservation value	Make the best possible use of all plant material with potential conservation value	Make the best possible use of all plant material with potential conservation value	Make the best possible use of all plant material with potential conservation value	Make the best possible use of all plant material with potential conservation value
4	Objectives	All available cutting material and seed harvested and grown on for transplant to best extent practical.	Trees and saplings is transplanted. All potential cutting material (and seeds if available) harvested for nursery propagation.	Soil associated with above-ground plants transplanted	Trees and saplings is transplanted. All potential cutting material (and seeds if available) harvested for nursery propagation.	Trees and saplings is transplanted. All potential cutting material (and seeds if available) harvested for nursery propagation.	All available seed collected cutting material harvested to an extent predicted to cover predicted requirements x 2.

		Four-tailed Grevillea	Green-leaved Rose Walnut	Hairy Joint-grass	Red Lilly Pilly	Rough-Shelled Bush Nut	Singleton Mintbush
4	Performance criteria	No unsalvaged material present on ground inspection	Trees translocated and cutting material collected to best extent practical for nursery propagation	No unsalvaged material present on ground inspection	Trees translocated and cutting material collected to best extent practical for nursery propagation	Trees translocated and cutting material collected to best extent practical for nursery propagation	No seed present on ground inspection
4	Threshold	More than 10% of the original material present	Tree not translocated. Less than 15 cuttings transferred to nursery facilities	More than 10% of the original material present.	Tree not translocated. Less than 15 cuttings transferred to nursery facilities	Tree not translocated. Less than 15 cuttings transferred to nursery facilities	Uncollected seed present on 10 or more plants
4	Corrective action	Project manager to address with contractors	Project manager to address with contractors	Project manager to address with contractors	Project manager to address with contractors	Project manager to address with contractors	Project manager to address with contractors
4	Evaluation and actions	Performance criteria met. All small plants salvaged.	Performance criteria met. Saplings and juveniles transplanted. Cutting propagation not undertaken as past results poor. Seed collected and propagated.	Performance criteria met. Large number of immature plants salvaged. BOS22 offset site captures impacted HJG habitat area.	Performance criteria met. Available seed used, cutting material unsuitable for propagation.	Performance criteria met. Available seed used.	Performance criteria met. Soil seedbank used as source of seedlings. Number propagated adequate to achieve translocation target

		Slender Screw Fern	Stinking Cryptocarya	Tall Knotweed	Weeping Paperbark	White Laceflower	Yellow-flowered King of the Fairies
1	Aim	Create a self-sustaining population	Maintain or enhance existing demographic function and genetic variability	Maintain a self-sustaining population.	Create self-sustaining populations (two sites)	Maintain or enhance existing demographic function and genetic variability	Maintain a self-sustaining population.
1	Objectives	Maintain or create a self-sustaining population (augment an existing patch)	Create or augment small sub-populations with diffuse connectivity to meta population in the Coolgardie-Wardell area conserving existing genetic variability	Plants complete their lifecycle and regenerate successfully	Plants complete their lifecycle and regenerate successfully	Create or augment small sub-populations with diffuse connectivity to meta population in the Coolgardie-Wardell area conserving existing genetic variability	Translocated clumps and individuals establish on new hosts flower set seed.
1	Performance criteria	Plants complete their lifecycle and regenerate successfully	Clumps of plants established numerically sufficient to replace or augment the number of affected individuals or sub-populations. Progeny from all translocated individuals is established by Year 3 and maintained through to Year 5.	At least 30 plants germinate and set seed each year	At least 50 plants germinate and set seed each year from Year 2	Clumps of plants established numerically sufficient to replace or augment the number of affected individuals or sub-populations. Progeny from all translocated individuals is established.	At least 20 plants establish flower and set seed each year from Year 2

		Slender Screw Fern	Stinking Cryptocarya	Tall Knotweed	Weeping Paperbark	White Laceflower	Yellow-flowered King of the Fairies
1	Threshold	Spore production observed each year (compare with control populations). Lateral vegetative growth observed from all transplants.	Less than 80% of no of original clumps or individuals are established. Less than 80% of impacted plants represented by established progeny.*	Less than 20 plants germinate and set seed in any one year.*	Less than 30 plants germinate and set seed in any one year from Year 2*	Less than 80% of no of original clumps or individuals are established. Less than 80% of impacted plants represented by established progeny.*	Less than 15 plants establish and set seed in any one year from Year 2*
1	Corrective action	No spore production lateral growth from <50% of transplants	Augment with nursery stock from (seed or cutting grown) back up stock.	Undertake searches for suitable local donor populations collect seed nursery propagate or clump transplant. Re-evaluate site moisture gradients to best target suitable planting sites.	Use stored seed or collect additional seed from remaining source population nursery propagate and plant out. Re-evaluate site conditions to best target suitable planting sites.	Augment with nursery stock from (likely cutting grown) back up stock.	Evaluate host sites of any plants not functioning as required and assess benefits of re-location.
1	Evaluation and actions	Performance criteria met. Sec3-11: Large salvaged population maintained at receival site for 3 years. Sec 1-2: Results poor.	Performance criteria met. Lumleys Lane: transplanting results poor Coolgardie Rd: Propagated seedlings growing slowly	Performance criteria met. Population shows initial evidence of self-perpetuation in damper spots. Dry weather not conducive to recruitment. Large amount of seed produced in Year 1-2.	Performance criteria met. Two large stands established, plants over 2m, good prospects to become self-sustaining	Performance criteria met. Both transplants and propagated plants growing well.	Performance criteria met. Transplanting results good, little loss of plants, plants maintaining vigour, reproductive output – self-sustaining as long as salvaged branches, bark remain intact.
2	Aim	Increased knowledge of the threatened plant species	Increased knowledge of the threatened plant species	Increased knowledge of the threatened plant species	Increased knowledge of the threatened plant species	Increased knowledge of the threatened plant species	Increased knowledge of the threatened plant species
2	Objectives	Relevant project results and observations documented.	Relevant project results and observations documented.	Relevant project results and observations documented.	Relevant project results and observations documented.	Relevant project results and observations documented.	Relevant project results and observations documented.
2	Performance criteria	Reporting to Include e.g. detail of growth and spore production.	Reporting to include observations of new growth on translocated trees results of nursery tasks. Progress of seedling establishment as relevant.	Reporting to Include e.g. detail of growth and seeding periods and results of nursery tasks.	Reporting to Include e.g. results of nursery tasks records of establishment and development.	Reporting to Include observations of new growth on translocated trees results of nursery tasks. progress of seedling establishment as relevant.	Reporting to Include e.g. detail of growth and seeding periods and results of nursery tasks.
2	Threshold	Reporting incomplete	Reporting incomplete	Reporting incomplete	Reporting incomplete	Reporting incomplete	Reporting incomplete
2	Corrective action	Project manager to address with sub-contractors	Project manager to address with sub-contractors	Project manager to address with sub-contractors	Project manager to address with sub-contractors	Project manager to address with sub-contractors	Project manager to address with sub-contractors
2	Evaluation and actions	Performance criteria met. Knowledge of species life cycle and translocation potential increased	Performance criteria met. Knowledge of species life cycle and translocation potential increased	Performance criteria met. Knowledge of species life cycle and translocation potential increased	Performance criteria met. Knowledge of species life cycle and translocation potential increased	Performance criteria met. Knowledge of species life cycle and translocation potential increased	Performance criteria met. Knowledge of species life cycle and translocation potential increased

		Slender Screw Fern	Stinking Cryptocarya	Tall Knotweed	Weeping Paperbark	White Laceflower	Yellow-flowered King of the Fairies
3	Aim	Achieve no net loss in local plant populations being impacted by the project	Achieve no net loss in local plant populations being impacted by the project	Achieve no net loss in local plant populations being impacted by the project	Achieve no net loss in local plant populations being impacted by the project	Achieve no net loss in local plant populations being impacted by the project	Improve options for augmentation through seedling production

		Slender Screw Fern	Stinking Cryptocarya	Tall Knotweed	Weeping Paperbark	White Laceflower	Yellow-flowered King of the Fairies
3	Objectives	Original number of individuals and area re-established	Equivalent original number of individuals re-established. following guidelines for replacement of mature trees by seedlings/cuttings i.e ten seedlings established for any mature trees lost five seedlings established for any saplings lost.	Original number of individuals and area re-established	Original number of individuals re-established	Equivalent original number of individuals re-established. following guidelines for replacement of mature trees by seedlings/cuttings i.e ten seedlings established for any mature trees lost five seedlings established for any saplings lost.	Research program for seed propagation established and propagation underway.
3	Performance criteria	Compare with donor site: 70% of original cover of plants established over an area equivalent to original in Year 1 increasing to 100% cover by Year 5	Compare with donor site. 70% of original number of plants established in Year 2 increasing to 100% minimum by Year 5	Compare with donor site. 70% of original cover of plants established over an area equivalent to original in Year 1 increasing to 100% cover by Year 5	Compare with donor site. 70% of original number of plants established in Year 2 increasing to 100% minimum by Year 5	Compare with donor site. 70% of original number of plants established in Year 2 increasing to 100% minimum by Year 5	Specialist propagation facility engaged and liaison with field personnel established. Consultation with OEH SOS program.
3	Threshold	>50% of original cover of plants established over an area equivalent to original in Year 1 or similar levels below target in subsequent year.*	>50% of original number of plants established in Year 2 or similar levels below target in subsequent years.*	>50% of original cover of plants established over an area equivalent to original in Year 1 or similar levels below target in subsequent year.*	>50% of original number of plants established in Year 2 or similar levels below target in subsequent years*	>50% of original number of plants established in Year 2 or similar levels below target in subsequent years*	Insufficient understanding of seedling production techniques achieved by Year 3 production not underway
3	Corrective action	Evaluate options for sourcing more propagation material from neighbouring patches collect additional seed following guidelines for sampling	Replace with nursery back up stock. Evaluate options for sourcing more propagation material from neighbouring patches collect additional seed following guidelines for sampling	Evaluate options for sourcing more propagation material from neighbouring patches collect additional seed following guidelines for sampling	Replace with nursery back up stock. Evaluate options for sourcing more propagation material from remaining plants adjacent to donor population collect additional seed following guidelines for sampling	Replace with nursery back up stock. Evaluate options for sourcing more propagation material from neighbouring patches collect additional seed following guidelines for sampling	Consider options for alternative research partners
3	Evaluation and actions	Performance criteria met. Translocated number approximately equal to target number.	Performance criteria met. Translocated number currently equal to or greater than target/impact number.	Performance criteria met. Translocated number currently equal to or greater than target/impact number.	Performance criteria met. On track to achieve no net loss. Suggest recount of impacted individuals before clearing.	Performance criteria met. On track to achieve no net loss.	Performance criteria met. Very few plants lost in clumps, no clump loss. Seed production occurring.
4	Aim	Make the best possible use of all plant material with potential conservation value	Make the best possible use of all plant material with potential conservation value	Make the best possible use of all plant material with potential conservation value	Make the best possible use of all plant material with potential conservation value	Make the best possible use of all plant material with potential conservation value	Make the best possible use of all plant material with potential conservation value
4	Objectives	All available plants and associated soil harvested and transplanted to best extent practical	Trees and saplings transplanted. Suitable cutting material for predicted requirements x 2 harvested seeds if available for nursery propagation.	All available plants and associated soil harvested and transplanted to best extent practical	Available seed is harvested for nursery propagation.	Trees and saplings are transplanted. All potential cutting material (and seeds if available) harvested for nursery propagation.	All available plants translocated to new hosts

		Slender Screw Fern	Stinking Cryptocarya	Tall Knotweed	Weeping Paperbark	White Laceflower	Yellow-flowered King of the Fairies
4	Performance criteria	No unsalvaged material present on ground inspection	Trees translocated no seed left unharvested.	No unsalvaged material present on ground inspection	Trees translocated and cutting material collected to best extent practical for nursery propagation (at least 20 cuttings)	Trees and saplings translocated and cutting material collected to best extent practical for nursery propagation	No unsalvaged material present on field inspection
4	Threshold	More than 10% of the original material present	Trees not translocated. Less than 15 cuttings transferred to nursery facilities	More than 10% of the original material present	Tree not translocated. Less than 15 cuttings transferred to nursery facilities	Tree and saplings not translocated. Less than 15 cuttings transferred to nursery facilities	Plants remain on host trees
4	Corrective action	Project manager to address with contractors	Project manager to address with contractors	Project manager to address with contractors	Project manager to address with contractors	Project manager to address with contractors	Project manager to address with contractors
4	Evaluation and actions	Performance criteria met. All in situ plants salvaged to the receival site. No propagation undertaken.	Performance criteria met. Attempt made to transplant all saplings. Propagated plants progressing well	Performance criteria met. Seedlings, sub-adults and mature plants salvaged, Seedlings grown on in nursery and introduced.	Performance criteria met. Seed collected from cross-section of trees in the impacted population.	Performance criteria met. Some seed collected.	Performance criteria met. No propagation planned at this stage, although seed available.

Table 13: Evaluation of Translocation Outcomes on Sections 1-2 & EWSSTA, as reported in Landmark Ecological Services 2017 (year 2) monitoring report

Evaluation – Sections 1 and 2

	Species	Hairy joint-grass	Moonee Creek Quassia	Noah's false chickweed	Slender screw-fern	Square-fruited ironbark	Square-stemmed spike-rush
1	Aim	Create a self-sustaining population	Maintain an self-sustaining population (augment remainder of an existing self-sustaining population by expanding and linking existing patches)	Create a self-sustaining population	Maintain or create a self-sustaining population (augment an existing patch)	Maintain a self-sustaining population (expand existing population)	Maintain or create a self-sustaining population (augment existing small patch or create new population)
1	Objectives	Plants complete their lifecycle and regenerate successfully	Patches are expanded and linked	Plants complete their lifecycle and regenerate successfully	Plants complete their lifecycle and regenerate successfully	Cleared land adjacent to existing forest is vegetated	Plants complete their lifecycle and regenerate successfully
1	Performance criteria	At least 50 plants germinate and set seed each year	At least 20 plants are established in each identified section of the receiving sites	At least 100 plants germinate and set seed each year	Spore production observed each year (compare with control populations). Lateral vegetative growth observed from all transplants.	At least 500 plants are established	At least 20 plants germinate and set seed each year
1	Threshold	Less than 30 plants germinate and set seed in any one year	>10 plants are established in any identified section of the receiving sites	Less than 50 plants germinate and set seed in any one year	No spore production, lateral growth from <50% of transplants	< 300 plants are established by Year 3, similar lack of progress towards targets in subsequent years	Less than 10 plants germinate and set seed in any one year
1	Corrective action	Undertake searches for suitable local donor populations, collect seed, nursery propagate or clump transplant. Re-evaluate site moisture gradients to best target suitable planting sites.	Transplant additional specimens from seed collected in later years of the project.	Undertake searches for suitable local donor populations, collect seed, nursery propagate or clump transplant. Re-evaluate site moisture gradients to best target suitable planting sites.	Undertake searches for suitable local donor populations, clump/slab transplant. Re-evaluate site moisture gradients to best target suitable planting sites.	Propagate additional seedlings from stored seed	Undertake searches for suitable local donor populations, clump transplant. Re-evaluate site hydrology for best planting site selection or modify hydrology.
1	Evaluation and actions	Reasonable attempts to translocate soil stored seed (questionable density). No further action feasible..	No strike from cuttings, no alternative sources of propagation material. Corrective actions not possible.	Two large plantings all dead. No seedlings observed to date.	Reasonable survivorship from transplants and limited lateral expansion. Sori not observed. Further transplant of local material is likely to result in unacceptable impacts to source populations, corrective actions not recommended.	~ 80 plants established. . 950 additional plants propagated and scheduled for planting in the second half of 2020.	Translocations undertaken as best possible with material of questionable value– no plants established. Corrective actions unlikely as propagation material is limited. DPIE (Save Our Species) has approached TfNSW regarding a proposal for the collection of Seed (and vegetative material, if necessary) from multiple populations within two active SoS sites located in the Clarence Valley. TfNSW have agreed in principa, with SOS implementing all aspects of the work. Consultation has been undertaken with NPWS who have provided written agreement to the translocation site within Bongil Bongil NP

	Species	Hairy joint-grass	Moonee Creek Quassia	Noah's false chickweed	Slender screw-fern	Square-fruited ironbark	Square-stemmed spike-rush
2	Aim	Increased knowledge of the threatened plant species	Increased knowledge of the threatened plant species	Increased knowledge of the threatened plant species	Increased knowledge of the threatened plant species	Increased knowledge of the threatened plant species	Increased knowledge of the threatened plant species
2	Objectives	Relevant project results and observations documented.	Relevant project results and observations documented.	Relevant project results and observations documented.	Relevant project results and observations documented.	Relevant project results and observations documented.	Relevant project results and observations documented.
2	Performance criteria	Reporting to Include e.g. detail of growth and seeding periods and results of nursery tasks.	Reporting to Include e.g. detail of growth and seeding periods and results of nursery tasks.	Reporting to Include e.g. detail of growth and seeding periods and results of nursery tasks.	Reporting to Include e.g. detail of growth and seeding periods and results of nursery tasks.	Reporting to Include e.g. detail of growth and seeding periods and results of nursery tasks.	Reporting to Include e.g. detail of growth and seeding periods and results of nursery tasks.
2	Threshold	Reporting incomplete	Reporting incomplete	Reporting incomplete	Reporting incomplete	Reporting incomplete	Reporting incomplete
2	Corrective action	Project manager to address with sub-contractors	Project manager to address with sub-contractors	Project manager to address with sub-contractors	Project manager to address with sub-contractors	Project manager to address with sub-contractors	Project manager to address with sub-contractors
2	Evaluation and actions	Reported in 2016 and current annual reports	Reported in 2016 and current annual reports	Reported in 2016 and current annual reports	Reported in 2016 and current annual reports	Reported in 2016 and current annual reports	Reported in 2016 and current annual reports
3	Aim	Achieve no net loss in local plant populations being impacted by the project	Achieve no net loss in local plant populations being impacted by the project	Achieve no net loss in local plant populations being impacted by the project	Achieve no net loss in local plant populations being impacted by the project	Achieve no net loss in local plant populations being impacted by the project	Achieve no net loss in local plant populations being impacted by the project
3	Objectives	Original number of individuals and area re-established	Original number of individuals and area re-established	Original number of individuals and area re-established	Original number of individuals and area re-established	Original number of individuals and area re-established	Original number of individuals and area re-established
3	Performance criteria	Compare with donor site: 70% of original cover of plants established over an area equivalent to original in Year 1, increasing to 100% cover by Year 5	Compare with donor site: 70% of original number planted out and established by year 4, 100% by Year 5	Compare with donor site: 70% of original cover of plants established over an area equivalent to original in Year 1, increasing to 100% cover by Year 5	Compare with donor site: 70% of original cover of plants established over an area equivalent to original in Year 1, increasing to 100% cover by Year 5	Compare with donor site: 70% of original number planted out and established by year 4, 100% by Year 5	5
3	Threshold	>50% of original cover of plants established over an area equivalent to original in Year 1 or similar levels below target in subsequent year	>50% individuals planted out and established by year 4 or similar levels below target in subsequent year	>50% of original cover of plants established over an area equivalent to original in Year 1 or similar levels below target in subsequent year	>50% of original cover of plants established over an area equivalent to original in Year 1 or similar levels below target in subsequent year	>50% individuals planted out and established by year 4 or similar levels below target in subsequent year	>50% of original cover of plants established over an area equivalent to original in Year 1 or similar levels below target in subsequent year
3	Corrective action	Undertake searches for suitable local donor populations, collect seed, nursery propagate or clump transplant.	Evaluate options for sourcing more propagation material from neighbouring patches, collect additional seed, following guidelines for sampling	Evaluate options for sourcing more propagation material from neighbouring patches, collect additional seed, following guidelines for sampling	Evaluate options for sourcing more propagation material from neighbouring patches, collect additional seed, following guidelines for sampling	Evaluate options for sourcing more propagation material from neighbouring patches, collect additional seed, following guidelines for sampling	Evaluate options for sourcing more propagation material from neighbouring patches, collect additional seed, following guidelines for sampling
3	Evaluation and actions	Reasonable attempts to translocate soil stored seed (questionable density). No further action feasible.	No strike from cuttings, no alternative sources of propagation material. Corrective actions not possible.	Less than 70% cover has been achieved. All plants from two large plantings dead. Cover zero.	Low cover has been achieved. This species is known to be difficult to transplant and slow growing and there are no practical options for supplementary collection.	~ 80 plants established, 950 additional plants propagated and scheduled for planting in the second half of 2020.	Translocations undertaken as best possible with material of questionable value– no plants established. Corrective actions unlikely as propagation material is limited. DPIE (Save Our Species) has approached TfNSW regarding a proposal for the collection of Seed (and vegetative material, if

	Species	Hairy joint-grass	Moonee Creek Quassia	Noah's false chickweed	Slender screw-fern	Square-fruited ironbark	Square-stemmed spike-rush
							necessary) from multiple populations within two active SoS sites located in the Clarence Valley. TfNSW have agreed in principal to fund the proposal, with SOS implementing all aspects of the work. Consultation has been undertaken with NPWS who have provided written agreement to the translocation site within Bongil Bongil NP

	Species	Hairy joint-grass	Moonee Creek Quassia	Noah's false chickweed	Slender screw-fern	Square-fruited ironbark	Square-stemmed spike-rush
4	Aim	Make the best possible use of all plant material with potential conservation value	Make the best possible use of all plant material with potential conservation value	Make the best possible use of all plant material with potential conservation value	Make the best possible use of all plant material with potential conservation value		
4	Objectives	Soil associated with above-ground plants transplanted.	All available seeds collected, stems harvested and roots excavated to best extent practical	Above-ground plants transplanted together with associated soil likely to contain soil-stored seeds.	All available plants harvested and transplanted to best extent practical		
4	Performance criteria	No unsalvaged material present on ground inspection	No unsalvaged material present on ground inspection	No unsalvaged material present on ground inspection	No unsalvaged material present on ground inspection		
4	Threshold	More than 10% of the original material present.	More than 10% of the original material present.	More than 10% of the original material present.	More than 10% of the original material present.		
4	Corrective action	Project manager to address with contractors	Project manager to address with contractors	Project manager to address with contractors	Project manager to address with contractors		
4	Evaluation and actions	No further action feasible	No seeds present, all stems were collected for cuttings	All material collected bar small fragments	All material collected bar small fragments		

Evaluation – Soft Soils

	Species	Hairy joint-grass	Tall knotweed
1	Aim	Create a self-sustaining population	Maintain a self-sustaining population.
1	Objectives	Plants complete their lifecycle and regenerate successfully	Plants complete their lifecycle and regenerate successfully
1	Performance criteria	At least 50 plants germinate and set seed each year	At least 30 plants germinate and set seed each year
1	Threshold	Less than 30 plants germinate and set seed in any one year	Less than 20 plants germinate and set seed in any one year
1	Corrective action	Undertake searches for suitable local donor populations, collect seed, nursery propagate or clump transplant. Re-evaluate site moisture gradients to best target suitable planting sites.	Undertake searches for suitable local donor populations, collect seed, nursery propagate or clump transplant. Re-evaluate site moisture gradients to best target suitable planting sites.
1	Evaluation and actions	Site 1 No plants observed in Year 4 Site 2 No plants observed in Year 4	Plants have died back and two short-lived seedlings observed. Findings are difficult to interpret since the translocation augments an existing population. The species is ephemeral and control plants have also died back. The addition of substantial amounts of seed to the system has been documented and is likely to have positive medium to long term impacts on the population. Further observation during the coming growing season is recommended before any corrective actions are considered.
2	Aim	Increased knowledge of the threatened plant species	Increased knowledge of the threatened plant species
2	Objectives	Relevant project results and observations documented.	Relevant project results and observations documented.
2	Performance criteria	Reporting to Include e.g. detail of growth and seeding periods and results of nursery tasks.	Reporting to Include e.g. detail of growth and seeding periods and results of nursery tasks.
2	Threshold	Reporting incomplete	Reporting incomplete
2	Corrective action	Project manager to address with sub-contractors	Project manager to address with sub-contractors
2	Evaluation and actions	Reported in 2016 and current annual reports	Reported in 2016 and current annual reports
3	Aim	Achieve no net loss in local plant populations being impacted by the project	Achieve no net loss in local plant populations being impacted by the project

	Species	Hairy joint-grass	Tall knotweed
3	Objectives	Original number of individuals and area re-established	Original number of individuals and area re-established
3	Performance criteria	Compare with donor site. 70% of original cover of plants established over an area equivalent to original in Year 1, increasing to 100% cover by Year 5	Compare with donor site. 70% of original cover of plants established over an area equivalent to original in Year 1, increasing to 100% cover by Year 5
3	Threshold	>50% of original cover of plants established over an area equivalent to original in Year 1 or similar levels below target in subsequent year	>50% of original cover of plants established over an area equivalent to original in Year 1 or similar levels below target in subsequent year
3	Corrective action	Undertake searches for suitable local donor populations, collect seed, nursery propagate or clump transplant.	Evaluate options for sourcing more propagation material from neighbouring patches, collect additional seed, following guidelines for sampling
3	Evaluation and actions	Site 1 Plants not established but biomass has been reduced and may stimulate germination. A further season of observation is recommended before corrective actions are considered. Site 2 Plants well established and approaching threshold. A further season's observation is recommended before considering corrective actions.	Plants have died back, observations difficult to interpret (see above). Further observation during the coming growing season is recommended before any corrective actions are considered.
4	Aim	Make the best possible use of all plant material with potential conservation value	Make the best possible use of all plant material with potential conservation value
4	Objectives	Soil associated with above-ground plants transplanted	All available plants and associated soil harvested and transplanted to best extent practical
4	Performance criteria	No unsalvaged material present on ground inspection	No unsalvaged material present on ground inspection
4	Threshold	More than 10% of the original material present.	More than 10% of the original material present
4	Corrective action	Project manager to address with contractors	Project manager to address with contractors
4	Evaluation and actions	All large clumps of plants transplanted, together with associated soil. Plants sparsely dispersed within exotic grasslands were not completely recovered – these constituted a small proportion of the total plant material.	All plants and associated soil translocated.

5.0 Corrective Measures/Recommendations

No further corrective measures are proposed for next year (2019/2020) to improve translocation outcomes for species on Sections 3-11 and Sections 1-2 & EWSSTA.

6.0 References

Dytham C (2011) Choosing and Using Statistics (3rd edition). Wiley-Blackwell, UK.

Ecos Environmental P/L (2011a). *Tintenbar to Ewingsdale Upgrade Threatened Plant Minimisation Strategy.* Report to the NSW Roads and Traffic Authority.

Ecos Environmental P/L (2011b). Sapphire to Woolgoolga Upgrade Threatened Flora Translocation Monitoring Report Year 1. Report to the NSW Roads and Traffic Authority.

Ecos Environmental P/L (2015). Tintenbar to Ewingsdale Upgrade of the Pacific Highway *Arthraxon hispidus* (Hairy Joint Grass) Translocation Project: Year 5 Monitoring Report. Report to the NSW Roads and Traffic Authority.

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

ECOS Environmental (2017). Woodburn to Ballina Threatened Flora Translocation Project (Sections 3-11) Annual Monitoring Report – Year 1. Report to Roads and Maritime Services.

R Core Team (2019). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Roads and Maritime Services (2015a). Flora Translocation Strategy, Pacific Highway Upgrade, Sections 1 and 2, Woolgoolga to Ballina, Version 2.

Roads and Maritime Services (2015b). Flora Translocation Strategy Pacific Highway Upgrade Sections 3-11 excluding Early Works Soft Soil Treatment Areas Woolgoolga to Ballina, Version 2 November 2015.

Landmark Ecological Services (2016).Translocation monitoring Sections 1 and 2 and Early Works Soft Soil Treatment Areas. Monitoring Results and Status Report as at June 2016. Woolgoolga to Ballina Pacific Highway Upgrade. Report to Roads and Maritime Services

Landmark Ecological Services (2017).Translocation monitoring Sections 1 and 2 and Early Works Soft Soil Treatment Areas. Annual Report 2017. Woolgoolga to Ballina Pacific Highway Upgrade. Report to Roads and Maritime Services.

7.0 Photographs Sections 1-11

Plates 1 – 38

Slender Screw Fern (Lindsaea incisa)

Plate 1: Slender Screw Fern - Area 1 Receival Site in Bundjalung Nat Park, three years after transplanting . The inverted plastic trays mark each plot of translocated fern. July 2019

Plate 2: Slender Screw Fern – Area1, Plot A1 (plot 1 on line A) showing fern fronds projecting above tray grid, three years after transplanting. July 2019

Plate 3: Slender Screw Fern –Area 1, Plot A15 (plot 15 on line A) showing fern fronds projecting above tray grid, three years after transplanting. July 2019

Plate 4: Slender Screw Fern –Area 1, Patch No. 11, dense fern fronds three years after transplanting. July 2019

Plate 5: Slender Screw Fern - Area 2 Receival Site in Bundjalung Nat Park, two years after transplanting . July 2019

Plate 6: Slender Screw Fern – fern rhizomes and fronds have spread outside about half of the plots. July 2019

Yellow-flowered King of the Fairies (Oberonia complanata)

Plate 7: Oberonia orchid plants at the Lumleys Lane South receival site, July 2019.

Singleton Mint Bush (Prostanthera cineolifera)

Plate 8: Singleton Mint Bush receival site in the 'Tabbimoble Triangle'. This small gully with sandy topsoil was the location of Transect 3 in Experiment 1 (effect of soil texture on survival). July 2018

Plate 9: Singleton Mint Bush. Recording plots in Experiment 2 (effect of propagation type – seedlings vs cutting, and fertiliser on Mint Bush performance). July 2018

Plate 10: Experiment 1. Recording Plot B6 (= transect , plot 6) planted with 12 month old seedlings after all 6 month old seedlings died. All survived and grew vigorously. July 2019

Plate 11: Two Singleton Mint Bush from the first planting (2.5 yrs old) growing in a sandy rill, and one Weeping Paperbark (Melaleuca irbyana) on the right, in the Tabbimoble triangle receival site. July 2019.

Tall Knotweed (Persicaria elatior)

Plate 12: Tall Knotweed seedlings in a plot at the Yaegal Nature Reserve receival site observed in Oct 2018. As summer 2018/2019 was very dry (see Figure 4), most of this cohort probably died before reaching maturity. Tall Knotweed is an annual, usually growing through summer and dying-off during winter-spring. If conditions remain damp after seed germination it grows rapidly and starts to flower in 2-3 months.

Plate 13: In July 2019, dead plants such as this one were in several plots and appear to have died 1-2 months ago, but why is unclear. They could be plants from the cohort observed in Oct 2018, which survived the summer drought and lived out their annual life cycle.

Plate 14: Seedlings probably a few weeks old were present in several plots in July 2019, probably germinating after recent falls of rain. Tall Knotweed is the broad-leaved species.

Plate 15: In July 2019 a few larger, young Tall Knotweed plants were also present, as in this photo. Note the surrounding sedge plants show evidence of frost die-back , although Tall Knotweed is unaffected.

Plate 16: Tall Knotweed translocation area in Yaegal Nature Reserve, July 2019. The receival site is located in an open area on the edge of swamp forest and cleared pastureland. Plots for monitoring the different introductions are spread along the edge in an area about 150 metres long and 15 metres wide. This area is usually covered with standing water for several months between Jan and June, but only for one or two weeks this year. View looking west towards Maclean Hill, the Pacific Highway is in the background.

Four-tailed Grevillea (Grevillea quadricauda)

Plate 17: Grevillea quadricauda receival site in the road reserve on Section 3, south of Quarry Rd, 3 years after salvage when small (<30cm high) and 2.5 years after planting out. Mean height and width were 1.5 m and survival 93% in July 2019.

Plate 18: Low numbers of flowers were present on most Grevillea quadricauda shrubs in July 2019.

Weeping Paperbark (Melaleuca irbyana)

Plate 19: Weeping Paperbark receival site at Tabbimoble Creek in Feb 2019 at the height of the drought last summer. Note dead grass.

Plate 20: Weeping Paperbark receival site at Tabbimoble Creek in July 2019. The mean height of Weeping Paperbark 2.5 years after planting out was 211.0 cm with addition of slow release fertiliser and 109.3 cm without fertiliser.

Rainforest Threatened Species Receival Sites

Plate 21: Rainforest species receival site at Lumleys Lane. Four threatened rainforest species were translocated to this site which is being restored to subtropical rainforest. Plantings are approx. 3 years old. July 2019

Plate 22: The Lumleys Lane rainforest species receival site backs onto a rocky hillslope covered in regrowth rainforest dominated by Broad-leaved Privet and Camphor Laurel. These exotic species have been killed along two drainage lines directly upslope of the receival site to stimulate regeneration of native rainforest species present as scattered trees, saplings and seedlings. July 2019

Plate 23: Second rainforest species receival site at Coolgardie Rd. Exotics were removed before planting out propagated plants of threatened rainforest species. July 2019

Stinking Cryptocarya (Cryptocarya foetida)

Plate 24: One of the few transplanted Stinking Cryptocarya (Cryptocarya foetida) still surviving and growing reasonably well at Lumley's Lane receival site, 3 years after salvage. July 2019

Plate 25: Stinking Cryptocarya (Cryptocarya foetida) have been propagated from seed and planted at the Coolgardie Road receival site. July 2019

Rusty Green-leaved Rose Walnut (Endiandra muelleri ssp. bracteata)

Red Lilly Pilly (Syzygium hodgkinsoniae)

Plate 26: Endiandra muelleri ssp. bracteata three years after transplanting. July 2019

Plate 27 & 28: Red Lilly Pilly (Syzygium hodgkinsoniae) seedling planted at Coolgardie Rd on the left and at Lumleys Lane on the right. This is a difficult species to establish using propagated plants. Typically they grow very slowly and the tips become infected by a red 'witches broom' malformation. This appears to stunt growth but occasionally healthy new leaves grow out of the witches broom. The plants were given additional attention including mulching, Maxicrop and watering during dry spells. A few are growing fairly well and may establish. The target for this species is 6. July, 2019

White Laceflower (Archidendron hendersonii)

Plate 29: White Laceflower (Archidendron hendersonii) at the Lumleys Lane translocation area, approx. 3 years after salvage transplanting. July 2019

Hairy Melichrus (Melichrus hirsutus)

Plate 30: Hairy Melichrus (Melichrus hirsutus) approx. three years after transplanting to the Mahogany Dv receival site at Pillar Valley. July 2019

Plate 31: Most of the Mahogany Dv receival site was burnt by a low intensity fire in September 2017. A small patch including the transplanted Melichrus escaped the burn. RFS may have wetted down the patch.

Hairy Joint Grass (Arthraxon hispidus)

Plate 32: Hairy Joint Grass receival site at Mitchell Rd, looking west away from highway. HJG plants within 2m of the fence had died back 2-3 months ago but the dead stems were still visible. July 2019

Plate 33: Hairy Joint Grass receival site at Mitchell Rd, looking east. HJG plants within 2m of the fence had died back 2-3 months ago but the dead stems were still visible. July 2019

Rotala (Rotala tripartita)

Plate 35: Rotala donor site, eastern side of the Pacific Hwy. November 2017

Plate 36: Filling one of the excavated Rotala ponds near Tabbimoble Ck, November 2017

Plate 37: One of two Rotala translocation ponds, July 2019. The ponds on the Tabbimoble Ck offset land need reworking with an excavator to make them larger, deeper and with a more gradually sloping bank.

Plate 38: Rotala with creeping stems and orangey brown leaves in July 2019, about 12 months after planting out. This plant is in a plastic pot and was moved two or three times as the water level fell to keep it within the wet mud zone. It was originally planted higher up when the pond was filled with water.

8.0 Photographs Sections 1-2 & Early Works Soft Soil Treatment Areas (EWSSTA)

Plates 39 – 50

Slender Screw Fern (Lindsaea incisa)

Plate 39: Kangaroo Trail translocation area in July 2019. The tags mark where small clumps of Slender Screw Fern were introduced.

Plate 40: Slender Screw Fern in the Kangaroo Trail translocation area in July 2019. In terms of the number of tagged points with live fern plants, the overall survival rate after 4 years was 15.8%

Plate 41: Kangaroo Trail translocation area in July 2019. This cluster of tags has been overrun by the exotic grass Broad-leaved Paspalum (Paspalum mandiocanum).

Plate 42: Slender Screw Fern in the Kangaroo Trail translocation area in July 2019. There were two introductions carried out two and four years ago. Most plants in the first introduction ("45 slabs") died. Surviving plants are mainly from the second introduction of 17 plants propagated at a nursery (now 2 years old).

Lindernia (Lindernia alsinoides)

Plate 43: Halfway Creek translocation area for Lindernia alsinoides. Approximately 800 plants were introduced to this site in two plantings (28/1/16, 30/5/17). After the first batch died a second one was introduced to the same site. There was no sign of it in July 2019 and only one was alive last year.

Plate 44: Halfway Creek translocation area for Lindernia alsinoides in July 2019.

Hairy Joint Grass (Arthraxon hispidus)

Plate 45: Dried up Hairy Joint Grass at the Kangaroo Trail Translocation Area in July 2019. An annual species, this plant would have died in May or June after seeding. Biomass reduction by brush-cutting and raking away mulch was carried out last year to stimulate seed germination.

Plate 46: Hairy Joint Grass failed to persist at the two early works receival sites at Trustrums Hill, but HJG was observed in the adjacent powerline easement which was brush-cut to reduce biomass last winter 2018.

Square-fruited Ironbark (Eucalyptus tetrapleura)

Plate 47: Square-fruited Ironbark (Eucalyptus tetrapleura) at burnt by frost the Sunnyside Rd receival site, Glenugie, July 2019.

Plate 48: All Square-fruited Ironbark had new growth on the tops burnt by frost.

Lepidosperma sp. Coaldale

Plate 49: White tags mark Lepidosperma sp. Coaldale at the receival site on offset land at Mahogany Dv. Pillar Valley. Plants were salvaged in August/15, kept at a nursery then planted in spring/16 in four plots. The land was burnt in August 2017

Plate 50: White tags mark Lepidosperma sp. becoming overgrown with Common Ground Fern (Calochlaena dubia)