Woolgoolga to Ballina Pacific Highway upgrade

Threatened Flora Translocation Project (Sections 1-11) Annual Monitoring Report 2020

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Woolgoolga to Ballina Threatened Flora Translocation Project (Sections 1-11) Annual Monitoring Report 2020

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Executive Summary

This annual monitoring report describes threatened flora translocations carried out for the Woolgoolga to Ballina (W2B) upgrade of the Pacific Highway, a 155 km section of new highway on the North Coast of NSW. Results of the five year monitoring program are presented for Sections 1-2 after five years and for Sections 3-11 after four years (starting a year later).

A total of 21 plant species were translocated, including 18 threatened species, 2 rare species and 2 vines hosting a threatened species of butterfly and a 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 insects

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

The translocations were implemented according to general guidelines in Translocation Strategies for Sections 1-2 and EWSSTA (RMS 2015a) and Sections 3-11 (RMS 2015b). The aims of translocation were to establish self-sustaining populations, avoid significant net loss to local threatened species populations, investigate species ecology and translocation methods, and make the best possible use of all plant material with potential conservation value.

Species were introduced to 20 receival sites, 7 on Sections 1-2 and 13 on Sections 3-11. Four translocation methods were used:

- Salvage transplanting.
- Propagation and introduction from cuttings.
- Propagation and introduction from seed.
- Propagation and introduction from the soil seedbank.

Trial-and-error comparisons of introduction methods and species performance at different locations with slightly different habitat were carried out for some species (e.g. Slender Screw Fern, Red Lilly Pilly, Weeping Paperbark). Formal experimental design was applied to

translocation of Singleton Mint Bush, investigating microhabitat preference and introduction methods. Soil seedbank and fire were used to propagate tubestock of this species, the first time this technique has been used to propagate a threatened plant species for conservation work. A three-step process was developed to identify where Singleton Mint Bush should be introduced at the nominated receival site:

1. Introduce Mint Bush tubestock right across the site and allow natural selection indicate where micro-habitats appeared to be most suitable for the species.
2. Employ formal experimental design to clarify the microhabitat and horticultural factors affecting species performance.
3. On the basis of these findings, introduce tubestock remaining to habitat at receival site most suited to the species.

Experiments examined the effect soil texture gradient, tubestock age, fertiliser addition and mode of propagation on the performance of introduced Singleton Mint. The following findings were used to refine translocation methods for Singleton Mint Bush:

- Soil texture/micro-habitat strongly affects the survival of young seedlings
- Older seedlings perform much better than younger seedlings.
- Plants propagated from seed perform better than cuttings.

In Nov/2019 a bushfire burnt the receival sites for Slender Screw Fern, Singleton Mint Bush and Weeping Paperbark on Sections 3-11. The bushfire reduced the translocated population of all three species. An apparently viable population of Slender Screw survives in parts of the two receival sites for this species in Bundjalung NP. Weeping Paperbark regenerated vigorously by resprouting after the fire. Some regeneration of Singleton Mint Bush occurred in the receival site from seed and by resprouting, but seedling recruitment, the main means of regeneration in this species, was poor, which suggests that little if any seed was produced before the bushfire or that conditions were suboptimal for the species, or a combination of both. Suitable habitat exists between the perimeter fence and Tabbimoble Ck where remaining tubestock has been planted.

Overall, the results of translocation after four years on Sections 3-11 met most aims, objectives and targets for all 16 species translocated, except Lindernia. Results were more mixed for species on Sections 1-2 where several species recorded zero survival including Moonee Quassia, Oberonia, Lindernia, Square-stemmed Spike Rush, Lepidosperma sp. Coaldale and Hairy Joint Grass.

1.0 INTRODUCTION

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

The threatened flora translocations for the W2B project were implemented in two stages:

- *Landmark Ecological Services and Bushland Restoration Services* carried out translocations on 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* carried out translocations on Sections 3-11 in 2016-2017. Implementation 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 included several unexpected finds, which were translocated in 2017, as described below.

The 'Strategy' below refers to the Translocation Strategy set out in RMS (2015 a&b).

A total of 21 plant species were translocated, including 18 threatened species, one rare species (not scheduled) and two species of vine that host of threatened butterfly and moth species during their larval stage (Table 1).

Translocations on Sections 1-2 and Early Works Soft Soil Treatment Areas (EWSSTA) started in 2015 and translocations on Sections 3-11 started in 2016. Results of translocations on Sections 1-2 and EWSSTA for the first two years were described in Landmark Ecological Services (2016 and 2017). For years 3-5 they were included in Ecos Environmental (2018-2020).

This report presents results after 5 years for Sections 1-2 and EWSSTA, and 4 years for Sections 3-11, to August 2020.

Following this introduction, Part 2 of the annual monitoring report describes the methods used to translocate species, including selection of receival sites and a summary of techniques used for salvage and propagation, and monitoring methods. Part 3 is a species by species account of translocation implementation and results. Part 4 assesses translocation outcomes in terms of the aims and objectives of the Translocation Strategy. Part 5 identifies actions required in the next 12 months and recommends some measure to complete aspects of experimental translocation work. A photo record of the translocation project is included.

Table 1: Conservation status of the species translocated and whether they were translocated on Sections 1-2 & EWSSTA starting in 2015 and/or on Sections 3-11 starting in 2016

Threatened Species	**EPBC Act status**	**BC Act status**	**Sec.1-2 & EWSSTA start 2015**	**Sec.3-11 Start 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 Birdwing 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 set out in the Strategy (RMS 2015 a & b) are 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 to further 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).

Translocation can contribute towards achieving conservation aims and mitigating some of the impact of development on threatened plant species. However, it is recognised that translocation is often experimental and outcomes cannot be guaranteed for a given species. Translocation is therefore not factored into offsetting packages for example, at least not at the current stage of its development as a potential conservation tool.

2.2.1 Sections 3-11

Sections 3-11 extend from Pillar Valley east of Grafton north to the Wardell area south of Ballina. The Strategy (RMS 2015b) identified twelve threatened species requiring translocation in Sections 3-11. Additional threatened plant species were found during pre-clearing surveys (i.e. unexpected finds) and incorporated into the translocation program, including the two species of vine that host threatened invertebrate species, taking the total to 18 species (Table 2).

Table 2: Number of individuals or areas of threatened species cleared during the W2B project on Sections 3-11.

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)

Species	**Translocation Target (RMS 2015a)**	**Unexpected Finds**	**Total number removed/ translocated**
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 Birdwing 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 and this population has now been included in the translocation program, but under a separate Green-leaved Rose Walnut Rehabilitation Plan (Geolink 2019) and not included in the present monitoring report.

Table 3: Number of individuals or areas of threatened species clreared during the W2B project on Sections 1-2.

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

The success of threatened plant species translocation depends largely on how well the habitat present at the receival site corresponds with habitat at the donor site, or the habitat requirements of the species being translocated. Plant habitat is determined by a complex of factors including climate, geology, soil profile, topographic position, aspect, hydrology, vegetation structure and species composition, and successional stage (e.g. mature, regrowth, patchy regrowth or cleared).

The receival sites selected for Sections 3-11 and for Sections 1-2 & EWSSTA are listed in Tables 4 and 5 below. Prior to translocation starting on Sec 3-11, the sites nominated in the Strategy were inspected to assess their suitability in terms of habitat and logistical factors (access, water availability etc.). Site locations for some species were modified (e.g. Tall Knotweed, Weeping Paperbark and rainforest species). This assessment is 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 translocations started in 2015.

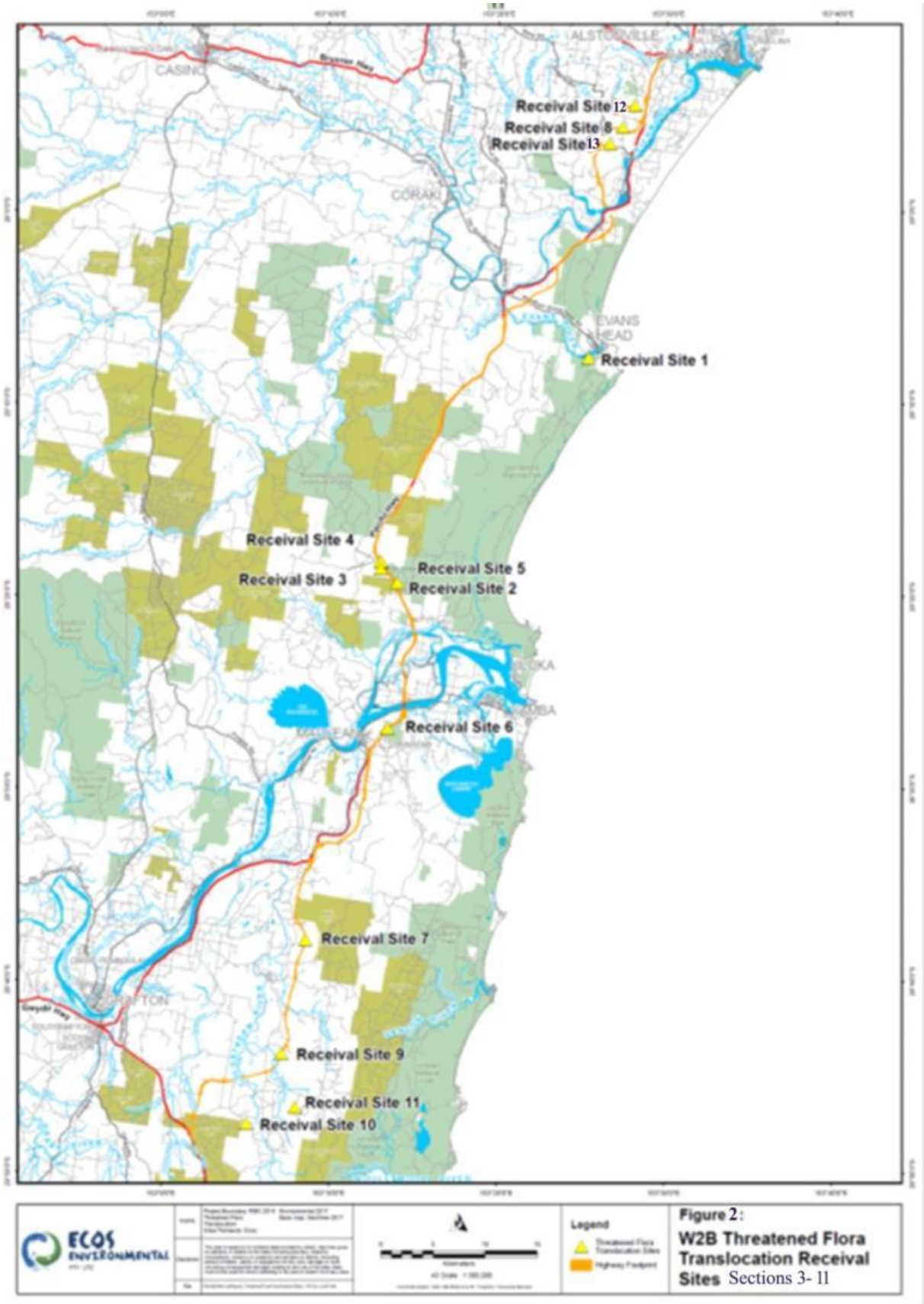
Table 4: Receival sites for species translocated on Sections 3-11. See Figure 2 below.

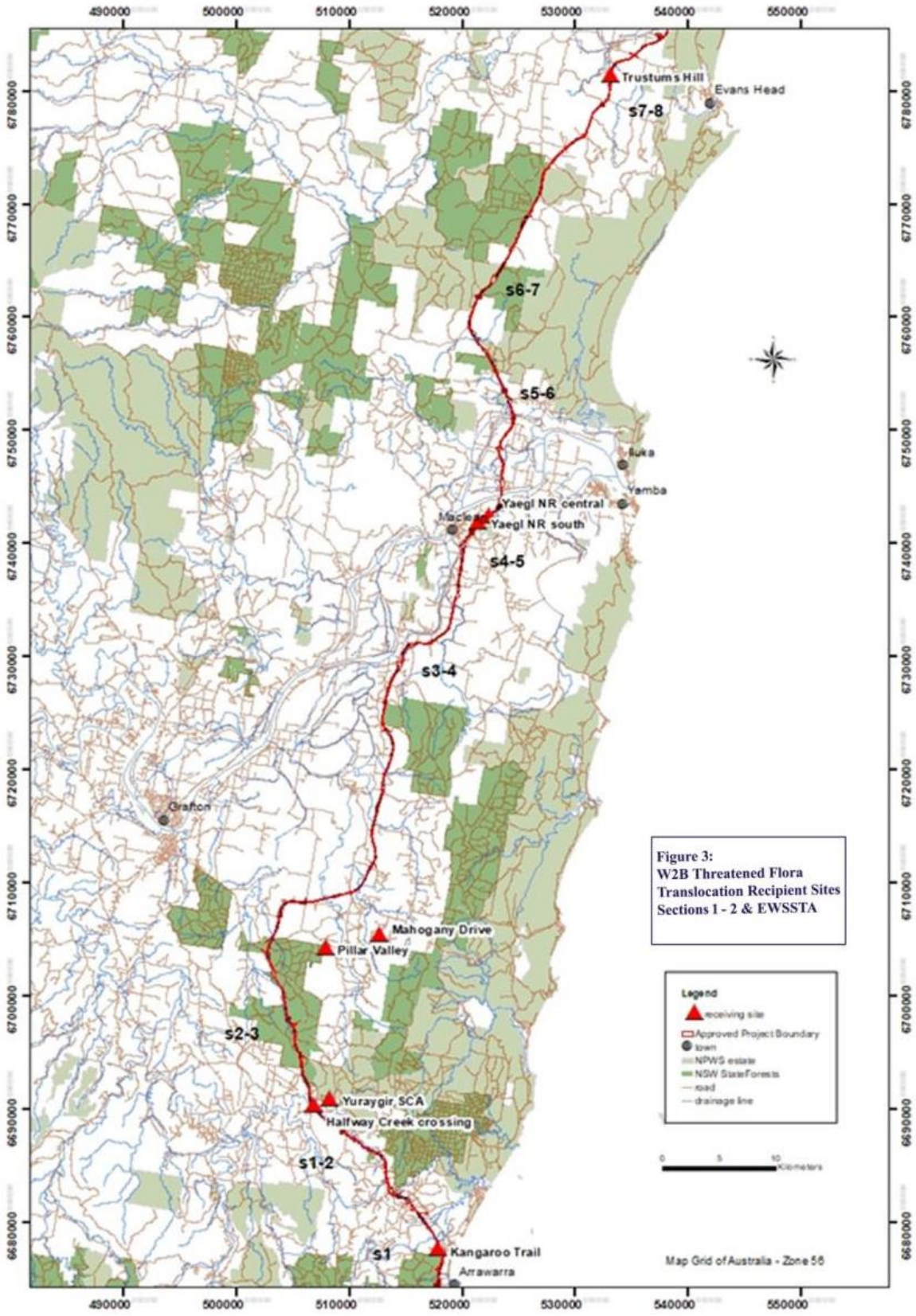
Species	**Receival Site**
Sections 3-11	
Yellow-flowered King of the Fairies (*Oberonia complanata*)	Site 1 - Bundjalung National Park (Evans Head) Site 13 - Lumleys Lane South
Slender Screw Fern (*Lindsaea incisa*)	Site 2 - Bundjalung National Park (Mororo Rd)
Singleton Mint Bush (*Prostanthera cineolifera*)	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 Birdwing 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
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


Receival Site 12
Receival Site 8
Receival Site 13
Receival Site 1
Receival Site 4
Receival Site 3
Receival Site 5
Receival Site 2
Receival Site 6
Receival Site 7
Receival Site 9
Receival Site 11
Receival Site 10
ECOS ENVIRONMENTAL
Legend
Figure 2:
W2B Threatened Flora Translocation Receival Sites Sections 3- 11


Trustums Hill
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
Map Grid of Australia - Zone 56

2.4 Translocation Methods

The threatened flora translocations were carried out using four main methods:
(i) Salvage transplanting into the receival sites (i.e. excavation of impacted plants).
(ii) Propagation of plants from cuttings and introduction to the receival sites.
(iii) Propagation of plants from seed and introduction to the receival sites.
(iv) Propagation of plants from the soil seedbank and introduction to the receival sites.
.
Propagation material was collected from plants on the clearing footprint. Different combinations of methods were applied for different species, as shown in Table 6. Summing the instances of each method in Table 6, the main methods were 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 one failed. More detail on methods is provided in the sections on each species below.

The soil seedbank was used to propagate Singleton Mint Bush, Fou**r**-tailed Grevillea and Tall Knotweed. Topsoil was collected under mature plants, assuming it would contain dormant seed of the subject species. Simulated bushfire was used to germinate the seed of Singleton Mint Bush and Fou**r**-tailed Grevillea This method proved to be practical and cost-effective, particularly as good quality seed and cutting were not readily available. Applying the same approach without fire, mud was collected under old Tall Knotweed plants and spread in plots at the receival site. As far as the writer is aware, the soil seedbank has not been used before to propagate threatened plant species.

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

(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*)	+	+	-	-

Species	**Transplant**	**Propagate Seed**	**Propagate Cuttings**	**Propagate Soil seedbank**
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*)	+	-	-	-
Richmond Birdwing 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 Monitoring

Monitoring was conducted 3-monthly in Year-1, 6-monthly in Year-2 and annually from Year 3 onwards. Monitoring for the present report was carried out in August 2020, representing the fourth year results on Sections 3-11 (third year approx. in case of unexpected finds) and fifth and final year results on Sections 1-2.

At each monitoring event, the following data were recorded for each tagged individual or plot:

- plant height, width, or crown-cover
- plant condition
- new shoot growth (present/absent)
- flowering, seeding
- recruitment
- evidence of disease, 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.

Monitoring results were entered in an Excel spreadsheet, saved as "W2B Translocation Monitoring 2016 to Aug 2020_4. xlsx".

The Strategy (RMS 2015b, p. 44) states that "*Monitoring of the translocations would be conducted during and after construction for a minimum of 3 years*, *a total of approximately 5 years*." On this basis, monitoring ends in 2021 for S.3-11 and this report discusses the fifth and final year of monitoring for S.1-2, as five years of monitoring and reporting will have been completed for S.1-2 (with this annual monitoring report).

2.6 Maintenance

Significant rates of mortality in translocated plants are often caused by growing conditions that can be manipulated to some degree to give the salvaged and propagated plants a better chance of survival and establishment at the receival site. This is achieved by horticultural interventions such as watering, mulching, shading, spraying to control weeds, digging out competing native species, fencing to exclude native or domestic grazing animals, and use of fertilisers. All such actions come under general heading of maintenance.

Maintenance activities carried out during the last 12 months (spring 2019 to winter 2020) 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 2019 and August 2020

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 RESULTS (SECTIONS 1-11)

3.1 Weather Conditions

Monthly and mean monthly rainfall between 2015 and 2020 at Evans Head (www.bom.gov.au/climate/data/) are plotted in Figure 4. The six year period included several drought events (defined as three or more consecutive months with below average rainfall), and high rainfall events causing flash flooding. Three periods of below average rainfall were in the dry season (Aug-Oct). Wilting in species such as *Lindsaea incisa* indicated severe water stress. Additional watering was carried for some species. Heavy rain events caused flash flooding and prolonged soil water logging, also adversely affecting some species (e.g. *Lindsaea incisa, Persicaria elatior*).

The NSW Far North Coast recorded its highest daily maximum temperature on record on 11/2/2017 (mid to high 40s). This event caused wilting, leaf damage and some mortality in species such as *Cryptocarya foetida*. The high temperature was during a drought that ended in March 2017 when 800-1000 mm of rain fell from Ballina to Maclean, causing flash floods and prolonged flooding of low lying receival sites. Wet conditions persisted to the end of June 2017.

An exceptionally long dry period occurred from October 2018 to December 2019 along much of the east coast of Australia including the project area. Bushfires were widespread. A fire that started near the Summerland Way burnt all the way to the coast including the receival sites for *Lindsaea incisa*, *Prostanthera cineolifera* and *Melaleuca irbyana* at Tabbimoble Ck, near the Iluka turnoff in Nov/2019. This bushfire provided an opportunity to record how a bushfire affected the survival/persistence of species after being translocated.

Overall, weather patterns between mid-2015 and mid-2020 were notable for several large deviations from average. There were four drought periods with more than three consecutive months of below average rainfall, and one period of exceptionally high rainfall in autumn 2017. Intervening periods were about average with respect to rainfall although higher than average in some months. Exceptionally high temperatures were recorded at the start of 2017, as noted above.

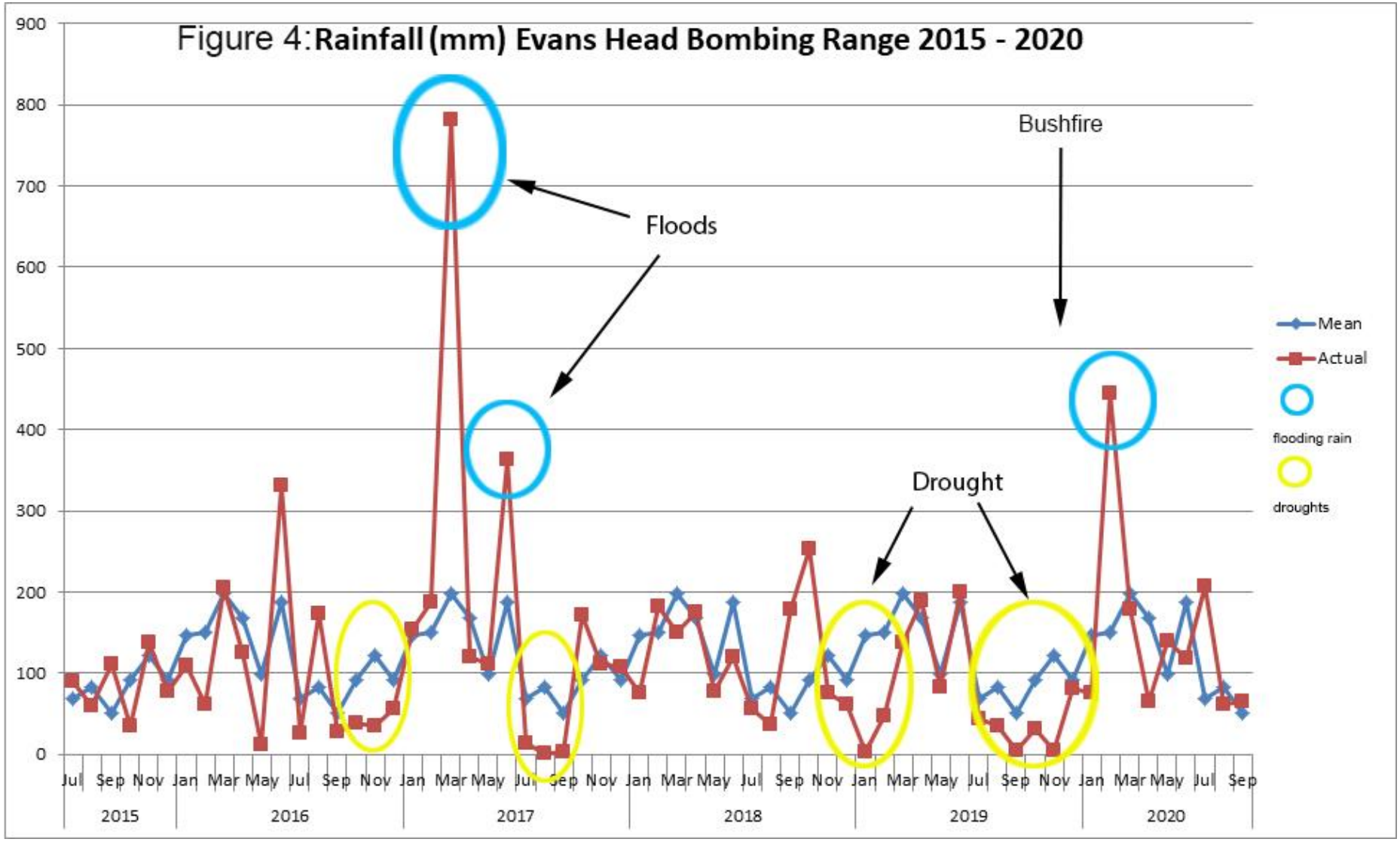


Figure 4: Rainfall (mm) Evans Head Bombing Range 2015 - 2020
900
800
700
600
500
400
300
200
100
0
Floods
Bushfire
Drought
Mean
Actual
flooding rain
droughts
Jul Sep Nov Jan Mar May Jul Sep Nov Jan Mar May Jul Sep Nov Jan Mar May Jul Sep Nov Jan Mar May Jul Sep Nov Jan Mar May Jul Sep
2015
2016
2017
2018
2019
2020

3.2 Translocation Results

Table 8: Summary of threatened flora translocation results on W2B sections 3-11 after four years (2016-2020).

S - survivorship %; CC - mean % crown-cover; Ht - mean height (cm); ~1-4 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 July/2019	Survival %/Cover-abundance/ No. of plants Aug/2020
Yellow-flowered Oberonia (*Oberonia complanata*)	Bundjalung NP Gumma Gurra	Transplanted Aug/2016	Transplanted - 11	~1 year S = 91% (10/11)	~3 years S = 91%	~4 years S = 91%
Unexpected finds	Lumleys Lane Sth	Transplanted Aug/2017	Transplanted – 12 small branches with orchid clumps	n/a	~2 years S = 100%	~3 years orchids apparently taken by collectors
						Bushfire Nov/2019
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%	~3 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%	~4 years Line A –S=0% Line B – S=8%; CC=2% Line C – S=25%; CC=18% Line D – S=0%; patches – S=20%; CC=1%
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	~2 years Line A – S=97%; CC=6.8% Line B – S=94%; CC=16.3% patches–S=100%; CC=68.5% &80%	~3 years Line A – S=12%; CC=5% Line B – S=75%; CC=20% patches–S=73%; CC=30% Area 1; CC= 1% Area 2
						Bushfire Nov/2019
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	2.5 years Total number surviving - 520 1st planting mean ht 121.1cm	3.5 years Total number surviving - 400 Small percentage resprouted indicating low fire intensity; very low density of seedlings across site, more towards Tabbimoble Ck
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	~ 2 years Mean Ht of plants (cm) zeros included (NF-no fert; F – fertiliser) 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)	~ 3 years T1 – no resprouts or seedlings T2 – no resprouts or seedlings T3 – few resprouts, seedlings T4 -- no resprouts or seedlings T5 -- few resprouts, seedlings

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 July/2019**	**Survival %/Cover-abundance/ No. of plants Aug/2020**
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	~20 months Seedlings Cuttings NF Ht=155.2cm Ht=116.1cm F Ht=142.4cm Ht=94.5cm Survival 94.5%	~32 months No seedlings, some resprouts:- A B C D E F Resp 0 33% 41% 8% 12% 0 No diff between cuttings/seedling fert/no fert
Experiment 3 (effect of seedling age – two plots on T2 replanted)	Tabbimoble Triangle	Experiment.planted 17/11/2017 with ~12 month old seedlings	Two plots from Experiment 1 (T2-5 and T2-6) replanted with 12 mth old seedlings, four per plot quarter 16 plants/plot Total 32 plants in experiment	n/a	~18 months T2-5 mean ht = 141.6 cm T2-6 mean ht = 165.5 cm Survivorship – 100%	~18 months T2-5 – no resprouts or seedlings T2-6 – no resprouts or seedlings Survivorship – 100%
						Bushfire Nov/2019
Weeping Paperbark (*Melaleuca irbyana*)	Tabbimoble Offset Land (2) Tabbimoble Triangle (1)	Seed propagation, seed collected and sown in 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	~3 years Total number of plants approx. 1500	~4 years Total number of plants approx. 900
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	~4 years – new plots (2) Pre-fire – post-fire Plot 1 (9) 234 cm 104 cm Plot 2 (12) 228 cm 108 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%	~ 3 years 19% of plots with live sdlgs or recently dead mature Tall Knotweed. Total number of plants ~ 37	~ 4 years 51% of plots with TK plants, most mature Total number of plants ~ 25
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%	~ 2.5 years No plots with Tall Knotweed – there was some when inspected in March/19 Total number of plants = 0	~ 3.5 years 4 plots with TK plants, most mature Total number of plants = 9
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%	~2 years 33% of plots with live sdlgs or recently dead mature Tall Knotweed. Total number of plants ~ 33 (mainly dead matures)	~3 years 27% of plots with TK plants, most mature Total number of plants ~ 21
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.	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	~ 3 years Survivorship - 93% Mean height – 155.9cm Mean width – 146.2cm	~ 4 years Survivorship - 93% Mean height – 163.7.6cm

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 July/2019**	**Survival %/Cover-abundance/ No. of plants Aug/2020**
		Soil seedbank collected Aug-Sept/16			Total number of plants 14	Total number of plants 14
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%	~ 3 years Survivorship – 25% Total number of plants 6	~ 4 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	~18 months Mean Ht – 42.9cm Survivorship – 89.3% Total number of plants 25	~30 months Mean Ht – 66.9cm (~50%>) 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%	~ 3 years Survivorship – 33.3% Total number of plants 1	~ 4 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	~18 months Mean Ht – 35.6cm Survivorship – 100% Total number of plants 19	~30 months Mean Ht – 66.6cm 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	~ 2 years Mean Ht – 59.5cm Survivorship – 92% Total number of plants 12	~ 3 years Mean Ht – 81.3cm Survivorship – 92% Total number of plants 12
	Coolgardie Rd	Propagated - seed collected Aug-Sept/16.Planted Feb/18	30 propagated plants including transplants (supertubes)	n/a	~ 18 mths Mean Ht – 49.2 cm Survivorship – 46.7% Total number of plants 14	~ 30 mths Mean Ht – 64.3cm Survivorship – 33% Total number of plants 10
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	~ 3 years Survivorship – 100% Total number of plants 2	~ 4 years Survivorship – 100% Total number of plants 2
	Coolgardie Rd		6 potted juveniles (6) introduced Feb/18	n/a	~ 18 mths Mean Ht – 152.7cm Survivorship – 100% Total number of plants 6	~ 30 mths Mean Ht – 217.6cm 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	~ 18 mths Mean Ht – 55.2cm Survivorship – 100%	~ 30 mths Mean Ht – 124.3cm Survivorship – 80%

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 July/2019**	**Survival %/Cover-abundance/ No. of plants Aug/2020**
					Total number of plants 5	Total number of plants 4 + 3 more planted = 7
Square-fruited Ironbark (*Eucalyptus tetrapleura*)	Sunnyside Rd Offset property, Glenugie	Transplanted Oct/2016	Transplanted – 8	~ 1 year Survivorship – 75% Total number of plants 6	~ 3 years Survivorship – 75% Total number of plants 6	~ 4 years Survivorship – 75% Not all E. tetrapleura 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	~ 3 years Survivorship – 100% Total number of plants 2	~ 4 years Survivorship – 100% Total number of plants 2
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	~ 3 years Recently germinated seedlings present	~ 4 years Recently germinated seedlings present
	Lumleys Lane, Section 10	Transplanted Nov/2016	Transplanted - 43 trays/plots (~2150 plants)	~ 1 year Survivorship –100% of plots. Total number of plants ~1000	~ 3 years Survivorship –100% of plots, Total number of plants ~2000	~ 4 years Survivorship –100% of plots. Total number of plants ~500
Lindernia (*Lindernia alsinoides*)	Mitchell Rd	Transplanted Dec/2016	Transplanted - 5 plots containing 30 sods	~6 months April/17 – 50% of sods June/17 – 0%	~2.5 years Survivorship – ? Need to monitor in summer	3.5 years No plants seen (better to monitor in summer when flowering)
						Bushfire Nov/2019
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, 50 plants introduced	n/a	~18 months Survivorship – 37.8% Total number of plants 17	~30 months Survivorship – 30% Total number of plants 15
Richmond Birdwing Vine (*Aristolochia pravevenosa*)	Coolgardie Rd	Propagated - cuttings collected Oct, Nov/2016, Planted Oct/2017	Propagated - 11 in 6 inch pots	100%	~ 2 year Mean Ht – 89.6cm Survivorship – 100% Total number of plants 11	~ 3 year Mean Ht – 88.5cm Survivorship – 91% Total number of plants 10
Pink Underwing Moth Vine (*Carronia multisepala*)	Coolgardie Rd	Propagated - cuttings collected in June/2017; Planted June/18	6 planted out June/18	n/a	~ 1 year Mean Ht – 8.3cm Survivorship – 83.3% Total number of plants 5	~ 2 year Mean Ht – 10 cm Survivorship – 40% Total number of plants 2

Table 9: Results of threatened flora translocations on W2B Sections 1-2 & EWSSTA after four years (2015-2020)

Species	Receival Site	Methods/Start Date	No. of plants translocated	Spring 2016	Autumn 2017	July 2019	Aug 2020
SECTION 1							
Lindernia	1. Yuraygir SCA	Slabs/clumps (15/8/15)	22 clumps/plants	3 clumps/plants	no plants observed	~ 4 years Survivorship – 0 Total no plants – 0	~ 5 years Survivorship – 0 Total no plants – 0
	2. Halfway Creek crossing	Soil slabs stored (31/8/15)	8 slabs	no plants observed (1 yr)	no plants observed (1.5 yr)	~ 4 years Survivorship – 0 Total no plants – 0	~ 5 years Survivorship – 0 Total no plants – 0
	2. Halfway Creek crossing	Nursery plants		n/a, not yet planted out	~ 500 plants newly planted	~ 2 years Survivorship – 1% Total no plants – 6	~ 5 years Survivorship – 0 Total no plants – 0
	3. Kangaroo Trail	Nursery plants 28/1/16	350	1 (6 mths)	no plants observed (1 yr)	~ 4 years Survivorship – 0 Total no plants – 0	~ 5 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	~ 2 years Survivorship – 0% Total no plants – 0	~ 5 years Survivorship – 0 Total no plants – 0
Slender screw-fern	3. Kangaroo Trail	Slabs (10/9/2015) and nursery plants (2016-17)	45 slabs	10 (1 yr)	4 (1.5yr) (+17 grown-on in nursery and planted May/17) = 21	~ 2 or 4 years Survivorship – 15.8% Total no plants – 9 Total no of tags - 57	~ 2 or 4 years Survivorship – 14% Total no plants – 8 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	~ 4 years Survivorship – 0 Total no plants – 0	~ 5 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	~ 4 years Survivorship – 0 Total no plants – 0	~ 5 years Survivorship – 0 Total no plants – 0
Moonee Quassia	(Dirty Creek road reserve)	Nursery cuttings	Zero – failed to strike				
SECTION 2					A		
Lepidosperma "Coaldale"	4. Mahogany Drive	Nursery, plants		35 planted out	20 (didn't look under ferns?)	~ 3 years Survivorship – 31.4% Total no plants – 11	~ 5 years Survivorship – 0 Total no plants – 0
Square-fruited ironbark	5. Pillar Valley	Nursery, seed		80 plants in nursery	79 planted	~ 2 year Survivorship – 92% Total no plants – 71	~ 3 year Survivorship – 90% (900 tubestock to be planted Oct/20)
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	1 + 4 seedlings observed but did not establish.	All plants died back, including controls Occasional seedlings (cotyledon stage) present.	~ 4 years Survivorship – 0 Total no plants – 0	~ 5 years One clump of healthy, mature plants 20m north of tagged points

Species	Receival Site	Methods/Start Date	No. of plants translocated	Spring 2016	Autumn 2017	July 2019	Aug 2020
Green-leaved rose-walnut	Adjacent to Maclean Interchange	Single small tree, root-pruned in prep for translocation		Translocation not required, to be protected in situ.		Translocation now required as the in situ tree died. Seed collection and propagation underway.	No suckers or recruitment at site of dead in situ tree. Propagated plants (10) to be introduced in Dec 2020. Note – this species is monitored and reported on separately
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	Not observed, biomass high	Not observed (biomass under management)	~ 4 years Total no plants – 0, but monitored in winter when only very small seedlings active	~ 5 years Total no plants – 0, but monitored in winter when only very small seedlings active
	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.)	~ 4 years Total no plants – 0, but monitored in winter when only very small seedlings active	~ 5 years Total no plants – 0, but monitored in winter when only very small seedlings active

3.3 Slender Screw Fern (*Lindsaea incisa*)

3.3.1 Translocation Method – Sections 3-11

There were two translocations of Slender Screw Fern (*L. incisa*) on Sections 3-11: - plants identified in the Strategy translocated in 2016, and unexpected finds translocated in 2017.

First translocation 2016

In the first translocation 127 trays (40 cm x 40 cm) of *L. incisa* were transplanted to the receival site in Bundjalung National Park in September 2016 (i.e. Area 1 - Table 8). Sods containing fronds and rhizomes were dug out to a depth of 6-8 cm, placed in trays, watered and transported to the receival site about 0.5 km away. These were planted in plots the size of the tray about 2 m apart in five lines, the lines at slightly different elevation, at the base of a slight hill slope (~1 degree). The aim was to record how microtopography affected survival and growth. As well as the single tray plots, the sods were planted in patches of four trays (ie approx. 80 cm x 80 cm square).

Plots and patches were watered to keep soil moist and no fertilisers were applied. The plastic trays with a wide grid base were inverted to protect *L. incisa* from animal grazing and digging, and to define the plots for monitoring. They also caught falling leaves and bark which were removed to prevent litter from smothering *L. incisa*. Additional watering was carried out during drought periods in 2016 and 2017.

Second translocation 2017 (unexpected finds) Area 1 and 2

The second translocation of Slender Screw Fern was carried out one year later in September 2017, to the same receival site in Bundjalung National Park. About half the plants were planted on the opposite side of the flat bottomed valley to the first batch, 50 m to south (Area 2). The other half were planted into Area 1 again, in patches (i.e. 4 trays to a patch). A total of 59 trays/plots and 23 patches were transplanted. Planting sites in Area 1 and 2 were selected above the level of flash floods that occurred in autumn 2017. Habitat in Area 2 was similar to Area 1, but there were differences in soil type and understorey. The soil consisted of a pale grey (higher content of fine sand) clay loam rather than dark brown, humic clay loam in Area 1, and the understory was dominated by Common Tea Tree (*Leptospermum polygalifolium*).

3.3.2 Results

Over the first three years, *L. incisa* crown cover fluctuated with flood and drought events, but overall the salvaged plants established successfully at the receival the site in Bundalung NP. At the July/19 monitoring (before the Nov/19 bushfire), *L. incisa* had recovered from frond die-off during drought at the start of 2019 (see Fig 4). Crown cover was 25% - 35% in most plots and patches in Areas 1 and 2. After the bushfire, monitoring in Aug 2020 recorded a substantial contraction of the translocated population, almost certainly as a result of the bushfire.

Effect of the Nov/2019 bushfire

After the fire *L. incisa* regenerated by resprouting from rhizomes in approximately 30% of the plots/patches. Overall there was a decrease in crown cover and distribution within the site. In Aug/20, mean crown cover was 12.8% in Area 1 and 6.1% in Area 2. In Area 1 *L. incisa* had contracted to the eastern part of site (eastern end of transects B and C). Patches (part of the second translocation) regenerated well, but plots (first translocation) declined markedly on

transect A (the lowest transect), the western half of Transect B and all of Transect D. Declines were either in the western part of the site or at a lower elevation. In Area 2, the patches have almost disappeared, but the plots have recovered fairly well.

It appears the bushfire has culled fern plants from (habitat where they were able to establish in the short-term (in absence of bushfire), but not able to survive a fire event. The fire was of medium to high intensity, burning the canopy as well as the ground layer. The micro-habitat factors involved – ie. why plants survived at some points within the site and not others- are unclear. Whether a similar response to fire would have occurred in a completely natural population is also unclear. Reference sites would have given some indication of this, but were not included in the Strategy.

In previous years the translocated population was able to recover from flood and drought dieback because rhizomes were still alive and able to reshoot. The decline in crown cover after the bushfire may be permanent if rhizomes were killed by the fire. It is unlikely fern regeneration was suppressed by the dense ground layer regrowth as this is also present at points where the fern has regenerated. Some plants may be very slow to reshoot but this also seems unlikely. The rhizomes of *L. incisa* are horizontal, thin (one or a few mm in diameter) and usually close to the surface.

In Area 1 prior to the fire, mean cover-abundance was highest on Line C and less on the other lines (see Fig 5; Table 8), suggesting that factors associated with micro-elevation affect *L. incisa* growth and survival. Of the four lines in Area 1, Line A was lowest in elevation and Line D the highest. Small differences in elevation may be related to gradients of soil moisture or species composition/competition. Similar sensitivity to micro-elevation was recorded during the translocation of *L. incisa* on the Sapphire to Woolgoolga Project (Ecos Environmental 2011b).

Overall, bushfire substantially reduced extent of the translocated population but a healthy population still survives in reduced areas (2).

Monitoring post-fire (Year 4 – July 2020)

As plot markers were burnt and we were unable to determine the exact location of many plots and patches, clumps of regenerated *L. incisa* were re-tagged and re-numbered in Aug/20 for on-going monitoring. In Area 1, 38 discrete clumps of Slender Screw Fern with a mean percentage crown cover of 12.8% (i.e. clump area/plot area x 100) were marked and given a new number for monitoring. In area 2, 21 discrete clumps of Slender Screw Fern with a mean percentage crown cover of 6.1% were tagged and numbered. There were also other tagged but unnumbered clumps (not monitored). The renumbered clumps were equated approximately with the lines and patches recorded the previous year (pre-fire) for purposes of extending the graphs below (see Figs 5 & 6).

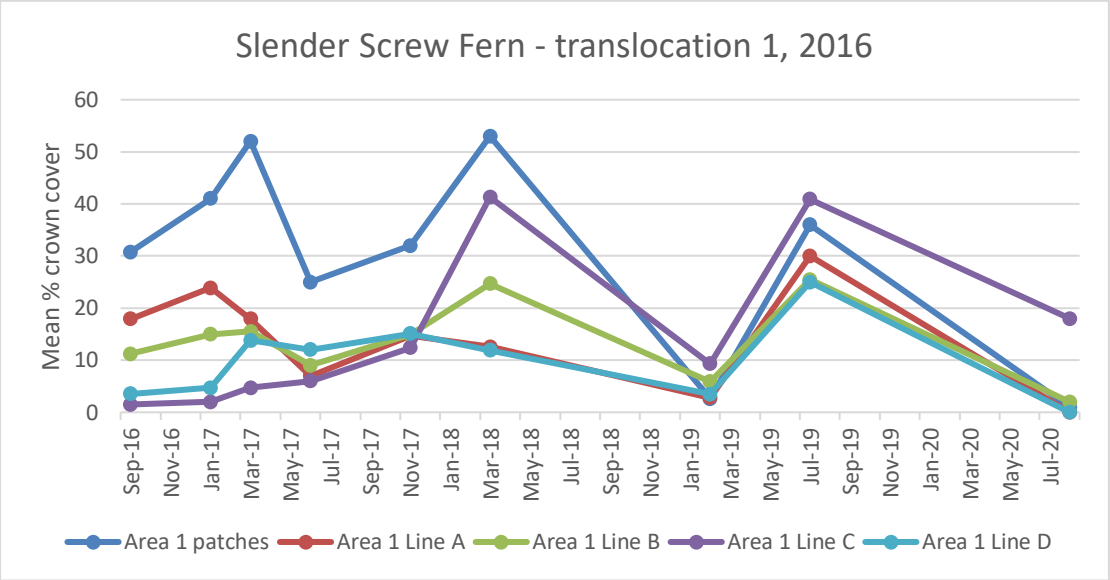


Figure 5: Slender Screw Fern translocation Area 1. Declines in crown-cover relate to extreme weather events, the first (on the left) to flash flooding, the second to unseasonal drought and the most recent to bushfire.

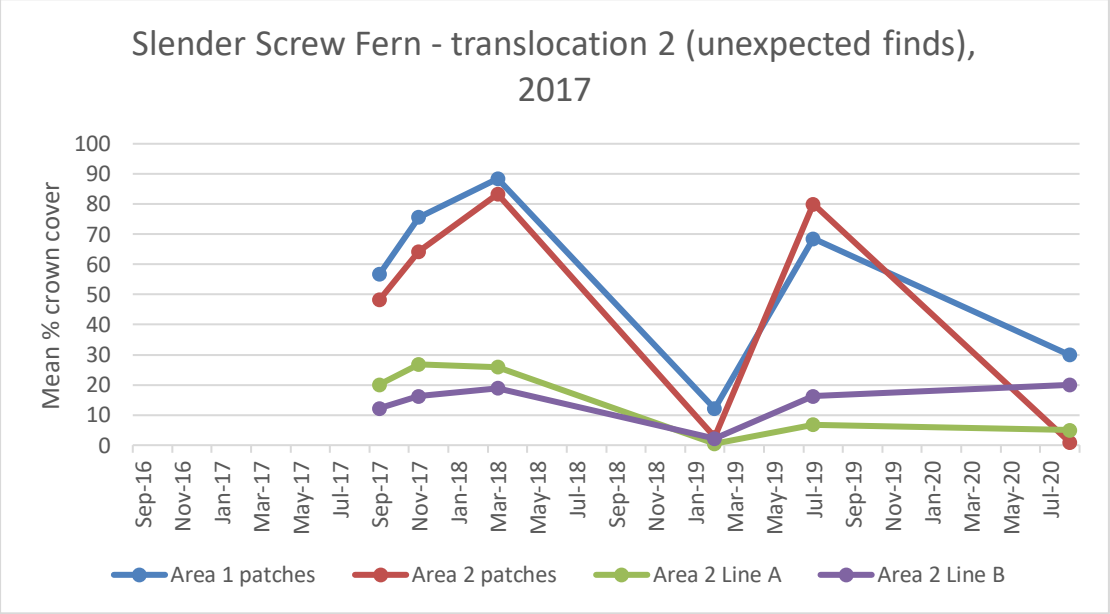


Figure 6: Slender Screw Fern translocation Area 2. Translocated a year later than Area 1. Declines in crown-cover relate to drought (left hand side), also seen in the graph above and most recently, to drought and bushfire (see also with Fig 4).

3.3.3 Results of Slender Screw Fern on Section 1-2 & EWSSTA

Results on Sections 1-2 & EWSSTA during the first two years were described in Landmark Ecological Services 2016 and 2017. The reports state that 3 of the original 45 slabs transplanted (equivalent to plots) survived after 2.5 years and 100% of 17 additional potted plants introduced in autumn 2017 were surviving after one year (Table 9). The latter planting consisted of fern divided and grown-on in a nursery. The high mortality of the first translocation was attributed to kangaroo grazing and flash flooding.

Monitoring by Ecos Environmental over the last three years recorded that out of 57 tagged points present at the site (representing planted *L. incisa*), 35.1% had surviving plants in 2018, 15.8% in 2019 and 9.3 % in 2020. Most of the surviving plants were healthy and there was some lateral expansion of clumps. The main threats were drought and smothering by the exotic grass Broad-leaved Paspalum (*Paspalum mandiocanum*).

3.4 Yellow-flowered Oberonia (*Oberonia complanata*)

3.4.1 Translocation Method

The 18 plants identified in the Strategy 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 about to fall over. As the orchid plants were unlikely to survive on the ground, 11 clumps of orchid were salvaged from the tree and relocated to a receival site near Evans Head, in Bundjalung National Park.

Rather than prising the orchid and roots 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 the roots. The pieces of bark with in situ orchid plants were attached to suitable trees with ribbon or wire at the receival site.

A second translocation of this species was carried out after additional plants were found during a pre-clearing survey south of Lumleys Lane (Section 10) in 2017. Twelve small sections of branch with clusters of orchid were removed from a *Melaleuca linariifolia* tree and attached to trees in adjoining swamp sclerophyll forest about 30 metres away in August 2017.

3.4.2 Results

One of the 11 plants translocated in 2016 died after relocation to the receival site due to including moss for moisture retention, which instead caused the orchids to rot. The other orchid clumps (without moss) had all grown and were looking healthy in Aug/2020, after 4 years. Some had dried racemes of seed pods.

Plants in the second translocation grew well and flowered during the first two years, but this year there was no sign of nearly all the orchid plants. As the supporting branches cut from donor tree had gone as well, they appear to have been stolen. A few juvenile orchid plants were noted on trees nearby and may have recruited from seed produced by the translocated plants.

3.5 Singleton Mint Bush (*Prostanthera cineolifera*)

3.5.1 Introduction

A broad plan for translocating Singleton Mint Bush (SMB) was set out in RMS (2015), including nomination of the receival site. As Mint Bush plants were already present on part of this site, propagated plants were introduced to habitat adjoining the occupied area with the aim of augmenting the existing population. Numerous factors can affect the outcome of a translocation, for example, receival site selection, weather conditions, species resilience and horticultural practices. Site selection is very important as it determines the pattern of microhabitat factors that will directly influence the survival of plants, such as soil texture, drainage, depth of water table, insolation and interspecific competition. Horticultural factors to do with propagation, planting and maintaining can also affect outcomes, some of which were explored in this translocation. Short and long term criteria for assessing translocation results and whether aims and objectives have been achieved were included in the plan. The translocation aimed to add to an existing population to compensate for plants lost to clearing. Since this was the first attempt at translocating SMB, the aims were also concerned with developing effective translocation techniques and increasing knowledge of species ecology.

There were several questions as to how this translocation would be carried out, including how to propagate plants and where to plant them within the nominated site, particularly as normally this species would recruit after fire in open conditions enriched with ash, not in an unburnt forest. Salvage of existing plants was not a feasible option due to their senescent condition, and seed and cuttings were either unavailable or of poor quality. It was decided instead to trial propagation by applying fire to soil seedbank collected from under SMB. Topsoil seedbanks are often used for revegetation, but utilising the soil seedbank and fire for propagation of a threatened species and to provide a source of plants for translocation does not appear to have been attempted before. Following success with this propagation technique, a three-step procedure was implemented to identify where SMB should be introduced within the receival site or surrounds.

1. Blanket planting of tubestock across the site and let natural selection indicate where microhabitat appears to be best suited to the species.

2. Apply experimental design to clarify the microhabitat and horticultural factors affecting species performance, as indicated by the pattern of survival observed in Step 1.

3. Introduce remaining tubestock to habitat most suited to the species, based on the findings of Steps 1 and 2.

Monitoring of results of the trial plantings and experiments was carried out for four years. During this time we were able to record the response of plantings to flood, drought and in the last year bushfire, which burnt the receival site in November 2019 when the SMB plants were approximately 3 years old. To be self-sustaining, a translocated population must be able to recover from natural disturbances that damage or kill plants. Such disturbances are a natural part of a changeable environment. In most Australian vegetation, recruitment of new individuals occurs mainly after fire. The regeneration response of translocated SMB plants after bushfire would be crucial in indicating whether the translocated population is able to recruit another cohort of plants after the fire and therefore likely to be self-sustaining.

Research Questions

Translocation methods, including where to position plantings within the general receival site so they had the best chance of survival, were developed iteratively based on a series of planting trials and experimental investigations. In developing translocation methods for SMB, the following questions about species ecology and translocation technique were investigated:

1. Can fire be applied in an ex situ situation to propagate seedlings from the soil seedbank and how is germination affected by the intensity of fire applied?

2. How does microhabitat variation (e.g. soil texture gradient) within a broadly suitable receival site affect the survival of introduced seedlings?

3. Does the age of tubestock affect their survival when introduced to a site?

4. How does the addition of fertiliser affect the performance of introduced plants?

5. Is there any difference in the performance of plants propagated from seed (soil seedbank) and from cuttings?

6. How is species persistence and translocation outcome affected by a bush fire event?

3.5.2 Methods

3.5.2.1 Soil Seedbank Propagation

To test the feasibility of propagating seedlings from the soil seedbank, two garbage bins of topsoil were collected to a depth of 1-3 cm from under SMB on the highway footprint. The soil was divided into 3 lots and two spread on sheets of tin to a depth of 6-8 cm, then covered with dry eucalypt leaves and twigs. Different thicknesses of litter were applied and burnt to simulate bushfire of different intensity. Three treatments were compared: a 10 cm thick layer for higher fire intensity, 5 cm for lower fire intensity and no litter or fire. The litter was ignited at one corner and allowed to burn across the soil, heating the topsoil and releasing combustion compounds that trigger seed germination. The cooled soil was placed in 40 cm x 40 cm x 6 cm plastic trays using a flat shovel to minimise disturbance and germinated under sprinklers in a shade house. Twenty trays of each treatment were prepared. Singleton Mint Bush seedlings began to appear in 3- 4 weeks and at 12 weeks, 10 seedling trays from each of the 3 treatments were selected at random and counts made of seedlings of all species. The trays were grown-on to identify grasses and other unknowns.

3.5.2.2 Receival Site

The receival site nominated in the Strategy, referred to as the ‘Tabbimoble Triangle’, is located on the eastern side of the highway on the northern side of Tabbimoble Ck. An area within the Triangle approximately 80 metres (N-S) by 60 metres (E-W) next to scattered in situ SMB was selected as the receival site. The vegetation consisted of layered, grassy, dry sclerophyll forest dominated by Swamp Box (Lophostemon suaveolens), White Stringybark (E. eugenoides), Blackbutt (E. piluaris), with a mid-stratum of small trees and fairly uniform across the site. The site was fenced to exclude wallabies and kangaroos.

3.5.2.3 Planting Trials

After successfully germinating seedlings of SMB using the seedbank method seedlings were potted into native tubes (October 2016). A standard, sterilised potting mix for natives was used and Seasol liquid fertiliser applied sparingly. When first introduced to the receival site in Autumn 2017, the seedlings were 6 months old, >30 cm high and hardened off. An initial planting followed by three experimental plantings were implemented in 2017, in March, April and November.

Initial 'blanket' planting - 6 month old tubestock

A total of 700 tubestock were planted across the whole of the receival site in March 2017, the plants spaced a few metres apart, and natural selection allowed to indicate what parts of the site were best suited to the species. An inspection three weeks later, after heavy rain and flash flooding, found that most of the tubestock in the northern two-thirds of the site away from the creek were dead or dying from a wilt disease (probably a root fungus), whereas plants in the southern one third, closer to the creek, were still healthy. Soil ribbon tests suggested that soil texture was variable within the receival site, with soil a sandy clay closer to Tabbimoble Creek and heavy clay further away. To examine the effect of soil texture more closely, and to discount possible effects due to flash flooding and application of herbicide during site preparation, planting trials were designed to examine survival and growth in relation to the local soil texture gradient and other factors, as follows:

Experiment 1 - effect of soil texture

To examine the effect of soil texture on species performance more systematically, in April 2017 after observing the results of the initial planting, five transects (T1-T5) were positioned at increasing distance from Tabbimoble Creek and in a small gully running into the creek. Transects ran at right angles to the putative soil texture gradient so soil texture on each transect would be roughly the same (to be checked by soil particle size analysis). Three 2 m x 2 m plots 10-20 m apart were placed on each transect. The plots were divided into quarters and each quarter planted with four tubestock (16 plants per plot). Experiment 1 was planted 3 weeks after the initial planting, on 12/4/2017, so seedlings were only a month older.

Experiment 2 - effect of propagation type (seedlings vs cuttings) and fertiliser

The second experiment was carried out to examine if plants propagated from cuttings from established in situ plants would perform any better than plants propagated from the soil seedbank. The effect of fertiliser was also included in this experiment by planting half with 12-month slow release fertiliser and half without. A small quantity of cuttings had been propagated during early works for the highway from a few young plants that grew where soil had been disturbed by geotechical investigations. These were potted into larger tubes and grown on. The seedlings were 12 months old and the cuttings 18 months old when planted. The experiment was situated on sandier soil closer to Tabbimoble Creek and planted 17/11/2017.

Experiment 3 - effect of tubestock age

Nearly all of the 6 month old seedlings died on transects further from Tabbimoble Ck where the soil sand content appeared to be lower. To test whether older seedlings would perform any better, 12 month old seedlings were planted in two of the three plots on T2 where all 6 month old seedlings had died. The same planting layout was used with 16 tubestock per plot and planted 17/11/2017.

3.5.2.4 Fire Response – translocation site vs reference area

The fire response of SMB was compared in the receival site and a reference area west of the highway representing the western side of the population bisected by the highway and containing most of the population. Fire intensity was low in the receival site and the reference area, although slightly higher in the reference area as indicated by flame scorch height (2-4 metres vs 3-8 metres). Fire response was compared in terms of mode of regeneration and seedling density of SMB in the two areas. In the receival site the data were recorded in all experimental plots (n = 23). In the reference area, a site was established about 15 m from banks of Tabbimoble Ck and 50 m west of the highway. Fire response of Mint Bush, seedling density and seedling height were recorded in five representative 1 m^2 plots. Data were recorded in Aug 2020, 9 months after the bushfire.

3.5.3 Results

Soil seedbank treatments

Total seedling density and number of species were much higher in the high fire intensity treatment, significantly less in the low fire intensity and very low in the no burn treatment. No Singleton Mint Bush seedlings germinated in the no burn treatment, very few in the low intensity treatment and hundreds in the high intensity treatment.

First planting of Singleton Mint Bush

Plants closer to Tabbimoble Ck survived and nearly all further away died from a wilt disease. The probable cause was the root pathogen *Phytophthora cinnamomi*, which is indigenous to soils in the North Coast region, although not often associated with disease in natural plant communities. 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 and 3 years old.

Experiment 1 - effect of soil texture

Two months after planting Experiment 1, transects furthest from the creek at the northern end of the site showed the same wilt symptoms as the first planting. Most plants were healthy on Transect 5 closest to the creek and Transect 3, the side gully. On Transect 4 in an intermediate position, half the plants were healthy and half were wilting. Survivorship varied from 0% to 77.1% depending on the position of transects relative to the soil texture gradient. Survivorship increased toward the creek as the topsoil became sandier (Figure 7). A ribbon test was used to examine soil texture but it would be preferable to have quantitative data on soil particle size to complete the experiment.

Experiment 2 – effect of tubestock age

Two plots on Transect 2 from Experiment 1 where all the 6-month old tubestock had died were replanted with 12-month old tubestock (Figure x – Transect 2a) for Experiment 2. Surprisingly, none of the 12-month old seedlings succumbed to the wilt disease, and survival remained at 100% after 2 years (see Figure 7). This result implies that the age of tubestock at introduction also has a major effect on survival.

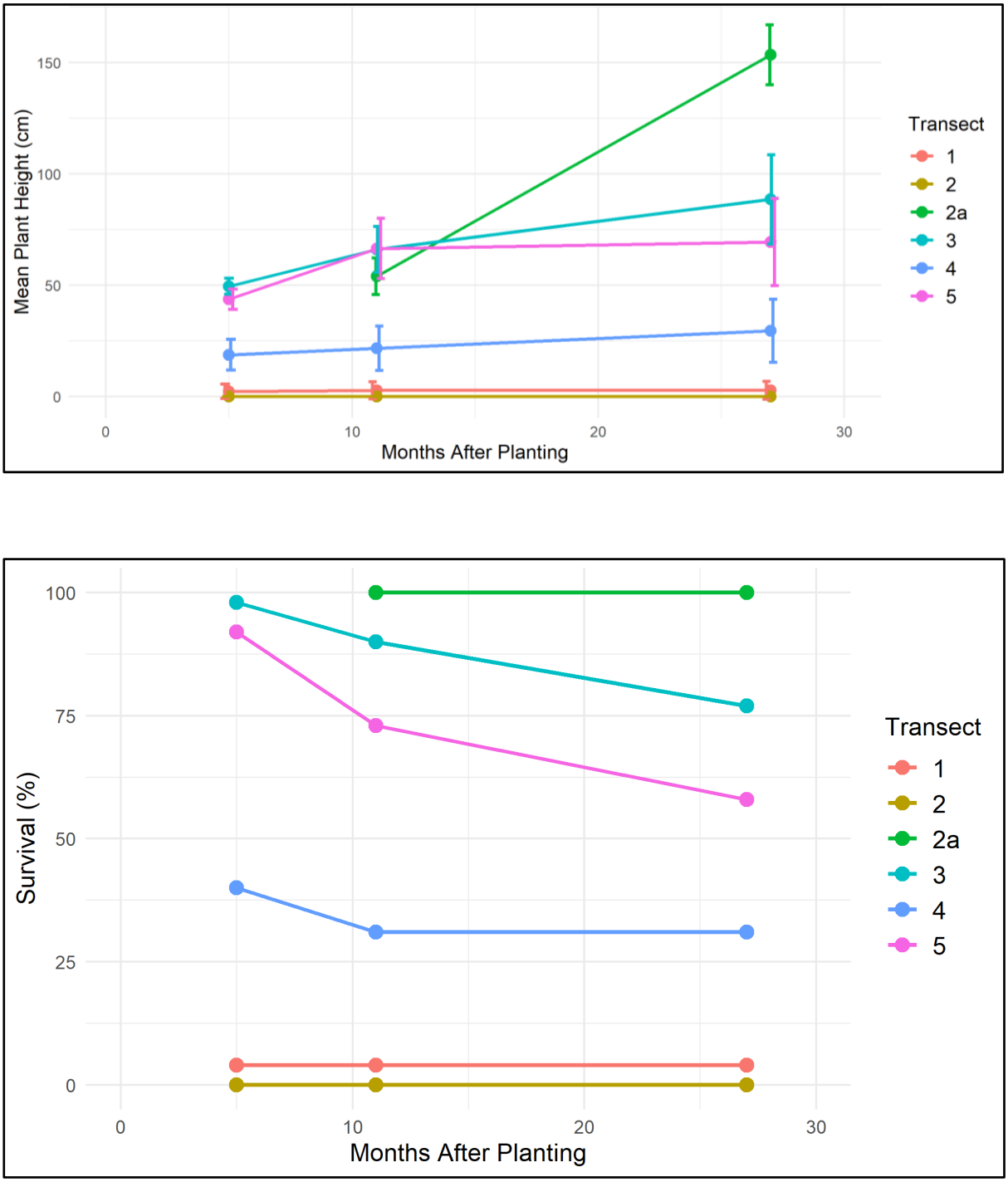


Figure 7: Experiment 1 (T1-T5) and Experiment 2 (T2a) showing mean height (cm) per transect (top graph) and survivorship (lower graph) at different times after introduction. Transects 1-5 were planted with 6 month old seedling tubestock and Transect 2 with planted 12 month old tubestock. The higher survival and growth of 12 month old tubestock is clearly evident.

Experiment 3 – effect of propagation type and fertiliser addition

Experiment 3 examined the effect of propagation type and fertiliser addition on rate of growth and survival. Height data were analysed using three-way ANOVA with three factors and two levels for each factor: propagation mode (seedlings vs cuttings), fertiliser addition (12 month slow release/no fertiliser) and two blocks. As the six plots were arranged in roughly a line, plots 1-3 were placed in Block 1 and plots 4-6 in Block 2. The factor Block was used to indicate any gradients in environmental factors that could have affected the results (e.g. shade and competition). The results of 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 ANOVA table shows that after 20 months fertiliser and block had no significant effect on growth rate (height), while propagation mode had a strong effect. The mean height of seedlings was about 45 cm more than cuttings. The seedlings grew more erect and also leafier than the cuttings.

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

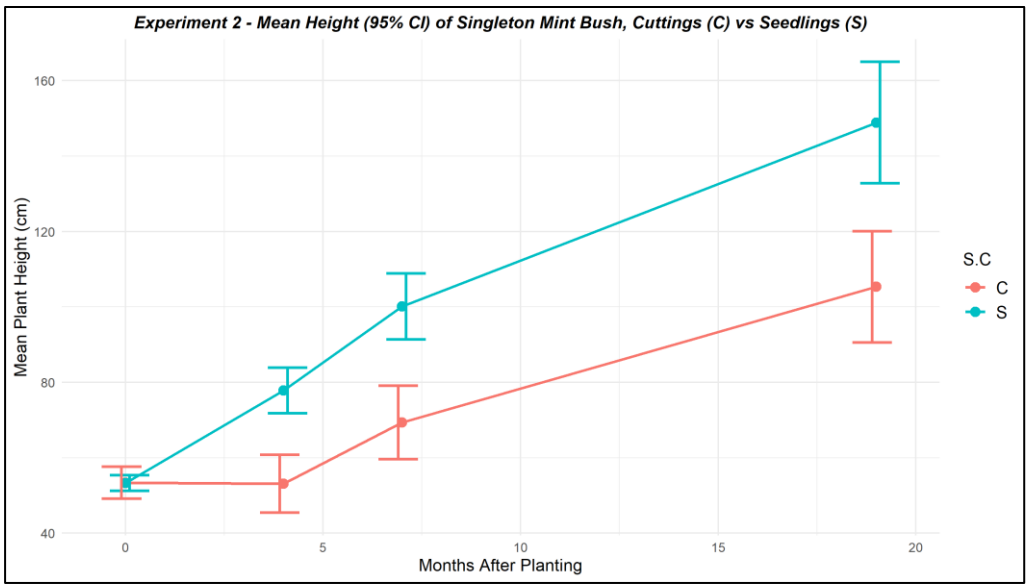


Figure 8: Comparison of the mean height of Singleton Mint Bush propagated from seed (S) and cuttings (C) over 20 months (approx.2 years). A significant difference in mean height is indicated where the 95% confidence limit bars are non-overlapping. After 20 months seedlings were about 45 cm higher than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

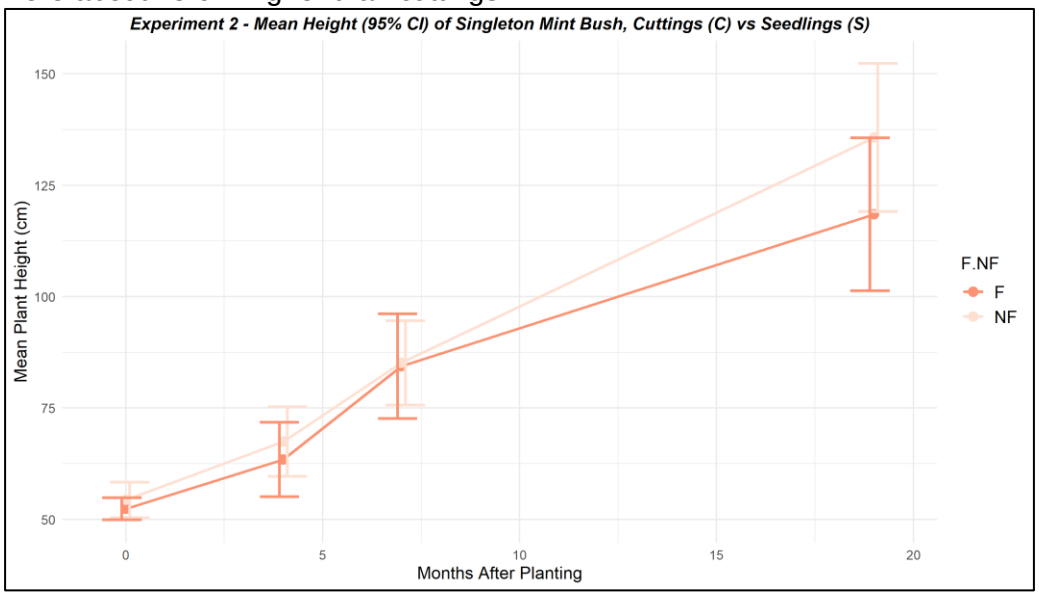


Figure 9: Effect of fertiliser (F) and no fertiliser (NF) treatments on mean height of Singleton Mint Bush over 20 months. No significant difference indicated by overlapping 95% confidence limit bars.

Response to bushfire - translocation area and reference site

In the reference area, all Mint Bush plants were killed by fire and regeneration was only from seed. Fire intensity as indicated by flame scorch was higher than the receival site, but still relatively low, as the forest canopy was unburnt and the fire confined to the understorey. The dead frames of Mint Bush showed all plants were old and senescent. Seedling density of SMB in the reference site was over 100/m^2 in one plot. In the translocation area, not all plants were killed by fire, and seedling density was much lower. Approximately 15% of plants were defoliated then resprouted from stems and branches. Although generally killed by fire, obligate seeders can show some resprouting after low intensity fire when they resprout from stem and branches rather than below ground. Seedlings were only recorded near the eastern margin of the receival site in a few plots in Experiment 1 and 3, not far from the perimeter fence adjacent to Tabbimoble Creek. Mint Bush plants were approximately 3 years old when burnt by the fire. Flowering occurred in years 2 and 3. Overall, regeneration was patchy in the translocated population, but vigorous in the naturally occurring population.

Table 10: Fire response of SMB in plots from the experiment transects (n=23) and the reference area (n=5), in terms of percentage resprouting and number of seedlings per plot.

	Plot	Resprouting	Seedlings
Experiment 1			
Transect 1	A	0	0
	B	0	0
	C	0	0
Transect 2	A	0	0
	B	0	0
	C	0	0
Transect 3	A	0	3
	B	0	7
	C	0	1
Transect 4	A	0	0
	B	0	0
	C	0	0
Transect 5	A	0	0
	B	0	0
	C	0	0
Experiment 2			
Transect 2a	A	0	0
	B	0	0
Experiment 3			
Transect 1	A	0	0
	B	33%	0
	C	42%	3
	D	8%	8
	E	0	3
	F	17%	1
Reference Site			
	A	0	15
	B	0	26
	C	0	61
	D	0	5
	E	0	104

3.5.4 Discussion

At least four lessons for translocation work in general were learnt from the translocation of SMB:-

- Microhabitat is as important as macrohabitat in selecting a translocation receival site.
- Short-term performance may not be a reliable indicator of a self-sustaining population.
- A translocation incorporating designed experiments can greatly improve understanding of how certain factors are influencing species performance.
- Horticultural practices can be as important as ecology in determining translocation outcomes.

Threatened species profiles and flora databases tend to define the habitat of threatened plant species in terms of landscape-scale variables such vegetation type, geology and climate, and have limited information on the finer-scale ecological niche of species, which may be crucial for survival of individuals and persistence of species at a location. Such studies have fallen out of favour somewhat with the increased focus on grouping biota into broad, functional categories for purposes of management. Microhabitat can be defined as a habitat of small or limited extent and which differs in character from some surrounding more extensive macrohabitat. Within an apparently suitable translocation site there may be significant but unnoticed variation in microhabitat such as soil texture, drainage, moisture budget, insolation and interspecific competition, which may render all or part of the site unsuitable for translocating a species. With little knowledge of a species' ecological niche or of local microhabitat variation, selecting microhabitat or planting points within suitable macrohabitat is often a case of 'hit and miss' and 'best informed guess'. Alternatively, blanket planting can be applied across an area and natural selection left to signal where microhabitat is most suitable. The latter approach followed by controlled experiments to clarify factors affecting survival and growth was employed in the translocation of SMB.

Following on from the initial planting, Experiment 1 confirmed that position within the site strongly affected the sensitivity of introduced SMB seedlings to a wilt pathogen present in the local soil. Mortality caused by the pathogen appeared to be linked with soil texture, which varies across the site and may reflect changes in interstitial soil environment (i.e. soil aeration, drainage, biota), which increase or decrease the virulence of the pathogen. It was hypothesised that the local distribution of SMB is controlled by this wilt pathogen (probably the microscopic fungus Phytophthora cinnamomii) and its activity is mediated by soil texture. The pathogen appears to kill young seedlings of SMB in heavier clay textured soil further from Tabbimoble Creek but not soil with higher sand content closer to the creek. Tabbimoble Creek carries sand eroded from nearby sandstone hills and during floods the sand spills out onto the edge of the clay soil floodplain where it is deposited, while silt and clay particles are carried further from the channel.

Experiment 2 showed the sensitivity of SMB to the wilt pathogen varied with tubestock age. The wilt disease completely disappeared when plots where all 6 month old seedlings had died were replanted with 12 month old seedlings. There are two possible explanations for this effect: (i) seedlings may develop disease resistance as they grow older, (ii) changes may occur in the microflora of sterilised soil as the soil medium ages and is recolonised by fungi, bacteria, protozoans etc. A more diverse soil microflora may supress the pathogen responsible for the wilt symptoms. Longer exposure to diverse soil biota may condition the root system of

seedlings to resist pathogenic microorganisms when introduced to the wild. Both the age of seedlings and of the soil medium after sterilisation may be influencing this result. Either way, it suggests that seedlings should be grown for at least a year before introduction to the receival site.

The experiments were able to tease out that the short-term success or failure of plantings was due to soil texture gradient and tubestock age. If 12 month old seedlings had been used in the first planting rather than 6 month old seedlings, a high establishment rate would probably have resulted across the whole site, without us being aware that young seedlings were highly vulnerable to a fungal wilt disease present in the soil, and that the local distribution of the species is probably controlled by the activity of this pathogen, mediated by variation in soil texture.

It can be premature to conclude that successful establishment of propagated plants in the short-term, indicates a successful translocation, or a self-sustaining population, as the introduced plants have not yet demonstrated they can recruit new individuals and an on-going population. The performance of propagated plants can be deceptive as they have bypassed the seed germination and seedling establishment stage in the wild when species are most vulnerable to environmental stress, competition and disease. In species from fire-prone vegetation, such as SMG, the seed germination and seedling establishment stage occurs after bushfire, when seedlings have a greater chance of survival. Although fire probably occurs once every 10 years of more, we were lucky enough to experience a fire in the third year of the translocation project.

Very low seedling density was recorded in the translocated population after fire. Given the results of experiment 1, it is likely that the absence of seedlings after bushfire over most of the site was due to very young seedlings succumbing to the fungal wilt disease. The poor recruitment response after fire tends to support Experiment 1 in suggesting that most of the receival site (within the fenced enclosure) is probably unsuitable for the species. As the plants were 3 years old when burnt, there should have been some seedbank as most flowered in 2018 and 2019. Poor recruitment in the translocation area may have been due to at least three factors: smaller seedbank, lower fire intensity and possible culling of seedlings by the wilt disease. Many SBM plants over 1.5 m high at the time of the fire had no seedlings regenerating around them, suggesting that either seed failed to germinate or the seedlings died. These results show firstly how short-term success is a poor indicator of persistence, and secondly, the value of conducting experimental treatments to discern how introduced plants are responding to microhabitat (soil texture) and horticultural factors (tubestock age).

In summary, the experiments indicated that a translocated population is only like to be self-sustaining (i.e. to recruit another generation from seed) in sandier soil close to Tabbimoble Ck where seedlings are not vulnerable to wilt disease. To complete the three-step introduction process outlined above (p. 30), the most appropriate place to introduce remaining Mint Bush tubestock would be between the creek and the receival site fence. This area was initially excluded as scattered SMB plants were present, but they are interspersed with large patches of suitable, unoccupied soil where plants could be introduced. In this microhabitat plants are more likely to grow to maturity and establish a viable soil seedbank, assuming the next fire will not be for another 10 years or more.

3.6 Weeping Paperbark (*Melaleuca irbyana*)

3.6.1 Translocation Method

Seed capsules were collected from a cross-section of trees in the New Italy donor population in August 2016. After germination, seedlings were grown in native tubes in a standard, pine-bark based, sterilised soil mix for natives and dilute Seasol liquid fertiliser. 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 three 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 area in grassy, open woodland dominated by Forest Red Gum, Swamp Oak, Paperbark and Swamp Box, two planting areas were marked out in open sections where trees had been cleared. These were fenced to exclude domestic and native grazing animals. Both areas are on a floodplain with heavy clay soil, typical of Weeping Paperbark habitat. The areas were open with few trees allowing for better tubestock establishment, although sapling regrowth has need control during the establishment period.

Tubestock were planted on the offset land south of Tabbimoble Ck in March/17 and north in 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. More tubestock were planted in April 2018 in the northern part of the Tabbimoble Triangle.

3.6.2 Survival and Growth

Mean plant height tripled between 2017 and 2019. Addition of 12 months slow release fertiliser resulted in a doubling of mean plant height, to 211.0 cm in 2019. Fertiliser was the standard treatment applied to plants following the first results of the fertiliser trial.

Mean height of seedlings (cm) over three years:

	no Fert	Fert
Mar-2017	31.4	42.3
Apr-2018	68.9	109.3
Jul-2019	108.9	211.0

Bush fire Nov 2019

The 3 receival sites (Tabbimoble Ck offset land – Area 1 and 2; Tabbimoble Triangle) were burnt in the Nov 2019. At Tabbimoble Triangle the fire was low intensity and at the offset land, medium to high intensity. The translocated population on the offset land was approximately 4 years old and most plants 1.5 – 2 m high (fertiliser added). No flowering or seed set had occurred. All stems were killed by the fire, but the majority of plants were still alive and reshot a dense coppice of new stems from around the stem base. In 9 months the translocated plants were half slightly less than pre-fire height.

Aug-2020	Mean Pre-fire Height (m) dead frames	Mean Post-fire Height (m)
Plot 1	2.3	1.0
Plot 2	2.5	1.1

In Aug 2020, fire and natural thinning had reduced the population to approx..900, still within target.

3.7 Tall Knotweed (*Persicaria elatior*)

3.7.1 Background

All Tall Knotweed were translocated from the same, swampy area next to the Maclean south turnoff to Yaegl Nature Reserve, 0.5 km to the north, to sites on the north western boundary of the reserve next to the highway: Yaegl South in 2015 and Yaegl North in 2016 -17. The Yaegl South translocation was carried out during Early Works and the results are described in Landmark Ecological Services 2016 and 2017. Results of the second round of translocation are reported in Ecos Environmental 2017, 2018 and 2019, and this report (2020). In effect there were at least four translocations, one (or two) implemented in 2015 and three in 2016-7.

3.7.2 Early Works – Yaegl South (2015)

Plants were translocated to the Yaegl South site in Sept and Nov/2015. The habitat consisted of paperbark swamp forest with a sparse ground cover of grass and sedge. Tall Knotweed plants were relocated by direct transplanting. Fifty five plants were planted at separate, labelled points about 10-20 metres inside the edge of the swamp forest. From the stem thickness of dead plants observed in Aug/2016 they were about one metre high when transplanted and were pruned at introduction. Some flowered and seeded at the planting points.

In Autumn 2016 three were alive and seedlings were observed at the tagged points in Spring 2016, but due to the dry spring-early summer in 2016 (Fig 4) the seedlings died off. The relatively high density of paperbark (*Melaleuca quinquenervia*) and sparse herbaceous ground layer may not have been conducive to Tall Knotweed establishment, but performance of this species is difficult to predict. No Tall Knotweed plants were recorded at the Yaegl South in April 2018, approx. three years after translocation.

In Aug/2020, one patch of vigorous Tall Knotweed plants about 1.5 m wide was observed about 20 m north of the tagged points, within the Paperbark forest. The site was wet and boggy, but otherwise there was nothing in particular to suggest why this small patch of plants was thriving at this particular point, or where the seed had come from.

3.7.3 Main Construction Phase – Yaegl North (plants salvaged Aug 2016 – 17)

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 att nursery until mature, introduced (Feb/17)	300 tubestock, mature plants in flower/seed

A new receival site was established at Yaegl North due to apparent poor establishment at the Yaegl South site. This is 150-250 metre north of the first site. Three introductions were carried out in 2016-17. The site was more open and on the edge of paperbark forest. Hydrological conditions (e.g. duration of flooding) were probably still similar to the Yaegl South site.

Reduction of ground layer vegetation was carried out by hand weeding in 2018 and herbicide spraying in 2019 and 2020 to stimulate seedling recruitment. This treatment was limited to the vicinity of plots, being careful avoid any Tall Knotweed plants.

1. In the first translocation (August 2016), seven old Tall Knotweed plants (up to 3.5 m long and prostrate) were transplanted and 20 plots were seeded with soil seedbank (mud) collected from around the old plants,. The old plants were planted in shallow water. Several bins of muddy substrate were collected assuming it would contain Tall Knotweed seed. The mud was spread in 1m x 1m cleared plots on the margin of paperbark forest where paperbark trees were widely spaced and the ground layer consisted of grasses and sedges. 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*). Plots were also placed in the Couch Grass zone (higher – no standing water) and the Water Couch zone (lower – shallow standing water) and spread out along about 150 metres of swamp edge. The plots were stacked and tagged for monitoring.

2. In November 2016 more Tall Knotweed plants were found during pre-clearing surveys and translocated to the receival site. These had grown from seed and were 0.5-0.7 m tall. The plants were dug up and transported to the receival site 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.

3. While carrying out the second translocation in Nov/16, several hundred recently germinated Tall Knotweed seedlings were found. These were salvaged and grown on in pots at the nursery. Tall Knotweed is fast growing and we had to prune them twice at the nursery to keep them at a manageable height, about a metre high. Planting was delayed until February/17 due to hot, dry conditions. Three hundred tubestock were planted in fifteen 4 m x 4 m plots, 20 plants per plot, in mid-February in anticipation of rain, which came as a flood one week later. All plants were flowering and seeding when planted.

3.7.4 Results – Yaegl North (Aug 2016 to Aug 2020)

Translocation 1- salvaged 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 in spring-early summer 2016. Seedling recruitment from the mud seedbank plots was sparse. It was recorded 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 in 2016 during the dry spring- early summer period. Some persisted in slightly damper microsites where they grew to maturity and set seed. A few plants survived to winter 2017 (like the old plants salvaged in August 2016).

In March 2018, 29% of the 27 seedbank plots had new Tall Knotweed plants.

In July 2019, 19% of plots had seedlings, and one or two had live or recently dead medium sized plants.

In August 2020, 51% of plots had new plants (total 25), height 20-60 cm, the majority with flowers.

Translocation 2 – salvaged young plants (0.5-0.7m high)

Most of these plant translocated in in Nov/16 survived and reached reproductive maturity. The site dried out soon after transplanting and additional watering was carried out to prevent die-off. After flooding rain in late Feb-March/17 they grew in standing water a metre deep and produced stems and roots underwater with little attachment to substrate. They flowered and seeded. A few plants were still alive at the end of June 2017.

In March 2018, a total new 23 plants were present at 8 of the 27 labelled plant points.

In July 2019, there were no seedlings or evidence of dead plants. The surface soil was dry.

In August/ 2020, new plants were present at four points (total 9 plants)

Translocation 3 - field seedling grown-on in nursery then introduced

The 15 plots for 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 trees, and open unshaded conditions might favour Tall Knotweed.

A week after planting the tubestock were inundated by a major flood at the end of February 2017. More than half the 1 m 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. In June 2017, 87% of plots had at least three live plants and where the water had receded small numbers of recently germinated seedlings were recorded. The seedlings were 5-10cm high and being grazed by kangaroos.

By March 2018, 87% of the plots had mature Tall Knotweed plants. Several plots had a high density and 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, despites loses in the flood.

In July 2019, 33% of plots had TK plants (total 33), most recently dead).

In Aug 2020, 27% of plots had TK plants (total 21), 30-60 cm high, flowering.

Population Ecology

Monitoring showed that Tall Knotweed is a rapidly growing, annual plant. In the nursery, it grew from seed to well over a metre high and start flowering in 2-3 months. Similar fast growth can occur in the field where conditions are damp and fertile. Tall Knotweed seed germinated in the field on damp substrate. There was no evidence it germinates under water even though some mature plants grew like an aquatic plant in water 0.5-1 m deep. Seed germinated as flood water receded, leaving damp ground. Observations indicated that seed can germinate any month of the year. Tall Knotweed seed has a hard, shiny, black seed indicating it can lie dormant when conditions are unsuitable. Intermittent appearance also indicates a seed dormancy mechanism, even though other observations indicated seed can germinate soon after being shed from the parent plant.

Most seed appears to germinate in autumn or winter. Survival through spring and early summer (usually the dry season) depends on the substrate remaining damp and not drying out completely. Sites that in the wet season appear to be suitable for Tall Knotweed may dry out in spring-summer so that seedlings die. However, more seedlings may germinate later in summer. Observations showed that Tall Knotweed grows in open habitat without trees and inside quite dense swamp forest. Availability of seed and prolonged soil moisture appear to be essential for recruitment and growth to maturity. Factors that reduce biomass in swampy or marshy ground layer vegetation may favour Tall Knotweed, including flooding, grazing, slashing and carefully targeted herbicide spraying.

The results of the four translocations showed it was not possible to maintain large numbers of Tall Knotweed at the translocation receival sites, similar to the initial numbers introduced, for more than a year. The translocations were able to establish a low density population, with annual recruitment taking place for three successive years. On-going recruitment from year to year in this annual species appears to depend on soil conditions not becoming too dry during the spring-early summer period, the dry season. Tall Knotweed appears to be favoured by average or above average rainfall at this time of year. If rainfall falls below average, the swamp dries out and seedlings have high mortality.

3.8 Four-tailed Grevillea (*Grevillea quadricauda*)

3.8.1 Translocation Method

Grevillea quadricauda is a shrub with a single-stemmed growth form typical of plants with an obligate seeder life cycle. Adult specimens of seeder species are not suited to direct transplanting, as they do not respond well to root disturbance and pruning, unlike resprouter species which can generally recover from transplanting and damage to their stem and/or root systems. (This is because resprouter species have dormant buds on stems, and roots, which enable regeneration after damage caused by natural disturbances such as fire and storm.)

As adult seeder species often transplant poorly, salvage was limited to small, juvenile plants on the highway footprint <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 about six months before planting out.

An attempt was made to propagate more plants using the soil seedbank method applied to Singleton Mint Bush, and also by seed collection and propagation. Very little seed was found in the short timeframe 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 the parent plant so that little seed is present under bushes, unlike Singleton Mint Bush.

3.8.2 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 ‘started to flower in 2017 and have had flowers and/seed pods at every monitoring to Aug 2020.

In the last 12 months to Aug 2020, mean height increased slightly to 163.7 cm and there were no mortalities. The shrubs were flowering and seeding when monitored in Aug 2020.

Survivorship and mean height of translocated *Grevillea quadricauda*:

Monitoring Date	Surviv %	Mean Height (cm)
Aug-20	93.3	163.7
Jul-19	93.3	155.9
Mar-18	93.3	115.8
Introduced Mar-17	100	60.8

3.9 Stinking Cryptocarya (*Cryptocarya foetida*)

3.9.1 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 in Section 10 adjacent to Coolgardie Rd. Four trees were too large to transplant given constraints with organising machinery with the contractor.

Two receival sites were used for this species. All the salvaged plants were introduced to the Lumleys Lane site nominated in the Strategy (referred to as BOS 22). Habitat at this site consisted hillside rainforest regrowth dominated by broad-leaved privet and camphor laurel. Most of the hillside forest was very rocky. An area lower down on the edge of forest in pasture next to a dam (for watering) was selected as the receival site. The soil type consisted of a heavy clay, yellow podzol with minimal topsoil, formed on metasediment.

Sapling sized individuals were translocated by direct transplanting carried out by hand. The 24 saplings were dug out with an intact soil-root ball and pruned to reduce evapotranspiration stress. Conditions at the receival site were exposed with few existing trees. After transplanting, the saplings were mulched and watered regularly to maintain moist soil conditions. Organic pelleted fertiliser and Seasol were applied to stimulate growth.

The second receival site was located near Coolgardie Rd adjacent to the area where most of the saplings had come from. Propagated plants were introduced to this site. This was because of the high mortality amongst the salvaged saplings at the first site, and the soil was better as the Coolgardie site, which included some alluvium along a section of Randles Ck. The general habitat more closely matched the donor site on the highway footprint.

Twenty eight (28) *C. foetida* propagated from seed were introduced to the site in Feb/18. Additional watering was carried out during dry periods. The plants were kept mulched and organic fertiliser applied.

3.9.2 Results

At the Lumleys Lane receival site, transplanted saplings started to reshoot after about 4 weeks. Epicormic shoots grew from the main stem and pruned branches. By January 2017, ~6 months after transplanting, 62.5% (15/24) of the saplings had reshot. Two more had reshot then died. Regeneration was slow but progressing satisfactorily until two extremely hot days in Feb/2017 (hottest on record for most of the Far North Coast), which caused leaf scorching and die-off in half the transplants.

By the end of the first year, the survival rate was 26.9%. Two individuals that died back during the heat wave reshot. After 3 years (July 2019) the survival rate was 25% and no more moralities have occurred since. Mean height increased from 99.7 cm in 2018 to 176.5 cm in 2020.

At the second receival site (Coolgardie Rd), the survival rate of 28 seedlings 18 months after planting out (July 2019), was 89.3%. Mean height was 42.9 cm. A year later (Aug 2020), survival rate was unchanged and mean height increased to 66.9 cm. This was despite drought conditions in 2019.

Habitat restoration has been carried at both sites, including spraying of herbaceous weeds, injecting exotic trees and planting of local rainforest species.

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

3.10.1 Translocation Method

Three saplings were transplanted to the Lumleys Lane 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 at the Coolgardie Rd receival site in in Feb/18.

More seed was collected from Section 10 and propagated for the site near the Maclean interchange (Section 4) where one tree inside the project boundary was accidently cleared. This work is being done in accordance with the Green-leaved Rose Walnut Rehabilitation Plan which is reported on separately.

3.10.2 Results

Only one of the three transplanted saplings reshot. This height of this individual increased from 147 cm to 194 cm in the last 12 months.

No losses of 19 seed propagated plants occurred in the last 12 months to Aug 2020. Mean height increased from 42.9 cm to 66.8 cm (Table 8), despite the 2019 drought.

3.11 Red Lilly Pilly (*Syzygium hodgkinsoniae*)

3.11.1 Translocation Method

A total of 42 Red Lilly Pilly were introduced to the rainforest receival sites at Lumleys Lane and Coolgardie Road, including six juveniles salvaged from under a large tree located on the clearing footprint north of Lumleys Lane in Oct/2016. About 50 Red Lilly Pilly were propagated from seed collected in August 2016. Twelve were planted out at the Lumleys Lane receival site on 1/6/2017 and the remainder grown-on for another six months. Thirty were introduced to the Coolgardie Rd receival site in December 2017, including the small potted transplants.

The plants received fairly intensive care, including additional watering during dry periods, mulching, shielding from direct sunlight and fertiliser. Chicken wire tree guards (1.2 m high) were installed to prevent grazing by wallabies.

3.11.2 Results

Red Lily Pilly performed better at the Lumley's Lane receival site, where the soil is poorer and the site more exposed. Plants received more mulch at Lumleys Lane, there is less competition from existing trees and plants have been in the ground for 6 months longer.

Overall, growth in this species was very sluggish, which is typical of this species. Growth was impeded by a red witches broom growth at the tips and leaf axils. In terms of height, growth rate was similar to *C. foetida* and *E. muelleri ssp bracteata*, but very few leaves were produced. New healthy leaves were sometimes produced from the red tip deformity. Picking off the red tip growth may also remove the growth buds, causing stunting. When young trees reach a few metres the red tip growth disappears. The red witch's broom could be produced by a symbiotic virus and is actually protective, shielding buds from grazing insects

Lumleys Lane receival site (Area 1) – 12 plants introduced

Date	Mean Height (cm)	%Survival
Aug-20	81.3	92%
Jul-19	59.5	92%
Jun-18	58.9	92%
Mar-18	58.4	100%
Planted out June-17		

Coolgardie Road receival site (Area 2) – 30 plants introduced

Date	Mean Height (cm)	%Survival
Aug-20	64.3	33%
Jul-19	49.2	47%
Jun-18	47.3	100%
Planted out Dec-17		

3.12 White Laceflower (*Archidendron hendersonii*)

3.12.1 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. All plants were dug out manually as described for *C. foetida.*

3.12.2 Results

Lumleys Lane receival site - The two transplants survived and are in good condition. Mean height after four years (Aug 2020) was 280 cm.

Coolgardie Rd receival site – The six transplants survived and are in good condition. Mean height after four years (Aug 2020) was 218 cm.

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

	Mean Height (cm) Lumleys Lane- Area 1	Mean Height (cm) Coolgardie Rd- Area 2
Aug-20	279.5	217.7
Jul-19	208.5	152.7
Jun-18	134	92.5
Jun-17	72	In nursery
transplanted Oct-16		

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

3.13.1 Translocation Method

Propagation of Rough-shelled Bush Nut from locally collected seed was used to translocate this species. Seeds were collected on the Blackwall Range adjacent to the highway footprint and from a group of six trees growing in a paddock at the end of Whytes Rd, Pimlico. These trees have the same unusual (unique?) densely coppiced growth form similar to the old trees cleared from the footprint at Coolgardie Road, therefore likely to preserve the same genotype. Approximately 50 seeds have been collected and eight individuals propagated and planted out.

3.13.2 Results

Of the first batch of seedlings planted in June 2017, mean height in Aug 2020 has increased to 124. 3 cm and a survival rate of 80%.

Three more seedlings propagated from locally collected seed have been plant, taking the net population to 7.

Rainforest Translocation Area 2 (Coolgardie Rd)

Mean height of first planting of propagated plants:

Date	Mean Height (cm)
Aug-20	124.3
Jul-19	55.2
Jun-18	31.2
Planted out June-17	

3.14 Square-fruited Ironbark (*Eucalyptus tetrapleura*)

3.14.1 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.

900 tubestock were propagated from seed collected at Glenugie in 2014 and stored in a fridge for 5 years. The tubestock were planted in Oct 2020.

3.14.2 Results

The tubestock introduced in 2017 have survived well and most are now over a metre high.

3.15 Hairy Melichrus (*Melichrus hirsutus*)

The two plants transplanted from the footprint in 2016 have survived and flowered each year from 2017 to 2020.

3.16 Hairy Joint Grass (*Arthraxon hispidus*)

3.16.1 Translocation Method

There were two rounds of salvage of Hairy Joint Grass (HJG) was the construction footprint : 2015 - Sections 1-2 & EWSSTA's, and 2016 - Sections 3-11 in 2016. Translocations were carried out by transplanting sods containing live plants or thought to contain seed.

Hairy Joint Grass was translocated on Sections 1-2 & EWSSTA at Kangaroo Trail on Section 1 in Sept/15 and at Trustrums Hill in July-Aug/15. The Trustrum's Hill receival site had two planting areas – Site 1, a low-lying area with 3 plots and Site 2 on higher ground with eight plots (Table 8)

On Sections 3-11, populations were translocated from Section 10 between Coolgardie Rd and Lumleys Lane, and from Section 3, Mitchell Rd. Plants on Section 10 were transplanted to a receival site at Lumleys Lane and those on Section 3 to the adjoining road reserve. Fifty trays of plants were salvaged from Section 10 and 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 immature seedlings.

HJG has been successfully translocated on other road projects including the Ballina Bypass and Tintenbar to Ewingsdale. 'With an understanding of the species' habitat requirements, life 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, and a suitable receival site, the species is relatively easy to translocate.

3.16.2 Results

<u>Sections 1-2 & EWSSTA</u>

The populations translocated on Sections 1-2 & EWSSTA appear to have declined markedly or died out, due to lack of biomass reduction. Landmark (2017) 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 in the previous two years (after translocation in Sept/15) is unclear.

Slabs were salvaged at Trustrums Hill (Woodburn south) in 2015 in July-Aug when the species is dormant or present as very small seedlings. A total of 25 slabs were planted in 3 plots at Site 1 and 8 plots at Site 2. The slabs transplanted had no plants but were thought to contain

seed. Based on research at T2E, HJG seed should have already germinated in July-August and tiny seedlings been present. Although minute, HJG seedlings can be distinguished by the relatively wide first leaf which is much broader than other grasses.

The 2017 monitoring report by Landmark stated that at Trustrums Hill (not a hill, a flat) 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 became 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. No evidence of HJG plants were observed at the plots at Trustrums Hill in Aug 2020.

Overall, the translocation of HJG at Trustrums Hill appears to have been unsuccessful in maintaining a population in the receival site plots, 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.

Sections 3-11

Plants at both receival site on Sections 3-11 grew to maturity and seeded each year from 2016 to 2019. Biomass reduction was carried out in late winter-early spring each year to create low, open conditions favourable for HJG seed germination. HJG is an annual grass so a new cohort of seedlings must germinate each year for a population to persist at a location. Studies indicate that at least a small proportion of seed produced each year has a prolonged dormancy mechanism (Ecos Environmental 2016).

3.17 Lindernia (*Lindernia alsinoides*)

3.17.1 Translocation Methods

After monitoring four receival sites where translocation of this species was attempted, it appears that Lindernia is a perennial, rhizomatous, semi-aquatic herb and requires specific habitat consisting of seepage areas (springs) and drainage lines in sandstone terrain, usually on lower hillslopes. The seepage zones are more-or-less permanent and often have peat soil overlying sand. At Mitchell Rd (Section 3-11) the peat layer was 20-30 cm deep. Natural vegetation at seepage sites consisted of sedges and herbs of marshy ground, and sphagnum moss, under an open woodland canopy of trees including Swamp Mahogany (*Eucalyptus robusta*) and *Melaleuca spp*.

Three receival sites were used for Lindernia on Sections 1-2 & EWSSTA. Translocation methods included (i) transplanting sods/clumps of plants, (ii) removal of soil slabs thought to contain seed and (iii) introduction of plants propagated from cuttings. All methods were unsuccessful which appears to be due to the absence of habitat (as described above) at the receival sites, and 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 and none were present in Aug 2020. 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 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

Transplanting of Lindernia on Sections 3-11 was carried out after an unexpected find. Thirty spade sized sods (20-30 cm thick) of Lindernia plants growing in black peat were transplanted in Dec 2016. The receival site is located on the opposite side of the highway to the donor site, on the same drainage line downstream.

3.17.2 Results

After transplanting at Mitchell Rd, run-off from earthworks deposited thick iron leachate at the receival site in autumn 2017 blanketing the plants at the receival site. In July 2019, water quality was much improved, and it seemed possible some plants may regenerate from seed or runners in the transplanted sods. In Aug 2020, iron leachate deposit was present again, so it is unlikely any plants will reappear. A few plants persist at the donor site on the upstream side of the highway where the drainage line crosses the project boundary fence.

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 Lindernia was not observed.

Halfway Ck Crossing – 12 out of 500 propagated plants survived after one year (June/18). Six plants surviving July 2019. No plants observed Aug 2020.

Kangaroo Trail – one plant out of 428 propagated plants survived after two years to July 2019. No plants observed Aug 2020.

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.

All in situ Linderna monitoring sites for W2B, including control sites had considerable loss of plants during the 2018-19 drought, and have been recorded as absent at all sites, suggesting the very dry conditions did not favour this species (C. Thomson pers. comm.). However, the drainage line at the Lindernia translocation site remained dam to boggy during this period, although without surface water, and the few remaining in situ plants were still present on the upstream side of the highway.

3.18 Rotala (*Rotala tripartita*)

3.18.1 Translocation Method

Approximately 10 plants growing in an elongated, man-made drainage depression on the eastern side of the highway were salvaged in Sept/17 and grown-on in pots at Ecos Environmental's nursery before planting out in the following wet season (early 2018). Habitat at the donor site consisted of a linear, marshy depression in a cleared paddock grazed by cattle which held shallow standing water in the rainy season and dried out during spring.

No matching wetland habitat could be found at available sites, so habitat was engineered at a site on the Tabbimoble Creek floodplain about 0.5 km to the south of the donor site. Two ponds were dug with an excavator on a minor natural drainage line in open woodland on heavy clay soil, that 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 (ie. with surface runners) 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 pots, by burying the pots, so they could be dug out and position adjusted. Hydrological conditions can be critical wetland plants that grow in shallow water or on the edge of wetlands.

Two adjustments to pot position were made as conditions dried out but runners had already been produced so some of the plant was left behind when a pot was moved. Pots were moved lower 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.

3.18.2 Results

Survivorship was 90% after approximately 6 months (July/18). Short stolons grew up to 10cm from pots taking root in the damp substrate. After 18 months to July 2019, survivorship fell to 37.8% or 17 plants (both ponds combined).

After 30 months (Aug 2020), all the plants in pots had died at both ponds, but the runners that escaped their pots in lower Pond 1 were found to be still alive and fifteen discrete clumps representing the original pot positions were counted, equivalent to a survival rate of 30%.

The Rotala plants still present were relatively high up on the edge of the pond, suggesting that this species cannot survive submersion for any length of time (as would have occurred to the pots placed lower down in the pond basin) and it can survive in dry ground, probably as a dormant runner, then reshoot again with a return to wet conditions.

No seedling recruitment was observed.

3.19 *Lepidosperma* sp. Coaldale

3.19.1 Translocation Method

Lepidosperma sp. Coaldale is a sedge about 1 m high with upright, cylindrical leaves growing from a short, woody rhizome. Habitat at the donor site (Wells Crossing) consisted of open woodland dominated by Scribbly Gum (*E. racemosa*) with a dense shrub understorey of *Leptospermum, Banksia, Xanthorrhoea* and other shrubs, 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 sandstone geology and a lower slope position, but there are differences in habitat including species composition, soil

depth and soil hydrology. The Mahogany Drive site 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 were replaced.

3.19.2 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%. No plants were found in Aug/2020. Much of the area where plots were located was covered in dense ground fern (*Calochlaena dubia*).

3.20 Richmond Birdwing Vine (*Aristolochia pravevenosa*)

This vine was propagated from hardwood stem cuttings collected from the clearing footprint on Randles Creek in Section 10 in Oct/16. Eleven plants were propagated and introduced to the Coolgardie Rd rainforest species translocation area in Oct/17

Survivorship to Aug/2020 was 91%. Mean height 88.6 cm and some of the plants were climbing higher into trees.

3.21 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 to Aug/2020 was 40%. Very little growth had occurred.

4.0 Assessment of Translocation Outcomes

4.1 Performance Criteria

Translocation implemented in a developmental context aims to minimise loss or impact to local threatened species populations by carrying out salvage transplanting, propagation and introduction of additional plants to maintain local population numbers, and maintaining habitat conditions adjacent to the development that are conducive to a self-sustaining population of the subject species.

Towards this general aim, several performance criteria were set out in the Translocation Strategy (RMS 2015b, p. 46), as follows:-

Short Term Criteria (to 5 years)
The translocation of each species:
· at least 70% of the transplants and enhancement introductions are surviving after the first year and 60% after five years (and arrangements for replacement from backup stock are underway in case of failure to meet this target);
· germination from freshly shed or soil-stored seed of Hairy joint-grass and Tall knotweed occurs following suitable seasonal rainfall
· flowering and seed production (or spore production) occurs in transplanted individuals (if appropriate to species timeframe and maturity of transplanted material)
· the translocated populations display similar growth development and vigour to naturally occurring populations
· regeneration occurs in transplanted individuals (if appropriate to species timeframe and maturity of transplanted material)
Habitat and threat management:
· good quality habitat restored in and surrounding the receival site;
· maintenance carried out at suitable intervals; and
· threatening processes including weed invasion controlled or eradicated.
Long Term Criteria (decades)
The timeframe of the current project will not permit the development of slow-growing species i.e. Green-leaved rose walnut to be followed to reproductive maturity. Annual plants however will complete many life cycles in timeframes of a decade or more. Details of long-term criteria are provided for information and adoption where feasible.
· translocated individuals survive to reproductive maturity;
· new seedlings or vegetative offspring are established;
· the number of individuals in the population is sustained or increased by natural recruitment;
· adequate levels of genetic fitness are maintained through generations
· reproduction including the production of flowers and fruit (or spores) and seed viability (spore viability) is consistent with levels in naturally occurring plants;
· natural habitat conditions are restored or maintained at the receival site.

Generally, the short-term criteria that would apply during the time-frame of the translocation monitoring allow for a decrease of 30% of translocated/introduced plants after one year and 40% after five years (RMS 2015 b, p. 46).

4.2 Achieving Aims and Objectives

As well as the Performance Criteria listed above, the Strategy presents a method for assessing outcomes in terms of whether Aims and Objectives defined in Strategy were attained or satisfied (RMS 2015b, p.25 Table 6) .

For example, there is a general aim of no net loss of threatened flora populations as a result of the development, meaning that populations remain functional, self-sustaining and viable at least in the short to medium.

An assessment of how well the translocation project has so far met the Aims and Objectives, according to the method set out in the Strategy is presented in Tables 12 and 13 below.

4.3 Translocation Outcomes

As Tables 12 & 13 are very long, an attempt was made present an overall assessment of outcomes in a more succinct format, which is presented in Tables 10 and 11. Each results of each translocation (i.e. a species at a site) was ranked as Good, Fair, Poor or Failed, based on target attainment and likelihood the translocated population will persist. For a Good ranking the number of plants must be above the 30-40% threshold for net population loss set in the Strategy. To persist the population would need to survive and remain ecological function – ie growing or producing seed – over the short to medium terms.

The results on Sections 3-11 after 3- 4 years met most of the translocation aims, objectives and performance criteria were overall results were assessed as Good for 16 translocations, Fair for 7 and Failed for 2. The failures were Lindernia and one of the orchid translocation sites (Table 10).

The results for Sections 1-2 & EWSSTA failed to meet project aims, objectives and performance criteria for most species. Failed translocations included Moonee Quassia, Lindernia, Square-stemmed Spike Rush, Hairy Joint Grass, Tall Knotweed and Lepidosperma sp. (Table 11). Little was learnt about the life cycle of Lindernia, but it is possible this species is annual and a seedbank may have formed and then the plants died off. However, no plants appeared in subsequent years.

The short-fall in Square-fruited Ironbark has been addressed with the introduction of another 900 tubestock to the Sunnyside Rd offset site in Sept 2020. (These plants were propagated from seed collected in 2010 on the Glenugie Section of the highway upgrade and stored in a fridge at about 6° C. The seed remained viable after 10 years, despite numerous short periods when the fridge was switched off.)

In addition to the translocation efforts for Square-stemmed Spike Rush, TfNSW has agreed to contribute funds to a DPIE (Save Our Species) proposal for the collection of Seed (and vegetative material, if necessary) from multiple populations within two active SoS sites located in the Clarence Valley. Consultation has been undertaken with NPWS who have provided written agreement to the translocation site within Bongil Bongil NP.

Table 10: Summary of translocation outcomes on Sections 3-11, after four years, or three years (unexpected finds). Overall establshment was ranked at Good, Fair, Poor and Failed in terms of target attainment and likelihood the translocated population will persist.

Species	Receival Site	Method	Target	Number surviving Aug 2020	Establishment: Good, Fair Poor, Failed	Comment
Yellow-flowered King of the Fairies	Bundjalung Nat Pk (Evans Hd)	Transplanted	(18) 11	10	**Good**	
Unexpected finds	Lumleys Lane Sth	Transplanted	35	2	**Failed**	Plants taken
Slender Screw Fern	Bundjalung Nat Pk Area 1 (Mororo Rd)	Transplanted	6350 fronds 127 trays 0.37 ha	survivorship 0 - 25%; mean crown-cover 1% - 25% per line/patches (with plants)	**Fair**	Bushfire in Nov 2019 caused substantial population contraction. Having survived fire and vagaries of climate, remaining plants have a good chance of persisting.
Unexpected finds	Bundjalung Nat Pk Area 2 (Mororo Rd)	Transplanted	4350 fronds 174 trays 0.3 ha	Survivorship 12 - 75%; mean crown-cover 1% - 20%	**Fair**	Bushfire in Nov 2019 caused population contraction. Remaining plants likely to persist.
Singleton Mint Bush	Tabbimoble Triangle	Soil seedbank	609 plants 0.424 ha	300	**Fair**	Bushfire in Nov 2019 caused population contraction. Low seedling recruitment, also resprouting
Weeping Paperbark	Offset property Tabbimoble Ck.	Seed	1700 2.761 ha	~900	**Good**	Population reduced by Nov 2019 fire but density still adequate to establish a functional population, plants healthy
	Tabbimoble Triangle					
Tall Knotweed (incl. unexpected finds)	Yaegl Nat. Res. (centre-north)	Transplanted & Soil Seedbank	(20) 350 (most seedlings)		**Fair**	Numbers below target but recruitment occurring each year, plants maturing and setting seed.
Four-tailed Grevillea	Quarry Rd (Sec.3)	Seed	(3) 15	14	**Good**	Plants vigorous, setting seed.
Stinking Cryptocarya	Lumley's Lane	Transplanted	(41) 24	7	**Fair**	Below target but survivors healthy.
	Coolgardie Rd	Seed		25	**Good**	High survival, slow but steady growth.
Rusty Green-leaved Rose Walnut	Lumley's Lane	Transplanted	(3) 6	1	**Fair**	Below target but survivors healthy.
	Coolgardie Rd	Seed		19	**Good**	High survival, slow but steady growth.

Species	Receival Site	Method	Target	Number surviving Aug 2020	Establishment: Good, Fair Poor, Failed	Comment
Red Lilly Pilly	Lumley's Lane	Seed	6	12	**Good**	High survival, slow but steady growth.
	Coolgardie Rd	Seed & Transplanted		10	**Fair**	Low survival, slow but steady growth.
White Laceflower	Lumley's Lane	Transplanted	(1) 8	2	**Good**	High survival, steady growth.
	Coolgardie Rd	Transplanted		6	**Good**	High survival, steady growth.
Rough-shelled Bush Nut	Coolgardie Rd	Seed	10	7	**Good**	High survival, steady growth.
Hairy Joint Grass - Section 10	Lumley's Lane	Transplanted	348 (1.3ha)	41 plots; survivorship 100%; no.~500	**Good**	Biomass reduction each year essential for persistence
Hairy Joint Grass - Section 3	Mitchells Rd	Transplanted	1000	20 plots; survivorship 100%; no.~500	**Good**	Biomass reduction each year essential for persistence
Species Unexpected and Additional to the Translocation Strategy			Target= no. impacted			
Richmond Birdwing Vine	Coolgardie Rd	Cuttings	5	11	**Good**	
Lindernia	Mitchells Rd (Sec.3)	Transplanted	30	0	**Failed**	
Square-fruited Ironbark	Offset land, Sunnyside Rd	Transplanted	8	6	**Good**	
Weeping Paperbark (note – also above)	Offset land, Sunnyside Rd	Transplanted	1	1	**Good**	
Hairy Melichrus	Offset land, Pillar Valley (Mahogany Drive)	Transplanted	1	2	**Good**	

Species	Receival Site	Method	Target	Number surviving Aug 2020	Establishment: Good, Fair Poor, Failed	Comment
Rotala	Offset land Tabbimoble Ck	Transplanted & Division	20	15	**Good**	

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 Aug 2020	Establishment: Good, Fair Poor, Failed	Comment
Hairy Joint Grass	Kangaroo Trail	Transpl/Soil Seed	2	0	**Failed**	
	Trustrums Hill	Transpl/Soil Seed	38	0	**Failed**	Insufficient biomass reduction
Lindernia	Kangaroo Trail	Cuttings	1811	0	**Failed**	Microhabitat non-matching
	Halfway Ck Crossing	Cuttings		0	**Failed**	Microhabitat non-matching
	Yuragir NP	Transpl/Soil Seed		0	**Failed**	Microhabitat non-matching
Moonee Quassia	Dirty Creek Road Reserve	Cuttings	73		**Failed**	Cuttings did not strike
Slender Screw Fern	Kangaroo Trail	Transplanted	45 slabs	8	**Fair**	14% survival of plants between yr3 and yr5
Square-fruited Ironbark	Pillar Valley	Pillar Valley	823	~950	**Good**	900 planted Oct/20 by Ecos Enviro
Square-stemmed Spike Rush	Halfway Ck Crossing	Halfway Ck Crossing	253	0	**Failed**	SoS project underway
Tall Knotweed	Yaegl NR	Yaegl NR	37	0	**Failed?**	Patch observed north of recipient site.
Lepidosperma sp. 'Coaldale'	Mahogany Drive	Mahogany Drive	35	0	**Failed**	

Table 12: Assessment 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 4 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. Annual life cycle completed in Years 1-4. Persistence depends on biomass reduction. Adjacent population declined so translocation area helping in maintaining local population.	Performance criteria met. 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 from soil seedbank and introduced. Bushfire reduced translocated populatoin, renewed naturally occurring population at receival site and on western side of highway, stimulating germination of thousands of seedlings.
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 hardy, resilient, will recruit in degraded regenerating habitat. Can be translocated by salvage or propagation from seed, seedlings grow slowly.	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. Experiments and general observation increased knowledge of species life cycle, habitat requirements 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. Local population reduced but maintained.	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. Bushfire reduced translocated populatoin, but renewed naturally occurring population at receival site and on western side of highway, stimulating germination of thousands of seedlings.
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, soil seedbank collected.	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 conserves large HJG habitat area.	Performance criteria met. Available seed used, cutting material unsuitable for propagation.	Performance criteria met. Propagated from locally collected seed.	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: Salvaged population maintained at receival site for 3 years. Population reduced by bushfire in year 4, viable population appears to survive in parts of the two receival areas. Sec 1-2: Results poor, small population surviving after 5 years, weeds a threat.	Performance criteria met. Lumleys Lane: transplanting results poor. Coolgardie Rd: Propagated seedlings introduced, growing slowly, good survival.	Performance criteria met. Annual species, translocated population has produced a small cohort of seedlings each year for 4 years. Large amount of seed produced in Year 1-2. Translocated population shows initial evidence of self-perpetuation in damper micro-habitat. However, numbers at any one time small so far.	Performance criteria met. Two large stands established, plants over 2m, recovered well from bushfire, good prospects to become self-sustaining. Third younger, stands also resprouted after fire, recovering.	Performance criteria met. Both transplants and propagated plants growing well.	Performance criteria met. Transplanting results good at Evans Head receival site. Some plants producing seed pods. Plants at Lumleys Lane site stolen.
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

		Slender Screw Fern	Stinking Cryptocarya	Tall Knotweed	Weeping Paperbark	White Laceflower	Yellow-flowered King of the Fairies
2	Evaluation and actions	Performance criteria met. Knowledge of species life cycle, response to environmental perturbations 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
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
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. Bushfire substantially reduced extent of the translocated population but healthy population survives in reduced areas (2).	Performance criteria met. Translocated number currently equal to or greater than target/impact number.	Performance criteria met. . Population established. Criteria difficult to assess as species annual, and fluctuates with weather conditions.	Performance criteria met. On track to establish populations/stands at 3 sites.	Performance criteria met. On track to achieve no net loss.	Performance criteria met. Evans Head – clump size increased, seed production occurring.

		Slender Screw Fern	Stinking Cryptocarya	Tall Knotweed	Weeping Paperbark	White Laceflower	Yellow-flowered King of the Fairies
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
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.	Performance criteria met. Attempt made to transplant all saplings.	Performance criteria met. Seedlings, sub-adults and mature plants salvaged, Seedlings grown in nursery and introduced.	Performance criteria met. Seed collected from cross-section of trees in the impacted population.	Performance criteria met. All plants at impact sites were salvaged. Some seed collected.	Performance criteria met. All plants at impact sites were salvaged.

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 planted in October 2020.	Translocations undertaken as best possible with material of questionable value– no plants established. Corrective actions unlikely as propagation material is limited.

	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 planted in October 2020.	Translocations undertaken as best possible with material of questionable value– no plants established. Corrective actions unlikely as propagation material is limited.

	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 (as reported in Landmark 2016 with some additional comment by Ecos Environmental)

	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 5 Site 2 No plants observed in Year 5	Landmark reported after two years that plants had died back and two short-lived seedlings were observed. No seedlings or regrowth of Tall Knotweed were recorded in the recipient site by Ecos Environmental in Years 3-5 although one patch of plants was recorded north of the recipient site in 2020.
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
3	Objectives	Original number of individuals and area re-established	Original number of individuals and area re-established

	Species	Hairy joint-grass	Tall knotweed
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	Landmark reported in the first two years that at 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. In years 3-5, Ecos recorded that plants had died out at both sites. In situ HJG in the adjoining powerline easement were increased by biomass reduction implemented by Ecos Environmental.	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 Actions

No corrective actions proposed for Sections 1-11 following the monitoring conducted in 2020.

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 3-11 (translocation started 2016)

Slender Screw Fern (*Lindsaea incisa*)

Plate 1: Slender Screw Fern (*Lindsaea incisa*) receival site (Area 1) in Bundjalung Nat Pk, 2 months after the Nov/19 bushfire. Jan 2020.

Plate 2: Imprint of an inverted plastic tray/plot marker burnt in the fire. We were unable to locate many other plots. There was no evidence that the burnt plastic had a toxic effect on plants. Plots with plastic residue developed lush regrowth and *L. incisa* resprouted in some of them. Jan 2020.

Plate 3: Area 1 receival site, Bundjalung Nat. Pk. Dense ground layer 8 months after the Nov 2019 bushfire. The stakes mark points where translocated *L. incisa* plants reshot after the fire. Aug 2020

Plate 4: This Slender Screw Fern has resprouted from rhizomes after the bushfire. Area 1 Receival Site in Bundjalung National Park. Aug 2020

Plate 5: Area 2 Receival Site Bundjalung Nat Park, 8 months after the Nov 2019 bushfire. Plots where Slender Screw Fern had reshot are marked with stakes and flagging tape. Aug 2020

Plate 6: The flat valley bottom separating the Area 1 and Area 2 receival sites still flooded from wet season rains 8 months after the bushfire. Line A in Area 1 where most plants failed to regenerate is on the edge of the floodplain to the right. Aug 2020.

Plate 7: Area 1 Receival Site in Bundjalung Nat Park, 8 months after fire. Slender Screw Fern reshot after the fire in some of the plots but not in others. Aug 2020

Yellow-flowered King of the Fairies (*Oberonia complanata*)

Plate 8: Oberonia plants growing on a piece of casuarina wood removed from the dead host tree and attached to the trunk of a Hard Corkwood (*Endiandra sieberi*) at the receival site with cloth tape and wire in Aug 2016. Paperbark was placed behind the wood, although not really necessary. After 4 years the plants were in good condition and dried seed capsules were present. Evans Head receival site, Aug 2020.

Singleton Mint Bush (*Prostanthera cineolifera*)

Plate 9: Experiment 1. Plot on Transect C with dead stems of Singleton Mint Bush killed by low intensity bushfire in Nov/2019. A few Mint Bush seedlings were recorded in the plot amongst dense ground layer regrowth. Aug 2020.

Plate 10: Experiment 2 plots 8 months after the Nov/19 fire. About 15% of plants in Experiment 2 survived the low intensity fire and reshot new branches from the main stem, such as the shrub in the foreground. Small numbers of seedlings were recorded in the plots. Aug 2020.

Plate 11: Close up of Mint Bush plant in Experiment 2 showing green branches that have reshot from the main stem and grey, fire-killed branches (see arrows).

Plate 12: Experiment 3 plot showing dead plants killed by the fire. No reshooting or seedlings were recorded in Experiment 3 plots.

Plate 13: A seedling of Singleton Mint Bush about 20 cm high, eight months after fire. Aug 2020.

Plate 14: Another small seedling of Singleton Mint Bush about 5 cm high, 8 months after the Nov 2019 bushfire. There are larger leaved seedlings of other species growing around it. Aug 2020

Plate 15: A Singleton Mint Bush from the first planting that reshot after being defoliated by the low intensity fire.. This was one of the largest Mint Bush plants, but no seedlings were recorded around it. It was located well back from the creek on heavy clay soil. Aug 2020.

Tall Knotweed (*Persicaria elatior*)

Plate 16: Tall Knotweed receival site at Yaegl North, showing a stake marking one of 15 plots where seedlings salvaged from the footprint were introduced in 2017 after being grow-on in a nursery. A few Tall Knotweed seedlings are present here amongst native and exotic grass and herbs. Sept 2020

Plate 17: Tall Knotweed in the Yaegl North receival site in Sept 2020. This mature plant is about 1 m high and has racemes of small pink flowers at the end of branches. Plants present at the Sept/20 monitoring ranged from seedlings to mature plants.

Plate 18: Tall Knotweed receival site, Yaegl Nat. Res. north. The tall sticks mark a plot from the first translocation (Aug-Sept 2016) after early works. This recently germinated Tall Knotweed seedling is probably 3-4 weeks old. An annual species, plants usually live for a year. Sept 2020.

Plate 19: Tall Knotweed seedling, Sept 2020

Plate 20: Yaegl North Receival Site located in open habitat on the edge of paperbark swamp forest. The area floods in the rainy season and dries out in spring. Depending on rainfall, the soil can dry out completely or remain damp to the start of the next rainy season. A small population of 21 Tall Knotweed (seedlings to medium sized flowering plants) was recorded in the receival site in Sept 2020.

Four-tailed Grevillea (*Grevillea quadricauda*)

Plate 21: *Grevillea quadricauda* shrubs to 2 m high in the receival site which is located in the road reserve on Section 3, south of Quarry Rd. Small plants were transplanted from the footprint to pots (four years ago), grown-on for a few months, then introduced to the receival site. Aug 2020.

Plate 22: Flowers and fruits (pods/follicles) of *Grevillea quadricauda* at the receival site in Aug 2020

Weeping Paperbark (*Melaleuca irbyana*)

Plate 23: Tabbimoble Ck Receival Site - Area 2, two months after the Nov/19 bushfire. Dead stems of *Melaleuca irbyana* can be seen resprouting at the base. Jan 2020.

Plate 24: Tabbimoble Ck Receival Site - Area 1, two months after the Nov/19 bushfire. Flood debris caught along the bottom of the fence is from heavy rain a week or two before this photo was taken. Jan 2020.

Plate 25 : Tabbimoble Ck Receival Site - Area 2, two months after the Nov/19 bushfire. *Melaleuca irbyana* reshot well in this section. Jan 2020.

Plate 26: Tabbimoble Ck Receival Site - Area 2. Close-up of a resprouting *Melaleuca irbyana* two months after the Nov 2019 bushfire. Jan 2020.

Plate 27: Eight months after fire, Receival Site 1 showing *Melaleuca irbyana* forming bushes of coppice shoots and dense grass and herb regrowth. Before the fire, *M. irbyana* was 2 – 3 m high and regrowth is already about 0.5 - 1 m high. Aug 2020

Plate 28: Reshooting *Melaleuca irbyana* amongst grass and herb regeneration after the Nov 2019 fire. The *M. irbyana* plants were 3 years old when burnt and their survival rate was high.

Plate 29: Close-up of a regenerating Weeping Paperbark (*Melaleuca irbyana*) showing basal shoots (coppice) and dead 3 year old stem killed by the fire. The fire in this receival site was of medium to high intensity. Regrowth was over a metre high after 8 months. Aug 2020.

Stinking Cryptocarya (*Cryptocarya foetida*)

Plate 30: Two transplanted Stinking Cryptocarya (*Cryptocarya foetida*) saplings that survived at the Lumleys Lane receival site, 4 years after transplanting. The one at the right (CF26) died back to the ground in the heatwave of Feb 2017, but reshot and now is 2.3 m high. The one on the left (CF3) is 2.6 m high. Survival rate 25%. Aug 2020.

Plate 31: *Cryptocarya foetida* propagated from seed and introduced to the Coolgardie Rd rainforest receival site in Feb/18. Survival rate is 90% after 2.5 years. Growth has been slow – mean height increased from 43 cm to 67 cm (n = 23) in the last 12 months (see Table 8). Aug 2020

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

Plate 32: Rusty Green-leaved Rose Walnut (*Endiandra muelleri ssp. bracteata*) propagated from seed and planted in the Coolgardie rainforest receival site in Feb 2018. Survival rate after 2.5 years was 100% and mean height increased from 35.7 cm to 66.6 cm in the last 12 months. Aug 2020

Plate 33: Transplanted *Endiandra muelleri ssp. bracteata,* Lumleys Lane receival site.

Red Lilly Pilly

(*Syzygium hodgkinsoniae*)

Plate 34: Red Lilly Pilly (*Syzygium hodgkinsoniae*) at the Lumleys Lane receival site. Propagated from seed and introduced June/2017. On the right hand side, the stem of SM4 has been broken (leaves still alive), probably by a wallaby or possum. Aug 2020.

Plate 35: Red Lilly Pilly (*Syzygium hodgkinsoniae*) at the Coolgardie Rd receival site. Propagated from seed and introduced Feb/2018.The one on the left has shot new leaves after dying back, and the one on the right has only a few leaves. Survival rate 33%, growth very slow.

Plate 36: Red 'witches broom' on Red Lilly Pilly (*Syzygium hodgkinsoniae*) growing points. If left alone, rather than pruning it off, healthy leaves may emerge from the deformed growth. The cause of the deformed growth is unknown, but is the reason this species is not sold in the nursery trade or planted by bush regenerators. The red growth is not seen in established trees and since healthy leaves can shoot from the growth, it may function to protect buds in slow growing seedlings. It could also be a disease associated with nursery grown plants.

White Laceflower (*Archidendron hendersonii*)

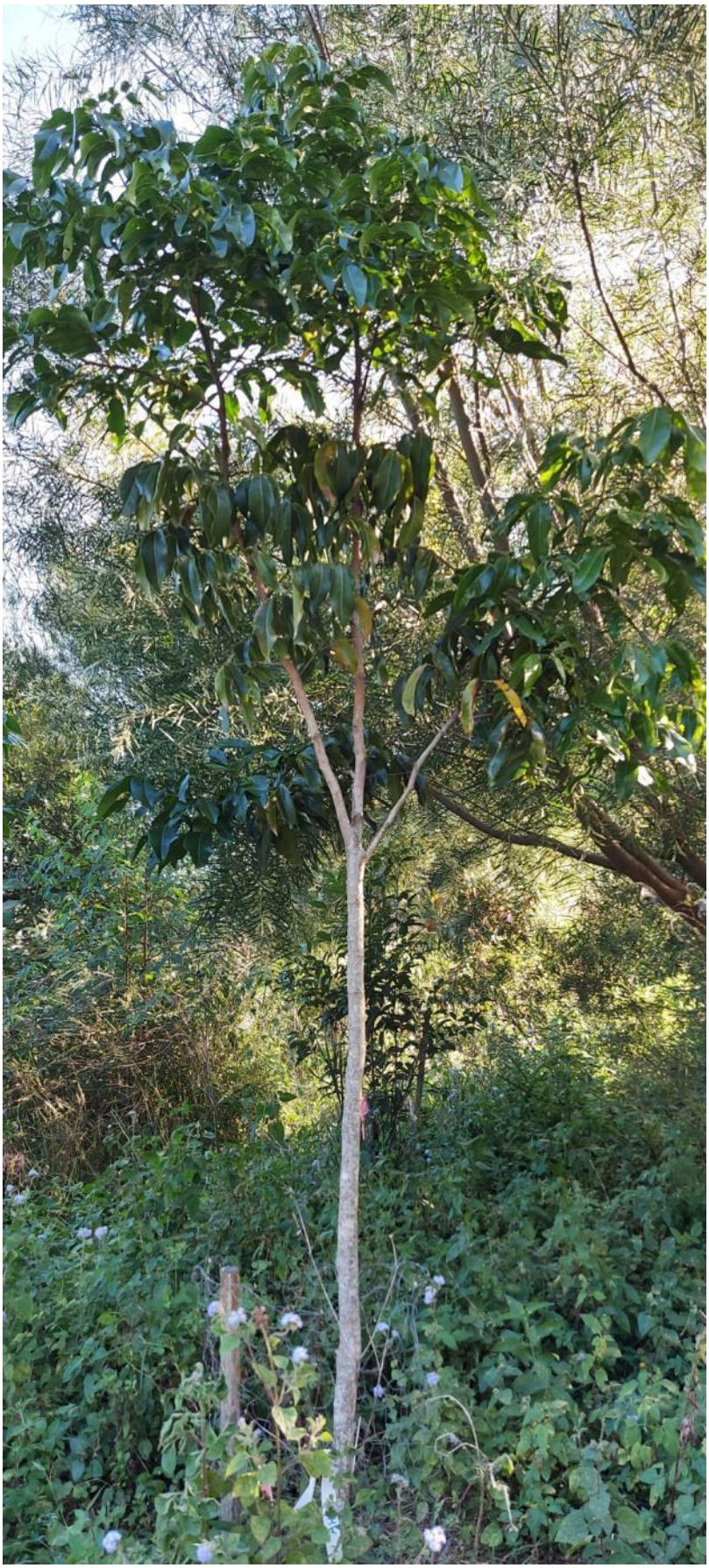


Plate 37: Transplanted White Laceflower (*Archidendron hendersonii*) AH1 at the Lumleys Lane receival site. This plant has increased in height from 68 cm in Jan/17 to 337 cm in Aug/20, one of the faster growing threatened rainforest species.

Hairy Melichrus (*Melichrus hirsutus*)

Plate 38: Transplanted Hairy Melichrus (*Melichrus hirsutus*) at the Mahogany Dv receival site – plant no. 1 with flower buds. Aug 2020

Plate 39: Transplanted Hairy Melichrus (*Melichrus hirsutus*) at the Mahogany Dv receival site – plant no. 2, Aug 2020.

Hairy Joint Grass (*Arthraxon hispidus*)

Plate 40: Hairy Joint Grass receival site at Mitchell Rd, looking east. When monitored, annual HJG plants had died back but the dead stems were still visible within 2 m of the fence. Aug 2020

Plate 41: Hairy Joint Grass receival site at Mitchell Rd. Monitoring point marker. Aug 2020.

Rotala (*Rotala tripartita*)

Plate 42: Rotala receival site on offset land south of Tabbimoble Ck. Photo shows the site after bushfire and heavy rain in Jan 2020. This is Pond 1 (the northern one) dug with an excavator.

Plate 43: The same pond as above (photo taken looking in the opposite direction) in Sept 2020, 8 months after the bushfire. Rotala plants were present at the arrows around the rim of the pond. Those planted lower down inside the chicken wire fence and submerged in the flood, appear to have died. The fence was installed after pig disturbance.

Plate 44: Clump of Rotala 3-5 cm high spreading by stolons, growing at Pond 1 on the upper part of the bank well above the water – see plate above. Sept 2020

Plate 45: More Rotala only a couple of centimetres high growing with weed seedlings at Pond 1. Sept 2020

Richmond Birdwing Vine (Aristolochia praevenosa)

Plate 46: Propagated Richmond Birdwing Vine introduced to the Coolgardie Road rainforest receival site. This species was propagated from hardwood cuttings 1-2 cm thick. Survival rate after planting is high (>80%). Here a plant is climbing into a tree above its wire cage (see arrow). Sept 2020

Lindernia (Lindernia alsinoides)

Plate 47: Lindernia receival site on a drainage line at Mitchel Rd, Section 3. Arrows indicate plot markers. No plants were recorded in Aug 2020. Orange iron precipitate sludge can be seen in the water at this swampy site. Salvaged plants introduced in sods survived for about 12 months. A few in situ Lindernia plants remain upstream of the receival site, on the eastern side of the highway.

Square-fruited Ironbark (Eucalyptus tetrapleura)

Plate 48: Square-fruited Ironbark has been grown from seed and introduced to the Sunnyside Road offset site at Glenugie. This sapling is part of a batch of 80 planted in 2017. A further 900 tubestock were planted at the same site in August 2020. This hardy eucalypt has a high survival rate.

Sections 1-2 & Early Works Soft Soil Treatment Areas (translocation started 2015)

Slender Screw Fern (*Lindsaea incisa*)

Plate 49: Kangaroo Trail receival site, Section 1. These are apparently plants grown-on in a nursery then introduced as all the slabs initially savaged were reported to have died (Landmark 2016). These plants would be 3-4 years old. Aug 2020.

Plate 50: Kangaroo Trail receival site, Section 1. Patch of labelled points with several live *L. incisa* plants. Aug 2020.

Lindernia (*Lindernia alsinoides*)

Plate 51: Lindernia receival site at Halfway Creek, where Lindernia was introduced in slabs (2015) then later as propagated plants (2017) - see Table 8. No Lindernia plants were present in Aug 2020.

Square-stemmed Spikerush (*Eleocharis tetraquetra*)

Plate 52: Square-stemmed Spikerush receival site at Halfway Creek, where slabs (i.e. transplanted sod containing plants) were introduced in 2015. No Square-stemmed Spikerush plants were present in Aug 2020.