Woolgoolga to Ballina Pacific Highway upgrade

Annual Threatened Flora Translocation Monitoring Report 2022

NSW GOVERNMENT

Woolgoolga to Ballina Threatened Flora Translocation Project

Annual Monitoring Report (No. 6) 2022

Prepared for:

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Contents

Executive Summary

This annual 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 new highway on the North Coast of NSW. Results are presented for Sections 3-11 after six years (2016-2022), or five years (2017-2022) in the case of Unexpected Finds. Results of translocations on Sections 1-2 and Early Works, which started one year earlier, were described in the 2020 report, completing five-year monitoring requirements for Sections 1-2 (2015-2020). They have been included in this report to provide an overall account of the translocation project. A total of 18 threatened plant species, 1 rare species and 2 vines hosting a threatened butterfly and a moth were translocated on the W2B project: -

Table 1: Threatened plant species translocated on the W2B project, showing their conservation status and occurrence on Sections 1-2 & EWSSTA, translocation starting in 2015, and 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

Threatened flora translocations on Sections 3-11 were implemented by Ecos Environmental Pty Ltd. The translocations were carried out according to a Translocation Strategy describing translocation methods, receival sites and evaluation criteria (RMS 2015a & b). Aspects of the Strategy including recipient site selection, propagation methods and research were modified if required. The aims of translocation were to establish new or augmented, self-sustaining populations of the impacted species, utilise translocation to avoid significant net loss to local threatened plant populations, investigate species ecology and translocation methods, and make the best possible use of all plant material with potential conservation value.

The impacted species were translocated to a total of 20 recipient sites, 13 on Sections 3-11 and 7 on Sections 1-2. Four main methods or approaches were applied to translocate species:

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

For some species, the translocation incorporated experimental trials investigating the effect on species performance of various factors such as planting location, soil type and maintenance method, particularly in the case of Singleton Mint Bush, as described in this report.

A bushfire burnt the recipient sites for Singleton Mint Bush, Slender Screw Fern and Weeping Paperbark on Sections 3-11 in Nov/2019, during the east coast bushfires of 2019-2020. The bushfire (and preceding drought) caused the first two species to contract to smaller sections of their recipient sites. The distribution of Weeping Paperbark within the three sites where it was planted was unchanged by fire, which killed above ground parts, then plants reshot from roots at the stem base and reached almost pre-fire height in only two years.

Overall, the results of translocation on Sections 3-11 met most aims, objectives and targets for all 15 threatened species translocated, except for Lindernia. Results were mixed for species on Sections 1-2 where several threatened species recorded zero survival and population establishment, including Moonee Quassia, Oberonia, Lindernia and Square-stemmed Spike Rush.

One corrective action stemming from the results of the current monitoring period and relating to the control of the invasive, exotic grass Setaria is included.

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 (Early Works Soft Soil Treatment Areas) 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.

'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 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).

The final monitoring results for Sections 1-2 and EWSSTA were described in Ecos Environmental (2020), completing five-year monitoring requirements. They are included in this report and the 2021 report. This report describes monitoring results for Sections 3-11 from 2016 to 2022, which represent 5-6 years since introduction, or 4.5 – 5 years in the case of Unexpected Finds.

Following this Introduction, Part 2 of the monitoring report presents an overview of the translocation methods applied. Parts 3 describes the implementation and results of the translocation program for each species on Sections 3-11, and Sections 1-2 and EWSSTA. Part 4 assesses the outcomes of the translocation project in terms of performance criteria and thresholds set out in the Translocation Strategy. Part 5 identifies any corrective measures considered necessary to achieve the translocation projects aims and objectives. Finally, a photo record documents the progress of the translocation project in 2022.

Table 1: Threatened plant species translocated on the W2B project, showing their conservation status and occurrence on Sections 1-2 & EWSSTA, translocation starting in 2015, and 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

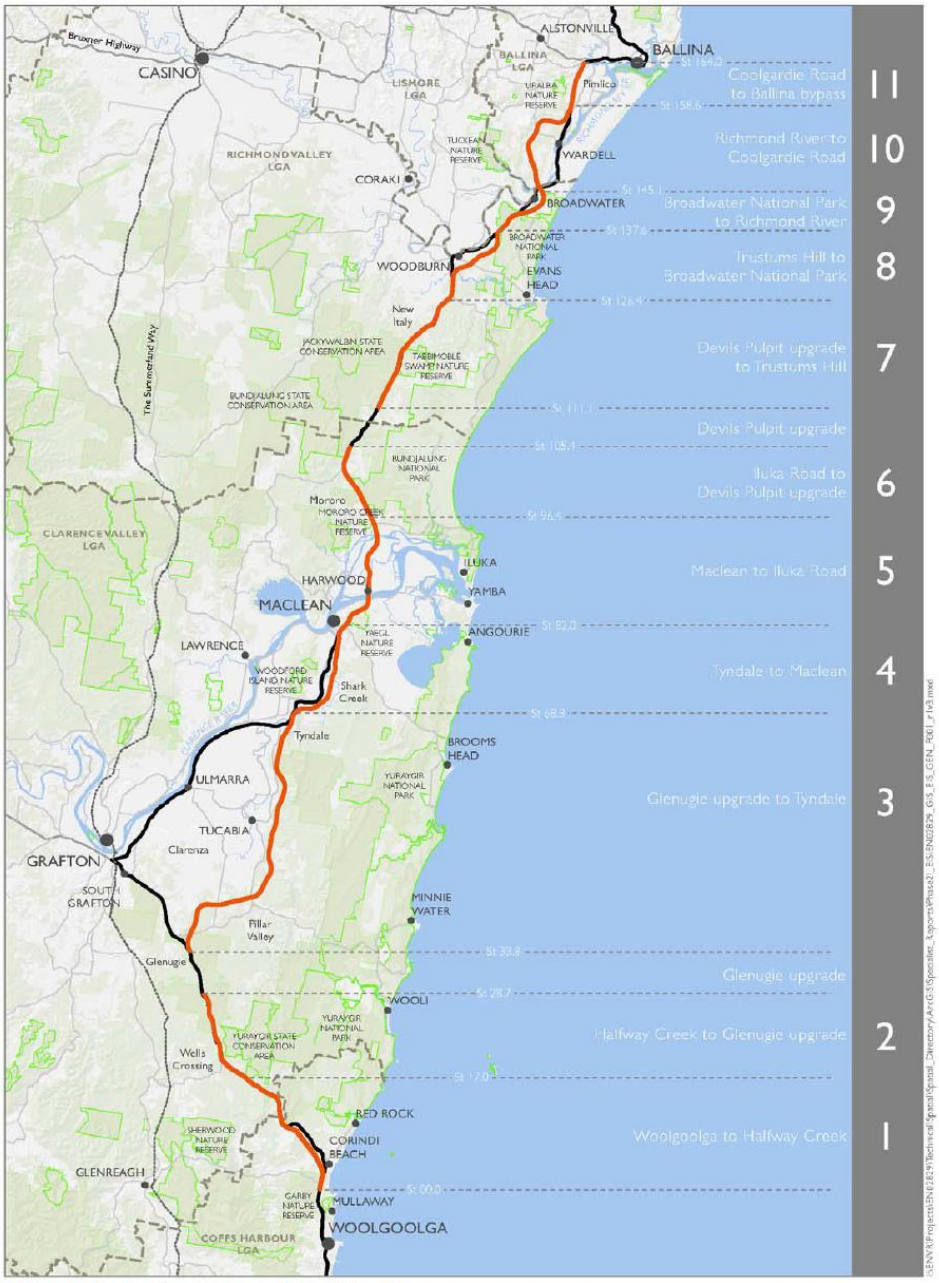


Figure 1: Woolgoolga to Ballina (W2B) Upgrade of the Pacific Highway showing the different Sections of the 155 km long project referred to in this threatened flora translocation monitoring report.

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 mitigate some of the impact of development on threatened plant species. However, it is recognised that the outcomes of translocation cannot be guaranteed for a given species and this field of conservation biology is still largely in an experimental stage. 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)
Singleton Mint Bush	609 (0.424ha)	35**	644 (0.43)

Species	**Translocation Target (RMS 2015a)**	**Unexpected Finds**	**Total number removed/ translocated**
(*Prostanthera cineolifera*)			
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 Recipient Sites

The success of threatened plant species translocation depends largely on how well the habitat present at the recipient 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 recipient 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 recipient 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.

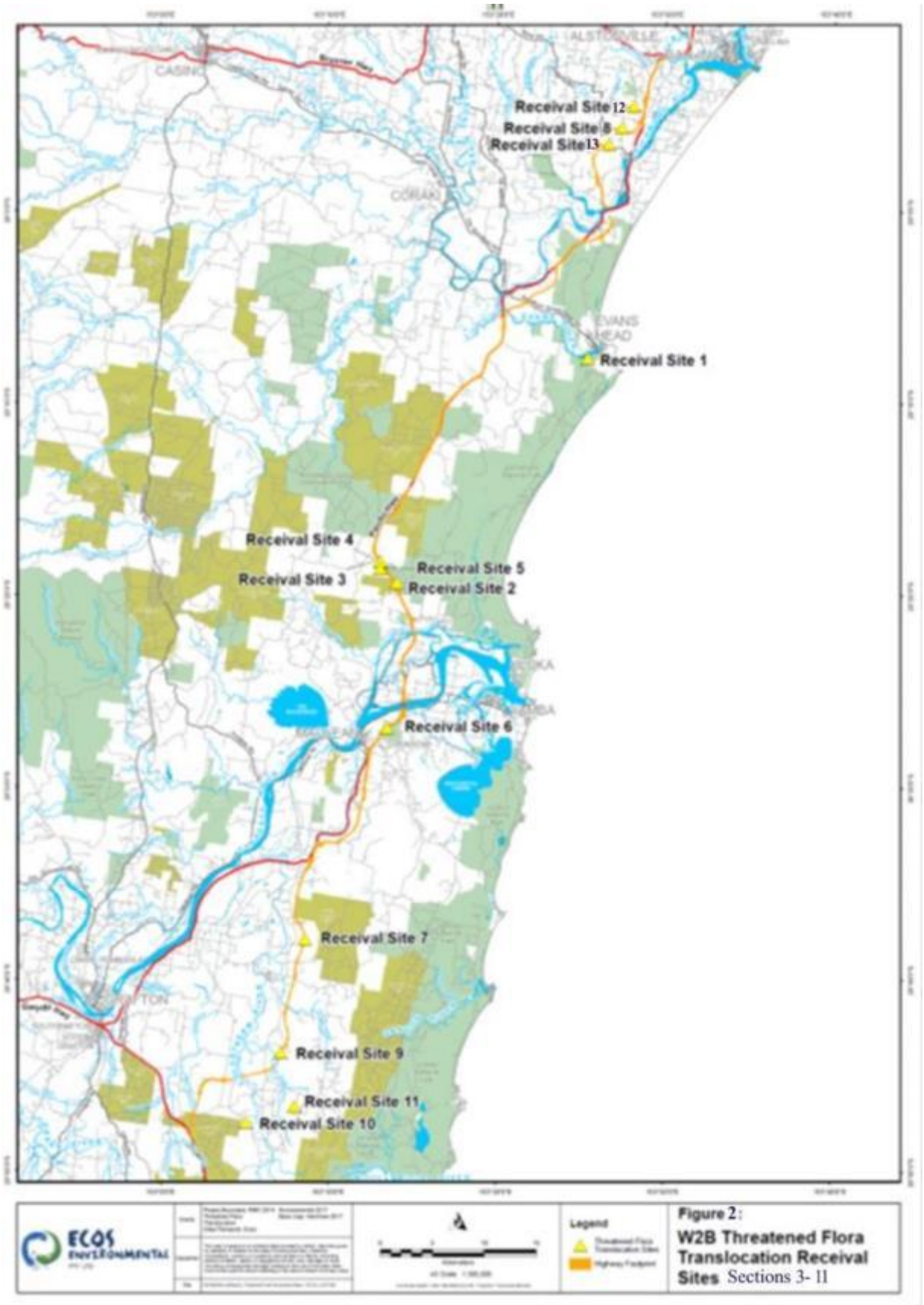
Table 4: Recipient sites for species translocated on Sections 3-11. See Figure 2 below.

Species	**Recipient Site**
Sections 3-11	
Yellow-flowered King of the Fairies (*Oberonia complanata*)	Site 1 - Bundjalung National Park (Evans Head) Site 13 - Lumley's 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 Lumley's Lane, as well as those already introduced to Coolgardie Rd.

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

Species	**Recipient 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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Receival Site 7
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Receival Site 10
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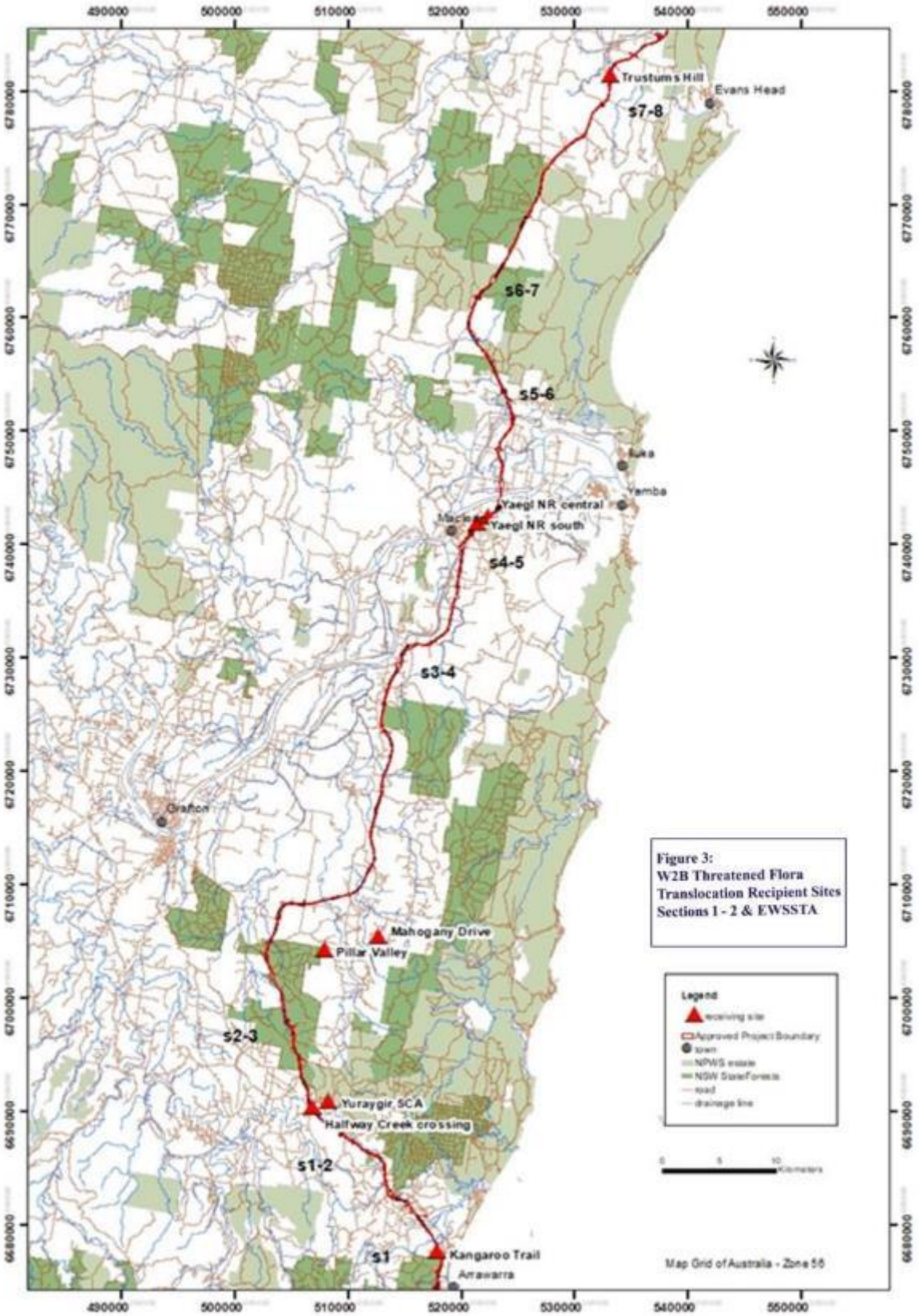
Figure 2:
W2B Threatened Flora Translocation Receival Sites Sections 3- 11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s5-6
Iluka
Yamba
Yaegl NR central
Yaegl NR south
Maclean
s4-5
s3-4
Grafton
Mahogany Drive
Pillar Valley
s2-3
Yuraygir SCA
Halfway Creek crossing
s1-2
s1
Kangaroo Trail
Arrawarra
Figure 3:
W2B Threatened Flora
Translocation Recipient Sites
Sections 1 - 2 & EWSSTA
Legend
Approved Project Boundary
town
NPWS estate
NSW StateForests
road
drainage line
Kilometers
Map Grid of Australia - Zone 56

2.4 Translocation Methods

Threatened flora were translocated to the recipient sites using four main methods:

(i) Salvage transplanting (i.e. excavation of impacted plants).

(ii) Propagation from cuttings and planting.

(iii) Propagation from seed and planting.

(iv) Propagation from soil seedbank and planting.

All propagation material came from the clearing footprint. More than one method was applied to several species, as shown in Table 6. Summing the methods in Table 6, transplanting was applied to 18 species, seed propagation to 8, cutting propagation to 5 and soil seedbank propagation to 3. Different methods applied to the same species provided back-up in case one failed and allowed testing of different propagation methods. Further details of translocation methods applied to each species is provided below.

Propagation from the soil seedbank was used for Singleton Mint Bush (SMB), Tall Knotweed (TK) and Fou**r**-tailed Grevillea (FG), although mainly for the first two species. Topsoil (or mud in the case of Tall Knotweed) was collected under mature plants assuming it would contain dormant seed of these species. Litter was burnt on top of salvaged topsoil to simulate bushfire and trigger germination of Singleton Mint Bush and Fou**r**-tailed Grevillea. The method was successful for SMB but not FG probably because winged seed are dispersed away from the parent plant and therefore were not present in the topsoil collected. Mud was collected under old Tall Knotweed plants and spread in plots at the recipient site.

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	+	+	-	-

Species	**Transplant**	**Propagate Seed**	**Propagate Cuttings**	**Propagate Soil seedbank**
(*Endiandra muelleri ssp. bracteata*)				
Red Lilly Pilly (*Syzygium hodgkinsoniae*)	+	+	-	-
White Laceflower (*Archidendron hendersonii*)	+	+	-	-
Rough-shelled Bush Nut (*Macadamia tetraphylla*)	-	+	-	-
Hairy Joint Grass - Section 10 (*Arthraxon hispidus*)	+	-	-	-
Hairy Joint Grass - Mitchell Rd Sect 3 (*Arthraxon hispidus*)	+	-	-	-
Additional Species				
Square-fruited Ironbark (*Eucalyptus tetrapleura*)	+	-	-	-
Hairy Melichrus (*Melichrus hirsutus*)	+	-	-	-
Lindernia (*Lindernia alsinoides*)	+	-	-	-
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 carried out three monthly in year 1, six monthly in year 2 and once a year in years 3 to 6. Monitoring for this report (no. 6) was carried out in November 2022, representing 5.5 – 6 years for the first round of translocation, and 4.5 – 5 years for Unexpected Finds translocated a year later (e.g. *Lindsaea incisa*). The time since translocation given in this report are times since introduction or planting out and do not include time required for propagation (also described).

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.

Monitoring results were entered in an Excel spreadsheet, saved as “W2B Translocation Monitoring 2016 to 2022 and Monitoring 2016 to 2022_process”.

2.6 Maintenance and Plant Care

Salvaged and propagated plants have a better chance of survival and establishment at the recipient site if horticultural measures are applied to reduce physiological stress and improve growing conditions, such as watering, mulching, shading, spraying to control weeds, removal of competing native species, fencing to exclude native and domestic grazing animals, and use of fertiliser. These methods, usually referred to as maintenance or plant care, are applied during the establishment phase which lasts for about five years.

Maintenance activities carried out during the last 12 months (i.e. spring 2021 to spring 2022) on are shown in Table 7. These varied according to species and recipient site, and included weed control, grass slashing, removing sapling competition, application of slow-release fertiliser, renewing monitoring tags and bush regeneration/habitat restoration at the two rainforest species recipient sites (Lumley’s Lane and Coolgardie Rd).

Table 7: Maintenance activities carried out between August 2020 and November 2022

Recipient Sites	Watering	Weed control	Mulching/fertiliser	Fence repair/exclude grazers	Renew monitoring tags	Grub saplings/reduce natives	Biomass reduction	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 - Lumley's Lane South Oberonia								
Sites on Section 1-2 and Early Work Areas		+			+		+	

3.0 RESULTS (SECTIONS 1-11)

3.1 Weather Conditions

Mean monthly and actual rainfall between 2015 and 2022 at Evans Head (www.bom.gov.au/climate/data/) are shown in Figure 4. This seven-year period included droughts, which were defined as three or more consecutive months of below average rainfall, floods and a major bushfire (see Figure 4). Periods of below average monthly rainfall were in winter-spring, except for 2018 & 2019 when drought extended into summer, culminating in the bushfires of 2019-2020. During the latter period, species such as *Lindsaea incisa* and *Prostanthera cineolifera* wilted and foliage shrivelled up, indicating severe water stress. Additional watering was carried out to alleviate moisture stress. Heavy rainfall events caused flooding and soil water logging which adversely affected some species such as *Lindsaea incisa* and *Persicaria elatior*.

The highest maximum temperature on record for the Far North Coast of NSW was recorded on 11/2/2017 (mid to high 40s). This event resulted in leaf scorching and mortality of transplanted *Cryptocarya foetida* at Lumley's Lane. This weather event occurred during a drought that ended in March 2017 when 800-1000 mm of rain fell in a few days from Ballina to Maclean, causing flash floods and prolonged flooding of low-lying recipient sites.Wet conditions persisted to the end of June 2017.

This was followed by an exceptionally long, dry period from October 2018 to December 2019 that affected much of the east coast of Australia and culminated in widespread bushfires. A fire burnt from the Richmond Range to the coast and crossed the W2B corridor between Ballina and Maclean in November/2021 burning recipient sites for *Lindsaea incisa*, *Prostanthera cineolifera* and *Melaleuca irbyana* at Tabbimoble Ck, near the Iluka turnoff. This bushfire provided an opportunity to study how translocated plants are affected by bushfire.

The overall weather pattern between mid-2015 and 2022 was notable for marked oscillations between drought and flooding rainfall. During this period there were five droughts defined as more than three consecutive months of below average rainfall, and six high rainfall events resulting in floods (see Figure 4). Exceptionally high temperatures were recorded at the start of 2017, as noted above. It appears that the saying 'Australia is a land of droughts and flooding rains' applies to the high rainfall, North Coast region of NSW as much as it does to the dry inland.

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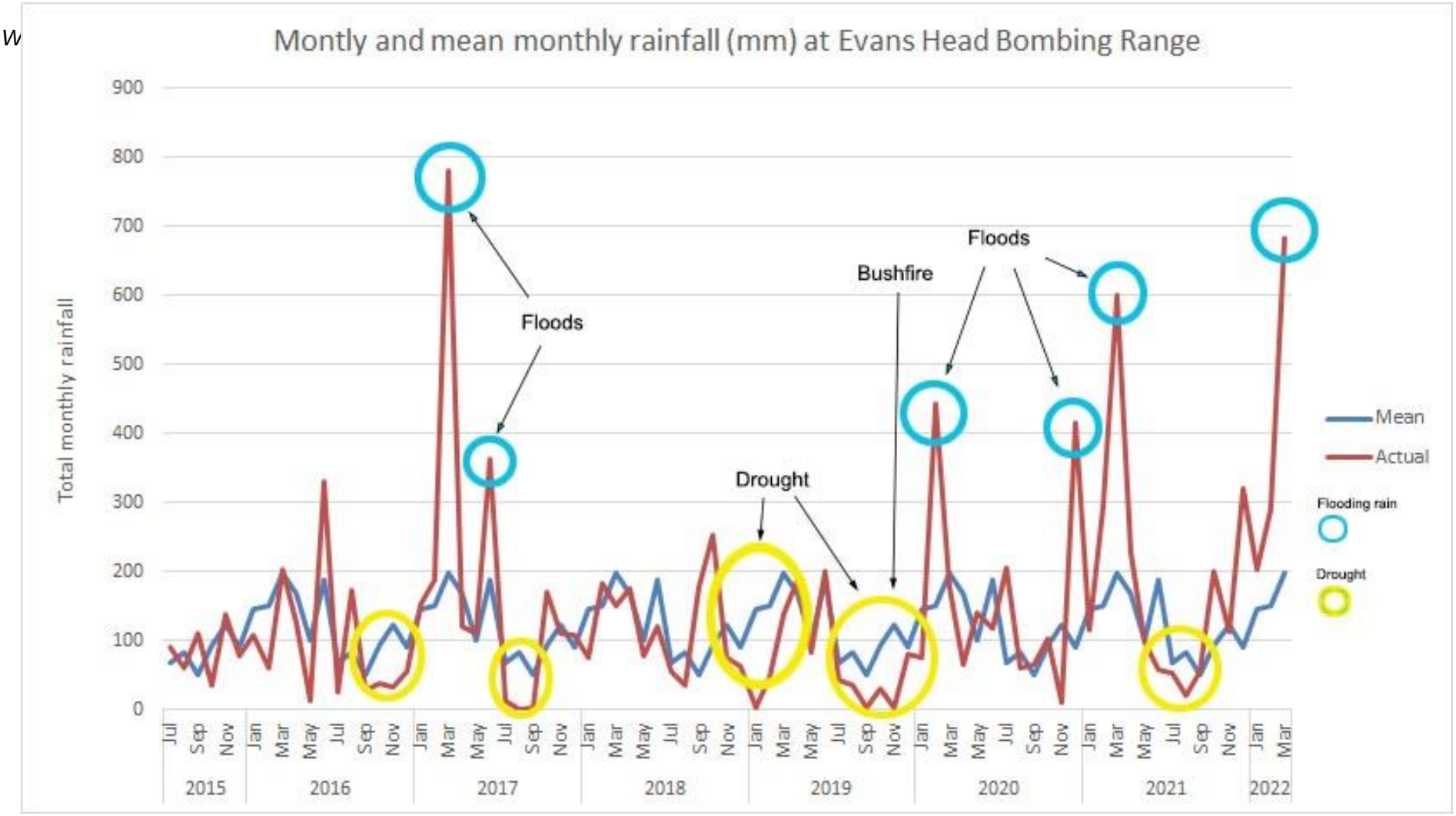


Figure 4: Monthly and mean monthly rainfall for Evans Head Bombing Range, representative of rainfall on Sections 3-11 from 2015 to 2022. The weather pattern was characterised by high rainfall variability with frequent droughts and floods, and a major bushfire that burnt recipient sites for Singleton Mint Bush, Slender Screw Fern and Weeping Paperbark in the Tabbimoble Creek area north of Iluka turnoff (Section 6) in November 2019.

3.2 Translocation Results

Table 8: Summary of threatened flora translocation results on W2B sections 3-11 after approximately six years (2016-2022) and five years (2017-2022) for unexpected finds. Some species/recipient sites were burnt by bushfire in November 2019, as indicated in orange.
S - survivorship %; CC - mean % crown-cover; Ht - mean height (cm); ~1-4 years - time since transplanting/introduction, or time since seed germination.

Species/Recipient Sites	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	Survival%/Cover-abundance/ No. of plants Nov/2021	Survival%/Cover-abundance/ No. of plants Nov/2022
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%	~5 years S = 91%	~6 years S = 91%
Unexpected finds Lumley's Lane Sth	Transplanted Aug/2017	Transplanted – 12 small branches with orchid clumps	n/a	~2 years S = 100%	~3 years orchids taken by collectors		
Slender Screw Fern (*Lindsaea incisa*)					Bushfire Nov/2019		
First Translocation Area 1 - Bundjalung NP	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% All S=95%; cc=16%	~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% All S=100%; cc=35%	~4 years; 9 months post-fire Line A –S=0% Line B – S=8%; CC=2% Line C – S=75%; CC=18% Line D – S=0%; patches – S=20%; CC=1% All S=25%; cc=3.4%	~5 years; 2 years post-fire Line A –S=0% Line B – S=25%; CC=3.2% Line C – S=80%; CC=29% Line D – S=0%; patches – S=20%; CC=0.5% All S=25%; cc=5.8%	~6 years; 3 years post-fire Line A – CC=0.3% Line B – CC =94.4% Line C – CC=150.3% Line D – CC=0 Patches – CC= 0
Second Translocation Unexpected finds. Area 2 & 1 - Bundjalung NP	Transplanted Sept, Oct 2017	Transplanted Area 2: Line A – 29 trays/plots Line B – 30 trays/plots Patches Area 2 = 7 Transplanted Area 1: Patches Area 1 =16 @ 25 fronds/tray Total fronds=~4350	n/a	~2 years Transplanted Area 2 Line A – S=97%; CC=6.8% Line B – S=94%; CC=16.3% Patches–S=100%; CC=68.5% Transplanted Area 1 Patches–S=100% CC= 80%	~3 years Transplanted Area 2 Line A – S=36.6%, CC=6.3% Line B – S=30%; CC=10.7% Patches – S=12% CC= 1% Transplanted Area 1 Patches–S=73%, CC=30%	~4 years; 2 years post-fire Transplanted Area 2 Line A – S=44%, CC=13% Line B – S=30%; CC=10.7% Patches – S=12% CC= 1% Transplanted to Area 1 Patches–S=73%, CC=34%	~5 years; 3 years post-fire Line A – CC=57% Line B – CC=115.8% Area 1 patches – CC=165.1% Area 2 patches – CC= 0%

Species/Recipient Sites	**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**	**Survival%/Cover-abundance/ No. of plants Nov/2021**	**Survival%/Cover-abundance/ No. of plants Nov/2022**
Singleton Mint Bush (*Prostanthera cineolifera*)					Bushfire Nov/2019		
Tabbimoble Triangle	Soil seedbank collected Aug/2016 1st tubestock planted 23/3/2017 when seedlings ~6 month old	First (blanket) planting - 700 tubestock	~3 months 1st planting ~30% survival 1st planting mean ht 31.4cm	2.5 years Total number surviving - 520 1st planting mean ht 121.1cm	3.5 years, 6 months post-fire Total number surviving (in-situ + translocated) - 608 Small percentage resprouted indicating low fire intensity; very low density of seedlings across site, more towards Tabbimoble Ck	4.years, 2 years post-fire Total number surviving (in-situ + translocated) - 341 Total translocated – 36 (experiments and site-wide, including recruitment)	5.years, 3 years post-fire Total number surviving (in-situ + translocated) - 190 Total translocated – 30 (experiments and site-wide, including recruitment)
Experiment 1 (effect of soil texture gradient and fertiliser on survival and growth) Tabbimoble Triangle	Exp.1 planted 12/4/2017 when seedlings ~7 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. 4 plants/quarter, 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)	~ 0.5 years post-fire T1 –no resprouts or seedlings T2 – no resprouts or seedlings T3 – no resprouts, 11 seedlings T4 - no resprouts or seedlings T5 - no resprouts or seedlings	~ 2 years post-fire T1 –no resprouts or seedlings T2 – no resprouts or seedlings T3 – no resprouts, 3 seedlings T4 - no resprouts or seedlings T5 – no resprouts or seedlings	~ 3 years post-fire T1 to T5 – nil
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 months old	Six plots, each plot divided into quarters, two quarters with seedlings, two with cuttings, half plots with Fert, half No fert. 3 plants/quarter, 12 plants/plot Total 72 plants in experiment	n/a	~1.5 years Seedlings Cuttings NF Ht=155.2cm Ht=116.1cm F Ht=142.4cm Ht=94.5cm Survival 94.5% No sig diff between cuttings vs seedling & fer vs no fert	~0.5 years post-fire A few sdlgs, some resprouts A B C D E F Resp 0 33 41 8 12 0 (%) Seedlings - 15	~2 years post-fire No sdgs, a few resprouts A B C D E F Resp 0 16 0 8 8 0 (%) Seedlings total - 3	~3 years post-fire No sdgs, a few resprouts A B C D E F Resp 0 8 0 8 8 0 (%) Seedlings total - 0
Experiment 3 (effect of seedling age – two plots on T2 replanted) Tabbimoble Triangle	Exp 3 planted 17/11/2017	Two plots on T2 from Experiment 1 replanted with 12-month old seedlings, same method - 4 plants/quarter,16 plants/plot Total 32 plants in experiment	n/a	~1.5 years T2 plot 5 mean ht = 141.6 cm T2-plot 6 mean ht = 165.5 cm Survivorship – 100%	~0.5 years post-fire T2 plots 5 & 6 – no resprouts or seedlings	-	-
Weeping Paperbark (*Melaleuca irbyana*)					Bushfire Nov/2019		
Tabbimoble Offset Land (Sites 1 & 2) Tabbimoble Triangle (Site 3)	Seed collected and sown in Aug/2016, tubestock planted early 2017	Planted at the 3 sites: 1. 600 tubestock 2. 500 tubestock 3. 400 tubestock	6 months 1. S ~80% 2. S ~80% 3 – recently planted	~2.5 years Total number of plants approx. 1300	~3.5 years since introduction, 0.5 year since fire Total number of plants approx. 900	~5 years since introduction, 2 years since fire Total number of plants approx. 900	~6 years since introduction, 3 years since fire Total number of plants approx. 700
		Fertiliser comparison: 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 since introduction, 0.5 years since fire– new plots (2)	~5 years since introduction, 2 years since fire– new plots (2)	3 yrs post-fire Plot 1- Ht (m) 3.0 ± 0.1

Species/Recipient Sites	**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**	**Survival%/Cover-abundance/ No. of plants Nov/2021**	**Survival%/Cover-abundance/ No. of plants Nov/2022**
					At fire - 225 cm 0.5 years post-fire – 103 cm	When burnt - 225 cm 2 years post-fire – 197 cm	Plot2 1- Ht (m) 2.8 ± 0.2
Tall Knotweed (*Persicaria elatior*)							
Translocation No. 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	~ 5 years 7/26 of plots with TK plants, most mature Total number of plants ~ 22	~6 years 5/26 of plots with TK plants, most seedlings Total number of plants ~ Translocation 1 and 3 - 177
Translocation No. 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	~ 4.5 years 2 plots with TK plants, most mature Total number of plants = 5	no TK
Translocation No. 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	~4 years 7/15 of plots with TK plants, most mature Total number of plants ~ 139	Total number of plants ~ Translocation 1 and 3 – 177 (difficult to tell apart) Down from 375 in 2016 (col. 3)
Four-tailed Grevillea (*Grevillea quadricauda*)							
Road Reserve south of Quarry Rd, Section 3	Transplanted - juvenile plants transplanted to pots Aug-Sept/16 and grown in nursery for ~6 months. Soil seedbank collected Aug-Sept/16	15 potted plants introduced to recipient site I n March/17.	~ 0.5 year 85% survived transplanting to pots; 100% survived after planting out. Mean ht – 60.8cm	~ 1.5 years Survivorship - 93% Mean height – 155.9cm Mean width – 146.2cm Total number of plants 14	~ 2.5 years Survivorship - 93% Mean height – 163.7.6cm Total number of plants 14	~ 3.5 years Survivorship - 93% Mean height – 163.7.6cm Total number of plants 14	~ 4.5 years Survivorship - 93% Mean height – 170..9cm Total number of plants 14
Stinking Cryptocarya (*Cryptocarya foetida*)							
Lumley's Lane - transplanted	Transplanted Sept-Oct/16	Transplanted – 24 saplings	Jan/17 - 62.5% survived Mar/17 - 26.9% June/17 – 26.9%	~ 3 years Survivorship – 25% Number of transplants 6	~ 4 years Survivorship – 25% Total number - 6	~ 5 years Survivorship – 25% Total number - 6	~ 6 years Survivorship – 20% Total number - 5
Coolgardie Rd - propagated	Propagated - seed collected Aug-Sept/16 Planted Feb/18	28 plants in 5 inch pots	n/a	~1.5 yrs Mean Ht – 42.9cm Survivorship – 89.3% Total number of plants 25	~2.5 years Mean Ht – 66.9cm Survivorship – 89.3% Total number of plants 25	~3.5 years Mean Ht – 85.5cm Survivorship – 89.3% Total number of plants 25	~4.5 years Mean Ht – 119.9cm Survivorship – 61% Total number of plants 17

Species/Recipient Sites	**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**	**Survival%/Cover-abundance/ No. of plants Nov/2021**	**Survival%/Cover-abundance/ No. of plants Nov/2022**
Rusty Rose Green Walnut (*Endiandra muelleri ssp. bracteata*)							
Lumley's 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	~ 5 years Survivorship – 33.3% Total number of plants 1	~ 6 years Survivorship – 33.3% Total number of plants 1
Propagated – Coolgardie Rd	Propagated - seed collected Aug-Sept/16 Planted Feb/18	19 plants in 5 inch pots	n/a	~1.5 yrs Mean Ht – 35.6cm Survivorship – 100% Total number of plants 19	~2.5 yrs Mean Ht – 68.5 cm Survivorship – 100% Total number of plants 19	~3.5 yrs Mean Ht –98.0 cm Survivorship – 94.7% Total number of plants 18	~4.5 yrs Mean Ht –144.7 cm Survivorship – 94.7% Total number of plants 18
Red Lilly Pilly (*Syzygium hodgkinsoniae*)							
Lumley's Lane – propagated seedlings	Transplanted and propagated - juveniles transplanted to pots (6) Oct/16; seed collected Aug-Sept/16. Planted June/17	13 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	~ 4 years Mean Ht – 83.4 cm Survivorship – 92% Total number of plants 12	~ 5 years Mean Ht – 82.3 cm Survivorship – 92% Total number of plants 12
Coolgardie Rd – propagated and transplanted seedlings	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 – 22.2 cm Survivorship – 34% Total number of plants 10	~ 3.5 years Mean Ht – 12.9 cm Survivorship – 17% Total number of plants 5	~ 4.5 years Mean Ht – 10.4 cm Survivorship – 17% Total number of plants 5
White Laceflower (*Archidendron hendersonii*)							
Lumley's Lane	Transplanted Oct/16 Saplings directly transplanted	2 saplings transplanted;	~ 1 year 100% survival transplants	~ 3 years Survivorship – 100% Total number of plants 2	~ 4 years Survivorship – 100% Total number of plants 2	~ 5 years Survivorship – 100% Total number of plants 2	~ 6 years Survivorship – 100% Total number of plants 2
Coolgardie Rd	Juveniles transplanted to pots, grown on and planted out	6 potted juveniles (6) introduced Feb/18	n/a	~ 1.5 years Mean Ht – 152.7cm Survivorship – 100% Total number of plants 6	~ 2.5 years Mean Ht – 217.6cm Survivorship – 100% Total number of plants 6	~ 3.5 years Mean Ht – 282.5cm Survivorship – 100% Total number of plants 6	~ 4.5 years Mean Ht – 305 cm Survivorship – 50% Total number of plants 3
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	~ 1.5 years Mean Ht – 55.2cm Survivorship – 100% Total number of plants 5	~ 2.5 years Mean Ht – 124.3cm Survivorship – 80% Total number of plants 4 + 3 more planted = 7	~ 3.5 years Mean Ht – 192.5 cm Survivorship – 80% Total number of plants 4 + 3 more planted = 7	~ 4.5 years Mean Ht – 231.8cm Survivorship – 80% Total number of plants 4 + 3 more planted = 7
Square-fruited Ironbark (*Eucalyptus tetrapleura*)							

Species/Recipient Sites	**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**	**Survival%/Cover-abundance/ No. of plants Nov/2021**	**Survival%/Cover-abundance/ No. of plants Nov/2022**
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	800 more tubestock planted in 2021 to meet target in Strategy	Approx. 50% surviving, in poor condition, most <1 m high
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	~ 5 years Survivorship – 100% Total number of plants 2	~ 6 years Survivorship – 100% Total number of plants 2
Hairy Joint Grass (*Arthraxon hispidus*)							
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	~ 5 years Young plants present along fence on edge of swampy drainage line.	~ 6 years Young plants present, particularly along chicken wire fence on edge of swampy drainage line.
Lumley's 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	~ 5 years Survivorship –10% of plots. Total number of plants ~50	~ 6 years A few plants present in the area planted with HJG in 2016 higher up the paddock, in dense pasture.
Lumley's Lane, Section 10	In-situ population managed by annual slashing					~ 5 years Large in-situ population present, dense in lowest part of paddock adjoining highway, covering over 1 ha.	~ 6 years A large population persists in the lower part of paddock next to the local road and the highway
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)	4.5 years No plants seen (better to monitor in summer when flowering)	5.5 years No plants
Rotala (*Rotala tripartita*)					Bushfire Nov/2019		
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	~1.5 years Survivorship – 37.8% Total number of plants 17	~2.5 yeas Survivorship – 30% Total number of plants 15	~3.5 years Survivorship – 40% Total number of plants 20	~4.5 years No plants present, died out due to encroaching, overtopping grass growth
Richmond Birdwing Vine							

Species/Recipient Sites	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	Survival%/Cover-abundance/ No. of plants Nov/2021	Survival%/Cover-abundance/ No. of plants Nov/2022
(*Aristolochia pravevenosa*)							
Coolgardie Rd	Propagated - cuttings collected Oct, Nov/2016, Planted Oct/2017	Propagated - 11 in 6 inch pots	100%	~ 2 years Mean Ht – 89.6cm Survivorship – 100% Total number of plants 11	~ 3 years Mean Ht – 88.5cm Survivorship – 91% Total number of plants 10	~ 4 years Mean Ht – 110.8cm Survivorship – 91 % Total number of plants 10	~ 5 years Mean Ht – 120.8cm Survivorship – 63 % Total number of plants 7
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 years Mean Ht – 8.3cm Survivorship – 83.3% Total number of plants 5	~ 2 years Mean Ht – 10 cm Survivorship – 40% Total number of plants 2	~ 3 years Mean Ht – 10 cm Survivorship – 40% Total number of plants 2	~ 4 years No plants

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

Species	Recipient 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
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 recipient 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 recipient site about 0.5 km away. These were planted in plots the size of the tray and placed about 2 m apart in five lines, the lines roughly parallel to the contour and at slightly different elevation in very gently undulating terrain (slope ~1 degree), at the edge of the coastal floodplain. The aim of this planting layout was to (i) spread out the translocated plants to increase likelihood of some plants establishing successfully and (ii) record how microtopography affected survival and growth. (Note – in Area 1, as well as the single tray plots, larger plots consisting of four trays (ie approx. 80 cm x 80 cm square) were planted in the second translocation in what appeared to be the best habitat based on the results of the first translocation.)

Plots were watered to keep soil moist and no fertilisers were applied. The plastic trays with a wide grid base were inverted over the single tray sized plots to protect *L. incisa* from possible animal grazing and digging, and to define the plots for monitoring. The inverted trays also caught fallen leaves and bark which were removed to prevent shading/smothering of *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 recipient site in Bundjalung National Park. About half the plants were planted in two lines of one-tray plots on the opposite side of the broad swale to the first translocation 50 m south (Area 2). The other half were planted in patches (i.e. 4 trays to a patch), 16 in Area 1 and 7 in Area 2 (see Table 8). A total of 59 tray-sized plots and 23 patches were transplanted. Planting sites in Area 1 and 2 were positioned 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. In Area 2, 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*).

Monitoring post-fire (2020 - 2022)

As most plot markers were burnt and we were unable to determine the exact location of many plots and patches, to continue monitoring clumps of regenerating *L. incisa* were tagged and given a new number in Aug/2020 (6 months after fire). The renumbered clumps were assigned to the lines and patches recorded pre-fire from their position within the recipient site. The longest axis of each clump was measured and a second axis at right angles measured to estimate of the area of each clump. If there was no tag at a clump, due to removal by flood water or animals, the clump was measured and designated as untagged. In 2022, the tags were relocated, and clumps were recorded again according to the new monitoring numbers.

Data analysis

The area of each clump was calculated by multiplying the two axes recorded. The clump area was then expressed as a percentage of plot area (L x W/40 cm x 40 cm), or if a patch (identifiable as substantially larger than the plot clumps) then patch area (L x W/80 cm x 80 cm). The percent values were then summed for each Line or Patch and the total divided by the original number of plots or patches on the Line or Patch. This gave a crown-cover value per plot or patch comparable to the pre-fire crown cover data, which was an average of all plots on a Line or all Patches. *L. incisa* crown-cover in Area 1 and Area 2 at different times pre- and post-fire were also comparable by summing the area of each clump/patch to give a total crown area of *L. incisa.*

3.3.2 Results

Crown-cover pre-fire

Over the first three years before the fire, *L. incisa* crown-cover fluctuated as drought and flood disturbances caused decrease in crown-cover, followed by crown-cover increase, as most plants were still alive and only defoliated or flattened. The transplanted *L. incisa* recovered from these disturbance events and established successfully at the recipient site. In July/2019, before the bushfire in November/2019, *L. incisa* had recovered from frond die-off during drought at the start of 2019 (see Fig 4) following late wet season rain. Crown-cover was 25% - 35% in most plots and patches in Areas 1 and 2.

Effect of the Nov/2019 bushfire

In Aug/2020, 6 months after fire, *L. incisa* had regenerated by resprouting from rhizomes in 32% of the pre-fire plots/patches, as indicated by 60 regenerating, discrete clumps/patches of *L. incisa* out of an original 189 plots or patches. In Area 1 (first translocation), the population contracted to Transect C and the eastern end of Transect B. Crown-cover had decreased, particularly on transect A (the lowest transect), the western half of Transect B and all of Transect D. Overall, losses were either in the western part of the site or at a lower micro-elevation. In Area 2 (second translocation), *L. incisa* recovered fairly well on Transects A & B, but patches in Area 2 had almost died out by 2020. The patches from the second translocation introduced to Area 1 in the vicinity of Transect C performed well. (Note - these patches were placed in Area 1 because results of the first translocation were good in this part of Area 1 and better protected from flash flooding.)

The bushfire appears to have caused *L. incisa* to contract to the eastern part of recipient site in a slightly more elevated position in relation to the swale. The fire (and possibly preceding drought), culled translocated plants from habitat where they were able to establish in the short-term (with the assistance of plant care including watering during drought periods) but unable to persist in the event of bushfire. Fire intensity was medium to high. *L. incisa* may have survived in the eastern end of Area 1 because groundwater was closer to the surface and provided enough capillary moisture for plants to survive very dry conditions and bushfire. It would be interesting to compare results of the separate in-situ monitoring project to see if the in-situ population also fluctuated in crown-cover and how it responded to fire (if burnt).

The translocated population had recovered from fairly severe flood and drought disturbances before the bushfire by reshooting from rhizomes after dieback. The fire in 2019 appears to have been of a more intense disturbance and killed many plants that survived previous drought and flood. Population contraction indicates rhizomes were killed either by fire or combined effect of fire and drought. It is unlikely that regeneration was suppressed by competition from dense ground layer regrowth after fire, as the species was also present in this regrowth. The

rhizomes of *L. incisa* are thin (one or a few mm in diameter) and grow horizontally in the topsoil close to the surface so may be vulnerable to hotter fires.

To examine the effect of micro-elevation and associated hydrology, *L. incisa* was planted in parallel lines at slightly different elevation within habitat that appeared to be suitable for the species. Before the fire, cover-abundance of *L. incisa* in Area 1 was highest on Line C and less on the other lines (see Fig 5; Table 8), suggesting that factors associated with micro-elevation affected *L. incisa* growth and survival. Of the four lines in Area 1, Line A was lowest in elevation and Line D highest but also further west. Small differences in elevation (a matter of a few centimetres) probably produce gradients of soil moisture and species composition/competition. Similar sensitivity to micro-elevation was recorded during the translocation of *L. incisa* on the Sapphire to Woolgoolga Project at Moonee Beach (Ecos Environmental 2011b).

Current year 2022

An increase in crown cover of *L. incisa* in 2020-2021 was followed by a very large increase in the current year, 2021-2022 (see Figs 5(a) & (b); Table 10 below).

Table 10: Changes in mean crown-cover of *L. incisa* over six years in Area 1 (the first translocation carried out in 2016) and Area 2 (the second translocation of unexpected finds in 2017). A medium to high intensity bushfire burnt both areas in 2019. A large increase in percent crown-cover (per plot and patch) occurred in both Area 1 and Area 2 in 2022. This data is graphed in Figure x and x below.

	Date								Fire			
2016, first translocation	**Sep-16**	**Jan-17**	**Mar-17**	**Jun-17**	**Nov-17**	**Mar-18**	**Feb-19**	**Jul-19**	**Dec-19**	**Aug-20**	**Aug-21**	**Nov-22**
Area 1 patches	30.75	41	52	25	32	53	2.6	36	0	1	2	0
Area 1 Line A	17.92	23.9	17.9	7	14.7	12.6	2.8	30	0	0	0	0.3
Area 1 Line B	11.25	15	15.5	9	14.9	24.7	5.9	25.5	0	2	3.2	94.4
Area 1 Line C	1.5	2	4.7	6	12.4	41.3	9.3	40.9	0	18	29	150.3
Area 1 Line D	3.525	4.7	13.8	12	15.1	11.9	3.5	25	0	0	0	0

	Date						Fire			
2017, unexpected finds	**Sep-16**	**Sep-17**	**Nov-17**	**Mar-18**	**Feb-19**	**Jul-19**	**Dec-19**	**Aug-20**	**Aug-21**	**Nov-22**
Area 1 patches	-	56.7	75.6	88.4	12.1	68.5	0	27	34	165.1
Area 2 patches	-	48.225	64.3	83.3	2.6	80	0	1	1	0
Area 2 Line A	-	20.1	26.8	25.9	0.5	6.8	0	6.3	13	57
Area 2 Line B	-	12.225	16.3	18.9	2.2	16.3	0	7	10.7	115.8

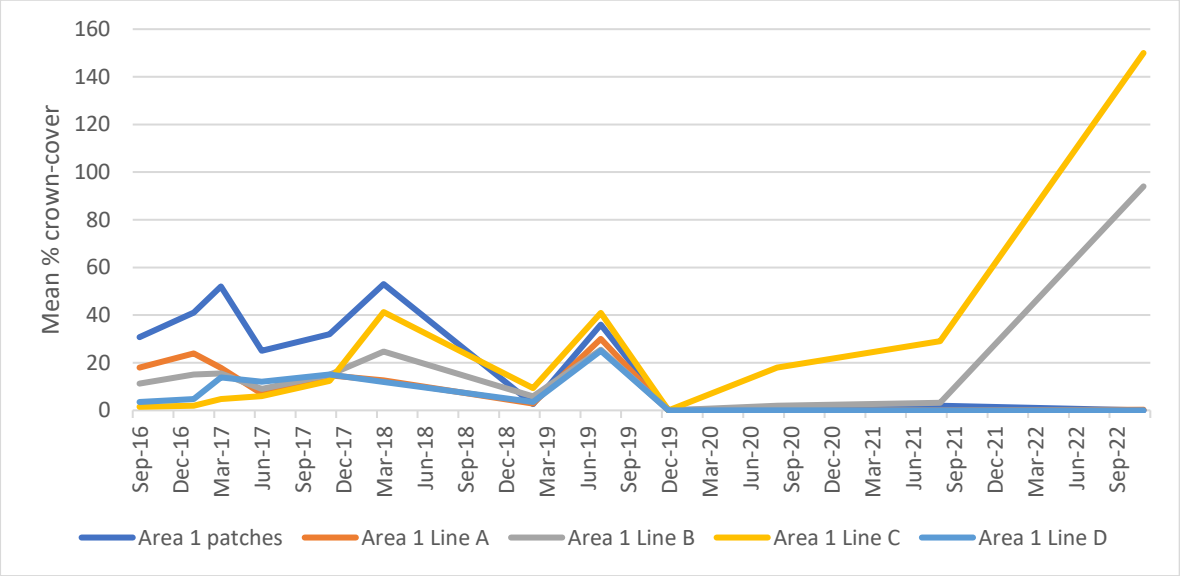


Figure 5(a): Slender Screw Fern – first translocation 2016, Area 1. Mean % crown-cover from 2016 when translocated to 2022. Mean % crown-cover is relative to plots (40 cm x 40 cm) on Lines, or patches (80 cm x 80 cm). Decrease in crown-cover occurred after environmental disturbances, the first to flash flooding, the second to drought and the most recent to drought and bushfire. After this event, Slender Screw Fern distribution contracted to the eastern end of Area 1 where it recovered after the fire by resprouting on Line C (yellow) and Line B (grey). Now confined to this section of Area 1, crown-cover increased greatly in 2022.

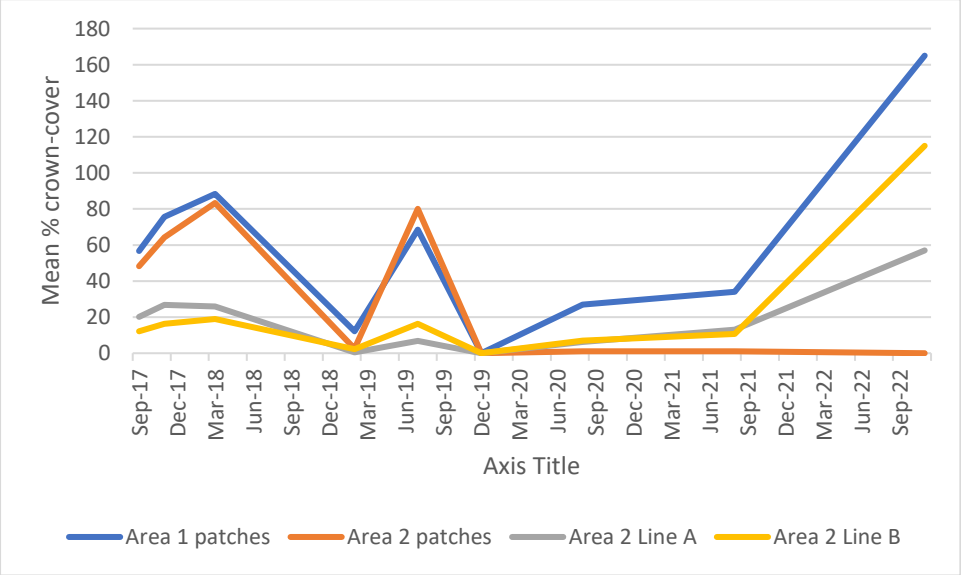


Figure 5(b): Slender Screw Fern – second translocation (unexpected finds) 2017, Area 1 and Area 2. Mean % crown-cover of Slender Screw Fern from 2017 when unexpected finds were translocated. Declines in crown-cover relate to flood and drought disturbances shown on Figure 4. Slender Screw Fern recovered well in the plots on Lines A and B in Area 2 and in the patches in Area 1. (Note - the patches were planted in the eastern end of Area 1 as results for the first year of the first translocation showed that plants were protected from flash

flooding and grew well, therefore survival more likely.) As for the first translocation, plants from the second translocation increased greatly in 2022.

Invasion of swale by exotic grass Setaria sphaecelata

A dense infestation of exotic *Setaria sphaecelata* (South African Pigeon Grass, or Setaria), a widespread pasture grass and invasive environmental weed, was recorded for the first time in Dec 2022 in swamp sclerophyll forest in the wide swale separating Area 1 and Area 2 at the Bundjalung National Park recipient site (see Plates 15-17). This invasive species overtops, smothers and often completely displaces the native ground flora of grasses, sedges, herbs and ferns (pers. obs.). Setaria was confined to the swale, 10-20 m from *L.incisa* plants which are on slightly higher ground (<50 cm difference in elevation). Setaria is commonly found on hills as well as low lying areas and may not have been growing at the level of the *L. incisa* plants, because it has not spread their yet. The infestation appears to have established recently, possibly assisted by the 2019 fire and floods.

As it represents a threat to the successfully established *L. incisa*, a recommendation is made in Section 5.0 to install monitoring plots at the recipient site to record the effect of Setaria invasion on plant species composition, map its extent, apply control methods and record whether control methods have been effective.

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

Monitoring of Slender Screw Fern on Sections 1-2 finished in 2020 after 5 years (initial translocation was carried out a year earlier in 2015). Monitoring by Ecos Environmental over the last three years recorded that out of 57 tagged points at the site, 35.1% had surviving plants in 2018, 15.8% in 2019 and 9.3 % in 2020. These results omit plants that had died previously, so survival rates were at least half those given. Surviving plants in 2020 were healthy and there was some lateral expansion of clumps but as the figures show, the translocated population at Kangaroo Trail Rd was in decline. 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 recipient 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 handsaw and chisel were used to remove sections of dead bark on which the orchid was growing so there was minimal disturbance of its roots. The pieces of bark supporting whole orchid plants were attached to suitable trees at the recipient site with cloth ribbon or wire.

A second translocation of this species was carried out after an unexpected find of additional plants was made during a pre-clearing survey south of Lumley's Lane (Section 10) in 2017.

Twelve small sections of branch with clusters of the orchid were removed from a *Melaleuca linariifolia* tree to adjoining swamp sclerophyll forest about 30 metres away and attached to the branches of paperbarks in August 2017.

3.4.2 Results

One of the 11 plants translocated in 2016 died after relocation to the recipient site due to moss placed for water retention that instead caused the orchids to rot. The other ten orchid clumps (without moss) were all looking healthy in Aug/2021, after 5 years. Some had dried racemes of seed pods.

Plants in the second translocation grew well and flowered during the first two years, but in 2020 all the orchid plants had disappeared and appear to have been stolen by orchid collectors, even though this species does not have colourful flowers. 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 Translocation Methods

Soil Seedbank Propagation

Topsoil was collected to a depth of 1-3 cm from under SMB on the highway footprint at Tabbimoble Creek and divided into three lots. Two were spread on sheets of tin to a depth of 6-8 cm, covered with different amounts of dry eucalypt leaves and twigs of different amounts and ignited to simulate bushfire of different intensity. Three treatments were compared: a 10 cm thick layer of litter (higher fire intensity), 5 cm of litter (lower fire intensity) and no litter or fire. After cooling the soil was transferred into plastic trays with a flat spade and placed under sprinklers in a shade house. Twenty trays of each treatment were prepared. Singleton Mint Bush seedlings were identified after 3-4 weeks and at 12 weeks, 10 trays from each treatment were selected at random and counts made of SMB seedlings and those of other species. SMB seedlings were potted-up and grown in standard, sterilised nursery soil mix for natives.

Recipient Site

The recipient site designated in the Strategy comprised an area of TfNSW land on the eastern side of the highway at Tabbimoble Creek, opposite the remaining part of the population on the western side of highway excluded from clearing. The forested section of this block closer to Tabbimoble Creek covering 100 m x 80 m was used as the recipient site. This site is on the coastal floodplain 3 km north of the Clarence River and supports grassy, layered, dry sclerophyll forest dominated by Swamp Box (*Lophostemon suaveolens*), White Stringybark (*E. eugenoides*), Blackbutt (*E. pilularis*) and Pink Bloodwood (*Corymbia intermedia*) with a mid-stratum of small trees, mainly *Acacia* and *Melaleuca* spp. and a lower stratum of grasses, herbs, sedges and scattered shrubs. Vegetation was relatively uniform in the recipient site and there was no obvious indication of variation in soil type. The recipient site contained approximately 50 SMB scattered over 0.1 ha about 30 m from Tabbimoble Creek. The site was fenced to exclude macropod grazing.

Planting Trials

Initial site-wide planting - 6 month old tubestock

Approximately 700 tubestock were planted throughout the recipient site at an average spacing of one per 4-6 m² in March 2017 when the seedlings were 6 months old and 35-45 cm high. An inspection three weeks later, after heavy rain and flash flooding, found that nearly all tubestock in the northern two-thirds of the site were affected by a wilt disease, whereas in the southern one third closer to the creek, the majority of plants were healthy. Soil ribbon tests indicated that soil texture varied within the recipient site, with increasing sand closer to Tabbimoble Creek and higher clay content further away. To examine the effect of soil variation on growth more closely, and to discount possible effects due to flash flooding and pre-planting herbicide application and other factors, further planting was carried out using an experimental design as described below.

Experiment 1 - effect of soil texture

Experiment 1 was designed to examine variation in soil texture and chemistry within the recipient site and their effect on survival of planted SMB. 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. Three 2 m x 2 m plots were placed on each transect 10-20 m apart. The plots were divided into quarters and each quarter (1 m x 1 m) 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 about a month older. Soil samples were collected from each plot and soil chemistry and particle size analysed by EAL at Southern Cross University, Lismore.

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

A second experiment was carried out to examine if plants propagated from cuttings would perform differently 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 geotechnical investigations associated with the highway pre-construction period. 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 closer to in-situ plants and Tabbimoble Creek and planted 17/11/2017.

Experiment 3 - effect of tubestock age

Nearly all 6-month-old seedlings died on transects T1 and T2 further from Tabbimoble Ck where soil sand content was low. 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 2m x 2m plot and planted 17/11/2017.

Fire Response – translocation site vs reference area

After the Nov/2019 wildfire, the fire response of translocated SMB in the recipient site was compared with a reference area next to Tabbimoble Creek on the western side of the highway, where most of the SMB population occurs. Fire intensity was low in the recipient site and moderate in the reference area, as indicated by flame scorch height (2-4 metres vs 8-12 metres). The fire response of SMB was recorded in the experimental plots (23, 2 m x 2 m plots) and over the rest of the recipient site in terms of mode of regeneration (Gill 1981), mortality and resprouting of pre-fire stems, seedling density and seedling height, 6 months and 2 years after fire. Four plots were established in the burnt reference area and the same data recorded.

Soil Analysis

Soil samples were collected from the experimental plots, next to in-situ SMB in the recipient site and in the reference area on the western side of the highway, to investigate variation in soil particle size (soil texture) and nutrient content. About 1 kg of topsoil was collected to a depth of 8 cm. Samples were bulked for Transects 1, 2, 4 and 5, which were oriented parallel with the creek and kept separate for Transect 3 which ran at right angles to the creek. A total of 17 samples including four from the reference area were analysed. Chemical analysis determined Ca, Mg, K, Na, N and P content, cation exchange capacity, pH, electrical conductivity, carbon and organic matter. Particle size analysis measured the percentages of gravel, sand, silt, and clay and assigned a standard soil texture class. Soil analysis was carried out at the Environmental Analysis Laboratory (EAL), Southern Cross University, Lismore.

3.5.2 Results

Propagation - soil seedbank treatments

Propagating SMB using the soil seedbank and fire was shown to be simple to apply, cost-effective and fast. Comparison of the three fire treatments showed that SMB seedling density and number of species germinating from the seedbank were much higher in the high fire intensity treatment, significantly less with low fire intensity and very low for the no burn treatment. No SMB seedlings germinated in the no burn treatment, very few in the low intensity treatment and many in the high intensity treatment.

Initial planting of Singleton Mint Bush

Seedlings planted within the recipient site closer to in-situ plants and Tabbimoble Ck survived but the majority of those planted more than 40 m from the creek died from a wilt disease, possibly caused by a microscopic water mould such as *Phytophthora*, which infects root hairs, preventing water uptake. The mean height (± s.e) of plants that survived the wilt disease was 31.3 ± 1.2 cm in November 2017, 91.4 ± 3.3 cm in July 2018 and 121.1 ± 12.8 cm in July 2019. The tallest plant in July 2019, four months before the fire was 268 cm. Some flowering occurred in spring 2019 but seed may not have fully matured when the fire occurred in Nov/2019 (discussed below).

Experiment 1 - effect of soil texture

Two months after the five transects in Experiment 1 were planted on Transects 1 & 2 at the northern end of the site (furthest away from the creek), SMB showed the same wilt symptoms as the first planting. Most SMB remained healthy on Transect 5 (closest to the creek) and on Transect 3 (the rill). On Transect 4 in an intermediate position, half the plants were healthy and half were wilting. Survivorship varied from 0% to 77%, increasing toward the creek as the topsoil became sandier (Figure 7). Soil analysis confirmed a gradient in soil texture with sand content increasing towards Tabbimoble Creek and clay content i(Figure 8).

Experiment 2 – effect of propagation type and fertiliser

Experiment 2 examined the effect of propagation type and fertiliser on rate of growth and survival. Height data were analysed using three-way ANOVA with three factors and two factor levels: propagation mode (seedlings vs cuttings), fertiliser addition (12 month slow release/no fertiliser) and block. As the six plots in Experiment 2 were arranged roughly in a line, plots 1-3 were placed in Block 1 and plots 4-6 in Block 2 as an indicator of variation in environmental factors such as shade and competition that could have affected the results. 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.

Experiment 3 – effect of tubestock age

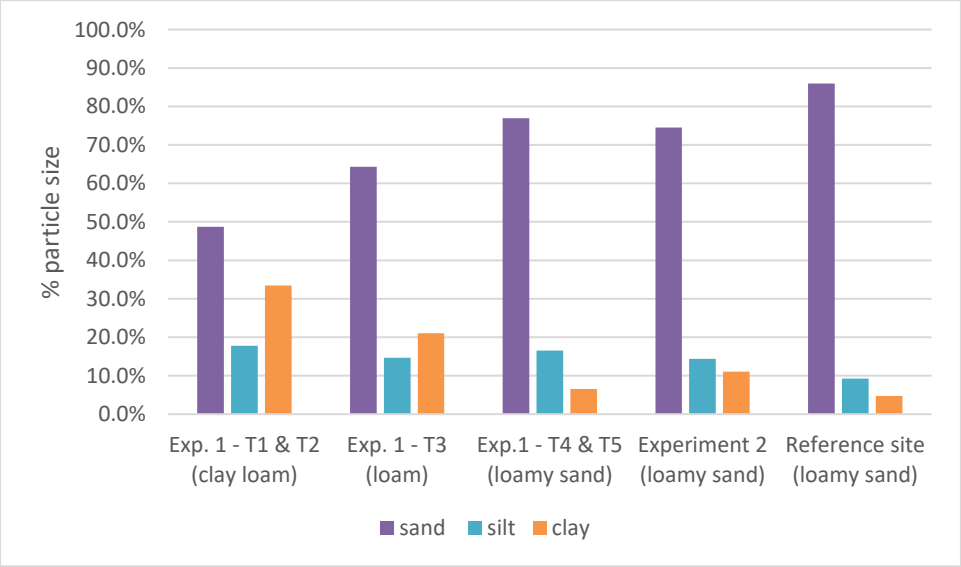
In Experiment 3, twelve month old seedlings were planted in two plots on Transect 2 from Experiment 1 where all 6-month old seedlings had died from wilt disease. Planted in November 2017, all plants survived for two years until the fire in November 2019 and there were no symptoms of the wilt disease that killed the 6-month-old seedlings. It appears the age of tubestock at introduction has a major effect on survival of translocated SMB. This could be related to the sterilised soil mix gradually being colonised by soil microflora and conditioning of seedling roots to tolerate sudden exposure to natural forest soil microflora. Lower rainfall between 2017 and 2019 than in 2016-17 may also have supressed the wilt disease, which appears to favour wet soil conditions.

Soil Analysis

The results of particle size analysis confirmed a soil texture gradient roughly at right angles to Tabbimoble Creek, grading from loamy sand close to the creek to loam and clay loam further away. The soil texture gradient appears to be related to sediment deposition by Tabbimoble Creek, which carries sand eroded from sandstone hills upstream and during floods the sand spills out onto the edge of the clay soil floodplain. Soil chemical analysis revealed variation in soil nutrient levels consistent with the changes in soil texture. T1 & T2 further from the creek and with higher soil clay content had higher CEC, Mg, K, Na, Total Carbon% and Total Nitrogen% than T 4 & 5 closer to the creek (Table 11). pH was slightly more acid and C:N ratio higher on T 4 & 5, predictable from higher sand content. P content was nearly constant.

Table 11: Results of soil chemical and particle size analysis of samples taken from experimental plots, elsewhere in the site and reference plots. Transects 1 & 2 were far from the creek; Lines 4 & 5 were close to the creek.

Mean values	**Transects 1 & 2** (far from ck)	**Transects 4 & 5** (close to creek)	**Reference plots**
CEC (cmol./kg)	8.4	6.0	4.0
% Ca	41.7	63.9	37.2
% Mg	49.8	32.1	52.8
% K	6.6	3.0	7.2
% Na	1.9	0.9	2.8
Total C %	4.5	0.7	3.1
Total N %	0.3	0.1	0.2
C:N ratio	15.3	26.1	20.9
P	2.7	2.8	2.9
pH	5.4	5.8	5.3



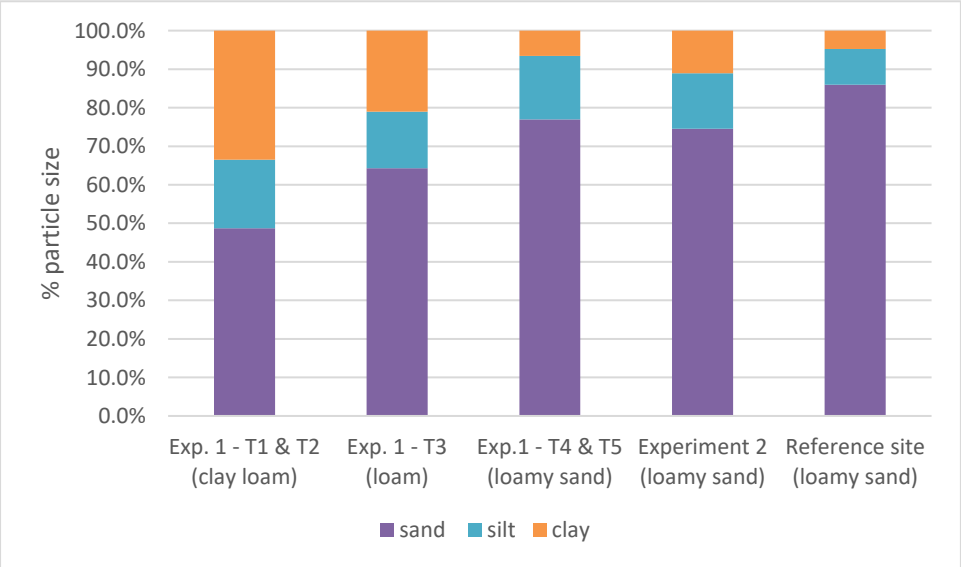


Figure 6 (a) & (b): Results of soil particle size analysis for plots on transects in Experiments 1 & 2 in the recipient site, and in the Reference Area shown as a bar chart and as stacked percentages. A soil texture gradient is evident with clay loam on T1 and T2 further away from the creek, grading into loam and loamy sand closer to the creek in T4, T5 and the Reference Site.

Population dynamics 2016-2022

The contribution of in-situ and translocated plants to the total population of SMB in the recipient site from 2016 to 2022 is shown in Figure 7. At the start of the project there was a population of about 100 SMB plants in the recipient site. Three years after translocation, before the Nov/2019 fire, the SMB population in the recipient site was increased substantially by addition of propagated plants. However, due to wilt disease related to soil texture variation and the pre-mature timing of fire, the translocated population regenerated weakly after fire, while the in-

situ population being older increased by seedling recruitment. By 2022 most of the translocation component had died out and the in-situ component remained, reducing in number due to natural thinning.

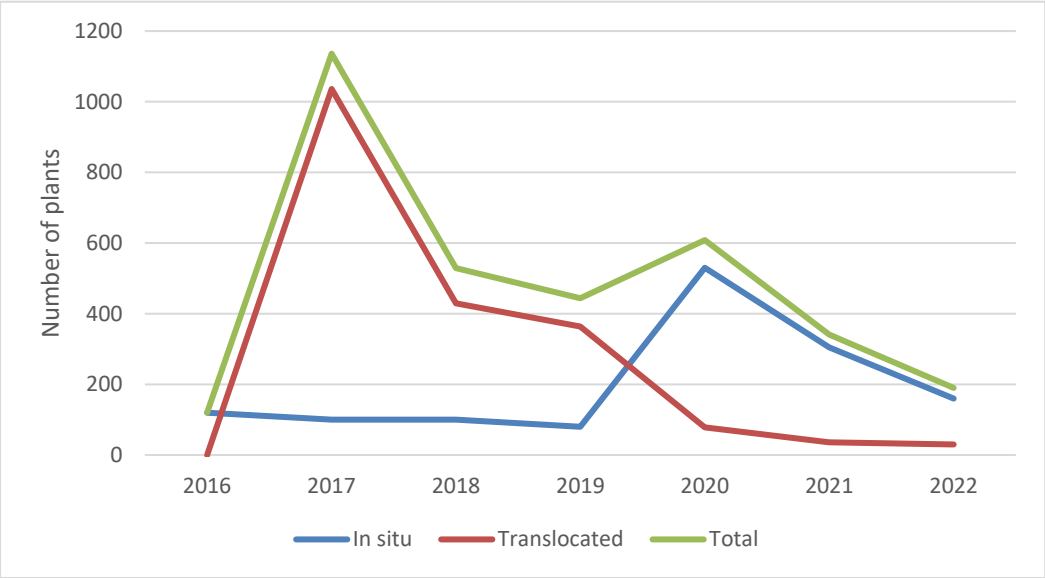


Figure 7: SMB population in the recipient site between 2016-2021 indicating numbers originating from translocation or the in-situ population.

Table 12: Number of SMB plants in the recipient site between 2016-2022 contributed by translocation and the in-situ population. 'Regen mode' indicates how each component regenerated after the 2019 fire. Normally this species would only regenerate from seed, as observed in the reference site, but resprouting occurred due to very low fire intensity in the recipient site.

Year	**In-situ origin**		**Translocated origin**			**Total**
	Original in-situ plants	Seedling recruitment after fire	Site-wide planting of propagated plants	Experiments 1-3	Seedling recruitment after fire	
2016	120					120
2017	100		700	336		1136
2018	100		200	229		529
2019	80		150	214		444
Fire November 2019						
Regen mode	resprout	seedling	resprout	resp./sdlg.	seedling	
2020	30	500	40	12	26	608
2021	25	280	30	6	3	344
2022	20	140	25	3	2	190
Percent contribution to total population 2022						
	11%	74%	13%	2%	1%	

Of 336 plants introduced to plots in the three experiment, 214 (63%) survived by mid-2019 before the fire. After a bushfire, a flush of seedling recruitment would normally produce a large increase in number of individual plants, but as the translocated plants were too young there was very little seedling recruitment and numbers fell to 38 in 2020 and 5 in 2022. Some plants resprouted after fire inside and outside the experiment plots due to very low fire intensity (Figure 7, Tables 12 and 13). By 2022, overall numbers had decreased by natural thinning to 160 in-situ plants and 30 translocated plants.

Summary: Translocation efforts were hampered by a naturally occurring wilt disease that killed nearly all 6-month old SMB seedlings from the initial planting in soil with higher clay content in the northern two thirds of the recipient site. When more advanced seedlings were planted, the disease was greatly reduced. However, these plants recruited very few seedlings after fire, as they were only 2.5 years old when burnt and little seed had been produced. It is also likely that due to the susceptibility of young seedlings to wilt disease on soil with a higher clay content, only the southern end of the site closest to Tabbimoble Creek with sandier soil was suitable habitat for SMB, which limited any potential to significantly increase the population size. Although translocation was not successful in increasing population size given the nature of the recipient site and the premature fire event, it did advance understanding of this species' ecology, particularly how its local distribution appears to be controlled by soil microflora and soil texture. It also demonstrated how horticultural practices influence and have unexpected effects on survival and growth of translocated plants.

If the in-situ population in the recipient site had simply been protected and no effort made to dampen the wildfire when it burnt across the road corridor, a healthy population would have regenerated after the wildfire from the in-situ plants and soil seedbank already present, without attempting to increase the population by translocation. Artificially inserting plants into the ecosystem was out of sync with natural cycles of weather and population recruitment.

Comparison of SMB fire response in the translocation area and reference area

All SMB plants in the reference area where fire intensity was higher were killed by fire and regeneration was only from seed, which is the characteristic fire response of an obligate seed regenerator. The dead frames of SMB showed all plants were old and senescent before the fire and were approximately 20 years old (previous fire observed by author). Mean seedling density of SMB was much higher in the reference area (42.00 ± 18.41 seedlings per m^2; no. of plots = 5)

In the translocation area, where fire intensity was low to very low, not all plants were killed by fire, and seedling density was much lower (1.13 ± 0.47, no. of plots = 23). In the three experiments, none of the remaining SMB plants resprouted in experiments 1 and 2 (all killed by fire), while in experiment 3 16.6% resprouted. This was probably due to variation in fire intensity and possibly wetting down of the forest edge by fire crews.

Seedlings next to translocated SMB were only recorded in experimental plots at the southern end of the recipient site approaching Tabbimoble Creek close to where in-situ SMB plants occur. Most of the in-situ SMB plants were killed by fire but some resprouted, as in the translocated plants, but there were more seedlings around the dead in-situ plants. The difference in seedling density appeared to be due to plant age, the in-situ plants being more than 10 years old and the translocated plants 3 years old.

SMB flowers in August- September and seed produced by the 2019 flowering before the fire may not have fully matured and been incorporated into the soil seedbank when the fire came through in November.

It is also possible that low densities of SMB seedlings germinating around translocated plants were killed by wilt disease, both in the experimental plots and the site-wide planting further away from Tabbimoble Creek where the soll was more conducive to wilt disease.

Overall, SMB remained where it was originally found when the translocation project was started, and efforts to expand the population by propagation and planting beyond in-situ plants, within the recipient site, were unsuccessful, although useful information was generated on the population ecology of SMB, including its life cycle and how its local distribution is constrained by interaction between small changes in soil texture and (pathogenic) soil microflora.

Lack of time to accumulate a soil seedbank probably reduced seedling recruitment in the translocated SMB. The plants were approximately 3 years old when burnt and some were over 2 metre high. Flowering (Aug-Sept) occurred in a few plants in year 2 and more in year 3 (2019) but there may not have been enough time for seed to fully mature and be incorporated into the soil seedbank before the fire. However, the initial planting and experiments indicate that SMB seedlings germinating on soil with higher clay content would have been killed by wilt disease when small.

In summary, it appears that very low seedling recruitment in translocated SMB plants was due to timing of the fire, which occurred before they had produced significant seed and accumulated a soil seedbank. In effect, the translocation was out of sync with the natural cycle of fire and plant maturation. However, even if fire had occurred later, the susceptibility of small seedlings to wilt disease on soil with a higher clay content, indicates that efforts to augment the in-situ population by planting in a wider area probably would have been unsuccessful. The population remained where it was originally found.

Table 13: Fire response of SMB in the three experiments and the reference area in terms of number of seedlings and established plants before and after the fire. Mean seedling density (± s.e.) was calculated from the plot data. Very few seedlings were recruited as the plants were still immature when burnt. Survivorship (%) is the number of plants surviving after introduction, which after fire is the percentage of plants in the experiments that resprouted. (Usually, this species only regenerates from seed after fire, but due to the very low fire intensity in the recipient site, some individuals survived and resprouted.) n = total number of plants translocated.

	2019 (4 mths pre-fire)		**2020 (6 mths post-fire)**		**2021**		**2022**	
	Plant survivor.	**Mean sdlgs (m²)**	**Plant survivor.**	**Mean sdlgs (m²)**	**Plant survivor.**	**Mean sdlgs (m²)**	**Plant survivor.**	**Mean sdlgs (m²)**
Experiment 1 (n=240)								
Transect 1	4%	0	0	0	0	0	0	0
Transect 2	0%	0	0	0	0	0	0	0
Transect 3	77%	0	0	0.73±0.49	0	0.13±0.13	0	0
Transect 4	31%	0	0	0	0	0	0	0
Transect 5	58%	0	0	0	0	0	0	0
Experiment 2 (n=32)								
Transect 2a	100%	0	0	0	0	0	0	0
Experiment 3 (n=72)								
	95%	0	17%	3.03±1.37	5%	0.5±0.25	3%	0.5±0.25
Reference Site								

	n/a	n/a	0	42.00±18.41	0	25.5±9.23	0	0

Regeneration of obligate seeders is generally suppressed by low fire intensity, so three factors – wilt disease, immaturity of translocated plants and low fire intensity - may have combined to constrain post-fire regeneration and limit the SMB population to sandier soil near Tabbimoble Creek.

Wilt Disease

SMB seedlings were affected by an apparent disease during translocation causing soft tissues of the growing stem apex and foliage to wilt (see photos in 2020 monitoring report) and death of many seedlings. These symptoms were common in 6 month old (hardened-off) seedlings introduced in autumn 2017, then again after floods in summer 2021/2022, but this time in older plants, up to 2 m tall. Some 50-75% of SMB plants in the recipient site were affected in March/2022, but only a small number in the reference area (<5 %). In older plants, the condition appears to result in defoliation rather than mortality, as stems remain green and probably reshoot.

The wilt symptoms occurred in the wet season during periods of high rainfall and soil saturation. Wilting is also common in SMB during drought periods, but the cause here is moisture stress, whereas the wilt observed in the wet season appears to be related to root damage caused by a soil pathogen. The leaves of SMB are soft and wilt easily during hot, dry weather, plants often defoliating to conserve moisture. The wet season wilt symptoms may be caused by *Phytophthora*, a microscopic water mould that infects root hairs. *P. cinnamomi* is reported to be indigenous to forests of the North Coast of NSW, where it is rarely associated with disease in natural vegetation, unlike in southern Australia (Pratt and Heather 1973; Weste 1994).

Summary

Translocation efforts augmented the in SMB population by about 16% after approximately 5 years (Table 12). The introduced plants were 2.5 years old when burnt and seed produced by flowering in September 2019 may not have ripened fully or been incorporated into the topsoil by November. Only the southern end of the recipient site closer to Tabbimoble Creek with sandier soil appears to be suitable habitat for SMB due to wilt disease killing seedlings in soil with higher clay content, which limited any potential to significantly increase population size. The increase in population size achieved was small, but information on species life history, ecology and translocation methods was greatly improved because of the translocation project.

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 (Table 8). After germination, seedlings were grown in native tubes in a standard, pine-bark based, sterilised soil mix for natives and dilute Seasol fertiliser applied. The tubestock were 6-months old, 35-45 cm high and well hardened-off when planted. From seed collection to planting took 8 months to complete.

Weeping Paperbark was introduced to three recipient sites: two on TfNSW offset land south of Tabbimoble Creek, west of the highway, and in the 'Tabbimoble Triangle' on the other side of Tabbimoble Creek, also RMS property. At the offset site 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, star picket and chicken wire fencing erected 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 needed control during the establishment period.

Tubestock were planted on the offset land south of Tabbimoble Ck in March/2017 and in the Tabbimoble Triangle in July/2017. All 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. Tubestock were planted in the northern part of the Tabbimoble Triangle in April 2018.

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 before the fire. 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

Regrowth after Nov/2019 bushfire

The three sites planted with *M. irbyana* at Tabbimoble Ck were burnt by a wildfire in November 2019 when the seedlings were approximately 3 years old and most plants were 1.5 m o 2 m high. Fire intensity at the two sites on the western side of the highway was medium to high and low at the site on the eastern side of the highway (the same recipient site used for Singleton Mint Bush). Fire killed the above ground stem system (low or high intensity) and the great majority regenerated by producing coppice shoots from the stem base and root crown. Nine months post-fire, the plants were about half their pre-fire height and 3 years after fire they were taller than before the fire. Of the 21 plants monitored, seed capsules were present on 4 plants in 2022 (none in 2021).

Mean Height (m)	2019 6 months pre-fire	2020 Approx. 9 months post-fire	2021 Approx. 2 years post-fire	2022 Approx.3 years post-fire
Plot 1	2.3 ± 0.1	1.0 ± 0.1	2.1 ± 0.1	3.0 ± 0.1
Plot 2	2.2 ± 0.1	1.0 ± 0.1	1.9 ± 0.1	2.8 ± 0.2

In November 2022, the total translocated population of M. irbyana was approx. 700 and plants over the three sites covered a similar total area to the impact site at New Italy, approximately 2 ha.

3.7 Tall Knotweed (*Persicaria elatior*)

3.7.1 Background

Tall Knotweed was translocated from a disturbed, swampy area next to the Maclean South turnoff to a recipient site about 0.5 km north in Yaegl Nature Reserve. There were four translocations of Tall Knotweed, one implemented in 2015 and three in 2016-7. Two planting areas were used next to the highway in the northwest corner of the reserve, Yaegl South planted in 2015 and Yaegl North planted in 2016 -17. The Yaegl South translocation was carried out during Early Works and results are described in Landmark Ecological Services (2016 & 2017). The second round of translocation was carried out by Ecos Environmental and results are described six annual monitoring reports (2017-2022), including the present one.

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 to mid-dense ground cover of grass and sedge. Tall Knotweed plants were relocated by direct transplanting. Fifty-five plants were planted about 10-20 metres inside the edge of the Paperbark 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 plants were alive and seedlings were observed at the tagged points in Spring 2016. Due to dry conditions in spring-early summer 2016 (Fig 4) all seedlings died. No Tall Knotweed plants were recorded at the Yaegl South in April 2018, approx. three years after translocation, but plants have been observed since. In Aug/2020, one patch of Tall Knotweed plants about 1.5 m wide was observed about 20 m north of the tagged points, inside the Paperbark forest. The site was wet and boggy, but there was no indication as to why this small patch of plants was thriving at this particular point, or where the seed had come from. About 30 plants were present in roughly the same area covering about 10 x x 20 m in 2022.

3.7.3 Construction Phase – Yaegl North (2016 & 2017)

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 second introduction site was established at Yaegl North 150-250 metre north of the first site. Three introductions were carried out in 2016-17. This site was more open and on the edge of paperbark forest rather than inside. Hydrological conditions (e.g. duration of flooding) appeare to be similar to the Yaegl South site.Three translocation were carried out salvaging further plants recorded by Geolink on the construction footprint at the Maclean South interchange, as follows:-

1. The first translocation was carried out in August 2016 and consisted of seven old Tall Knotweed plants. The plants were growing prostrate in water and were up to 3.5 m long. These plants were transplanted to shallow water at the recipient site and 20 plots were seeded with mud collected from around the old plants (see Table 8). Mud was spread in 1 m x 1 m plots where paperbark trees were widely spaced. Half the plots were in shallow standing water 1-10 cm deep and dug over with a spade to reduce sedge and grass competition (mainly *Eleocharis acuta* and *Paspalum distichum*). Twenty-nine plots were placed in the Couch Grass zone (higher – no standing water) and the Water Couch – Eleocharis zone (lower – shallow standing water) along about 150 metres of Paperbark swamp edge. Each plot was marked with a monitoring number.

2. In November 2016 more Tall Knotweed plants were found during pre-clearing surveys and translocated to the recipient site. These were seedlings 0.5 to 0.7 m tall. The plants were planted in the recipient site further into the swamp as conditions were dry. Twenty-seven clumps containing approximately 48 plants were transplanted and tagged for monitoring.

3. While carrying out the second translocation in November 2016, several hundred small, recently germinated seedlings of Tall Knotweed were observed. These were transplanted into pots and grown-on at Ecos' nursery. Tall Knotweed proved to be very fast growing and had to be pruned twice at the nursery to keep them at a manageable height (~1m). Planting was delayed until February/2017 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 that came as a flood one week later. All plants were flowering and seeding when planted and fortunately over 1 m tall as they were submerged with only the tops above water.

After introduction of Tall Knotweed, reduction of ground layer vegetation was carried out in the recipient site by hand weeding in 2018 and by herbicide spraying in 2019 and 2020 with the aim of stimulating seed germination.

3.7.4 Results – Yaegl North (Aug 2016 to Nov 2022)

Translocation 1- salvaged old plants and 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. Tall Knotweed seedling recruitment in the mud plots was sparse and recorded mainly in plots in the Couch Grass zone which is slightly higher than the Water Couch – Elaeocharis zone. Small, recently germinated Tall Knotweed seedlings were identified from their sticky, scented first true leaves.

Most seedlings died in 2016 during a 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.

In November 2021, 27% of plots had plants (22), height 20-60 cm, the majority with flowers.

November 2022 – see below.

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)

In November 2021, plants were present at two points (total 5 plants)

November 2022 – see below.

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 in late February 2017 there was a major flood. 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. In June 2017, 87% of the 15 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% respectively in one plot). These plants had all recruited naturally from seed produced by the plants introduced in February 2017, despite 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.

In Nov 2021, 47% of plots had TK plants (total 139), 70-150 cm high, most flowering.

By November 2022, seedlings were appearing 10-20 m away from the plot markers and it was difficult to determine what seedlings belonged to which translocation. A count of the total number of individuals was used to indicate the status of the translocated population (Figure 8; Table 14).

3.7.5 Total Translocated Population

The translocated population persisted on the recipient for six years (2016-2022) and fluctuated in number in response to highly variable weather conditions which included floods and droughts (Figure 4).

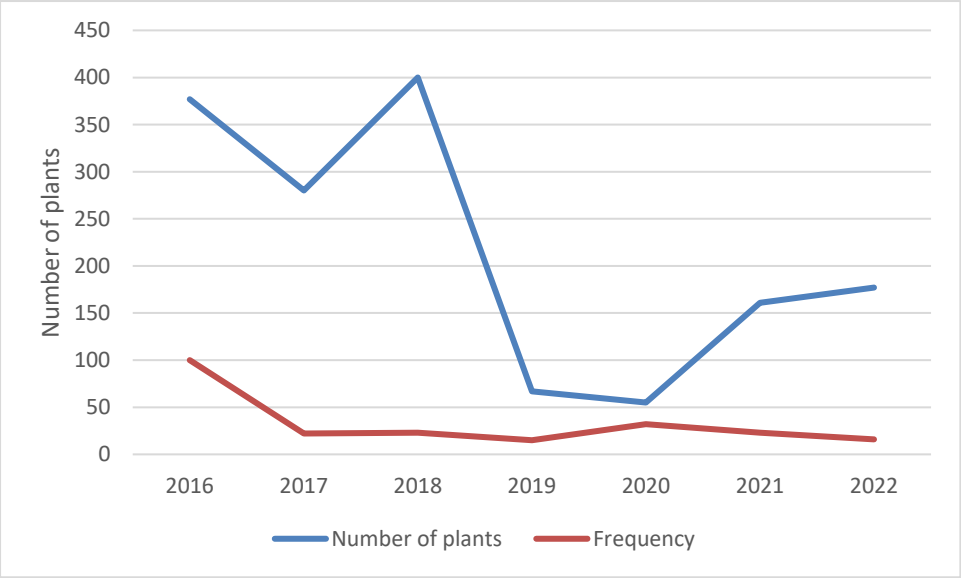


Figure 8: Changes in total number of Tall Knotweed plants at the Yaegl North recipient site over six years, after introduction in 2016 & 2017 (results of three translocations combined). 'Frequency' is the number of plots with Tall Knotweed shown as a percentage (i.e. 0-100 on the vertical axis). After the first 12 months, frequency stayed roughly constant at around 25%, while the number of plants fluctuated, declining steeply in the drought year 2019, and rebounding in 2021-2022.

Table 14: Changing size of translocated Tall Knotweed population between 2016 and 2022, at the Yaegl Nature Reserve recipient site. (This data is presented in the graph above.)

	Number of plants	Frequency
2016	377	100
2017	280	22
2018	400	23
2019	67	15
2020	55	32
2021	161	23
2022	177	16

Tall Knotweed Population Ecology

Monitoring of the translocations showed that Tall Knotweed is a fast growing, annual plant, with occasional over-mature plants persisting into a second year. Most plants in the nursery grew from seed to over a metre highl and flowered in only 3 months. Similar rapid growth was observed in some plants in the field.

Field observations indicated that seed germinates mostly as wet season floodwater recedes leaving damp open ground, although germination can occur any time of year if the substrate is damp and ground layer free of dense herbaceous growth. Survival of seedlings and young plants through the dry spring and early summer period requires the substrate to retain some moisture and not dry out completely. However, if mortality occurs, more seedlings germinate when rain returns. Tall Knotweed is favoured by disturbances that reduce herbaceous biomass and create small gaps or larger open areas on swampy or marshy ground, such as floods, grazing, slashing, and herbicide spraying. Flooding can kill herbaceous growth by prolonged submergence, creating open sites where Tall Knotweed germinated. In the past, fire burning into swamps in the dry season also probably created open sites for germination.

Tall Knotweed seed has a shiny, hard, black seed coat indicating it can lie dormant if conditions are too wet or dry, or ground layer vegetation too dense. There was no evidence of seed germinating underwater. When mature plants are flooded, they can continue growing like aquatic plants in water more than a metre deep if some leaves remain above water.

We were unable to maintain the large numbers of Tall Knotweed plants recorded at the impact site opposite the southern Maclean exit, at the recipient site. However, the impacted population was largely artificial, growing in an area of heavy soil disturbance, drainage work and possible soil dumping. The translocation established a low-density population in the recipient site (Figure x), with yearly recruitment and growth to maturity taking place naturally each year (with a bit of help by spraying out dense herbaceous ground layer to create open sites). On-going recruitment from year-to-year will depend on the ground layer vegetation not becoming too dense and soil conditions not too dry during the spring-early summer dry season. Numbers of this annual plant are likely to fluctuate seasonally and between years according to variation in rainfall and disturbance.

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, because they have dormant buds on stems, and roots for regeneration after damage caused by natural disturbances such as bushfire and storm blow-down.

Since adult seeders often transplant poorly, transplanting was limited to smaller, juvenile plants <30 cm in height on the highway footprint. These were transplanted into pots and grown-on in a nursery before planting out. Large pots were used so there was less disturbance of the root system during transplanting and the plants were grown in soil from the donor site (sandy loam). Care was taken not to over-water. Fifteen plants were grown in pots for about six months before introduction to the recipient site.

An attempt was made to propagate more plants using the soil seedbank method (as applied to Singleton Mint Bush), and also by seed collection and propagation. Very little seed was found in the short time-frame available 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, where soil was collected.

The recipient site for *G. quadricauda* is located in forest on the edge of the highway south of Tyndale adjacent to Pine Brush State Forest. The vegetation consisted of mature, heathy open forest growing on a deep, sandy loam soil. No fertilisers were applied except for a few pellets of an organic fertiliser while the plants were in the nursery.

3.8.2 Results

The juvenile plants transplanted to pots and grown in the local sandy soil, grew rapidly and continued rapid growth after introduction. All plants 'started to flower in 2017 and flowers and/seed pods have been recorded at every monitoring since. In the last 12 months, mean height increased slightly and there were no mortalities. Some plants had flowers or seed follicles, as in previous years.

Survivorship and mean height of translocated *Grevillea quadricauda*:

Monitoring Date	Surviv %	Mean Height (cm)
Nov-22	93.3	170.9
Nov-21	93.3	165.2
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 translocation target for *Cryptocarya foetida* was revised down from 41 in the Strategy (RMS 2015) to 28, as several individuals (with tags) had been mis-identified and were *C. microneura* or *C. triplinervis*. Some plants appeared to be hybrids between *C. foetida* and *C. microneural*, which were transplanted. In total, 24 sapling sized individuals (1-4 m tall) were transplanted by digging out a root ball by hand. All came from Randle's Creek in Section 10 adjacent to Coolgardie Rd. Previously TfNSW (RTA) supplied machinery and an operator to carry out transplanting, but on this project (W2B), management said it was the responsibility of the Principal Contractor and attempts by the writer to get them to supply machinery (excavator and truck) were unsuccessful, so all trees of threatened species too large to transplant manually, including *C. foetida,* were cleared.

Two recipient sites were used for this species - Lumley's Lane and Coolgardie Rd. All sapling size plants were introduced to Lumley's Lane, as per the Strategy (referred to as BOS 22). Habitat consisted of a lower, south-facing hillside covered by pasture and a few trees, adjoining rainforest regrowth on the Blackwall Range escarpment. Most of the regrowth forest is dominated by exotic broad-leaved privet and camphor laurel. An area lower down at the edge of forest and pasture next to a dam (to be used for watering) was selected as the recipient site. The soil type consisted of a heavy clay with minimal topsoil and surface rock formed on metasediment and basalt colluvium (cobbles), eroded from basalt capping the top of the escarpment.

Translocation was carried out by direct transplanting. The 24 saplings were dug out with a soil-root ball about 50 cm in diameter and the stem was pruned to reduce evapotranspiration stress. 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 recipient site was exposed with few existing trees so the transplants were relatively exposed.

A second recipient site was selected at Coolgardie Rd next to Randle's Ck, the original location of most of the *C. foetida* saplings. This area wasn't used for transplanting, as Lumley's Lane was the site nominated in the Strategy and use of the Coolgardie Rd area had to be approved. Propagated plants were introduced to the second recipient site after it became available because of the high mortality of salvaged saplings at Lumley's Lane, which was attributed mainly to an extreme heat event (see below). Soil conditions at the Coolgardie Rd site, which included some alluvium along Randle's Ck, appeared to match more closely the impact site on Randle's Ck on the highway footprint.

Twenty-eight *C. foetida* propagated from seed were introduced to Coolgardie Rd in Feb/2018. Additional watering was carried out during dry periods. The plants were mulched, organic and slow-release fertiliser applied and weed control carried out each year. Bush regeneration was carried out in rainforest adjoining the recipient site. Large exotic trees including a large *Ficus benjamina* were not removed as they were facilitating natural rainforest regrowth.

To restore natural habitat at Lumley's Lane, an area of about 1 ha was planted with local rainforest species (some salvaged from the footprint) and bush regeneration carried out in adjoining rainforest regrowth dominated by Broad-leaved Privet and Camphor Laurel. The latter species were poisoned to release any supressed native rainforest species growing with the exotics and to stimulate germination of native species from the soil seedbank (if present).

3.9.2 Results

Saplings of *C. foetida* transplanted to Lumley's Lane started to reshoot about 4 weeks after introduction. Epicormic shoots grew from the main stem and pruned branches. By January 2017 (~6 months after transplanting) 62.5% of the saplings had reshot and were alive. Two extremely hot days in Feb/2017 (hottest on record for most of the Far North Coast) caused leaf scorching and die-off in about half the surviving transplants, which reduced survival rate at the end of Year 1 to 26.9%. Two individuals defoliated in the heat wave reshot. No more mortalities occurred, and survival levelled off at 25% (6/24). In 2022, the tallest of six surviving *C. foetida* at Lumley's Lane was 4.2 m, increasing from 1.3 m in 2017 (no. 3/0012).

The survival rate of 28 *C. foetida* propagated seedlings at Coolgardie Rd in 2022, after approximately six years, was 61% and the mean height of surviving plants was 120 cm (Figure x). Survivorship had declined from 89% to 61% in 12 months, a steep drop compared to previous years. About half of the surviving plants had unhealthy yellowish or dull leaves, which appeared to be due to very high rainfall in 2022 (resulting in the record Feb/2022 Lismore flood and a second flood shortly after) and prolonged soil saturation. Yellowing of leaves, an indicator of soil waterlogging, was present on few plants in previous years as floods probably drained away faster. It is unlikely slow release fertiliser was over-applied as yellowing was absent on other translocated rainforest species.

Habitat rehabilitation work carried out at both sites from 2016 to 2021 included spraying of herbaceous weeds, injecting exotic trees, planting of local rainforest species and removal of exotics from adjoining natural rainforest and regrowth, as described above. Results have been positive although the response of native vegetation very slow on the poor metasediment soil.

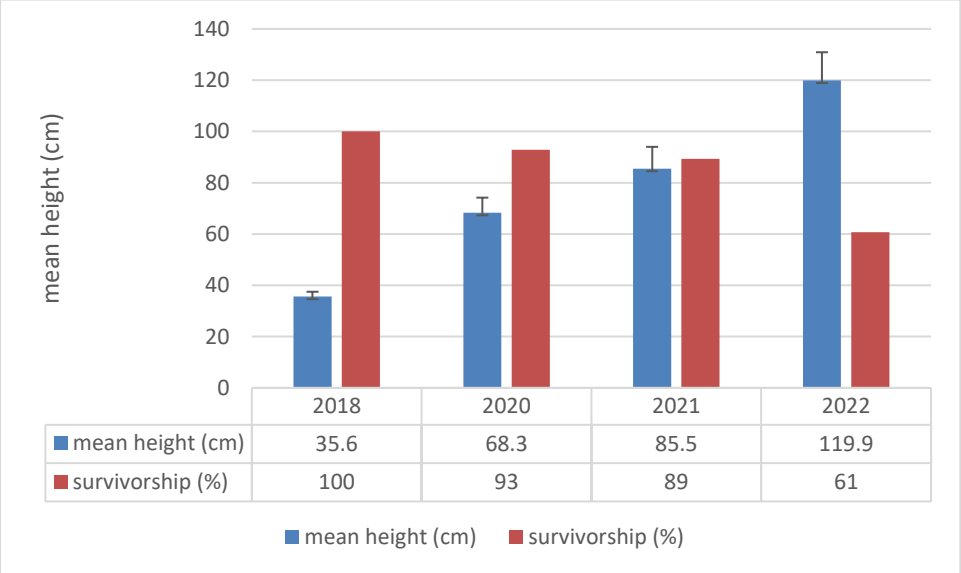


Figure 9: Mean height (cm) standard error bars shown and survivorship (%) of *Cryptocarya foetida* propagated from seed at the Coolgardie Rd recipient site, showing increasing height of surviving individuals and a decline in percent survival in 2022 due to very high rainfall and prolonged soil waterlogging in the first half of the year.

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

3.10.1 Translocation Method

Three saplings were transplanted to the Lumley's Lane recipient site and three juveniles to pots for growing-on at the nursery. Some larger trees were unfortunately cleared. 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 recipient site in Feb/2018.

(Note - more seed was collected from Section 10 and propagated for the recipient site near the Maclean South 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 and reported on separately.)

3.10.2 Results

Only one of the three transplanted saplings at Lumley's Lane reshot. The height of this individual was approximately 3.3 m in 2022.

The survival rate of propagated seedlings introduced to Coolgardie Rd was 90% after 6 years. Mean height increased slowly each year to 145 cm in 2022 (Figure 10). There was little evidence of leaf yellowing as seen *C. foetida.*

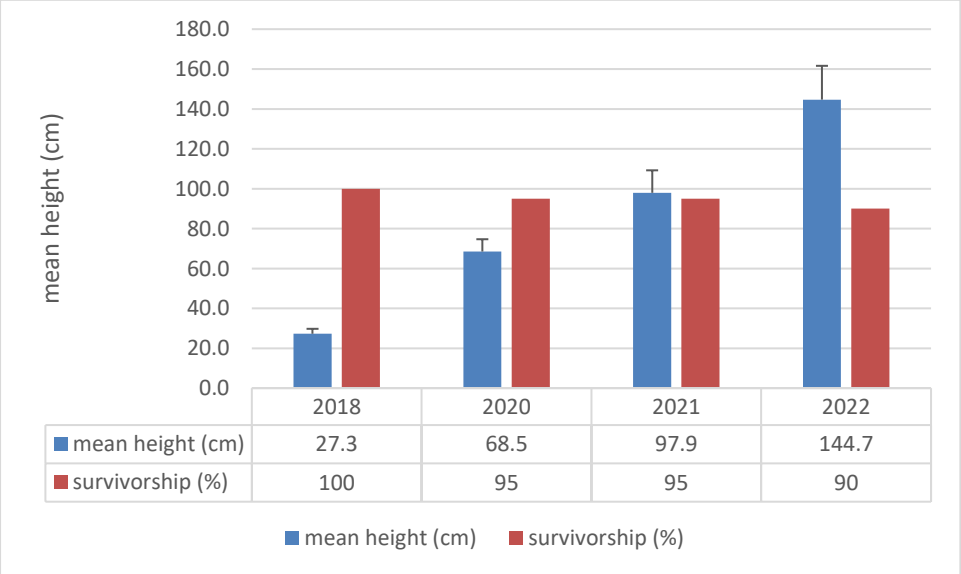


Figure 10: Mean height (cm) standard error bars shown and survivorship (%) of *Endiandra muelleri ssp. bracteata* propagated from seed at the Coolgardie Rd recipient site, showing increasing height of surviving individuals and a 10% decline survival in six years.

3.11 Red Lilly Pilly (*Syzygium hodgkinsoniae*)

3.11.1 Translocation Method

A total of 42 Red Lilly Pilly seedlings were introduced to the rainforest recipient sites at Lumley's Lane and Coolgardie Road, including six juveniles salvaged from under a large tree (cleared) north of Lumley's Lane in Oct/2016. About 50 Red Lilly Pilly were propagated from seed collected in August 2016. Thirteen were planted out at the Lumley's Lane recipient site on 1/6/2017 and the remainder grown-on for another six months. Thirty were introduced to the Coolgardie Rd recipient site in December 2017, including the small potted transplants. The plants received intensive care, including additional watering during dry periods, mulching, shielding from direct sunlight and addition of fertiliser. Wire tree guards (1.2 m high) were installed to reduce grazing by wallabies.

3.11.2 Results

Propagated seedlings introduced to Coolgardie Rd showed very slow growth, susceptibility to disease and a low survival rate. Survival of 30 seedlings after 3.5 years (2021) was 17% with 5 surviving. Mean height averaged over all seedlings including zeros was 12 cm (see below). The tallest plant was 1.4 m, but it had 'red tip' and few leaves. In Nov/2022, 5 plants were still surviving and mean height was 10.4 cm.

Soil over most of the Coolgardie Rd site was a hard alluvial clay derived from metasediment and possibly too heavy textured for this species. The species grows naturally nearby on gravelly sand in the channel of Randle's Creek and the large cleared tree grew on coastal sand-slope colluvium at the base of the Blackwall Range on the highway footprint. These soil conditions were approximated closer to the creek, but planted seedlings grew poorly.

This species has proven difficult to establish on other translocation projects due to lack of vigour and infection of growing tips with a red witches broom, even on basaltic krasnozem (e.g. T2E Project near Bangalow). Nurseries don't grow the species because witches broom stunts or completely stops growth. Mature trees have been transplanted successfully and they don't develop the witches broom problem (e.g. BH2Y) so it is a pity effort wasn't made to salvage a single large tree cleared at Lumley's Lane.

It was observed that if the witches broom is left on the plant rather than picking off the scab-like hardened tissue, healthy leaves often emerged from the hard cap of red tissue. Picking it off appeared to worsen the problem as this removed apical buds still functional inside the witches broom, so no growth occurred. Sometimes shoots were produced from the stem below the red tip infection, but then became infected too.

Red Lilly performed better at Lumley's Lane than Coolgardie Rd. Survival of 13 seedlings after 3.5 years was 92% and mean height averaged over all seedlings including zeros was 83.4 cm. The tallest plant was 1.4 m with new leaf growth. Plants at Lumley's Lane received more mulch, competition from existing trees was less, soil drainage was better and seedlings were planted 6 months earlier than at Coolgardie Rd. However, the condition of most plants was fairly poor. The soil was a clay formed on metasediment on a lower slope, but the site was sloping and better drained. Initially the site was open with few shade trees. Although growth was better, plants were susceptible to red tip and dieback. This species appeared to be infected with three different diseases, sometimes all were present on one plant. I have called these 'red tip', 'leaf decline' and 'brown spot'. In 2022, some plants were also infected with Myrtle Rust.

Lumley's Lane recipient site (Area 1) – 13 plants introduced

Date	Mean Height (cm)	%Survival
Nov-22	82.3	92%
Nov-21	83.4	92%
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 recipient site (Area 2) – 30 plants introduced

Date	Mean Height (cm)	%Survival
Nov-22	10.4	17%
Nov-21	12.9	17%
Aug-20	22.2	34%
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 recipient site at Lumley's Lane in 2016 and six juveniles were transplanted to pots, grow-on at Ecos' nursery then planted at Coolgardie Rd in 2017. Plants were dug out manually as described for *C. foetida.*

3.12.2 Results

Lumley's Lane recipient site - two transplanted saplings were in good condition in 2022 after six years. Mean height was 415 cm.

Coolgardie Rd recipient site – the six plants were in good condition in 2021. In 2022, three had died, probably from prolonged soil waterlogging due to floods at the start of the year. Mean height 4.5 years after planting was 305 cm and the tallest plant was 380 cm.

Table 15: Mean height and survivorship of sapling and juvenile White Laceflower transplanted to the two rainforest species translocation sites. N = number of plants translocated.

	Mean Height (cm) Lumley's Lane	**Surv. (%) N=2**	**Mean Height (cm) Coolgardie Rd- Area**	**Surv. (%) N=6**
Nov-22	415.0	100	305.0	50
Nov-21	345.8	100	282.5	100
Aug-20	279.5	100	217.7	100
Jul-19	208.5	100	152.7	100
Jun-18	134	100	92.5	100
Jun-17	72	100	In nursery	

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

3.13.1 Translocation Method

Rough-shelled Bush Nut was translocated using seedlings propagated from locally collected seed. These were introduced to the Coolgardie Rd recipient site which is close to the locations impacted on the footprint. Seed were collected from rainforest regrowth on the lower slopes of the Blackwall Range near Coolgardie Rd and an unusual group of trees on a property at the end of Whytes Rd, Pimlico growing on sandy soil on the inland edge of the Pleistocene sandplain. These plants have a densely coppiced growth form, somewhat like the tree cleared next to Coolgardie Road and may preserve a similar genotype. From approximately 50 seeds collected, eight seedlings were planted out.

3.13.2 Results

This species performed well on the poor metasediment soil at Coolgardie Rd. In 2022, only one of the seven seedlings planted had died. Mean height after 4.5 years was 231.8 cm.

Mean height (cm) of Macadamia tetraphylla propagated from seed and introduced to the Coolgardie Rd rainforest species recipient site:

Date	Mean Height (cm)	Survivorship (%) N=7
Nov-22	231.8	86
Nov-21	192.5	86
Aug-20	124.3	86
Jul-19	55.2	100
Jun-18	31.2	100

3.14 Square-fruited Ironbark (*Eucalyptus tetrapleura*)

3.14.1Translocation Method

Eight saplings were transplanted from a crown land site on the footprint where a small number of Square-fruited Ironbark were planted for a special occasion (local government?) about 5 years previously. They were planted at the Sunnyside Rd offset site where a natural population of *E. tetrapleura* occurs in Oct/2016.

Seventy-nine tubestock propagated from seed were planted as part of the first round of translocations (Sect 1&2) at Sunnyside Rd in autumn 2017.

Seed of Square-fruited Ironbark was collected by Ecos Environmental for the RTA at Glenugie in 2014 and stored in a fridge at 5 degrees C. On informing TfNSW about the seed in 2020 as *E. tetrapleura* was still well below the translocation target, Ecos Environmental was engaged by TfNSW to propagate 800 tubestock from this seed and plant them at the Sunnyside Rd offset site. The seed was still viable after five years in cold storage. Propagation was carried out and planting completed in Oct 2020.

3.14.2 Results

Three saplings from the crown land site turned out to be Square-fruited Ironbark. The others were different species.

The first round of 79 tubestock planted in autumn 2017 grew poorly. Leaves were few and unhealthy looking and plants looked stunted. This was in contrast to saplings of Square-fruited Ironbark growing naturally near the planted tubestock. These may have been from suppressed lignotubers growing in the paddock when the property was purchased by TfNSW and cattle removed.

When inspected in December 2022, the second planting of 800 tubestock planted in 2020 had grown but the plants looked in poor condition, similar to the first planting. Mortality was about 50%.

In has only become clear that the naturally recruiting ironbarks at Sunnyside Rd in the open paddock downslope from the shed were *E. tetrapleura* in the last couple of years. Previously it was thought they were *E. fibrosa*. The naturally recruited *E. tetrapleura* near the planted tubestock are growing well and are small trees now 3-4 metres high. They will probably eventually cover the paddock, forming an *E. tetrapleura* forest. The soil at Sunnyside is a very

low nutrient, poorly drained, hard, sandy clay and the poor condition of the translocated *E. tetrapleura* may be typical of how the species grows in the first years as it establishes.

3.15 Hairy Melichrus (*Melichrus hirsutus*)

The two plants transplanted from the footprint in 2016 have survived and flowered each year from 2017 to 2022.

3.16 Hairy Joint Grass (*Arthraxon hispidus*)

3.16.1 Translocation Method

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

HJG was translocated on Sections 1-2 & EWSSTA to Kangaroo Trail on Section 1 in Sept/15 and to a site on the southern outskirts of Woodburn (also referred to as Trustrum's Hill, but on the floodplain, not a hill) in July-Aug/15. The Trustrum's Hill recipient site next to a powerline easement had two planting areas – Site 1, a low-lying area with 3 plots and Site 2 on a slightly higher terrace, with eight plots (Table 9)

On Sections 3-11, HJG was translocated from Section 10 between Coolgardie Rd and Lumley's Lane, and from Section 3, Mitchell Rd, SE of Tucabia. Plants on Section 10, were translocated to a recipient site at Lumley's Lane and from Section 3 to the adjoining road reserve at Michell Rd. Fifty trays of plants were salvaged from Section 10 and planted into 43 1 m x 1m plots at Lumley's Lane recipient site in Nov/16. Each plot had approximately 50 plants (43 x 50 = 2150 plants). At Mitchell Rd, approximately 1000 plants were translocated to 20 plots in Sept/16. All plants consisted of young seedlings of this annual grass species, which flowers and seeds in autumn.

3.16.2 Results

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

The populations translocated on Sections 1-2 & EWSSTA either declined 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 recipient site. However, on monitoring this site in autumn 2018, Ecos Environmental recorded 11 clumps of HJG in seed and some were near tags with 'A.h.' (*Arthraxon hispidus*). No HJG plants were recorded in the previous two years (after translocation in Sept/15) but from the tags they appeared to be sourced from the initial translocation.

Slabs were salvaged on EWSSTA at Trustrum's Hill (Woodburn South) in July-Aug 2015, a time of year when this annual species is either dormant as seed 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 at Trustrum's Hill/Woodburn south. The slabs had no HJG plants but were thought to contain seed of this species. Based on research carried out by Ecos on the Tintenbar to Ewingsdale project, HJG seed should have germinated in July-August and tiny seedlings would have been present. (Although minute, HJG seedlings can be distinguished by the relatively wide first leaf which is much broader than other grasses, but not mention is made of this.)

The 2017 monitoring report by Landmark stated that at Trustrums Hill (not a hill, but a floodplain) one plant was observed by bush regenerators at Site 1 in February 2016, and none were observed during monitoring in autumn 2016 and autumn 2017 (Table 9) and the slabs were overgrown with dense Setaria grass (Setaria sphacelate). Attempts were made to reduce biomass (by slashing?), but no further plants were recorded. At site 2 with eight plots, dead plants were recorded in autumn 2016 and 2017 indicating that HJG (an annual) had recruited from seed, but no dead plants were observed in June 2018. No evidence of HJG plants was observed at the plots at Trustrums Hill in Aug 2020 when monitoring finished.

Overall, the translocation of HJG at Trustrum's Hill was unsuccessful in maintaining a population in the recipient 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 prefers the edge of wetlands, but not standing water.

Sections 3-11

HJG recipient sites on Sections 3 and 10 (Mitchell Rd and Lumley's Lane), produced new annual plants each year from 2016 to 2022, although HJG crown-cover has decreased due to removal of cattle and build-up of perennial grass. HJG requires an open site where the ground layer vegetation for at least part of the second half of the year is low and open, and there are gaps between perennial grass plants where seedlings of HJG can germinate and begin their annual life cycle. In its present habitat on agricultural land, these conditions are maintained by cattle grazing, or tractor slashing if cattle are removed.

At Lumley's Lane on Section 10, a very large HJG population in the paddock at the offset site (referred to as BOS 22), decreased in 2020 and 2021 due to dense pasture growth (without cattle grazing), but HJG remained in the lower half of the paddock next to the highway. A similar situation persisted in 2022. A dense population of HJG was present next to the local access road and highway, just inside the gate in Dec/2022. This paddock was slashed probably twice in the last two months by the contractor looking after the koala tree plantings (small blocks have been planted in the offset site).

3.17 Lindernia (*Lindernia alsinoides*)

3.17.1 Methods and Results Section 3

Transplanting of Lindernia, an unexpected find on Section 3 made by Geolink during a pre-clearing survey, was carried out in December 2016. Thirty spade sized sods (20-30 cm thick) of Lindernia, a small herb, growing in black peat were transplanted to a recipient site on the opposite side of the highway on the same drainage line, downstream about 100 metres from the impact site. This site selected at short notice, proved a poor choice, as being on the downstream side of the small creek it received drainage from earthworks on the construction site.

After transplanting at Mitchell Rd on Section 3 in December 2016, run-off from earthworks deposited iron leachate at the recipient site in autumn 2017, blanketing plants with sludge. In July 2019, water quality was much improved, and it seemed possible some plants could regenerate from seed or runners from the transplanted sods. In Aug 2020, iron leachate deposit was present again. No plant were present when inspected in 2021 and 2022.

Survivorship:

Mitchell Road – all plants in 30 sods appeared dead after two years (June/18). No Lindernia plants have been recorded since. A few plants have persisted in the road reserve in the drainage swamp on the opposite side of the highway, in what remains of the original seepage swamp (November 2021).

In-situ Lindernia sites monitored for the W2B project, recorded substantial decline during drought in 2018-19 drought (C. Thomson, Jacobs, pers. comm.), suggesting the very dry conditions may have been a cause of the loss of translocated plants. However, the drainage line at the Lindernia translocation site at Mitchell Road remained damp to boggy during this period and on the upstream side of the highway, the few remaining in-situ plants were still present.

The Lindernia translocations were useful in clarifying the narrow habitat niche of this species. Lindernia is a perennial, rhizomatous, semi-aquatic herb with a specialised habitat consisting of swampy drainage lines and seepages or springs in hilly sandstone terrain. The seepage zone is active in the rainy season, but sub-surface moisture keeps the soil damp so that a peaty soil develops over sand. At Mitchell Rd (Section 3-11) the peat layer was 20-30 cm deep. Natural vegetation consists of sedges and herbs of marshy ground, and sphagnum moss, under an open woodland canopy of waterlogging tolerant trees including Swamp Mahogany (*Eucalyptus robusta*) and Paperbarks (*Melaleuca spp*.). With clearer understanding of the habitat of this species, translocation may be more successful if it has to carried out again.

3.17.2 Methods and Results Sections 1-2

Three recipient sites were used for translocating Lindernia on Sections 1-2 & EWSSTA (see Table 9). 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. These sites were monitored by Landmark and then by Ecos Environmental. The translocations were unsuccessful and from our inspections appeared to be due to selection of recipient sites with unsuitable habitat. Soil tat all sites had a clay-silt texture rather than peat overlying sand soil profile that appears to be required by Lindernia. Macropod grazing was not the cause of plant death as the same result occurred at Kangaroo Trail (fenced) and Halfway Ck Crossing (unfenced).

A large number of propagated plants was introduced to the Kangaroo Trail and Halfway Ck Crossing recipient sites. A handful survived at Halfway Creek by July 2019 and none were present by Aug 2020. At Kangaroo Trail, a planting of 350 nursery propagated plants in Jan/16 died out in six months. A second large planting was carried out in autumn 2017 (428 plants Table 9), but nearly all plants died again after 12 months. The habitat selected was clearly unsuitable for Lindernia.

Survivorship:

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 9).

3.18 Rotala (*Rotala tripartita*)

3.18.1 Translocation Method

Approximately 10 plants growing in a man-made drainage depression on the eastern side of the highway opposite Tullymorgan Road were salvaged in Sept/17 and grown-on in pots at Ecos Environmental's nursery before planting out 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 rescue site, a TfNSW offset property. Two ponds were dug with an excavator on a minor 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 from plants salvaged from the donor site. These were planted into the recipient site in pots by burying the pots, so they could be dug up and their position adjusted with respect to water level. Hydrological regime can be critical for wetland plants that grow in shallow water or on the edge of wetlands.

Two adjustments were made to the position of pots as water fell in the pond during dry weather. Stolon runners had already been produced extending out from the pots a short distance, 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 site disturbance by wild pigs.

3.18.2 Results

Survivorship was 90% after approximately 6 months (July/18) and stolons grew up to 10cm from pots taking root in the damp substrate. After 18 months, survivorship fell to 38% or 17 plants (both ponds combined). After 30 months (Aug 2020), all the plants in pots had died at both ponds, but runners outside pots in Pond 1 were still alive and fifteen discrete clumps representing original pot positions were counted, equivalent to a survival rate of 30%. The Surviving plants 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 pots placed lower down in the pond basin) and it can survive in seasonally dry ground, probably as a dormant runner, then reshoot again with a return to wet conditions.

Rotala plants were present at the same positions in 2021 as 2020, along the eastern side of Pond 1 (the northern pond) over a distance of 17 m. The number of plants/clumps had increased slightly to approximately 20. At Pond 2 (the southern pond on same drainage line), three clumps were recorded after none were recorded the year before, possibly because they were leafless and unobserved, or they may have been recruited from seed.

In 2022, no Rotala plants appeared to be present at Pond 1 or Pond 2. At Pond 2 where most plants were found in 2021, dense grass was overtopping the edge of the pond where the

Rotala grew last year, so it may have been shaded out. Wild horses, removed from property in 2022, may have kept grass growth in check around the ponds. Rotala may have been adversely affected by the high rainfall and prolonged submergence during the floods at the start of 2022. Overall, the response of Rotala to translocation at both of the artificial ponds showed little growth or vigour. It appears to spread by surface stolons or runners, but little stolon growth occurred from where it was planted around the edges of the ponds. The freshly excavated clay substrate at the ponds may not have provided good habitat for Rotala, which may require high soil organic matter for healthy growth being a marsh plant. The plants flowered but no evidence of seedling recruitment on the more or less bare edges of ponds was observed. It is possible regrowth of the Rotala plants will occur as growth conditions change.

3.19 Richmond Birdwing Vine (*Aristolochia pravevenosa*)

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

Survivorship in 2021 was 100% after four years and in 2022 decreased to 63% (Table 8), due to loss of four plants probably to flood and extended period of saturated soil, which had a similar effect on other translocated species such as White Laceflower and Stinking Cryptocarya.

3.20 Carronia (Carronia multisepala)

Propagated from stem cuttings collected Nov/17. Six plants introduced to the Coolgardie Rd rainforest species translocation area in June/18. Survival to Aug/2020 was 40%. Very little growth had occurred and the two plants surviving in 2021 were dead in 2022.

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 healthy, 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 recipient 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 recipient 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 set of criteria for assessing outcomes, including 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 and populations to be functional, self-sustaining and viable at least in the short to medium term.

4.3 Translocation Outcomes

As Tables 12 & 13 of the Strategy are long and repetitive, an attempt was made to provide a more succinct assessment, which is shown in Tables 16 and 17 below. Results of each translocation was ranked as Good, Fair, Poor or Failed, based on species survival after translocation (survivorship), target attained, population health and likelihood the translocated plants will persist and establish a functional population. 'Good' requires that plant number is above than the 30-40% loss threshold specified in the Strategy. A population is likely to persist in the short-term if it exhibits healthy growth. Pesistence over the long-term requires the population to reach reproductive maturity, produce seed and recruit seedlings (or vegetative recruits if a clonal reproducer) and demonstrate population sustainability. For most plant species translocated, this is can not be directly assessed as the processes involved may take several decades or longer. However, it is still possible for the translocation practicioner to make a subjective assessment of the likelihood of long-term persistence base on various indicators.

Sections 3-11

The results on Sections 3-11 after 5-6 years met most of the translocation aims, objectives and performance criteria set out in the Strategy. Overall results were assessed as Good for 16 translocations, Fair for 7 and Failed for 1 (Lindernia), or possibly 2 (Rotala). One of the Oberonia tranlocation sites also failed due to orchid theft (Table 8).

Sections 1-2 & EWSSTA

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. Coaldale (Table 17). Little was learnt about the life cycle of Lindernia, but it is possible this species is annual and a seedbank had formed when 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 are not performing well, but more than compensated for by healthy, natural regeneration of Square-fruited Ironbark occurring at the Sunnyside Rd offset property now under conservation management.

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

Species	Recipient Site	Source of plants	Target	Number surviving Dec 2022	Establishment: Good, Fair Poor, Failed	Comment
Yellow-flowered King of the Fairies	Bundjalung Nat Pk (Evans Hd)	Transplanted	(18) 11	10	**Good**	
Unexpected finds	Lumley's Lane Sth	Transplanted	35	2	**Failed**	Plants taken by orchid collector?
Slender Screw Fern	Bundjalung Nat Pk Area 1 (Mororo Rd)	Transplanted	6350 fronds 127 trays 0.37 ha	Survival and crown-cover good on Line C only (note - point of planting layout was to spread planting out to maximise intersection of at least some favourable habitat (i.e. Line C)	**Good**	After fire in Nov 2019, translocated population in Aug 2020 had contracted to eastern end of Area 1, crown-cover increased in 2021 and in 2022 was more than double before the fire. Having survived bushfire, drought and floods over five years, remaining plants have a good chance of persisting. Area covered about 0.2 ha.
Unexpected finds	Bundjalung Nat Pk Area 2 (Mororo Rd)	Transplanted	4350 fronds 174 trays 0.3 ha	Survival and crown-cover good on both Lines and Patches (see Table 10)	**Good**	Crown-cover on Lines A and B and Patches recovered at the 2019 fire and in 2022 crown-cover was higher than before the fire. Remaining plants likely to persist. Area covered about 0.2 ha.
Singleton Mint Bush	Tabbimoble Triang le	Soil seedbank	609 plants 0.424 ha	Total number of SMB in recipient site approx. 350, but only ~10% of these of translocated origin, including final planting in 2021	**Fair**	Bushfire in Nov 2019 caused the translocated population to contract to a narrow section of habitat within the recipient site comprising sandier soil on the natural levee of Tabbimoble Ck. where a small in-situ population of SMB was present at the start. Low seedling recruitment and resprouting of translocated plants increased the existing population by about 15%, but there was no increase in area.
Weeping Paperbark	Offset property Tabbimoble Ck.	Seed	1700 2.761 ha	~700	**Good**	The translocated plants regenerated after the Nov/2019 fire by resprouting and survival rate was >80% in the three areas. In 2022, plants were taller than before the
	Tabbimoble Triangle					

Species	Recipient Site	Source of plants	Target	Number surviving Dec 2022	Establishment: Good, Fair Poor, Failed	Comment
						fire and population number and area adequate for establishing a self-sustaining population. Likely to persist over the long term due to ability to resprout vigorously if stem killed. In 2022, three years post-fire and six years after introduction, about 15% of plants flowered and formed a canopy seedbank.
Tall Knotweed (incl. unexpected finds)	Yaegl Nat. Res. (centre-north)	Transplanted & Soil Seedbank	(20) 350 (most seedlings)	177 mature plants to recently recruited seedlings (an annual species)	**Fair/Good**	Recruitment occurring each year, plants maturing and setting seed. Numbers increased in 2021 and 2022 compared to previous. Persisted through drought events.
Four-tailed Grevillea	Quarry Rd (Sec.3)	Seed	(3) 15	14	**Good**	Plants vigorous, setting seed.
Stinking Cryptocarya	Lumley's Lane	Transplanted	(41) 24	5	**Fair**	Below target but survivors healthy.
	Coolgardie Rd	Seed		17	**Good**	High survival, slow but steady growth.
Rusty Green-leaved Rose Walnut	Lumley's Lane	Transplanted	(3) 6	1	**Fair**	Below target but survivor healthy.
	Coolgardie Rd	Seed		17	**Good**	High survival, slow but steady growth.
Red Lilly Pilly	Lumley's Lane	Seed	6	12	**Good**	High survival, slow but steady growth.
	Coolgardie Rd	Seed & Transplanted		5	**Fair**	Low survival, slow but steady growth.
White Laceflower	Lumley's Lane	Transplanted	(1) 8	2	**Good**	High survival, steady growth.
	Coolgardie Rd	Transplanted		3	**Good**	Reasonable 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)	Population in receival site decreased but increased in	**Good**	Large population persists in paddock on offset land and Lumley's Lane. Biomass

Species	Recipient Site	Source of plants	Target	Number surviving Dec 2022	Establishment: Good, Fair Poor, Failed	Comment
				surrounding BOS 22 paddock		reduction each year essential for persistence
Hairy Joint Grass - Section 3	Mitchells Rd	Transplanted	1000	Scattered plants present	**Fair**	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	7	**Good**	
Lindernia	Mitchells Rd (Sec.3)	Transplanted	30	0	**Failed**	
Square-fruited Ironbark	Offset land, Sunnyside Rd	Transplanted	8(4)	4	**Good**	
Square-fruited Ironbark	Offset land, Sunnyside Rd	Seedlings	800	~400	**Fair**	~50% survival, condition poor, seedlings growing slowly, but very poor soil
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**	
Rotala	Offset land Tabbimoble Ck	Transplanted & Division	20	15	**Poor**	Survived five years of drought, flood and bushfire but in 2022 no plants were recorded. May reappear from dormant rhizomes?

Table 17: W2B Sections Sections 1-2 and EWSSTA - overall results after 4 Years. Each species translocation to each recipient 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	Recipient Site	Method	Target	Number surviving Aug 2020	Establishment: Good, Fair Poor, Failed	Comment
Hairy Joint Grass	Kangaroo Trail	Transpl/Soil Seed	2	0	**Failed**	Insufficient biomass reduction
	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	Propagated Cuttings	73	0	**Failed**	Cuttings did not strike
Slender Screw Fern	Kangaroo Trail	Transplanted	45 slabs	8	**Fair**	Of plants present in Year-3, 14% still present in Year-5
Square-fruited Ironbark	Pillar Valley	Propagated seedlings	823	80	**Fair**	Plants in poor condition
Square-stemmed Spike Rush	Halfway Ck Crossing	Transplanted	253	0	**Failed**	SoS project underway
Tall Knotweed	Yaegl NR	Transplanted	37	0	**Failed?**	Patch observed north of recipient site.
Lepidosperma sp. 'Coaldale'	Mahogany Drive	Transplanted	35	0	**Failed**	

Table 18: Assessment of Translocation Outcomes on Sections 3-11 following 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, mature size, flowered and seeded for five years to 2022. Adjacent population enhanced.	Performance criteria met. Population number and genetic diversity maintained by transplanting and seed propagation. Above target, plants increasing in height. Adjacent population enhanced.	Performance criteria met. Population declines in small translocation area, but large population persists in lower section of surrounding paddock, where biomass slashing has been carried out each year. Population likely to persist if slashing carried out – not between Jan – April when it flowers.	Performance criteria met. Total number above target, survival low at one site, high at the other. 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. Modest augmentation of existing population achieved (15%). .
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 and high survival rate in infertile soil	Performance criteria met. Knowledge of species life cycle and translocation potential increased – e.g. species hardy, resilient, will recruit in degraded or regenerating habitat. Can be translocated by transplanting or propagation from seed, seedlings grow slowly.	Performance criteria met. Knowledge of species increased – e.g. species life cycle confirmed as annual. Susceptible to displacement by dominant exotic perennial grasses. Co-exists with native Foxtail Grass	Performance criteria met. Knowledge of species life cycle and translocation potential increased. Limited translocation potential of propagated seedlings due to slow growth, susceptibility to disease, low survival rate.	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
3	Objectives	Original number of individuals and area re-established	Equivalent original number of individuals re-established. following guidelines for	Original number of individuals and area re-established	Equivalent original number of individuals re-established. following guidelines for	Equivalent original number of individuals re-established. following guidelines for	Original number of individuals re-established

		Four-tailed Grevillea	Green-leaved Rose Walnut	Hairy Joint-grass	Red Lilly Pilly	Rough-Shelled Bush Nut	Singleton Mintbush
			replacement of mature trees by seedlings/cuttings i.e ten seedlings established for any mature trees lost five seedlings established for any saplings lost.		replacement of mature trees by seedlings/cuttings i.e ten seedlings established for any mature trees lost five seedlings established for any saplings lost.	replacement of mature trees by seedlings/cuttings i.e ten seedlings established for any mature trees lost five seedlings established for any saplings lost.	
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 population, but renewed naturally occurring population at recipient 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.
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

		Four-tailed Grevillea	Green-leaved Rose Walnut	Hairy Joint-grass	Red Lilly Pilly	Rough-Shelled Bush Nut	Singleton Mintbush
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
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*

		Slender Screw Fern	Stinking Cryptocarya	Tall Knotweed	Weeping Paperbark	White Laceflower	Yellow-flowered King of the Fairies
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 recipient site for 3 years. Population reduced by bushfire in year 4, apparently viable population survives in parts of the two recipient areas. Sec 1-2: Results poor, small population surviving after 5 years, weeds a threat.	Performance criteria met. Lumley's 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 recipient site. Some plants producing seed pods. Plants at Lumley's 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
2	Evaluation and actions	Performance criteria met. Knowledge of species' ecology, particularly life history, population dynamics and environmental interactions increased, as well as translocation methods.	Performance criteria met. Knowledge of species' ecology, particularly life history, population dynamics and environmental interactions increased, as well as translocation methods.	Performance criteria met. Knowledge of species' ecology, particularly life history, population dynamics and environmental interactions increased, as well as translocation methods.	Performance criteria met. Knowledge of species' ecology, particularly life history, population dynamics and environmental interactions increased, as well as translocation methods.	Performance criteria met. Knowledge of species' ecology, particularly life history, population dynamics and environmental interactions increased, as well as translocation methods.	Performance criteria met. Knowledge of species' ecology, particularly life history, population dynamics and environmental interactions increased, as well as translocation methods.

		Slender Screw Fern	Stinking Cryptocarya	Tall Knotweed	Weeping Paperbark	White Laceflower	Yellow-flowered King of the Fairies
3	Aim	Achieve no net loss in local plant populations being impacted by the project	Achieve no net loss in local plant populations being impacted by the project	Achieve no net loss in local plant populations being impacted by the project	Achieve no net loss in local plant populations being impacted by the project	Achieve no net loss in local plant populations being impacted by the project	Improve options for augmentation through seedling production
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.	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.
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	Trees and saplings transplanted. Suitable cutting material for predicted requirements x 2	All available plants and associated soil harvested and	Available seed is harvested for nursery propagation.	Trees and saplings are transplanted. All potential cutting material (and seeds if	All available plants translocated to new hosts

		Slender Screw Fern	Stinking Cryptocarya	Tall Knotweed	Weeping Paperbark	White Laceflower	Yellow-flowered King of the Fairies
		transplanted to best extent practical	harvested seeds if available for nursery propagation.	transplanted to best extent practical		available) harvested for nursery propagation.	
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 recipient 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 19: Evaluation of Translocation Outcomes on Sections 1-2 & EWSSTA, as reported in Landmark Ecological Services 2017 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
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 Recommended Corrective Action

One recommended corrective action arising from the last monitoring event is summarised in Table 8.

Table 20: Monitoring finding, recommended corrective action and TfNSW response

Monitoring finding	Recommended corrective action	TfNSW response
Tall exotic grass Setaria sphaecelata recorded for the first time in 2022 as a large infestation close to the translocated population of Slender Screw Fern (*Lindsaea incisa*) in Bundjalung NP, which threatens to reverse the present successful translocation outcome (see Sect 3.3.2, Plates 15-17).	Record extent of recent infestation of the invasive, exotic grass Setaria or South African Pigeon Grass (*Setaria sphaecelata*) next to translocated Slender Screw Fern (*Lindsaea incisa*) at the recipient site in Bundjalung National Park. Carry out removal of Setaria from the recipient site with two treatments over 12 months. Hand pull Setaria clumps or spray with selective herbicide (Fusilade – grass specific) if necessary. Conduct second treatment 6 months after first treatment. Record effectiveness of treatment 3 months after second treatment. (total period 15 months)	Adopted

6.0 References

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

Ecos Environmental (2004). Brunswick Heads to Yelgun Pacific Highway Upgrade: Translocation Plan for Threatened Flora. Report to the Roads and Traffic Authority, Grafton.

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.

Pratt, B. H. and Heather, W. A. (1973). The origin and distribution of *Phytophthora cinnamomi* rands in Australian native plant communities and the significance of its association with particular plant species. **Aust. J. Biol. Sc. 26** 559-73.

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.

Weste, G. (1994). Impact of Phytophthora species on native vegetation of Australia and Papua New Guinea. **Australasian Plant Pathology 23**, 190-209.

Appendix 1: Photographs Sections 3-11, 2022

Plates 1 and 2: Singleton Mint Bush (*Prostanthera cineolifera*) in the Tabbimoble Creek Recipient Site, the fine leaved, light green shrub in the foreground. Regeneration after the 2019 fire occurred from seed in the soil seedbank and by resprouting of scorched plants. Usually killed by fire, some survived and resprouted as fire intensity (estimated from flame scorch height) was very low. Translocated plants produced few seedlings as they were only just three years old and little seed had been produced. Most seedlings came from the in situ plants in the same area, growing near the creek on sandier soil.

Plates 3 and 4: Singleton Mint Bush (*Prostanthera cineolifera*) in the Tabbimoble Creek Recipient Site.

Seedling of Singleton Mint Bush in Dec 2022 three years after the 2019 fire. The translocated population was 3 years old when burnt and plants were similar in size to the one of the left.

Plates 5 and 6: Tall Knotweed (*Persicaria elatior*) Recipient Site in Yaegl Nature Reserve near Maclean in Dec/2022 showing (above) a clump of Tall Knotweed and (below) a single plant, note the terminal pink flower spikes. This species is an annual completing its life cycle in 12 months. Plants have regenerated each year since being translocated in 2016-17, numbers fluctuating with annual rainfall.

Plates 7 and 8: Tall Knotweed (*Persicaria elatior*) Recipient Site in Yaegl Nature Reserve near Maclean in Dec/2022 showing (top) a patch of seedlings at the edge of the swamp and (below) habitat with area of dead ground cover killed by submergence during floods. Tall Knotweed did not appear in this bare area even though plants and mud seedbank were introduced earlier (see stake) possibly because of acid sulphate soil, indicated by a white precipitate on the soil surface after ground cover was scrapped away during introduction.

Plates 9 and 10: Exotic species recorded in Yaegl NR Recipient Site in 2022 – Water Hyacinth (above) and Coastal Morning Glory (below). Exotic species may persist in low abundance or build up over time. Spraying is not recommended due to possible adverse effects on native frogs.

Plates 11 and 12: Slender Screw Fern (*Lindsaea incisa*) Recipient Site in Bundjalung National Park, Area 1 Dec/2022, 5- 6 years after translocation in Nov-Dec/2016. Regenerated after drought, flood and a wildfire three years ago in Nov/2019

Plates 13 and 14: Slender Screw Fern (*Lindsaea incisa*) Recipient Site in Bundjalung National Park Area 1, Dec/2022. Close-up of Slender Screw Fern (top) and habitat (bottom). Translocated Nov-Dec/2016, burnt in wildfire Nov/2019.

Plates 15 and 16: (top left and right) Exotic grass *Setaria sphacelata* invading Slender Screw Fern Recipient Site in Bundjalung National Park, threatening the future of translocated population.

Plate 17: Slender Screw Fern (*Lindsaea incisa*) in Bundjalung National Park Recipient Site, Area 1, in Dec/2022 showing tall, dense *Setaria sphacelata* (South African Pigeon Grass, or Setaria) on the right, which has invaded the swale between Area 1 and Area 2 (to the right out of sight). It has already smothered much of native ground layer flora in the swale. The red line marks the boundary of Setaria on the right and currently uninvaded native ground cover with translocated *L. incisa* on the left.

Plates 18 and 19: Weeping Paperbark (*Melaleuca irbyana*) in Tabbimoble Ck Recipient Site, Area 1 in Dec/2022. Planted in 2017, these plants are up to 3.5 m high, and have regrown from ground level after being burnt in a bushfire in Nov/2019 (i.e. 6 year old plants with 3 year old stems).

Plate 20: Weeping Tea-tree/Paperbark (*Melaleuca irbyana*). This small tree about 3 m high was introduced as a seedling in early 2017. The coppiced stems are only three years old as the above ground plant was killed in the 2019 fire then resprouted from the base.

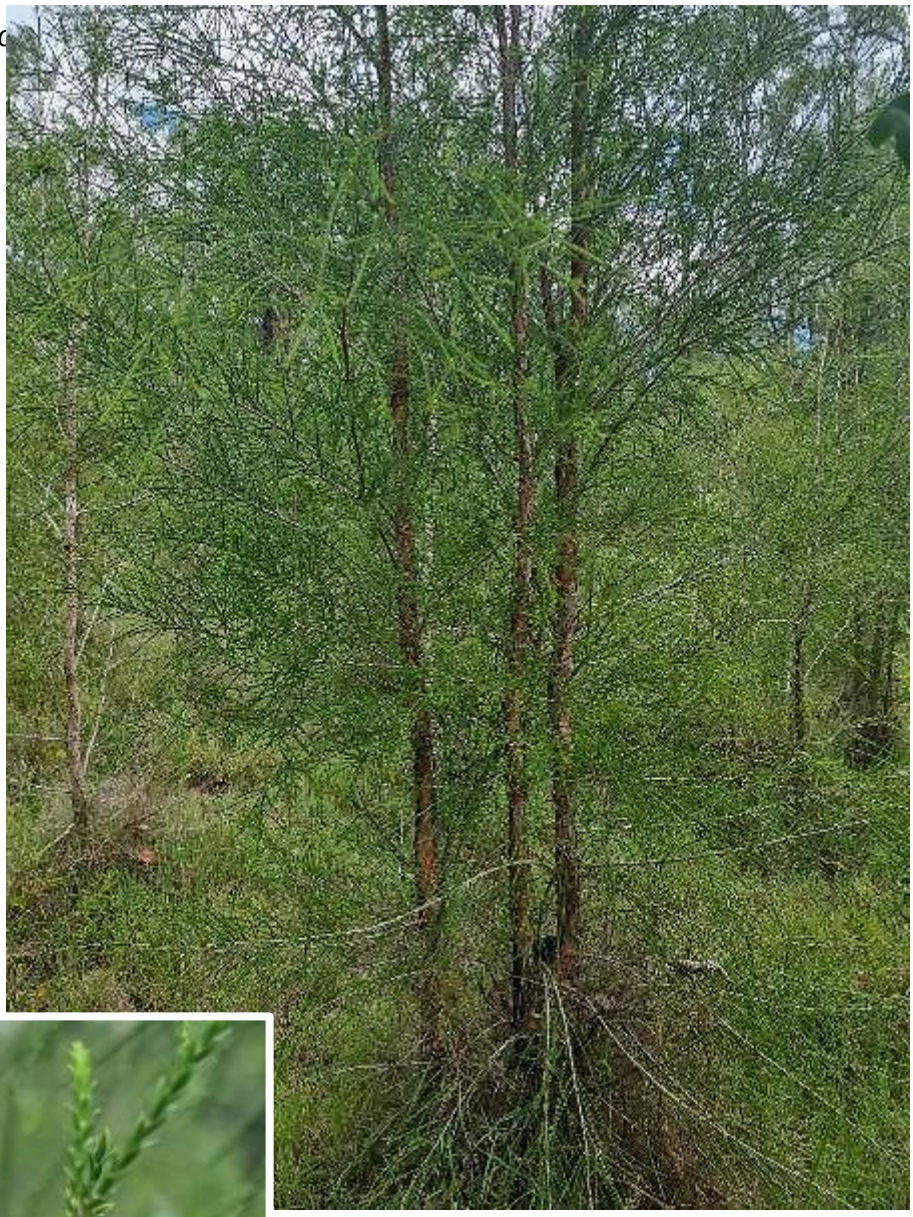
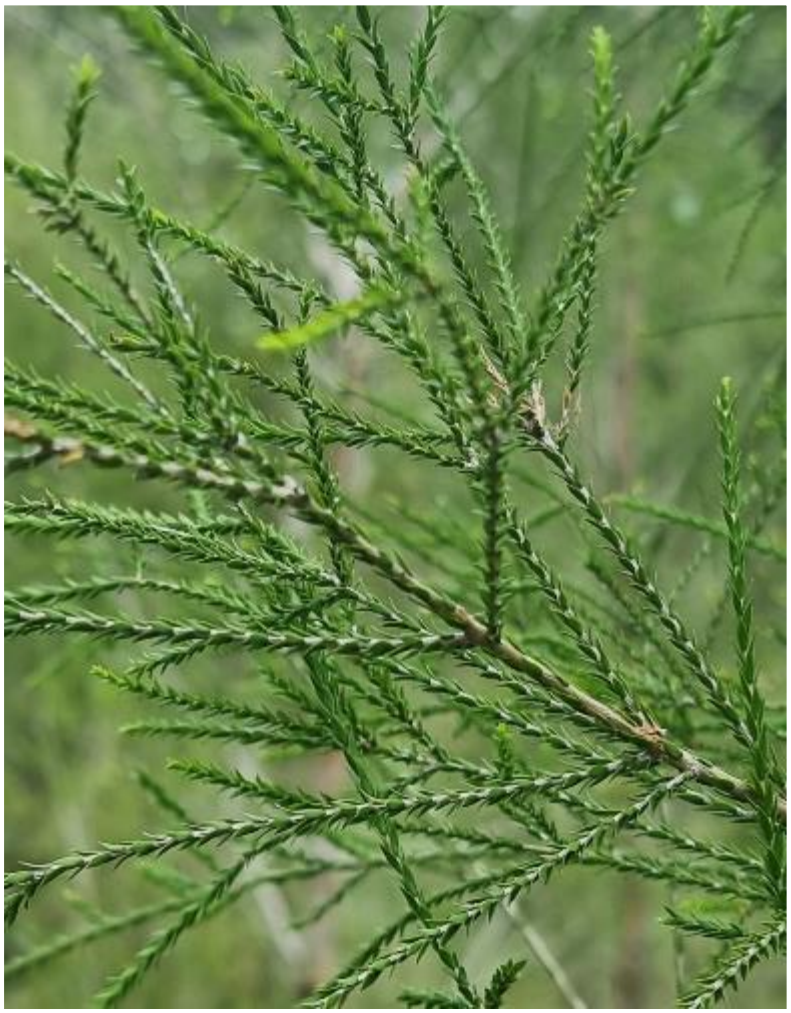


Plate 21: *M. irbyana* branchlets and leaves, which are 2-3 mm long.
Plate 22: *M. irbyana* woody seed capsules recorded for the first time in 2022 (plants six years old). These have formed after flowering and store seed which is released after fire or as the branchlets age.



Plates 23 and 24: Weeping Paperbark (*Melaleuca irbyana*) in Tabbimoble Recipient Site, Area 2, in Dec/2022, six years after introduction. Planted at the same time as Area 1 above and also burnt in the 2019 fire.

Plate 25: Stinking Cryptocarya (*Cryptocarya foetida*) in the Coolgardie Rd Recipient Site, propagated from seed and planted approximately 4.5 years ago. At the end of 2022, plant no. CF6 on the left was the tallest individual at 160 cm and in good condition. Several plants appeared dead including the plant on the right, probably due to flooding rains in early 2022 and a long period of saturated soil conditions.

Plate 26: Native Guava (*Rhodomyrtus psidioides*) in the Coolgardie Rd Recipient Site in 2022. This species was not translocated, but is endangered due to Myrtle Rust. The plant was 1.8 m high and showed no symptoms of Myrtle Rust. This species once grew as a small tree but now occurs as small root suckers where the trees used to grow. The roots suckers are usually <50 cm high and any higher are infected with rust and die-off.

Plate 27: Rusty Green-leaved Rose Walnut (*Endiandra muelleri ssp. bracteata*) in the Coolgardie Rd Recipient Site. This species propagated from seed and introduced to recipient has a high survival rate and a faster growth rate although seedlings were still <2 m high after 6 years.

Plate 28: Richmond Bird Wing Vine (*Aristolochia pravenosa*) in the Coolgardie Rd Recipient Site. This species was propagated from cuttings and had a high survival rate although several plants died during the wet conditions at the start of 2022.

Plate 29: White Laceflower (*Archidendron hendersonii*) in the Coolgardie Rd Recipient Site. This species was propagated from seed and all plants survived until 2022 when half were lost to flooding and prolonged wet soil condition. This surviving plant was 3.8 m high, 4.5 years after introduction. Rainforest remnant on Randle's Ck in the background.

Plate 30: Red Lilly Pilly (*Syzygium hodginsoniae*) in the Coolgardie Rd Recipient Site. One of the few translocated plants of this species surviving in the recipient site, although in poor condition with few leaves and growing very slowly, which is typical of this species when propagated from seed and planted in the wild.

Plate 31: Hairy Joint Grass (*Arthraxon hispidus*) on the right in Dec 2022 inside the gate on the lower slope next to Lumley's Lane. A dense population of HJG was growing with other perennial exotic and native grasses, herbs and sedges.
The top photograph shows the offset site paddock at Lumley's Lane. When grazed by cattle 6-7 years ago, HJG occurred over most of the paddock and native Foxtail Grass was common. HJG persists on the lower part of the paddock in the foreground under the perennial tussocks of exotic *Paspalum* spp. Slashing once or twice a year in the latter half of the year is essential for this annual grass species to persist. Cleared paddocks form its habitat today.

Plate 32: Hairy Joint Grass (*Arthraxon hispidus*) gets its name from the hairy leaf sheaths directly below the leaf blades which alternate with longer, smooth, purple-brown internodes along the grass stem. Most of these stems are probably individual plants that have grown from seed. Hairy Joint Grass is an annual grass, living for about one year and regenerates each year from seed and flowers in March. Most of its natural habitat has been converted to agricultural land, where it has persisted by adapting to cattle grazing pasture. Cattle keep pasture low and form small gaps where its seed can germinate. If cattle are removed and pasture increases in height and density it disappears. Tractor slashing can be substituted for cattle grazing to maintain suitable habitat.

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Plates 33 & 34: Rotala (*Rotala tripartita)* Recipient Site in Dec 2022. No Rotala was present at the two artificial ponds. Plants persisted at Pond 1 (top) in 2021 at the top of the earth bank on left side of pond, which was overtopped with grass in 2022, stimulated by the fire in 2019. There was no grazing to keep grass down as wild horses have been removed, which may have affected Rotala if it prefers open, unshaded conditions.