Translocation Monitoring

Monitoring Results and Status Report – June 2016

Pacific Highway Upgrade: Woolgoolga to Ballina

Sections 1, 2 & Early Works Soft Soil Treatment Areas

NSW GOVERNMENT

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

Landmark Ecological Services Pty Ltd
PO Box 100, Suffolk Park 2481
Phone 02 6685 4430
Email landmark@landmarkonline.com.au

For

NSW Roads and Maritime Services

June 2017

EXECUTIVE SUMMARY

New South Wales Roads and Maritime Services (Roads and Maritime) is required to implement translocation strategies for threatened flora species, where translocation is assessed as feasible, for a construction stage incorporating Sections 1 and 2 and Soft Soils Early Treatment Works of the Woolgoolga to Ballina Pacific Highway upgrade. The translocations set out in the strategies have been partly implemented. Material has been removed from the construction corridor for direct transplants and and/or seeds and cuttings have been collected for nursery propagation and growing on. In addition, the strategies set out requirements for monitoring and reporting. This status report includes the results of formal monitoring inspections conducted in May 2016.

Nine flora species have been translocated, or prepared for translocation. These are:

Green-leaved rose walnut	*Endiandra muelleri* subsp. *bracteata*
Hairy joint-grass	*Arthraxon hispidus*
Moonee Creek Quassia	*Quassia* sp Moonee Creek
	Lepidosperma Coaldale
Noah's false chickweed	*Lindernia alsinoides*
Slender screw-fern	*Lindsaea incisa*
Square-fruited ironbark	*Eucalyptus tetrapleura*
Square-stemmed spike-rush	*Eleocharis tetraquetra*
Tall knotweed	*Persicaria elatior*

Six receiving sites have been employed to date, some with multiple species. Methods have included direct transplant (plants, soil slabs including plants and/or soil-stored propagules) and planting out of nursery raised cuttings, seedlings or grown on harvested seedlings. Monitoring locations have been established at each receiving site for each species present.

Initial translocation actions are complete for some species while intermediate steps (propagule collection and nursery production) are underway for others. Some translocations require adaptive actions.

Delays to translocation actions and a generally low survivorship of translocated plants, many of which are wetland species, are due to:

- a very dry summer and autumn period during 2015-16 – delays to planting, poor development of some transplants;
- prolonged negotiations between Roads and Maritime and landholders in Section 1 delaying access to donor sites and forcing translocation actions in sub-optimal seasons;
- replacing seed and transplant techniques with the less reliable method of transplant of soil-stored seed and rhizomes (due to delayed access to donor sites); and
- difficulty obtaining seed from Square-fruited ironbark where bushfires had affected forest adjacent to the project
- failure of cuttings of Moonee Creek Quassia (known to be difficult to strike)

Overall, it is considered too early for formal evaluation of the translocations against targets, but planning is underway for supplementary actions where prospects for achieving targets can realistically be improved.

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1. Introduction

1.1 Project background

New South Wales Roads and Maritime Services (Roads and Maritime) has approval for the Woolgoolga to Ballina (W2B) Pacific Highway upgrade project under Part 5.1 of the NSW Environmental Planning and Assessment Act 1979 (EP and A Act) and the Commonwealth Environment Protection and Biodiversity Act 1999 (EPBC Act). In accordance with the NSW Minister's Conditions of Approval (MCoA) D7, a Flora Translocation Strategy has been prepared and partly implemented.

In accordance with MCoA condition A8, the required translocation strategies have been submitted, approved and partly implemented, in stages. The project is divided into 11 sections, of which Section 1, from Woolgoolga to Halfway Creek (17 km), and Section 2, from Halfway Creek to Glenugie (15 km), have been the subjects of a Flora Translocation Strategy for Sections 1 and 2 (Roads and Maritime 2015a). In addition, due to the presence of soft soils in the vicinity of the Clarence River and Richmond Floodplains, initial works have been required in advance of the main construction of the highway. A second Flora Translocation Strategy specifically addresses Early Works Soft Soil Treatments Works (Roads and Maritime 2015b) and includes threatened flora species occurring in parts of Sections 4, 5 and 8.

A total of nine species were identified for translocation (Table 1). Eight species were identified in the translocation strategies. An additional undescribed species, *Lepidosperma* "Coaldale", not currently listed as threatened, was located in pre-clearing surveys and also identified for translocation. *Lepidosperma* "Coaldale" was located at Wells Crossing in Section 2.

Table 1: Flora species identified for translocation

Common name	Scientific name	TSC Act	EPBC Act	Section 1	Section 2	Soft Soils
Green-leaved rose walnut	*Endiandra muelleri* subsp. *bracteata*	E				x
Hairy joint-grass	*Arthraxon hispidus*	V	V	x		x
Moonee Creek Quassia	*Quassia* sp Moonee Creek	E	E	x		
	Lepidosperma Coaldale				x	
Noah's false chickweed	*Lindernia alsinoides*	E		x		
Slender screw-fern	*Lindsaea incisa*	E		x	x	
Square-fruited ironbark	*Eucalyptus tetrapleura*	V	V	x*	x	
Square-stemmed spike-rush	*Eleocharis tetraquetra*	E		x		
Tall knotweed	*Persicaria elatior*	V	V			x

* Square-fruited ironbark was detected in Section 1 during pre-clearing surveys and is additional to documentation in the relevant translocation strategy.

The strategies set out methods to be used for translocation, receiving sites suited to establishment of new populations and performance targets, including no net loss of plants, establishment of self sustaining populations and the generation of new knowledge about translocation techniques. It was acknowledged that translocation would be difficult or experimental for some species and that appropriate seasonal conditions would be necessary for a reasonable chance of success.

1.2 Project roles

Bushland Restoration Services Pty Ltd undertook site- and species-specific planning from the broad strategies, prepared the receiving sites, carried out translocation actions and undertook maintenance. Landmark Ecological Services Pty Ltd carried out monitoring inspections, evaluation and reporting.

1.3 Monitoring schedule

The strategies require that monitoring inspections are conducted quarterly for the first year; every six months in the second year and once a year thereafter. It is desirable to synchronise monitoring inspections over all sites, though translocation actions have been staggered. Formal monitoring inspections were conducted in May 2016.

At the point of the formal monitoring inspections, some plants had been translocated as early as July 2015 (some of the Hairy joint-grass and Tall knotweed) while others had not yet been translocated (due to weather, seasonal factors, construction schedules and restricted access). As of May 2016, the Square-fruited ironbark, *Lepidosperma* "Coaldale", some of the Noah's false chickweed and some of the Slender screw-fern remain in nurseries, as an extended dry period has made planting out risky. In addition, a Green-leaved rose walnut has been prepared for translocation but cannot be transplanted until adjacent services have been moved. Alternatively, for this species, a decision may be made to underbore (translocation not necessary in this circumstance). Plants translocated early in the operations had been informally monitored during management and incidental inspections to detect any major problems with the sites and translocated plants (Table 2).

It is proposed that monitoring continues through Year 2 on a six monthly basis. Where new translocation plantings are undertaken during Year 2, additional inspections should be conducted to achieve quarterly monitoring.

1.4 Translocation progress

Early indications are that some of the Noah's false chickweed, Slender screw-fern and Tall knotweed have established well from direct transplants. Nursery propagation from seeds, cuttings and rhizome division has been successful for Noah's false chickweed, Square-fruited ironbark, Ledidosperma "Coaldale" and Tall knotweed.

Overall, however, a mixed success rate has been achieved in the early stages of the translocations. Results have been unsatisfactory for species that have been translocated at inappropriate times of the year (prolonged negotiations between Roads and Maritime and private landholders had resulted in delayed access to donor sites and imminent construction left no flexibility in collection timing). Non-optimal access times have made it impossible to harvest seed from plants or transplant seedlings and adult plants directly, for some species. Soil with stored dormant seed and rhizome fragments has been collected as an alternative. It is considered too early to judge the success or otherwise of attempts to grow plants from soil-stored propagules. Seeds and rhizomes are likely to retain viability in the soil and seedlings or sprouts may emerge in the next growing season.

Weather conditions have been unusually dry for most of the translocation period, delaying plantings and producing poor conditions for development. Many translocated plants are wetland species.

Weed management has been conducted and fencing arranged where required (Kangaroo Trail Road).

It is too early for rigorous evaluation of progress towards performance targets.

A summary of the progress of the translocations is provided in Table 3 and full details provided in Appendices 1 and 2. Appendices 1 and 2 also include details of methods used for each translocation.

Table 2 Translocation and monitoring actions July 2015 – May 2016

Sp = site preparation, Pl = planting, Mo = monitoring, iM = informal monitoring (incomplete record), Ma = Management				2015										2016
Donor site		**Receiving site**	**Methods**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**
SECTION 1														
#Square-stemmed spikerush	Redbank Creek	Halfway Creek Crossing	Soil slabs (stored)		Pl									Mo
Hairy joint-grass	Redbank Creek	Kangaroo Trail	Soil slabs (stored)			Pl	Ma, iM	Ma, iM		Ma, iM	Ma, iM	Ma	Ma	Mo
Noah's false chickweed	Redbank Creek	Kangaroo Trail	Nursery plants							Pl	Ma	Ma	Ma	Mo
Noah's false chickweed	Redbank Creek	Halfway Creek	Nursery plants											
#Noah's false chickweed	Redbank Creek	Halfway Creek	Soil slabs (stored)		Pl									Mo
Noah's false chickweed	Redbank Creek	Yuraygir SCA	Slabs		Pl		Ma, iM	Ma, iM			Ma, iM		Ma, iM	Mo
Slender screw-fern	Redbank Creek		Nursery raised plants (small no established)											
Slender screw-fern	Redbank Creek	Kangaroo Trail	Slabs/plants			Pl	Ma, iM	Ma, iM		Ma, iM	Ma, iM	Ma, iM	Ma, iM	Mo
Moonee Quassia	Dirty Creek	Dirty Creek road reserve	Nursery cuttings (no strike)											
SECTION 2														
Square-fruited ironbark		Glenugie offset	Nursery, raised from seed											
Lepidosperma "Coaldale"	Wells Crossing	Mahogany Drive	Nursery plants from rhizome division											
SOFT SOILS														
Tall knotweed	Maclean Interchange	Yaegl NR south	Nursery plants (seedlings)					Pl			Ma, iM	Ma, iM		Mo
Green-leaved rose-walnut	Maclean Interchange	Maclean Interchange road reserve	Single small tree (direct transplant)				Sp	Sp		Sp				
Hairy joint-grass	Trustrums Hill	Trustrums Hill road reserve	Slabs/plants (directly transplant)	Sp, Pl	Pl		Ma, iM			Ma, iM	Ma, iM	Ma, iM	Pl	Mo
Tall knotweed	Yaegl north	Yaegl NR South	Soil/plants (direct transplant)			Pl	Pl	Ma, iM			Ma, iM	Ma, iM		Mo
Tall knotweed	Yaegl central east	Yaegl NR Central	Soil/plants (direct transplant)	Pl										Mo
Tall knotweed	Yaegl central west	Yaegl NR South	Plants (direct transplant)							Pl	Ma	Ma		Mo

access restricted by construction activity between planting and monitoring inspection

Table 3 Translocation status summary

Donor site		Receiving site	Methods	Summary of current status	Recommendations and proposed future actions
SECTION 1					
Noah's false chickweed	Redbank Creek	Yuraygir SCA	Slabs	Low survivorship (very dry conditions)	Continue maintenance. No further planting as success judged more likely at alternative sites. Additional nursery raised plants are available.
		Halfway Creek crossing	Soil slabs stored	No plants observed (very dry conditions). Soil-stored seed likely to persist and may germinate next growing season.	Continue observation next growing season.. Note that access for management has been limited due to adjacent construction.
		Halfway Creek crossing	Nursery plants	Planting delayed due to dry conditions, plants now overgrown and new cutting propagation proposed.	Additional planting proposed when conditions are suitable.
		Kangaroo Trail	Nursery plants	Low levels of survivorship, but some plants are well established and some have flowered and fruited.	Germination from seed produced *in situ* is possible when conditions are suitable. Additional planting proposed.
Lepidosperma "Coaldale"	Wells Crossing	Glenugie offset	Nursery, plants	Plants well established in nursery, to be planted out when conditions are suitable	Planting proposed in selected location when conditions are suitable.
Slender screw-fern	Cassons Creek	Kangaroo Trail	Slabs/plants	Some of the slab transplants have established, may expand slowly. (Conditions have been too dry.)	Limited options for sourcing additional material, no further planting proposed.
			Nursery (small no established)	A small number of plants are retained in a nursery	Planting to be conducted in suitable conditions.
Hairy joint-grass	Redbank Creek	Kangaroo Trail	Stored soil	No positive results to date, likelihood of success was always low and conditions have been very dry. Soil-stored seed may be present in a dormant condition. However, soil was collected from approximate location of 2 plants located in Biosis 2014 survey. Soil-stored seed likely to be low in density or absent.	Continued monitoring could produce positive results though unlikely. Soil-stored seed may be present in a dormant condition. However, soil was collected from approximate location of 2 plants located in Biosis 2014 survey. Soil-stored seed likely to be low in density or absent.

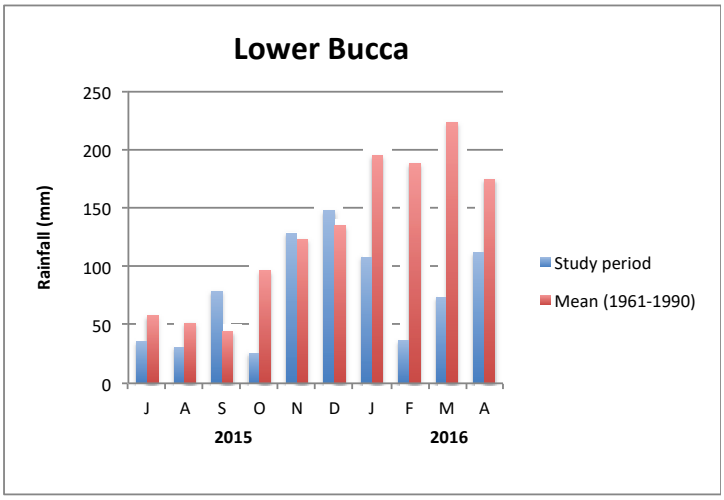
Donor site		Receiving site	Methods	Summary of current status	Recommendations and proposed future actions
Square-stemmed spikerush	Redbank Creek	Halfway Creek Crossing	Soil slabs stored	No positive results to date, likelihood of success was always uncertain. Soil-stored seed may be present in a dormant condition, or rhizome fragments may be present in soil. However, soil was collected from approximate location of plants located in Jacobs 2014 survey, no above-ground plants were present. Soil-stored seed may be low in density or absent. Conditions have been dry, seasonal inspections needed. Limited options for sourcing additional material.	Continued monitoring could produce positive results though uncertain. Ephemeral species, assessment difficult.
Moonee Quassia	Dirty Creek	Dirty Creek road reserve	Nursery cuttings	No strike	The low likelihood of success of the cutting approach is well documented. Populations at the Pillar Valley will be checked for fruit production and seed propagation pursued, to be planted at Pillar Valley
SECTION 2					
Square-fruited ironbark		Pillar Valley	Nursery, seed	~150 germinants are available for pottong on in the nursery. Seed collection has not followed prescriptions in translocation strategy for reasons including bushfire, seed tree availability, and difficulty of collecting mature seed, but compatible with intent to capture genetic representation.	Populations at Pillar Valley will be checked for mature capsules and propagation from seed conducted, to be planted at Pillar Valley
SOFT SOILS					
Tall Knotweed summary			Slabs, plants, Nursery, seed	A lot of material has been transplanted and includes slabs, plants and nursery stock. Seed collected.	Interpretation of the results will be difficult as this is an ephemeral species, but early indications are that performance criteria will be on track (applies to all Tall Knotweed operations)
Tall knotweed	Yaegl north	Yaegl NR South	Soil	Completed	
Tall knotweed	Yaegl central east	Yaegl NR Central	Soil	Completed	
Tall knotweed	Yaegl central west	Yaegl NR South	Plants	Completed	

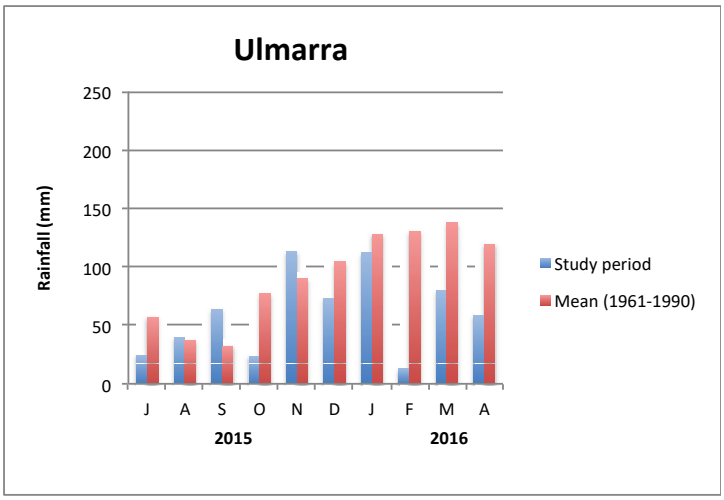
Donor site		Receiving site	Methods	Summary of current status	Recommendations and proposed future actions
Tall knotweed	Maclean Interchange	Yaegl NR south	Nursery plants, plants	Completed	
Green-leaved rose-walnut	Maclean Interchange	Maclean Interchange road reserve?	Single small tree has been prepared for translocation	Uncertain if translocation required	Tree prepared for translocation if required.
Hairy joint-grass	Trustums Hill	Trustums Hill road reserve	Slabs/plants	Large amounts of material (slabs and clods) were moved in two operations to sites in the adjacent road reserve. Plants developed well initially but then died back, possibly because conditions were dry (though management requirements of Hairy joint-grass are poorly understood). Some of the plantings were in a power line easement (Site 1) and vehicle movements in this area have been destructive. Additional material was moved to the east of power line (Site 2).	Monitoring inspections were conducted when plants were dying back over winter. Biomass is high at the power line site (Site 1). Proposed to fence the area and graze to promote germination and development. Ongoing removal of *Casuarina glauca* seedlings required at Site 2. RMS is investigating removal of the power line.

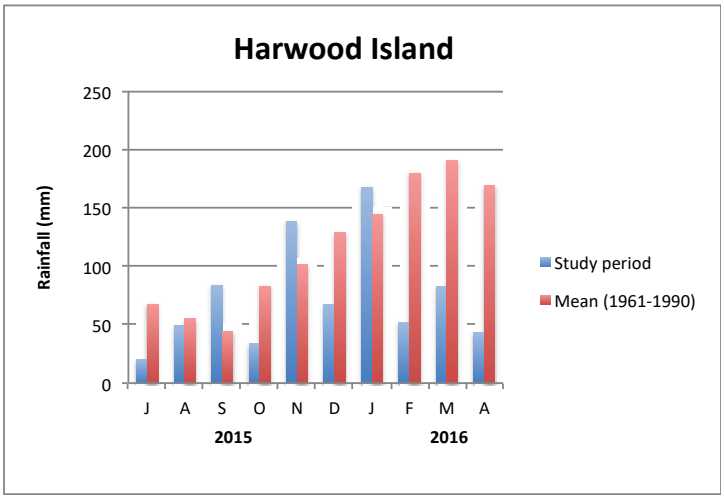
1.5 Rainfall

The unusually dry summer and autumn experienced in the area of the translocation activities is demonstrated using the monthly rainfall data for weather stations close to the south (Lower Bucca) and north (Ulmarra) of Sections 1 and 2 and representative of the Soft Soils Treatment Areas (Harwood Island). Weather stations for which data was available at least from 1960 to present were selected for illustration purposes.

Very heavy rain fell during an east coast low in early June 2016, shortly after the monitoring inspections were conducted. While soil moisture conditions have improved dramatically, the season remains less than ideal for planting.







Source http://www.bom.gov.au/climate/data/index.shtml extracted 1 June 2016

2 Methods

Data collection for monitoring was consistent with the methods identified in the threatened flora translocation strategies (Roads and Maritime Services 2015a and b), and followed the interpretation of Jacobs (2014) where appropriate.

Data collected, as relevant to site and species, included:

- Genus, species and subspecies.
- Identifier – unique plant number.
- Location – location; easting, northing & description.
- General condition – score on a scale of 0 to 5, where 0 is dead and 5 is excellent.
- Leaf condition – healthy/unhealthy, colour, vigour.
- Flower/fruit – flower/fruit presence.
- Length of new shoots – average length of new shoots (estimate) and abundance of new shoots (counts or basic scale).
- Disease symptoms – evidence of disease (including presence / absence of Myrtle Rust, Cinnamon Fungus)
- Recruitment.
- Evidence of any other damage or disturbance.
- Plant community type.
- Canopy cover.
- Mid-storey cover.
- Ground-layer cover and composition.
- Weed abundance and composition.
- Recruitment of canopy and mid-storey species.
- Climatic events (e.g. drought, flood, unusually cold winter temperatures etc.).
- Maintenance carried out – when and what kind of maintenance carried out at the site since the last monitoring
- Any other ecological impacts.

Habitat monitoring transects (following Jacobs 2014) were set up in central locations within each planting area. Transects were 20m long, oriented N-S and marked with double pink flags on tree trunks or stakes.

Habitat data collected included:

- Dominant flora species in each structural layer
- Prevailing site conditions and (ie soil moisture, climate, and water levels and flow)
- Landscape parameters (ie landform, drainage, slope and aspect)

Cover of vegetation layers was recorded using the 20 metre transect with the canopy and midstorey (greater than one metre high) cover recorded as percentage foliage cover every five metres (four points) along the transect.

Groundcover attributes were recorded at every metre (20 points) as either forb, grass, shrub (less than one metre high), bare/water, litter or exotic

For species with growth forms not suited to counts and measurements of individual stems, eg Hairy joint-grass and Slender screw fern, area- and density-based measurements were preferred in order to track growth and development.

Photographs were taken at each location including:

- Habitat view from north point of transect
- Individual plants and/or clusters of plants, insect attack, dieback and habitat conditions.

Where populations or individuals of the translocated threatened flora species were present in the vicinity of the receiving site, a sample of a reference population was identified at the time of translocation and marked in order to compare the growth and development of plants that have been translocated.

3 Results

3.1 Monitoring locations

The strategies set out details of flora species to be translocated, including locations of donor populations and of receiving sites (Table 3). Multiple options for receiving sites are generally provided. In some instances, plants had been shared between two receiving sites to spread risks or to optimise use of best-suited habitat.

Multiple species were translocated to some of the receiving sites, in which case habitat monitoring transects were usually set up for each species. Monitoring locations were established at six receiving sites, summarized as follows (Table 4) and mapped (Figure 1). Most monitoring locations include marked habitat transects.

Table 4 Summary of receiving sites and monitored threatened species

Location	Species
Kangaroo Trail	Noahs false chickweed, Slender screw fern, Hairy joint-grass
Halfway Creek Crossing	Noahs false chickweed, Square-stemmed spike-rush
Yuraygir SCA	Noahs false chickweed
Yaegl NR south	Tall knotweed
Yaegl NR central	Tall knotweed
Trustrums Hill	Hairy joint-grass

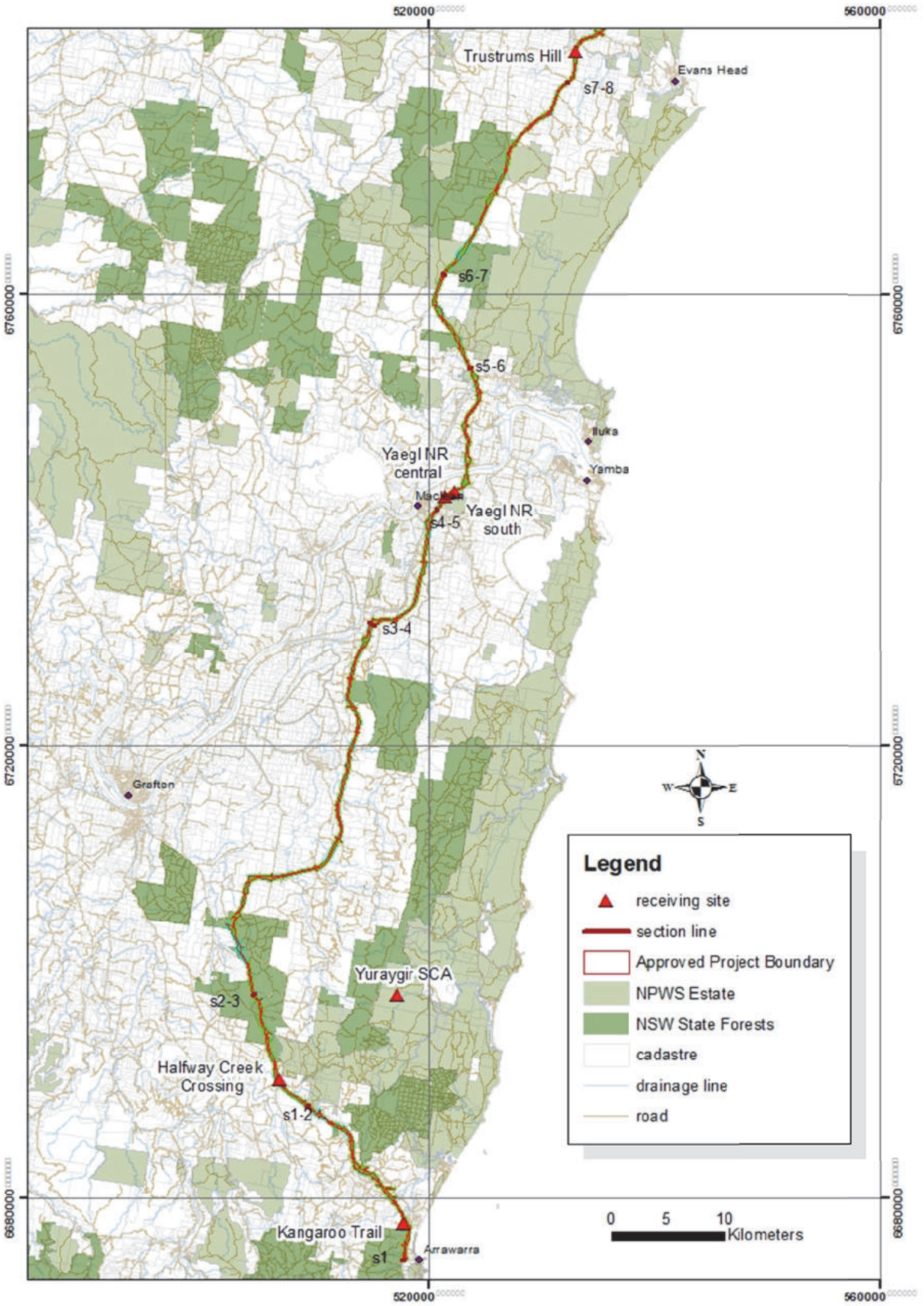


Figure 1 Locations of receiving sites

3.2 Species-specific results

The results, including location, habitat conditions, details of individuals of each threatened species are summarized in Table 5 with details, including a selection of photographs, provided in Appendix 1 for species for which translocation plantings have been undertaken and Appendix 2 for species where planting has not yet taken place.

Table 5 Translocation results

Donor site		Receiving site	Methods	Results
SECTION 1				
Noah's false chickweed	Redbank Creek	Yuraygir SCA	Slabs/plants	6 plants remaining of original 22. Flowers on 2 plants, seed capsules on 1
		Halfway Creek crossing	Soil slabs stored	no plants observed
		Halfway Creek crossing	Nursery plants	n/a, not yet planted out
		Kangaroo Trail	Nursery plants	30 plants remaining of original 350. Flowers on 17 plants, seed capsules on 11
Lepidosperma "Coaldale"	Wells Crossing	Mahogany Drive	Nursery, plants	n/a, not yet planted out
Slender screw-fern	Cassons Creek	Kangaroo Trail	Slabs/plants	Plants at 17 of original 45 planting points. 19 plants retained in nursery
			Nursery (small no established)	
Hairy joint-grass	Redbank Creek	Kangaroo Trail	Stored soil	no plants observed
Square-stemmed spikerush	Redbank Creek	Halfway Creek Crossing	Soil slabs stored	no plants observed
Moonee Quassia	Dirty Creek	Dirty Creek road reserve	Nursery cuttings	No strike
SECTION 2				
Square-fruited ironbark		Glenugie offset	Nursery, seed	80 plants retained in nursery
SOFT SOILS				
Tall Knotweed summary			Slabs, plants, Nursery, seed	44 plants present, including dead stems with retained seed in process of shedding
Green-leaved rose-walnut	Maclean Interchange	Maclean Interchange road reserve?	Single small tree has been prepared for translocation	Uncertain if translocation is required
Hairy joint-grass	Trustrums Hill	Trustrums Hill road reserve	Slabs/plants	One plant was observed by bush regenerators in February, and a small number of plants were observed during formal monitoring (Site 1). Recently transplanted clumps at Site 2 were present as dead material, regeneration expected in next growing season.

4 Discussion

Nine flora species have been translocated, or prepared for translocation. It is considered too early for formal evaluation of the translocations against targets, but some areas of poor or uncertain progress are recognised and planning is underway for supplementary actions where prospects for achieving targets can realistically be improved. Site- and species-specific recommendations are included in Section 5, Appendix 1 and have been summarised in Table 3.

Factors including a very dry summer and autumn period have delayed some translocation actions and affected the success of others. In addition, no plants have developed from soil-stored propagules to date.

The translocation techniques and stages are discussed further as follows:

Nursery propagation

Standard nursery techniques have been employed to successfully raise seedlings of Square-fruited ironbark, to grow on seedlings transplanted from the field (Tall knot-weed), to grow on plants from rhizome division (Lepidosperma “Coaldale”) and to strike and grow on cuttings (Noah’s false chickweed). These techniques are recommended for continuing use where more plants are required e.g. further seed collection for Square-fruited ironbark is planned. Cuttings of Moonee Creek Quassia, however, have failed to strike in the nursery.

Direct transplant

The technique of transplanting slabs of soil containing clumps of plants has been moderately successful and has been employed for Noah’s false chickweed, Slender screw-fern, Hairy joint-grass and Tall knotweed.

Noah’s false chickweed has transplanted successfully. The species has a short lifecycle, producing flowers and seeds within a growing season (some plants were flowering when planted), so it will be worth continuing observations at sites where success has been short-lived, since seeds may have been incorporated into the soil seed bank and may germinate and develop in subsequent seasons.

For Slender screw-fern, the slab/ clump transplant technique has produced limited success, despite the recognised difficulty of transplanting the species. Disturbance generally kills the plants, so taking a large soil mass that minimises root disturbance appears to be key. Direct transplant to the field has been successful, and small clumps have established in the nursery.

Hairy-joint grass was transplanted with reasonable success in the short term. Maintaining suitable conditions (removal of competing biomass) will be necessary for persistence along with a suitable soil moisture regime.

Tall knotweed was transplanted successfully. Young plants developed through their lifecycle while the transplant of over-mature plants was also worthwhile as capsules developed and shed seed.

Dry conditions are likely to have contributed to a less-than-ideal survival rate.

Development from soil-stored propagules

No success has been achieved to date where slabs of soil from sites containing soil-stored seed of the target species were transplanted. The technique was used for Noah’s false chickweed,

Square-stemmed spike-rush, Hairy joint-grass and Tall knotweed (dead plants with soil at their bases were also employed in the latter species).

All species have seeds which are capable of survival in dormant condition in the soil. Rhizome fragments of Square-stemmed spike-rush may also be present in soil.

This technique was employed to supplement other methods, or, in instances where plants could not be located at the survey locations provided. The technique was a means of maximising the potential for capture of material from a recorded location. Survey records were two years old or older, environmental conditions may have changed and altered the natural occurrence of the plants. In addition, locations were approximate, having been recorded with hand-held GPS (usually +/- 3-5m). In some instances, (Redbank Creek area) searches and propagule collection were conducted in non-optimal seasonal conditions due to access problems and the construction schedule.

Failure to achieve seedling emergence from the transplanted soil may be due to:

- Uncertain seed density. In the case of Hairy joint-grass at Redbank Creek, soil was collected from the approximate location of two plants located in Biosis' (2014) survey. Soil-stored seed was likely to have been low in density or may have been absent.
- A short delay between collection and planting (due to access problems, construction schedule and logistics) was necessary for some collections.
- Dry conditions. The target species require swamp or seasonally wet habitats. Dormancy-breaking requirements for seeds are not known in detail for the target species but may include soil disturbance, a specific light regime, temperature fluctuations and wet/dry cycling. Wet conditions will be required for development.

Continuing monitoring may detect germination and development in subsequent seasons. The potential for success of the method is difficult to gauge, but may be successful and cost-effective when seed soil density is adequate and environmental conditions are suited.

Development and maintenance stages

In addition to the dry conditions, transplants and nursery raised plants of Noah's false chickweed were affected by marsupial grazing at Kangaroo Trail Road, though the site had been fenced. A more suitable fence design is recommended. Slender screw-fern plants do not appear to be susceptible to marsupial grazing, but improved fencing at Kangaroo Trail Road is required for general protection. Weed management, mainly exotic grasses, has been ongoing.

Access to Halfway Creek Crossing has been restricted by construction works between soil transplant and formal monitoring. It is difficult to judge whether outcomes could have been improved.

5 Evaluation

Detailed evaluation of translocation progress is planned after another year's development of existing translocations and further translocation actions.

One aim of the translocations is to achieve no net loss of the flora species for which translocation was assessed as feasible. The extent of direct impacts to the plants had been assessed in 2014 surveys and tabulated in the translocation strategies (reproduced in Table 6). Quantities had been expressed as counts of individuals and, for some species, areas of occurrence.

A number of issues are predicted when the survey results come to be used for evaluation:

- Some species are ephemeral and their abundance and distribution will vary seasonally;

- Count data will be difficult to replicate for species such as Slender screw fern and Noah's false chickweed, for which individual plants will be delineated differently by different observers; (generally an area and cover abundance measure will be preferred for such species)
- Methods for collection of original survey data are not documented in a form that will facilitate consistent replication.

The targets were reviewed in the process of pre-translocation planning, though limitations including seasonal variation in abundance will remain.

Table 6 2014 survey results

Section	Location	Species	Clearing Area	
			No individuals	Area (ha)
1	Cassons Creek (formerly referred to as Corindi Creek)	Slender screw fern	2820	0.013
1	Redbank Creek	Square-stemmed spike-rush	185	0.041
1	Redbank northern tributary	Hairy joint-grass	2	
1	Redbank northern tributary	Noahs false chickweed	1811	
1	Redbank northern tributary	Square-stemmed spike-rush	68	0.774
1	Dirty Creek Range north	Moonee Quassia	73	0.080
2	Wells Crossing	Square-fruited ironbark	302	4.355
2	Wells Crossing north	Square-fruited ironbark	7	0.022
2	Wells Crossing north	*Lepidosperma* Coaldale	16	
2	Bald Knob Tick Gate Road south	Square-fruited ironbark	170	5.045
2	Bald Knob Tick Gate	Square-fruited ironbark	3	0.215
2	Glenugie south	Square-fruited ironbark	2	0.341
2	Glenugie	Square-fruited ironbark	83	7.128
2	Franklins Road	Square-fruited ironbark	205	3.320
2	Franklins Road north	Square-fruited ironbark	52	0.426
4	South Arm north	Tall knotweed	6	0.087
4	South Arm north	Tall knotweed	6	0.087
4	Maclean interchange	Tall knotweed	12	0.022
4	Maclean interchange	Green-leaved rose walnut	0	0
5	Yaegl south	Tall knotweed	1	0.001
5	Yaegl central east	Tall knotweed	5	0.023
	Yaegl central west	Tall knotweed		
5	Yaegl north	Tall knotweed	7	0.071
8	Trustums Hill	Hairy joint-grass	38	0.256

6 Recommendations

Green-leaved rose walnut

Await notification of requirement for translocation (may be underbored).

Hairy joint-grass

Continued maintenance at Trustrums Hill. Explore options for reduction of biomass at planting sites (slash and rake or re-instate grazing). Check for seedling emergence from soil-stored seed in next growing season. Control Swamp oak saplings at Site 2.

Moonee Creek Quassia

Collect seed from a new potential donor and receiving site at Mahogany Drive for plantings to augment the existing population.

Lepidosperma "Coaldale"

Plant existing nursery stock when conditions are suitable. Observation of the Wells Crossing location from which *Lepidosperma* "Coaldale" was transplanted suggests that some of the site remains uncleared (3 July 2016) and surveys are recommended to detect any new shoots from rhizome fragments or seedlings (protect *in situ* or use for new propagation material).

Noah's false chickweed

Continue to maintain existing plantings and monitor for seedling emergence during next growing season. Upgrade fencing.

Produce new cutting grown plants from over-grown nursery stock. Plant when conditions are suitable (500 to Halfway Creek crossing, 500 to Kangaroo Trail Road).

Slender screw-fern

Continue to maintain existing plantings. Plant existing nursery stock when conditions are suitable. Survey donor site locations within the clearing boundary to detect any newly emerged plants (protect *in situ* or use for new propagation material). Upgrade fencing.

Square-fruited ironbark

Plant existing nursery stock when conditions are suitable. Fencing required. In view of the difficulty in locating seed in the vicinity of the donor sites (a recent fire has destroyed material in much of the intended collecting area), collect seed from the receiving site at Pillar Valley for plantings to augment the existing population.

Square-stemmed spike rush

Monitor for seedling emergence during next growing season, continue to maintain site. (Unlikely that propagation material will be available in the vicinity).

Tall knotweed

Monitor for seedling emergence during next growing season, continue to maintain site.

References

Biosis, 2014. Vegetation Survey Report: Woolgoolga to Ballina Pacific Highway Upgrade Section 1 Woolgoolga to Halfway Creek. Prepared for Roads and Maritime Services, 29 July 2014.

Jacobs, 2014. Woolgoolga to Ballina Pacific Highway Upgrades, NSW Roads and Maritime Services, Threatened Flora Pre-construction Surveys, Rev02

Roads and Maritime Services, 2014. Woolgoolga to Ballina Pacific Highway Upgrade: Threatened Flora Management Plan (Stage 1). Roads and Maritime Services, NSW.

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

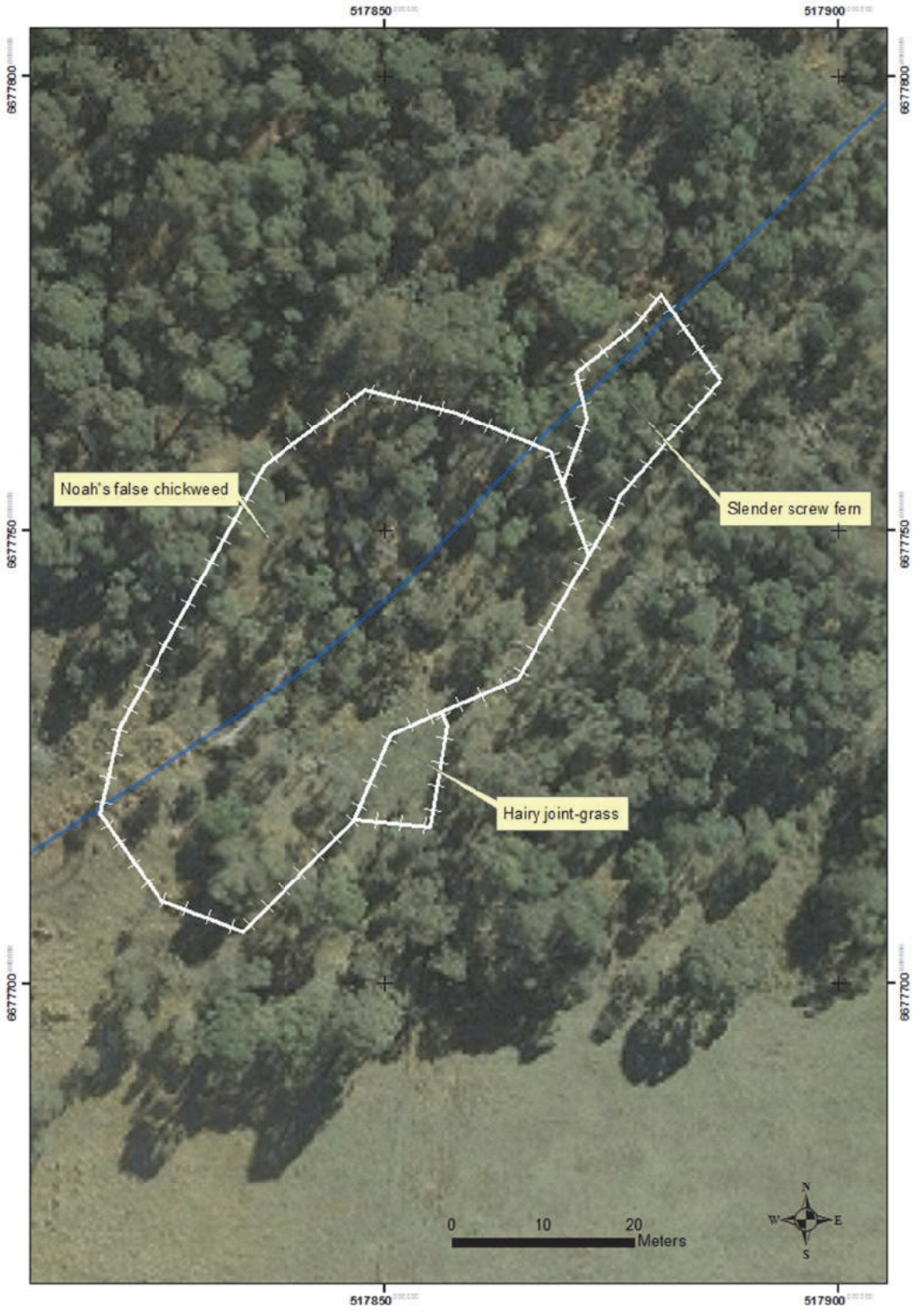
Roads and Maritime Services, 2015b. Flora Translocation Strategy, Early Works Soft Soil Treatment Areas (part Stage 1), Woolgoolga to Ballina Pacific Highway Upgrade, Version 3.

Appendix 1 Receiving site details

Kangaroo Trail Road

Noah's false chickweed *Lindernia alsinoides*
Slender screw-fern *Lindsea incisa*
Hairy joint-grass *Arthraxon hispidus*

Layout



Fenced planting areas for three species

Translocation methods

Noah's false chickweed *Lindernia alsinoides*
Area of fenced area 0.177 ha

Approximately 350 well grown plants (nursery stock) were planted on 28 January 2016.
Plant locations were marked with a spike label.

Points were re-numbered and marked during May 2016 monitoring inspections. Surviving plants were numbered on white spike labels La 1-30. At points where plants could not be detected, labels were replaced with temporary markers (flagged bamboo stakes).

It is recommended that the temporarily marked points be retained for close inspection during next growing season in case they have re-sprouted, or in case seedlings have developed from seed shed close to the points. The markers should then be removed.

Slender screw fern *Lindsaea incisa*
Area of fenced area 0.023 ha

Slabs 30cm x 30cm x 10cm deep were dug from donor site and transplanted.
Slabs were transplanted directly to receiving site at seven locations on 10 September 2015.
Central points were marked with spike labels. Slabs were planted in a square around a central point, 6 – 8 slabs.

Hairy joint-grass *Arthraxon hispidus*
Area of fenced area 0.008 ha

No plants were observed and soil from the locations of the two documented records was used as a likely source of soil-stored seed.

Eight slabs 30cm x 30cm x 10cm deep were dug from the donor site and transplanted on 10 September 2015.

Kangaroo Trail Road La – receiving site details

Site code	KT-La
Species	*Lindernia alsinoides*
Common name	Noah's false chickweed
Date	04-May-16
Marker	ll on trunks, pink
Location	North of Section 1 depot on RMS land
Location 2	
Easting	517854
Northing	6677752
Transect orientation	N-S
Climate previous	dry
Climate current	dry, sunny
Landform	flat
Drainage	good
Slope	flat
Aspect	flat
Soil moisture	dry
Water levels	dry
Water flow	dry
Plant condition (0-5)	4-5
Height	
Width	Small to large clumps
DBH	
Leaf cond	4-5
Length new shoots	
Flowers	Present
Fruit	Present
Recruitment	Vegetative spread
Disease/insect	Possible insect damage or bruising of plants
Dieback	
Threats	Marsupial grazing
VegComm	*Eucalyptus resinifera* forest
Canopy species	*Eucalyptus resinifera*
Midstorey species	*Lophostemon suaveolens*
Understorey species	*Imperata cylindrica*
Canopy	42
Midstorey	0
Forb	30
Grass	60
Shrub (<1m)	5
litter	35
bare/water	15
exotic	
Weed Species	*Cuphea carthagenensis* occasional, *Andropogon virginicus*, other exotic grasses, all sparse
Weed abundance	Low
Recruitment	occasional saplings
Disturbance	Dead exotic grasses (sprayed)
Comments	Wallaby-proof fencing required
Abundance summary	30 plants/clumps

Habitat transect

Flowering plant – Plant 6

Possible insect damage or deterioriation of bruised plants

Notes and recommendations

(Individual plant/clump data see following page)

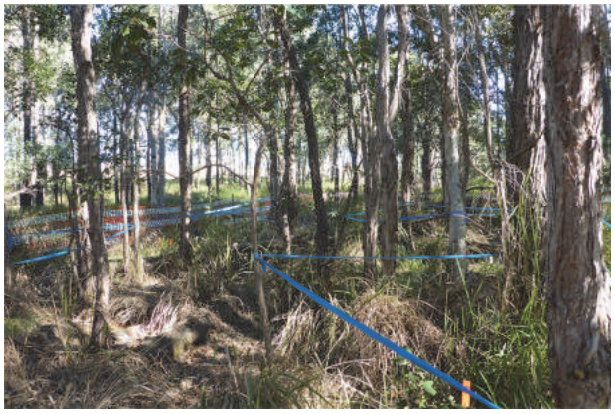
Survivorship has been low as a result of very dry conditions, probable marsupial grazing and insect damage. Several of the surviving plants were flowering and producing capsules, mostly empty, indicating that seed had been shed into the surrounds. It is likely that recruitment from seeds will take place in the next growing season, along with further vegetative spread. Progression through the plant's lifecycle represents an early approach towards a target for the species. Planning is in place for supplementary plantings and fencing repair/upgrade for marsupial exclusion is to be undertaken urgently.

Details of plants observed May 2016

Plant no	Easting	Northing	General condition	Leaf condition	Flowering/ fruiting	Shoot length	Count new shoot	Dis-ease	Recruitment	Threats	Other	Notes
1	517866	6677746	4	5		compact clump in active growth					grazed?	
2	517862	6677745	5	5		small clump in active growth						
3	517860	6677744	5	5		small clump in active growth						
4	517860	6677744	5	5								
5	517861	6677748	5	5		small clump in active growth						
6	517864	6677748	5	5	fl/fr	medium clump						photo
7	517859	6677746	4	4							grazed	
8	517859	6677746	4	4	fl/fr	small clump in active growth					grazed	
9	517860	6677746	5	4		small clump in active growth						
10	517860	6677747	5	5	fl	spreading						
11	517863	6677753	5	5	fl/fr	spreading						
12	517867	6677747	5	5	fl/fr							
13	517867	6677742	4	4		spreading						
14	517866	6677742	4	4		spreading					grazed	
15	517867	6677739	4	4		very small						
16	517859	6677752	5	5	fl/fr	small						
17	517844	6677739	5	5	fl/fr	big clump spreading						
18	517844	6677733	5	5	fr	small spreading clump						
19			5	4		small spreading clump						
20	517842	6677734	5	5	fl/fr	small clump in active growth						
21	517843	6677717	5	5	fl	small spreading clump						
22	517830	6677732	5	5	fl	small spreading clump						
23	517827	6677716	5	5	fl	very small plant						
24	517828	6677713	5	5	fl/fr	big patch						
25	517828	6677724	5	5	fl	medium patch						
26	517831	6677714	5	5	fl/fr	big patch						
27	517822	6677720	5	5	fl	small spreading patch						
28	517828	6677715	5	5	fl/fr	very big patch, spreading						
29	517841	6677710	5	5		small patch						
30			5	4		medium patch, spreading						grazed

Kangaroo Trail Road Li – receiving site details

Site code	KT Li
Species	*Lindsaea incisa*
Common name	Slender screw fern
Date	04-May-16
Marker	ll on trunks, pink
Location	North of Section 1 depot on RMS land
Location 2	
Easting	517879
Northing	6677768
Transect orientation	N-S
Climate previous	dry
Climate current	dry, sunny
Landform	flat to gentle slope
Drainage	good
Slope	slight
Aspect	south
Soil moisture	dry
Water levels	dry
Water flow	dry
Plant condition (0-5)	3-5
Height	
Clump diameter (cm)	2-30
DBH	
Leaf cond	
Length new shoots	
Flowers	
Fruit	
Recruitment	
Disease/insect	
Dieback	
Threats	Exotic grass (sparse)
VegComm	*Eucalyptus resinifera-Lophostemon suaveolens-Melaleuca quinquenervia*
Canopy species	*Eucalyptus resinifera, Lophostemon suaveolens, Melaleuca quinquenervia*
Midstorey species	*Lophostemon suaveolens*
Understorey species	*Imperata cylindrica*
Canopy	44
Midstorey	38
Forb	10
Grass	60
Shrub (<1m)	5
litter	70
bare/water	0
exotic	0
Weed Species	*Paspalum wettsteinii* and other exotic grasses
Weed abundance	sparse
Recruitment	Limited vegetative spread
Disturbance	
Comments	
Abundance summary	17 clumps



Habitat transect

Clump 7.1

Notes and recommendations

(Individual plant/clump data see following page)

Survivorship has been low as a result of very dry conditions, with 17 clumps surviving from an original 45 clumps. Further vegetative spread is likely, if probably slow, when soil moisture conditions are suitable. Ongoing low level weed maintenance required.

Supplementary plantings are generally not recommended as sources of transplant material are limited and would cause depletion of wild populations. Successful establishment requires optimal conditions. A small number of nursery-held plants will be planted out when suitable conditions prevail.

No sign of grazing damage but the species will benefit from upgraded protective fencing planned for the site.

Details of plants observed May 2016

No	General condition	Leaf condition	Diameter of clump (cm)	Count new shoot	Threats	Other
1.1	5	5	20			quite strong growth in small clumps
1.2	5	5	5			quite strong growth in small clumps
1.3	5	5	5			quite strong growth in small clumps
1.4	5	5	10			quite strong growth in small clumps
2.2	4	4	5			
3.1	4	4	10			small fronds
3.2	4	4	10			small fronds
3.3	4	4	10		grass	small fronds
3.4	3	3	2			small fronds
3.5	4	4	10			small fronds
4.1	5	5	30			
4.2	5	5	10			
4.3	5	5	5			
5.1	5	5	20			
6.1	5	5	20			
6.2	5	5	9			
7.1	5	5	20			

Kangaroo Trail Road Ah – receiving site details

Site code	KT Ah
Species	*Arthraxon hispidus*
Common name	Hairy joint-grass
Date	04-May-16
Marker	
Location	North of Section 1 depot on RMS land
Location 2	
Easting	
Northing	
Transect orientation	
Climate previous	dry
Climate current	dry, sunny
Landform	flat to gentle slope
Drainage	good
Slope	slight
Aspect	south
Soil moisture	dry
Water levels	dry
Water flow	dry
Plant condition (0-5)	
Height	
Width	
DBH	
Leaf cond	
Length new shoots	
Flowers	
Fruit	
Recruitment	
Disease/insect	
Dieback	
Threats	
VegComm	*Melaleuca quinquenervia-E. resinifera-Corymbia intermedia* forest
Canopy species	*Melaleuca quinquenervia, E. resinifera, Corymbia intermedia*
Midstorey species	
Understorey species	
Canopy	
Midstorey	
Forb	
Grass	
Shrub (<1m)	
litter	
bare/water	
exotic	
Weed Species	*Paspalum wettsteinii* and other exotic grasses
Weed abundance	sparse
Recruitment	
Disturbance	
Comments	
Comments 2	
Abundance summary	No emergence from soil-stored seed

General habitat view from N corner of planting area looking south


Typical soil distribution area

Notes and recommendations

No formal habitat transect established, planting area too small. Similar to KT La adjacent. No Hairy joint-grass observed so far from soil-stored seed (dry conditions, seasonal factors). Soil seed density is likely to be low in soil from a donor site where two plants had been documented. Continue observations and weed maintenance next growing season.

Halfway Creek crossing

Noah's false chickweed *Lindernia alsinoides*
Square-stemmed spike-rush *Eleocharis tetraquetra*

Layout

Locations of receiving sites at Halfway Creek Crossing

Translocation methods

Noah's false chickweed *Lindernia alsinoides*

Slabs 30 x 30 x 10cm were collected on 31 August 2015 and stored in crates for transplanting as access to Halfway Creek Crossing was delayed. As a result, plant were in poor condition, but as soil-stored seed was likely to be present in the collected slabs, the translocation proceeded.
10-12 slabs were planted (10 September 2015) at each of eight plots.
Nursery stock was raised simultaneously for supplementary plantings if required.

The centre of each plot was marked with a spike label.

Plot locations

Plot no	Easting	Northing
1	0506879	6690368,
2	0506871	6690378
3	0506873	6690374
4	0506880	6690363
5	0506883	6690361
6	0506875	6690357
7	0506879	6690348
8	0506890	6690358

Typical planting layout for *Lindernia alsinoides slabs*

Square-stemmed spike-rush – *Eleocharis tetraquetra*

Slabs 30 x 30 x 10 cm were collected on 31 August 2015 and stored in crates for transplanting as access to Halfway Creek Crossing was delayed. No plants were observed above ground at the donor site, but soil was collected from the documented locations of the species where soil-stored seeds and rhizomes were likely to be present.
75 slabs were planted (10 September 2015) at each of three transect planting locations, ends marked with flagged trunks or stakes. Slabs were placed at 1m intervals.

Location of transects

Transect no	Easting	Northing
1	506813	6690348
2	506821	6690350
3	506834	6690353

Halfway Creek crossing La – receiving site details

Site code	HWCC La
Species	*Lindernia alsinoides*
Common name	Noah's false chickweed
Date	12-May-16
Marker	ll on trunks, pink
Location	South of channel, east of highway
Easting	506875
Northing	6690354
Transect orientation	N-S
Climate previous	dry
Climate current	dry, sunny
Landform	flat, edge of swamp
Drainage	periodically inundated
Slope	flat
Aspect	flat
Soil moisture	dry
Water levels	dry
Water flow	dry
Plant condition (0-5)	None observed
Height	
Width	
DBH	
Leaf cond	
Length new shoots	
Flowers	
Fruit	
Recruitment	
Disease/insect	
Dieback	
Threats	
VegComm	*Eucalyptus tereticornis, Melaleuca alternifolia* forest
Canopy species	*Eucalyptus tereticornis, Melaleuca alternifolia*
Midstorey species	*Acacia floribunda, Melaleuca alternifolia*
Understorey species	*Lomandra longifolia, Dichondra repens, Oplismenus imbecillis, Hypolepis muelleri*
Canopy	47.5
Midstorey	10
Forb	80
Grass	90
Shrub (<1m)	0
litter	5
bare/water	0
exotic	0
Weed Species	none (some e.g. Pinus in vicinity)
Weed abundance	
Recruitment	
Disturbance	
Abundance summary	No emergence from soil stored seed

Habitat transect

Notes and recommendations

No plants observed

(Individual soil translocation photos see following page).

Access to this site for maintenance and inspection following planting has been restricted by construction.

No emergence from soil-stored seeds (dry conditions), but observations should be continued into the next growing season.

Planning is in place for supplementary plantings.

Noah's false chickweed soil translocation centre points. Photos taken from 2m from centre facing south.

Plot 1

Plot 2

Plot 3

Plot 4

Plot 5

Plot 6

Plot 7

Plot 8

Halfway Creek crossing Elt – receiving site details

Site code	HWCC Elt
Species	*Eleocharis tetraquetra*
Common name	Square-stemmed spikerush
Date	12-May-16
Marker	ll on trunks, pink
Location	South of channel, east of highway
Location 2	
Easting	506820
Northing	6690352
Transect orientation	N-S
Climate previous	dry
Climate current	dry, sunny
Landform	flat
Drainage	n/a
Slope	flat
Aspect	flat
Soil moisture	standing water in small shallow pools
Water levels	shallow
Water flow	
Plant condition (0-5)	
Height	
Width	
DBH	
Leaf cond	
Length new shoots	
Flowers	
Fruit	
Recruitment	
Disease/insect	
Dieback	
Threats	
VegComm	
Canopy species	*Melaleuca alternifolia*
Midstorey species	*Acacia* sp
Understorey species	*Imperata cylindrica,* sedge (Carex sp? no fertile material)
Canopy	50
Midstorey	0
Forb	65
Grass	40
Shrub (<1m)	
litter	
bare/water	
exotic	
Weed Species	none along transect
Weed abundance	
Recruitment	
Disturbance	
Comments	
Comments 2	
Abundance summary	No emergence from soil stored seed

Habitat transect

Location of soil distribution Transect 1

Location of soil distribution Transect 2

Notes and recommendations

Access to this site for maintenance following planting has been restricted by construction.
No emergence from soil stored seed (dry conditions, unknown soil propagule density). Observation to continue next growing season.

Yuraygir SCA

Noah's false chickweed *Lindernia alsinoides*

Layout and translocation methods

21 plants/clumps were directly transplanted, 15 August 2015, to the Yuraygir SCA receiving site, placing plants/clumps into natural gaps in the native vegetation. The planting area was approx. 30 x 40m.

Yuraygir SCA La – receiving site details

Site code	YSCA La
Species	*Lindernia alsinoides*
Common name	Noah's false chickweed
Date	12-May-16
Marker	ll on trunks, pink
Location	SW section of SCA
Location 2	
Easting	508328
Northing	6691033
Transect orientation	N-S
Climate previous	dry
Climate current	dry, sunny
Landform	side of shallow gully
Drainage	poor
Slope	very gentle
Aspect	NE
Soil moisture	dry to slightly moist
Water levels	dry
Water flow	none
Plant condition (0-5)	Mostly 5
Height	2-10 cm
Clump diameter (cm)	Up to 20 cm
DBH	
Leaf cond	4-5
Length new shoots	
Flowers	present
Fruit	empty capsules
Recruitment	vegetative spread
Disease/insect	
Dieback	
Threats	
VegComm	*Eucalyptus robusta* forest
Canopy species	*Eucalyptus robusta*
Midstorey species	*Melaleuca* sp
Understorey species	*Sedges (Lepidosperma* sp.*), Xanthorrhoea fulva, Banksia oblongifolia*
Canopy	2.5
Midstorey	10
Forb	95
Grass	0
Shrub (<1m)	80
litter	0
bare/water	0
exotic	0
Weed Species	none
Weed abundance	0
Recruitment	n
Disturbance	
Comments	
Comments 2	
Abundance summary	6 plants/clumps

Habitat transect

Flowering plant – Plant 19

Notes and recommendations

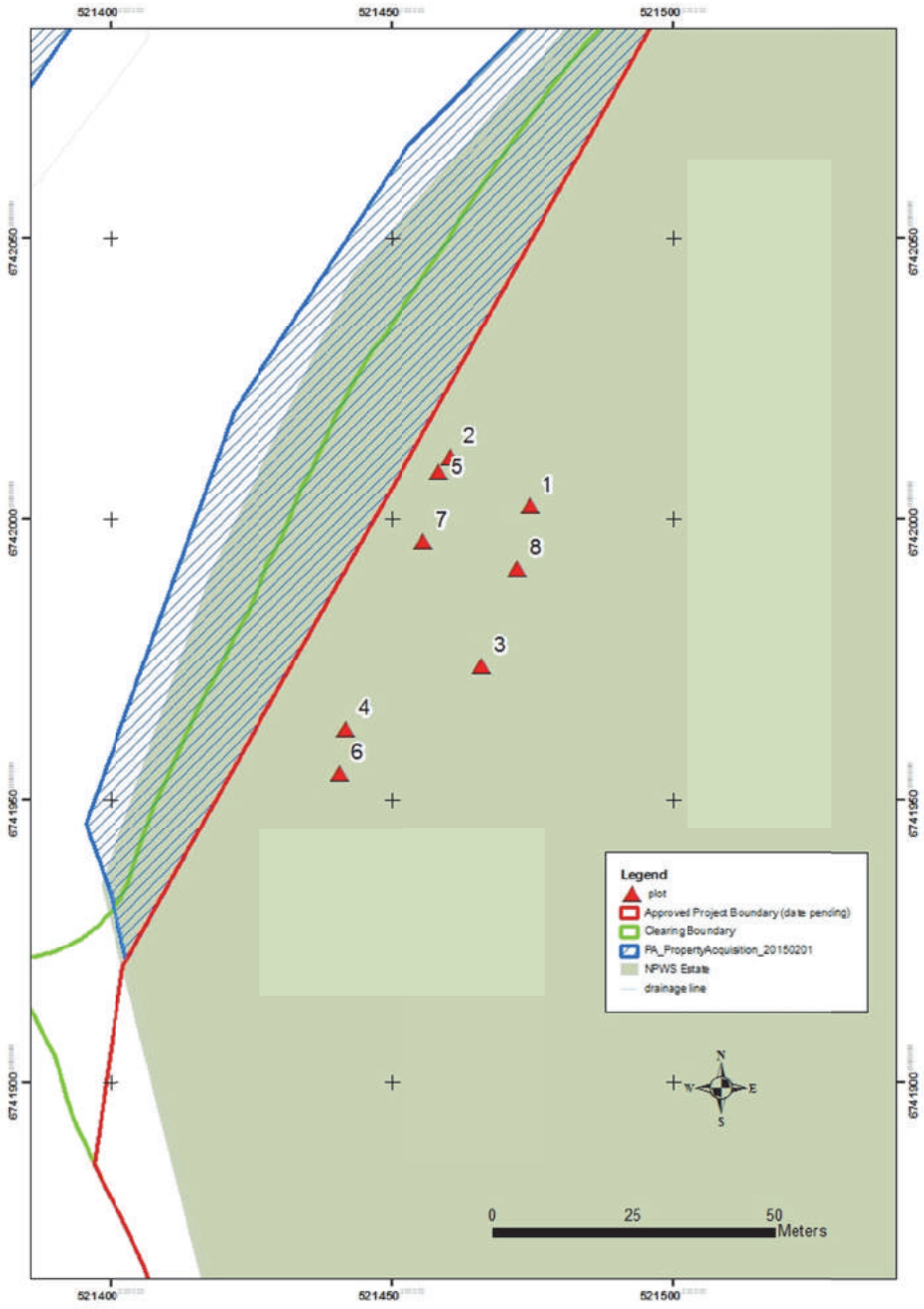
(Individual plant/clump data see following page)
Survivorship has been low as a result of very dry conditions, with six plants surviving out of 22 plantings. Several of the surviving plants were flowering. It is possible that recruitment from seeds will take place in the next growing season, along with further vegetative spread. Locations of dead plants to be checked for a further year.
This site is not recommended for further supplementary plantings as apparently drier than the alternatives at Kangaroo Trail and Halfway Creek Crossing. However, the established plants are doing reasonably well despite the dry conditions.

				Monitoring observations May 2016						
Plant/clump no	**Easting**	**Northing**	**Description Aug 2015**	**Condition general**	**Condition leaf**	**Diameter (cm)**	**Stems (cm)**	**Height (cm)**	**flowering/fruiting**	**Notes**
1	508316	6690997	1 small clump	0						
2	508326	6691003	2 plants	5	5	7	5	4		shrinking at clod margins, dry
3	508320	6691006	1 small clump	0						
4	508325	6691011	1 small clump	0						shrinking at clod margins, dry
5	508323	6691014	1 small clump	5	5	10	10	10		less dry
6	508318	6691014	2 small clumps	0						
7	508321	6691018	2 plants	4	4	3	2	2		small, fairly dry
8	508317	6691017	2 plants	0						
9	508324	6691022	medium clump	0						
10	508318	6691020	medium clump	0						
11	508332	6691025	1 small clump	0						
12	508313	6691017	2 small clumps	5/5	5	6/4	6/3	6/4	fl	two small clumps, one with flowers
13	508310	6691027	1 plant	5	5	6	6	6		
14	508316	6691029	4 plants	0						
15	508320	6691030	medium clump	0						
16	508326	6691029	1 small clump	0						shrinking at clod margins, dry
17	508329	6691030	1 small clump	0		3x3	3x2	3x10		3 small plants, fairly dry
18	508329	6691034	1 plant	0						
19	508325	6691035	medium clump	5	5	20	10	8	fl/fr	
20	508325	6691035	2 plants	0						
22	508323	6691041	1 small clump	0						

Yaegl NR south

Tall knot-weed *Persicaria elatior*

Layout



Location of translocation plots at Yaegl NR south

Translocation methods

A number of separate operations were undertaken, using direct transplant of live plants, dead plants with capsules and seeds retained, and soil assumed to contain soil-stored seeds. In addition, small seedlings were dug, potted and grown on in a nursery and later planted. The methods used at each plot are reported with the monitoring observations.

Yaegl NR south Pe – receiving site details

Site code	YNRS Pe
Species	*Persicaria elatior*
Common name	Tall knotweed
Date	15-May-16
Marker	ll on trunks, pink
Location	East of highway on SW edge of reserve
Location 2	
Easting	521457
Northing	6741998
Transect orientation	N-S
Climate previous	dry
Climate current	dry, sunny
Landform	flat
Drainage	poor
Slope	flat
Aspect	flat
Soil moisture	dry
Water levels	dry
Water flow	dry
Plant condition (0-5)	mostly 0 - seasonal dieback expected
Height	up to 0.9m
Width	
DBH	
Leaf cond	
Length new shoots	
Flowers	two flowers observed
Fruit	Dead capsules shedding seeds
Recruitment	none observed
Disease/insect	
Dieback	seasonal dieback expected
Threats	
VegComm	*Melaleuca quinquenervia* forest
Canopy species	*Melaleuca quinquenervia*
Midstorey species	none
Understorey species	
Canopy	32.5
Midstorey	0
Forb	25
Grass	
Shrub (<1m)	
litter	100
bare/water	
exotic	
Weed Species	none
Weed abundance	
Recruitment (canopy, mid)	Occasional *Melaleuca quinquenervia* saplings
Disturbance	
Comments	
Comments 2	
Abundance summary	44 plants, mostly died back

Habitat transect

Plant with live material present, Plot 3

Notes and recommendations

(Individual plant/clump data see following page)

A mix of transplanted soil, plant clumps with soil and planting of nursery stock at this site is likely to have resulted in considerable seed inputs to this site. As this operation is an augmentation of an existing population of ephemeral plants scattered in the general vicinity, and seed will be washed both from the site and into the site with floodwater, it will be difficult to evaluate the progress of population development. Observations will continue in the next growing season, no additional augmentation is considered necessary in the short term.

Control plants at Yaegl NR Central receiving site will aid interpretation of the development of translocations.

Monitoring observations 15-May-16

Heights of sprawling plants measured as though upright. fl = flower, fr = fruit

Plot 1	Easting	**521475**	Northing	**6742002**
	Donor	Yaegl north	**Planting date**	9/09/2015
	Direct transplant, central point surrounded by plants at 2.5 and 5m at cardinal points, plus one central			
	Habitat	Paperbark	**Threats**	None evident
	Point no	**h (m)**	**Notes**	
	1	0.5	dead plant with seeds	
	2	0.5	dead plant with seeds	
	3	0.6	dead plant with seeds	
	4	0.25	dead plant, no fl/fr	
	5	0.6	dead plant with seeds	
	6	0.25	dead plant, no fl/fr	
	7	0.8	dead plant with seeds	
	8	0.6	dead plant with seeds	
	9	0.2	dead plant, no fl/fr	
Plot 2	**Easting**	521461	**Northing**	6742011
	Donor	Yaegl north	**Planting date**	9/09/2015
	Direct transplant, central point surrounded by plants at 2.5 and 5m at cardinal points			
	Habitat	Paperbark	**Threats**	None evident
	Point no	**h (m)**	**Notes**	
	1	0.6	dead plant with seeds	
	2	0.6	dead plant with seeds	
	3	0.3	dead plant with seeds	
	4	0.5	dead plant with seeds	
	5	0.4	dead plant with seeds	
	6	0.7	dead plant with seeds	
	7	0.4	dead plant with seeds	
	8	0.4	dead plant with seeds	
Plot 3	**Easting**	521466	**Northing**	6741974
	Donor	Maclean Interchange	**Planting date**	29/11/2015
	Seedlings grown on in nursery and planted out, central point surrounded by plants at 2.5 and 5m at cardinal points			
	Habitat	Paperbark	**Threats**	None evident
	Point no	**h (m)**	**Notes**	
	1	0.6	dead plant with seeds plus two live branches with flowers	
	2	0.7	dead plant with seeds	
	3	0.8	dead plant with seeds	
	4	0.5	dead plant with seeds	
	5	0.6	dead plant with seeds	
	6	0.6	dead plant with seeds	
	7	0.5	dead plant with seeds	
	8	0.5	dead plant with seeds	
		low grass more or less continuous, some leaf litter patches		
Plot 4	**Easting**	521442	**Northing**	6741963
	Donor	Yaegl north	**Planting date**	9/09/2015
	Clods of soil transplanted at 5m from centre in cardinal directions			
	Habitat	Paperbark	**Threats**	None evident
	Point no		**Notes**	
	1		no plant	
	2		no plant	
	3		no plant	
	4		no plant	

Plot 5	**Easting**	521458	**Northing**	6742008
	Donor	Maclean Interchange	**Planting date**	29/11/2015
	Habitat	Paperbark	**Threats**	None evident
	Point no	**h (m)**	**notes**	
	1	0.4	dead plant with seeds	
	2	0.5	dead plant with seeds	
	3	0.4	dead plant with seeds	
	4	0.6	dead plant with seeds	
	5	0.5	dead plant with seeds	
	6	0.4	dead plant with seeds	
	7	0.4	dead plant with seeds	
	8	0.8	dead plant with seeds	
	9	0.5	dead plant with seeds	
		ground bare with leaf litter		
Plot 6	**Easting**	521441	**Northing**	6741955
	Donor	Yaegl Central West	**Planting date**	18/01/2016
	Direct transplant, 5 m from central point in cardinal directions plus one plant at 2.5m			
	Habitat	Paperbark	**Threats**	None evident
	Point no	**h (m)**	**Notes**	
	1	0.3	dead plant with seeds	
	2	0.3	dead plant no seeds	
	3	0.4	dead plant with seeds	
	4	0.2	small live plant with flowers	
	5		no plant	
Plot 7	**Easting**	521456	**Northing**	6741996
	Donor	Yaegl North	**Planting date**	9/09/2015
	Direct transplant of clods, 5 m from central point in cardinal directions			
	Habitat	Paperbark	**Threats**	None evident
	Point no		**Notes**	
	1		no plant	
	2		no plant	
	3		no plant	
	4		no plant	
Plot 8	**Easting**	521472	**Northing**	6741991
	Donor	Maclean Interchange	**Planting date**	29/11/2015
	Seedlings grown on in nursery and planted out, central point surrounded by plants at 2.5 and 5m at cardinal points			
	Habitat	Paperbark	**Threats**	None evident
	Point no	**h (m)**	**Notes**	
	1	0.9	dead plant with seeds	
	2	0.8	dead plant with seeds plus several live branches with flowers	
	3	0.6	dead plant with seeds	
	4		no plant	
	5	0.3	dead plant no fl/fr	
	6	0.6	dead plant with seeds plus small live branches with flowers	
	7		no plant	
	8		no plant	
		low grass, cover high Melaleuca quinquenervia in overstorey		

Yaegl NR central

Tall knotweed *Persicaria elatior*

Layout and translocation methods

Planting date 2 July 2015

Direct transplant of dead plant material, with seeds, and soil slabs measuring 30 x 20 x 10cm
Controls were selected from naturally occurring clumps of plants in the vicinity.

Plots and controls were marked with spike labels

Location of plots and controls

Plot number	Easting	Northing
Plot 1	522422	6742551
Plot 2	522434	6742541
Control 1	522425	6742548
Control 2	522432	6742545
Control 3	522437	6742528
Control 4	522424	6742564

Yaegl NR central Pe

Site code	YNRC Pe
Species	*Persicaria elatior*
Common name	Tall knotweed
Date	15-May-16
Marker	ll on trunk at S, on stake at N, pink
Location	East of highway, opposite drainline to west of highway
Location 2	
Easting	522423
Northing	6742572
Transect orientation	N-S
Climate previous	dry
Climate current	dry, sunny
Landform	flat
Drainage	poor
Slope	flat
Aspect	flat
Soil moisture	dry
Water levels	dry
Water flow	dry
Plant condition (0-5)	0
Height	
Width	
DBH	
Leaf cond	
Length new shoots	
Flowers	
Fruit	
Recruitment	new plants present but probably not from transplants
Disease/insect	
Dieback	
Threats	
VegComm	Exotic grassland on edge of *Casuarina glauca - Melaleuca quinquenervia*
Canopy species	
Midstorey species	
Understorey species	*Paspalum urvillei*
Canopy	0
Midstorey	0
Forb	20
Grass	95
Shrub (<1m)	
litter	
bare/water	10
exotic	
Weed Species	Exotic grasses, *Ipomoea caraica* occasional
Weed abundance	
Recruitment (canopy, mid)	
Disturbance	
Comments	
Comments 2	
Abundance summary	

Habitat transect

Large clump with live flowering material present, control point 3, May 2016

Flowering plant in the vicinity of the controls May 2016

Notes and recommendations

(Individual plant/clump data see following page)

So far no new seedlings have been observed where soil clods have been transplanted, but conditions have been dry.

This operation is an augmentation of an existing population of ephemeral plants scattered in the general vicinity, and seed will be washed both from the site and into the site with floodwater. It will be difficult to evaluate the progress of population development. Observations will continue in the next growing season, no additional augmentation is considered necessary in the short term. Controls will aid interpretation of the development of translocated plants.

Monitoring observations

Planting date 2 July 2015

Direct transplant of dead plant and soil clods measuring 30x20x10cm

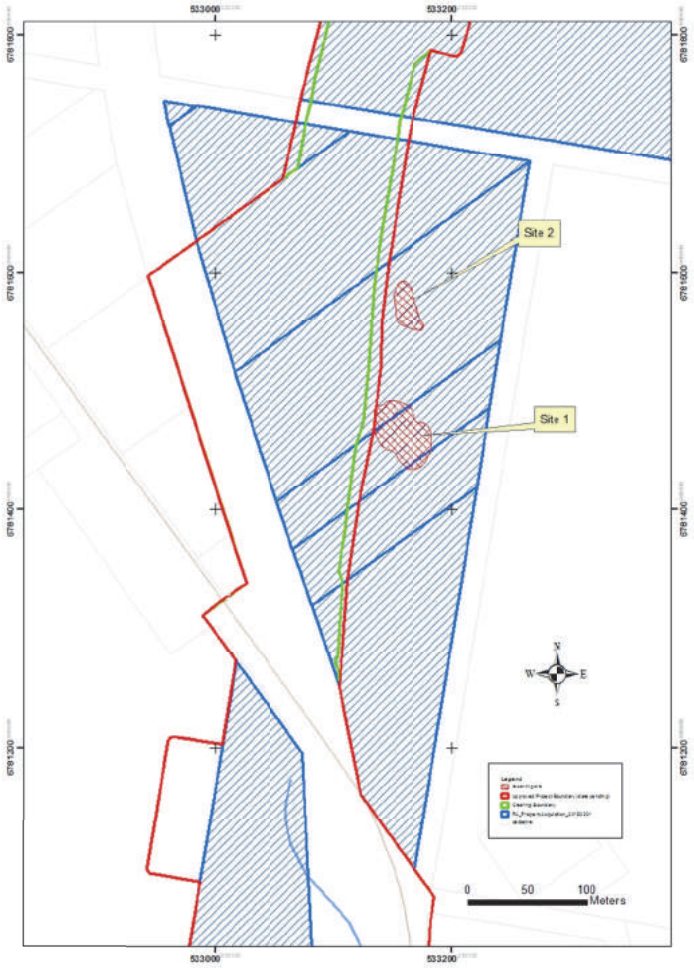
Absence of material at two out of four of the control points illustrates the transient nature of the species.

Plot number	Observations 2 Jul 2015	Observations 15 May 2016
Plot 1		
Plot 2		
Control 1	large clump of dead material	large clump dead material growing with exotic grasses
Control 2	large clump of dead material	none
Control 3	large clump of dead material	large clump dead and live (flowering) material
Control 4	large clump of dead material	none

Trustrums Hill

Hairy joint-grass *Arthraxon hispidus*

Layout



Locations of planting sites

Translocation methods

Site 1

29 July 2015 and 6 August 2015

The biggest clumps in the donor site were selected for translocation. The plants were all dead and no seed was observed on the plant material. Twenty five slabs of average area 0.5 m^2 and 10 cm deep, including clumps of plant material and topsoil, were transferred to crates. The slabs were transported to Site 1 and divided between three plots.

Location of plots at Site 1 (points at ne and sw corners)

Plot no	Easting	Northing
1.1 sw	533162	6781451
1.1 ne	533165	6781456
1.2 sw	533161	6781453
1.2 ne	533160	6781459
1.3 sw	533169	6781466
1.3 ne	533168	6781473

Digging of turf slab

Transport of slab

Site 2

Planting date 18 April 2016
Casuarina glauca seedlings at receiving site removed and treated. Approx. 5 clumps of Hairy joint-grass (naturally occurring) were observed in receiving site.

64 slabs of Hairy joint-grass, dimensions as for Site 1, were dug from the donor site (new growth had occurred since Site 1 translocation). The slabs were transported to the receiving site and planted 1 slab at 1m in the cardinal directions from the central marker and 4 clumps in between the cardinal directions at 2 m. Centre marked with spike label.

Translocated Hairy joint-grass slab

Plot 2.4

Locations of plots at Site 2

Plot	Northing	Easting	Number of slabs translocated
2.1	533173	6781555	8
2.2	533167	6781564	8
2.3	533164	6781561	8
2.4	533155	6781566	8
2.5	533163	6781574	8
2.6	533156	6781575	8
2.7	533160	6781587	8
2.8	533157	6781590	8

Trustrums Hill Ah – details of receiving sites

Site code	TH Ah
Species	Arthraxon hispidus
Common name	Hairy joint-grass
Date	14-May-16
Marker	ll tree at N, pink
Location	Site 1 south of RMS-owned land on east of highway. Site 2 at north of site adjacent to Swamp Oak forest
Location 2	
Easting Site 1	533162
Northing Site 1	6781451
Easting Site 2	533162
Northing Site 2	6781577
Transect orientation Site 2	N-S
Climate previous	dry
Climate current	dry, sunny
Landform	flat
Drainage	poor
Slope	flat
Aspect	flat
Soil moisture	dry
Water levels	dry
Water flow	dry
Plant condition (0-5)	0 (seasonal dieback expected)
Height	
Width	
DBH	
Leaf cond	
Length new shoots	
Flowers	
Fruit	
Recruitment	
Disease/insect	
Dieback	
Threats	
VegComm Site 2	Exotic grassland on edge of *Casuarina glauca - Melaleuca quinquenervia*
Canopy species Site 2	
Midstorey species	0
Understorey species	0
Canopy	5
Midstorey	25
Forb	
Grass	
Shrub (<1m)	50
litter	35
bare/water	Exotic grasses
exotic	
Weed Species	
Weed abundance	
Recruitment	
Disturbance	
Comments	
Comments 2	
Abundance summary	Dead plant material present

Site 1 following planting, Jul-Aug 2015

Site 1 May 2016, showing biomass development on planting site at right of photo, also vehicle damage (powerline maintenance)

Site 2 May 2016

Notes and recommendations

(Individual plant/clump data see following page) Biomass reduction through fencing and grazing is currently under investigation by RMS, also inquiries re possible removal of phone lines. At Site 2, *Casuarina glauca* seedlings will require ongoing removal. Controls are available to guide interpretation of observations of translocated plants.

Monitoring observations May 2016

Controls

Plant/clump no	Easting	Northing	Method	Observations July 2015	Observations May 2016
Control 1	533152	6781530	search 5 m radius	fairly sparse	None present, overgrown with Casuarina glauca and exotic grasses, tall grasses to 1.5m high
Control 2	533151	6781491	search 5 m radius	fairly sparse	None present, overgrown with Casuarina glauca and exotic grasses, tall grasses to 1.5m high
Control 3	533148	6781489	search 5 m radius	fairly sparse	present, sparse in low grass and herbaceous pasture weeds to 30 cm high
Control 4	533147	6781503	search 5 m radius	fairly sparse	mid dense patch, dead weeds to 1.3m + tall grass, but with lower open patches

Site 1

One plant detected in search February 2016

Grass has grown to 1m, but there are some open patches and lower grass, Hairy joint-grass material observed (May 2016).

Site 2

Dead clumps, recently translocated, are still in place but no retained seed observed (May 2016).

Appendix 2 Additional translocation actions

Preparation of Quassia Moonee Creek cuttings

25 June 2015
Seven clusters of stems, possibly clonal, were recognised in the field. 120 cuttings of sizes ranging from 10cm to 50cm in length were taken and numbered by cluster.

Cuttings were placed in plastic bags and transported to Cutting Edge Nursery, proprietor Greg Lascalles, where they were placed in a specialised misting facility.

No strike was achieved.

Seed collection – Square-fruited ironbark

Donor sites identified in Section 2 were searched for seed following pre-construction clearing when freshly felled trees were windrowed. No seed was present at many locations as a result of recent fires and generally unpredictable seed availability. In addition, some fruits displayed indications of hybrid origin (rounded angles on fruit)– no collections were made from suspected hybrids.

Most seed was collected from the Franklins Road area, with collections taking place between July 2015 and February 2016. Approximately 80 plants are held in the nursery awaiting suitable planting conditions.

Green-leaved rose walnut at Maclean Interchange

This tree (diameter approx. 10 cm) has been prepared for translocation and awaits advice as to requirements.

Preparation for the translocation commenced on 19 October 2015 with weed control and vine removal in the immediate area surrounding the tree. A trench was dug around 50 cm deep, 1 m away from the stem, then roots were severed for another 10 cm deeper with a crowbar.
Subsoil and topsoil were replaced and the trench area was watered thoroughly. Further preparation works were conducted by an arborist, who removed a dead acacia and cut vines. The tree remains in good condition.


Freshly trenched tree, 19 October 2015

Lepidosperma "Coaldale"

Plants of *Lepidosperma* sp. Coaldale were removed from the donor site at Wells Crossing on 20 July 2015. The plants were dug up shovel deep and the placed in plastic bags with the sandy soil kept around the rhizomes. The plants were removed from 17 separate locations, some of which were single plants while others were clumped and connected underground to the same rhizome. The rhizomes were shiny black in appearance, straight and brittle. Few lateral roots were apparent.

Plants were transferred to the car and covered in wet hessian for transport to Mullumbimby Creek Native Plant Nursery, where they were potted up on 21 July 2015. The plants with local soil were potted up in 12 inch pots in a mix of 2 parts potting mix 1 part coarse sand 1 part peat moss. The plants were then placed in a shady part of the nursery.

A total of 36 plants were removed and tagged and numbered to indicate their relationship to connecting rhizomes. Rhizomes were numbered 1-17 and, where multiple plants arose from the same rhizome, the numbers were assigned alphabetical suffixes from a up to f.

Plants are numbered as follows:
1, 2 a-c, 3 a-b, 4, 5 a-c, 6 a-f, 7 a-b, 8 a-c, 9, 10 a-b, 11, 12 a-d, 13 a-b, 14, 15 a-b, 16 and 17.

Plants developed successfully in the nursery, with the exception of the two divisions from rhizome 15. Plants are being held in the nursery for planting in appropriate conditions.

Newly dug clump of *Lepidosperma* "Coaldale" with multiple shoots from a single rhizome.