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CLLMM Survivorship Monitoring (2015 Plantings)

FINAL Project Report

To the Department of Environment, Water and Natural Resources, Government of South Australia

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27/05/2016

Citation

Tuck, J. and Barron, P. (2016) *CLLMM vegetation survivorship monitoring (2015 plantings).* Report to the Department of Environment, Water and Natural Resources, Government of South Australia. Barron Environmental, Nairne, South Australia.

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ACKNOWLEDGEMENTS

Sincere thanks to the following people for their assistance with this project:

- Sacha Jellinek & Blair Kavanagh, Vegetation Program, DEWNR for site and project information and support throughout the project.
- Kerri Bartley, Goolwa to Wellington LAP, for local knowledge of sites and landholder connections.
- Richard Owen, Hindmarsh Island Landcare Group, for facilitating access to Hindmarsh Island sites and providing site histories.
- The many landholders who granted access to their properties over the course of the surveys.
- NGT team members who assisted with field work and data entry: Rose Thompson, Jess Bourchier, Craig Billows and Sheryl Holliday.

This project was funded under the Coorong, Lower Lakes and Murray Mouth Recovery Project by the South Australian Government's Murray Futures program and the Australian Government.

Government of South Australia

Australian Government

EXECUTIVE SUMMARY

The Coorong, Lower Lakes and Murray Mouth (CLLMM) region is one of Australia's highest profile wetland systems, internationally recognised under the Ramsar Convention. The region provides diverse ecological, cultural, social and economic value to surrounding regions and the state of South Australia. The CLLMM Recovery Project (2011-16) is funded by the South Australian Government's *Murray Futures* program and the Australian Government to protect and enhance the resilience of this Ramsar listed wetland. The CLLMM Recovery Project includes the Vegetation Program which is a landscape scale habitat restoration program. The program has undertaken extensive habitat restoration activities, including planting local native species across the CLLMM region.

The monitoring undertaken for this report involved the collection, collation and provision of field data from 19 revegetation sites situated across the CLLMM region during spring 2015 and autumn 2016, to determine survivorship rates of 2015 plantings. Survivorship monitoring was conducted at 17 sites in spring 2015; 15 of these sites were then revisited in autumn 2016, along with two additional sites. Nearly 11 000 plants were inspected during the autumn surveys, at an average of more than 600 plants per site.

The results of the study indicated:

- An overall revegetation survivorship success rate of 59.5% at the time of monitoring in autumn 2016, achieved after a challenging, dry summer.
- Wide variability in survivorship rates at individual sites, ranging from as low as 25.4% up to a peak of 97.3%. This variability reflects the breadth of physical variables that can affect planting success, including soil type, topography, hydrology and exposure to sun and wind, however in an encouraging overall trend, ten of the seventeen sites demonstrated survivorship rates of over 60%.
- A number of sites with very high survivorship rates despite the challenging conditions, showing evidence of appropriate species selection, along with effective site preparation and planting technique.
- A range of site preparation and planting methods, which for some sites appeared to strongly influence plant survival and health.
- The prevailing dry post-planting growing conditions may have exacerbated the impacts of poor and/or late site preparation and planting on some sites.

A defining feature of the 2015 revegetation effort was the extended low-rainfall period immediately after planting, from July to December 2015, which provided difficult conditions for seedlings in the establishment phase.

Weedy grasses and other invasive species persist across most sites. Suppression of this competition and the establishment of a natural, native vegetation structure will be a major factor in longer term survivorship and the subsequent restoration of more complex native habitat.

The report includes a summary of suggested site management actions, and a set of broader recommendations, including pest plant and animal management, guarding of plants, and possible directions for follow-up monitoring and analysis.

The results of this study give a comprehensive record of the survivorship of the 2015 plantings, including a detailed dataset and site photopoints, which can be referred to when conducting future assessments of revegetation success and planning for additional or infill plantings. There is also potential for this dataset to be used in more complex analysis along with other datasets such as soil survey results, site history and planting methods, in order to better identify the major determinants of revegetation success.

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1. INTRODUCTION

1.1. Objectives and background of the CLLMM Vegetation Program

The Coorong, Lower Lakes and Murray Mouth (CLLMM) region is an internationally significant wetland system, recognised under the Ramsar Convention, supporting a diverse range of habitats and species at the terminus of the Murray River in South Australia. The CLLMM region is highly diverse supporting freshwater, estuarine and marine ecosystems over its estimated 142,500 hectares, and is culturally significant to the local Ngarrindjeri Nation.

The CLLMM Recovery Project (2011-16) is funded by the South Australian Government's *Murray Futures* program and the Australian Government to protect and enhance the resilience of this Ramsar listed wetland. The CLLMM Recovery Project includes the Vegetation Program which is a landscape scale habitat restoration program. The initial focus of the project was emergency works in response to long-term drought conditions, but with the return of water to the Lower Lakes system in 2010 (around the time the Long Term plan for the CLLMM site was released (DEH 2010)), the emphasis shifted to habitat restoration and building ecosystem resilience. The Vegetation Program has undertaken extensive habitat restoration and revegetation activities to provide habitat benefits for the fauna and flora of the CLLMM region.

1.2. Project scope

In September 2015, Barron Environmental was engaged to carry out the CLLMM Vegetation Survivorship Monitoring (2015 plantings) project. The project involved establishing and conducting transect-based vegetation survival monitoring at 2015 planting sites during spring 2015 and autumn 2016. This monitoring enables the density of surviving plants from the 2015 plantings to be determined and is an important part of tracking the effectiveness of habitat restoration activities (at both site specific and program-wide scales) and ultimately improving the future delivery of similar activities in the region.

Barron Environmental again partnered with NGT Consulting for 2015, after successfully delivering the 2014 CLLMM monitoring project. NGT Consulting delivered the CLLMM monitoring project for the 2013 plantings.

1.3. Project objectives

The project was split into two major components: fieldwork, followed by data entry and production of project reports.

The key objectives of the fieldwork component included:

- Undertaking field-based survivorship monitoring at revegetation sites in spring and autumn.
- Estimating the survivorship of the planting at each revegetation site.
- Providing a basic photographic record of sites.
- Providing an independent check against reported works completed.

The key objectives of the data entry and project report component included:

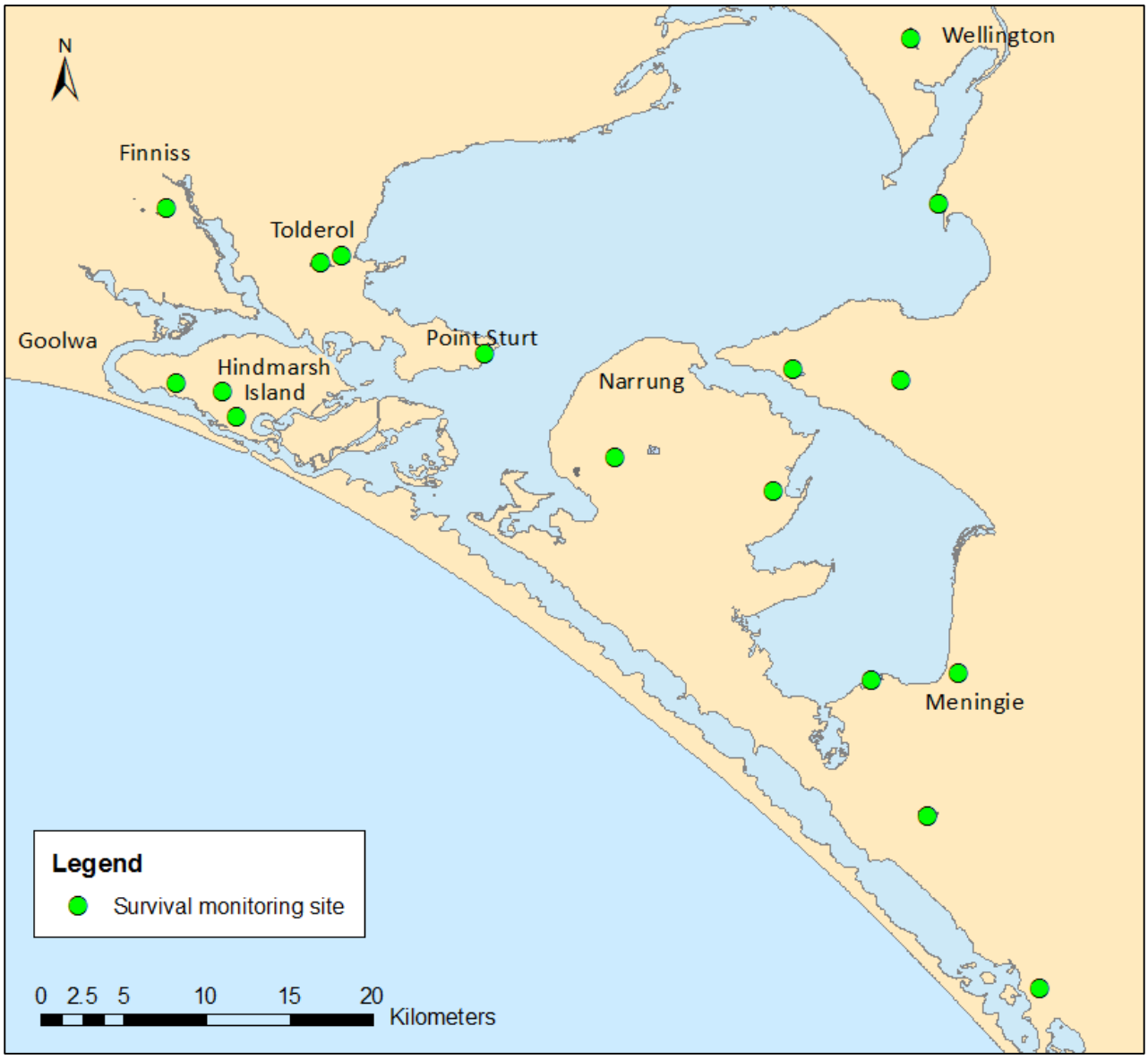
- Entering all field data from the spring and autumn monitoring into a Microsoft Access database.
- Producing a short interim report following the spring monitoring.
- Producing a final report of the spring and autumn monitoring including a discussion of the results and recommendations on any follow up management required.

2. METHODOLOGY

2.1. Monitoring sites

The monitoring sites were situated within the CLLMM region, including sites around the edge of Lake Alexandrina, Lake Albert, the Finniss River, Point Sturt, Hindmarsh Island and south along the Coorong lagoon. In total, 19 sites were visited and assessed throughout the project, including the Hindmarsh Island multi-site (refer to Figure 1).

Figure 1 - Map of the CLLMM region showing autumn 2016 monitoring locations



Sites were firstly surveyed in spring 2015 (450 transects across 17 sites - refer to Table 1) approximately three months after planting, to assess survivorship due to planting technique and grazing. 15 of these sites were then assessed in autumn 2016, along with two other sites not monitored in spring (454 transects across 17 sites - refer to Table 2), to assess survivorship after the plants experienced their first summer season.

Table 1 – Spring 2015 monitoring sites (sites not surveyed in Autumn 2016 in italics)

Site no.	Site name	Transects
1	*Alexandrina Dairies Remnant*	50
2	*Alexandrina Dairies Sandhill*	31
3	Carol Block	30
4	Grey and Mundoo	7
5	Gunner Samphire	47
6	Hartnett	41
7	Henshell	7
8	Hindmarsh Island	14
9	Kindaruar Farm	32
10	Mason Midway Infill	28
11	Meningie Lookout Rd	17
12	Sanders Remnant	50
13	Sanders Samphire	22
14	Warrengie	12
15	Watkins	22
16	Wellington Dairies	13
17	Wellington Lodge Lake Edge Infill	27
Total		**450**

Table 2 - Autumn 2016 monitoring sites. Sites not surveyed in spring 2015 in italics)

Site no.	Site name	Transects
1	Carol Block	33
2	Grey and Mundoo	19
3	Gunner Samphire	54
4	Hartnett	25
5	Henshell	6
6	Hindmarsh Island	12
7	*Hoopman Infill*	25
8	Kindaruar Farm	32
9	Mason Midway Infill	17
10	Meningie Lookout Rd	12
11	*Poltalloch Inland Dunes Infill 2015*	41
12	Sanders Remnant	50
13	Sanders Samphire	17
14	Warrengie	61
15	Watkins	21
16	Wellington Dairies	9
17	Wellington Lodge Lake Edge Infill	20
Total		**454**

2.2. Field survey methodology

The sampling component of the surveys consisted of a number of 50m transects, with the number of transects on each restoration site determined by, and proportional to, the size of the site. Hence for the autumn surveys, the number of transects on individual sites ranged from 6 transects at the Henshell 2015 site, up to 61 transects at the Warrengie 2015 site.

To ensure the robustness of the method and prevent site selection bias for transects, the starting coordinates for each site were determined by DEWNR from randomly generated points in ArcGIS.

Plantings were implemented in distinct zones/ecosystems. The classification system was revised from zones to ecosystems in 2014, therefore some sites are no longer classified by zone (which is based on differences in landform and soil type). Transect direction was determined on-site, and where possible were run only within the zone/ecosystem in which a transect was started (Figure 2).

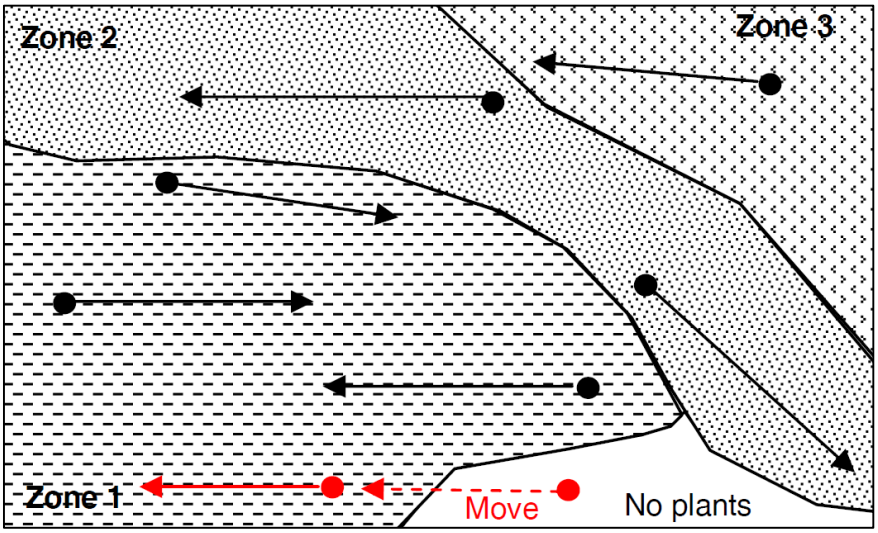


Figure 2 - Transect direction

Each transect consisted of a 50m line, starting at the supplied coordinates. The transect was then walked, counting all individual plants one metre to the left of the transect. At the end of the 50m transect line, the direction was reversed, and plants on the other side were counted while walking back to the starting point (Figure 3).

Each plant – either dead or alive – was identified to species level and recorded on a datasheet for that transect (refer to section 8). Where species identification of a dead plant was not possible, it was counted as “Dead (unknown species)”.

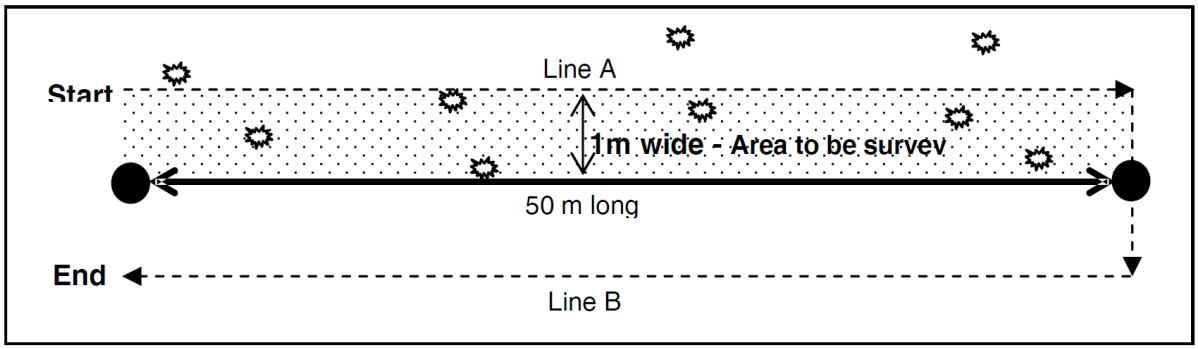


Figure 3 - Transect area

2.3. Site photographs

At each site, at least one photo was taken at locations which reflected overall site condition. Easting and northing was recorded for each photo, along with bearing and approximate height.

2.4. Observational notes

Observations were taken at each site, recording overall plant health, conditions of tree guards, impacts from pest plants and animals, stock incursions, and site condition notes including site preparation and any signs of follow-up maintenance such as spraying of weeds or fence repair. Areas found to be unplanted were also recorded and where possible transects were moved to a nearby planted location. Notes were recorded on a site datasheet (refer to section 7) and transcribed in section 10.

2.5. Data management

All transect data was entered into a Microsoft Access database supplied by DEWNR and delivered as an electronic file.

3. RESULTS

3.1. Overall survivorship for the 2015 plantings

Across the 17 sites that were sampled in Autumn 2016, a total of 10 749 plants were counted and assessed, with 59.5% of all plants recorded as being alive after their first summer since planting in 2015 (Table 3).

Table 3 - Autumn 2016 survivorship by site, with site survival percentages grouped into 5 colour-coded categories: brown (0-20%), orange (20-40%), yellow (40-60%), light green (60-80%) and dark green (80-100%).

Site name	Total Plants	Alive	Dead	Survival (%)
Carol Block	1220	887	333	72.7
Grey and Mundoo	113	110	3	97.3
Gunner Samphire	986	340	646	34.5
Hartnett	1135	979	156	86.3
Henshell	500	290	210	58.0
Hindmarsh Island	218	161	57	73.9
Hoopmann Infill	611	306	305	50.1
Kindaruar Farm	692	180	512	26.0
Mason Midway Infill	120	114	6	95.0
Meningie Lookout Rd	378	319	59	84.4
Poltalloch Inland Dunes Infill	566	254	312	44.9
Sanders Remnant	1215	779	436	64.1
Sanders Samphire	563	272	291	48.3
Warrengie	741	188	553	25.4
Watkins	620	418	202	67.4
Wellington Dairies	523	434	89	83.0
Wellington Lodge Lake Edge Infill	548	363	185	66.2
Total	**10749**	**6394**	**4355**	**59.5**

In Table 4, these 17 sites are grouped according to five broad (colour-coded) percentage categories of survivorship success (based on Durbridge 2012). It can be seen that more than half (59%) of all sites achieved survivorship rates of over 60%, while 18% of sites had survivorship rates below 40%.

Table 4 - Summary of autumn sites by survivorship percentage category (as applied in Durbridge 2012)

Survivorship category		# sites	% sites
0-20%	Very Poor	0	0.0
20-40%	Poor	3	17.6
40-60%	Average	4	23.5
60-80%	Good	5	29.4
80-100%	Excellent	5	29.4
Total		**17**	**100**

For the 15 sites that were visited in both spring 2015 and autumn 2016, there is an opportunity to compare the change in survivorship rates after the 2015/16 summer season, see Table 5.

Table 5 - Change between spring and autumn survivorship for the 15 sites monitored in both rounds. NOTE: the colour-coding of "percentage change" categories is reversed to reflect a positive or minimal change (green) through to a larger, negative change (brown).

Site name	Spring survival (%)	Autumn survival (%)	% change
Carol Block	86.2	72.7	-13.5
Grey and Mundoo	88.2	97.3	+9.1
Gunner Samphire	75.1	34.5	-40.6
Hartnett	92.4	86.3	-6.1
Henshell	76.4	58.0	-18.4
Hindmarsh Island	92.9	73.9	-19.0
Kindaruar Farm	69.5	26.0	-43.5
Mason Midway Infill	92.2	95.0	+2.8
Meningie Lookout Rd	92.5	84.4	-8.1
Sanders Remnant	89.7	64.1	-25.6
Sanders Samphire	76.8	48.3	-28.5
Warrengie	79.7	25.4	-54.3
Watkins	85.7	67.4	-18.3
Wellington Dairies	82.5	83.0	+0.5
Wellington Lodge Lake Edge Infill	76.4	66.2	-10.2
Average	**83.7**	**65.5**	**-18.2**

More detailed comparative analysis by percentage category is presented in Table 6. While all 15 sites visited in both spring 2015 and autumn 2016 showed survivorship rates of over 60% in spring, by autumn the number of sites with survivorship over 60% had dropped by five, to 10.

Table 6 - Summary of sites visited in both Spring 2015 and Autumn 2016, according to survivorship percentage category

Survivorship category		# sites Spring 2015	# sites Autumn 2016
0-20%	Very Poor	0	0
20-40%	Poor	0	3
40-60%	Average	1	2
60-80%	Good	5	5
80-100%	Excellent	9	5
Total		**15**	**15**

Table 7 presents the change in survivorship percentage for the 15 sites monitored in both spring and autumn. Importantly, three sites experienced a large drop in survivorship of between 40 and 60 % between the two monitoring seasons. However, the majority of all sites recorded relatively small drops of between 0 and 20%, or even recorded positive changes. This last scenario was possible on smaller sites with relatively small sample sizes, due to transects being run in slightly different locations.

Table 7 - Summary of survivorship percentage change measured between spring and autumn sites

Survivorship percentage change		# sites	% sites
80-100%	Very Poor	0	0%
60-80%	Poor	0	0%
40-60%	Average	3	20%
20-40%	Good	2	13%
0-20%	Excellent	10	67%
Total		**15**	**100%**

3.2. Survivorship of each species identified

The results of revegetation survivorship according to species in Table 8 provides a useful overview of the composition of the Vegetation Program 2015 revegetation works – see the full species list in Appendix C. However, this comes with some limitations.

It should be noted that some genus were difficult to identify to the species level in the field, including *Vittadinia* sp., *Dianella* sp. and many of the grasses. Some *Eucalyptus* species were also difficult due to the high variability of juvenile foliage.

Additionally, a large proportion (41%) of dead plants were unable to be accurately identified to species level, due to loss of the whole plant, or loss of foliage making identification difficult or impossible in the field.

This limits the value of more detailed analysis of this data, by creating a substantial bias (of missing data) that it is reasonably assumed would impact upon the survivorship statistics for the majority of individual species listed here.

Table 8 - Autumn survivorship by species (species with >30 plants counted – see Appendix C for full list)

Species	Plants	Alive	Dead	Survival (%)
Acacia dodonaeifolia	37	32	5	86.5
Acacia leiophylla	46	37	9	80.4
Acacia longifolia ssp. *sophorae*	96	43	53	44.8
Acacia myrtifolia	54	20	34	37.0
Acacia paradoxa	119	82	37	68.9
Acacia pycnantha	253	155	98	61.3
Allocasuarina verticillata	1000	645	355	64.5
Atriplex paludosa ssp.	165	151	14	91.5
Atriplex rhagodioides	101	98	3	97.0
Atriplex semibaccata	119	110	9	92.4
Austrostipa flavescens	49	16	33	32.7
Austrostipa sp.	129	105	24	81.4
Banksia ornata	71	43	28	60.6
Billardiera cymosa (NC)	253	210	43	83.0
Bursaria spinosa ssp.	110	78	32	70.9
Callitris gracilis	146	102	44	69.9
Carpobrotus rossii	108	42	66	38.9
Clematis microphylla	65	65	0	100
Dianella brevicaulis	179	123	56	68.7
Disphyma crassifolium ssp. *(NC)*	273	264	9	96.7
Dodonaea viscosa ssp. cuneata	62	40	22	64.5
Dodonaea viscosa ssp. spatulata	173	121	52	69.9
Enchylaena tomentosa var.	224	197	27	87.9

Species	Plants	Alive	Dead	Survival (%)
Eucalyptus diversifolia ssp. *diversifolia*	520	214	306	41.2
Eucalyptus fasciculosa	132	113	19	85.6
Eucalyptus incrassata	158	93	65	58.9
Eucalyptus odorata	98	87	11	88.8
Eucalyptus porosa	97	89	8	91.8
Eucalyptus sp.	67	0	67	0.0
Ficinia nodosa	220	159	61	72.3
Gahnia filum	173	110	63	63.6
Hakea mitchellii	85	75	10	88.2
Kunzea pomifera	264	173	91	65.5
Leptospermum myrsinoides	123	61	62	49.6
Leucophyta brownii	25	25	0	100
Leucopogon parviflorus	70	5	65	7.1
Maireana oppositifolia	56	55	1	98.2
Melaleuca halmaturorum	619	471	148	76.1
Melaleuca lanceolata	337	168	169	49.9
Melaleuca uncinata	86	58	28	67.4
Myoporum insulare	151	120	31	79.5
Olearia axillaris	443	361	82	81.5
Olearia ramulosa	39	36	3	92.3
Pelargonium australe	109	102	7	93.6
Poa sp.	124	121	3	97.6
Puccinellia stricta	48	1	47	2.1
Rhagodia candolleana ssp.	294	281	13	95.6
Rytidosperma caespitosum	104	88	16	84.6
Tetragonia implexicoma	73	73	0	100
Themeda triandra	50	46	4	92.0
Vittadinia sp.	73	66	7	90.4
Dead (unknown species)	1784	0	1784	0.0
Total (including unlisted species)	**10749**	**6394**	**4355**	**59.5**

3.3. Overall survivorship in each ecosystem

Six distinct ecosystem types were planted in 2015, with *Eucalyptus diversifolia* ssp. *diversifolia* mallee being the most commonly planted with 33%. *Allocasuarina verticillata* low woodland showed the highest survival with 78%, however this ecosystem was only found on two sites, making it difficult to ascertain whether this was due to site-specific factors.

Eucalyptus porosa grassy woodland and Samphire Swamp also recorded survival of more than 65% and were each found at four sites.

Plantings in the remaining ecosystems were less successful, with survival of less than 50% in *Eucalyptus fasciculosa*, *Eucalyptus diversifolia* and *Allocasuarina verticillata* / *Callitris gracilis* ecosystem types.

Table 9 – Autumn survivorship by ecosystem type

Ecosystem	Ecosystem description	Plants	Alive	Dead	Proportion of total plants in ecosystem (%)	Survival (%)
1	*Eucalyptus fasciculosa* low open grassy woodland of the Mt Lofty Ranges	1550	769	781	14.4	49.6
4	*Eucalyptus diversifolia* ssp. *diversifolia* mallee	3558	1699	1859	33.1	47.8
5	*Allocasuarina verticillata* low woodland with shrubby understorey	1635	1269	366	15.2	77.6
6.1	*Eucalyptus porosa* grassy woodland	2154	1418	736	20.0	65.8
9	Samphire swamp	1491	1088	403	13.9	73.0
10.4	Non-eucalypt woodland (*Allocasuarina verticillata* / *Callitris gracilis* woodland)	361	151	210	3.4	41.8
Total		**10749**	**6394**	**4355**	**100**	**59.5**

3.4. Overall survivorship in each zone

The classification of planting polygons was revised in 2014 from zones to ecosystems. While the planting database didn't specify a zone for all transects, three distinct planting zones were recorded across the revegetation sites (**Error! Reference source not found.**): Saline Edge (13% of all plants counted), Sandhill (7%) and Other Inland (34%). The remaining 46% of plants were planted in areas that did not have the zone specified.

Saline Edge and Other Inland plantings both managed over 50% survival while plantings where the zone was not specified in the database were the most successful with 69% survival.

Plantings in the Sandhill zone had low survival, with just 25% of plants surviving through to autumn 2016. However, this zone was only found on Warrengie – a site with particularly poor survival and with site preparation and planting issues.

Table 10 - Autumn survivorship by planting zone

Zone	Zone description	Plants	Alive	Dead	Proportion of total plants per zone (%)	Survival (%)
0	Inundated	-	-	-	-	-
1	Lake/Lagoon Edge	-	-	-	-	-
2	Saline Swamp	-	-	-	-	-
3	Saline Edge	1369	774	595	12.7	56.5
4	Rising Ground	-	-	-	-	-
5	Slope/Embankment	-	-	-	-	-
6	Cliff	-	-	-	-	-
7	Cliff Top	-	-	-	-	-
8	Sandhill	741	188	553	6.9	25.4
9	Other Inland	3685	2003	1682	34.3	54.4
10	Coastal	-	-	-	-	-
13	Blowout	-	-	-	-	-
n/a	Zone not specified	4954	3429	1525	46.1	69.2
	Total	**10749**	**6394**	**4355**	**100**	**59.5**

4. DISCUSSION

4.1.1 Overall survivorship

At the time of monitoring in autumn 2016, overall survivorship of the 2015 plantings was fair, considering the very low rainfall conditions since planting (discussed in section 4.1.6). Survivorship levels dropped moderately from 84.7% to 59.5% between the spring 2015 and autumn 2016 monitoring periods, with three-quarters of all sites recording autumn survivorship rates of over 60%.

The first summer after establishment provides challenges for seedlings due to higher temperatures and limited moisture. Substantial losses of plants occurred but overall, the loss between spring and autumn monitoring events was not markedly higher than seen in previous years.

A number of high-performing sites managed to achieve excellent seedling survival despite the difficult, dry conditions. The experience built up over the multi-year CLLMM revegetation project was evident in species selection, seedling health, site preparation and planting technique, and resulted in a very successful planting year at many sites.

In particular, the Hartnett, Meningie Lookout Road and Wellington Dairies sites all recorded survivorship of more than 80%. These were relatively large sites, each with more than 300 plants counted during monitoring. Additionally, a number of smaller sites also recorded high survival, including Grey & Mundoo, Mason Midway Infill, Carol Block and the combined Hindmarsh Island sites.

Due to a number of factors including the prevailing dry summer, a number of sites suffered poor survival. The three sites that suffered the highest mortality rates (a negative change of 40-55%) over the summer were Warrengie, Kindaruar Farm and Gunner Samphire – these sites are discussed in more detail in section 4.1.5. Notes and photos for individual sites are included in section 10.

The survival rate of 59.5% seen in autumn 2016 is slightly lower that previous survivorship monitoring results, by Tuck & Barron in 2015(a) (67%), Tuck and Bachmann in 2014 (68%), and those published by the Goolwa to Wellington LAP (Durbridge, 2012) in relation to 2010 and 2011 plantings in the CLLMM region.

4.1.2 Survival at ecosystem level

The *Allocasuarina verticillata* low woodland and Samphire Swamp ecosystems both recorded survival of more than 70%, and each had large sample sizes of more than 1400 plants counted.

The Samphire Swamp ecosystem had 20 different species planted across four sites. Three of these sites had survivorship of 73%, 82% and 89% in their Samphire Swamp ecosystem

plantings, but poor survival at Gunner Samphire (47%) brought the overall ecosystem survival rate down.

The *Allocasuarina verticillata* low woodland ecosystem had a diverse mix of over 50 different species. It was only found on two sites, with the majority found on the highly successful Hartnett site (86% survival). The other site where it was found – Henshell – recorded below average survival (58%), suggesting that site specific factors at Hartnett (such as site preparation, weed control, planting method, guarding, etc.) may have been more influential drivers of planting success than the ecosystem type.

The less successful ecosystem types tended to be dryland sites, where drier soils and lack of proximity to water may have influenced the poorer survival. *Eucalyptus diversifolia* ssp. *diversifolia* (48% survival) had a substantial proportion at Warrengie and Gunner Samphire – both sites with poor overall survival. It is difficult to derive trends for a given ecosystem when site-specific factors may strongly influence survival.

4.1.3 Survivorship at zone level

Any discussion of survivorship in different zones is limited due to the lack of zone information for many plantings, with 46% of plants located in polygons with no zone recorded.

Of the plantings where the zone was recorded, there was moderate variation in survivorship between zones. Those in the Sandhill zone were particularly poor; however, as stated in the results above, this zone was only found at Warrengie – a site with poor overall survival. In contrast, the Sandhill zone fared well in the previous year's (2014) plantings with 69% survival – above the 67% survival overall for that year – and this may support the thought that the preparation and planting method at Warrengie was more influential than the Sandhill location.

While the Saline Edge zone and Other Inland zone plantings had survival around 55%, plantings where the zone was not specified were substantially higher at 69%.

4.1.4 Survivorship at species level

While some species such as *Leucopogon parviflorus* (7%) and Acacia myrtifolia (37%) showed poor survivorship, many of these were small sample sizes that could be affected by a single patch of dead plants. It should be noted that a large proportion (41%) of all dead plants were unable to be positively identified to a genus or species level. As such, the survivorship data for the majority of individual species are likely to be considerable over-estimates and this particular element of analysis is therefore unfortunately limited in value.

Additionally, it could be difficult at times to determine if some grasses were dead or dormant. However, grasses made up less than 5% of all identified plants and did not have a strong influence on overall survivorship.

Despite these limitations, it should be noted that the most reliably identifiable species were ones that have foliage that is either tougher and more fibrous, or less attractive to grazing animals. *Eucalyptus diversifolia* ssp. *diversifolia* (41% survival) and Melaleuca lanceolata (50%) are among the few species that saw substantial die-off and also remained identifiable after plant death.

Many trees and shrubs such as *Eucalyptus* sp. or *Acacia* sp. are generally difficult to identify once they have lost their foliage, and the lack of identification means that plant deaths are not necessarily reflected in the statistics for those species.

At the other end of the scale, all *Atriplex* species again recorded over 90% survival, but this will be skewed by the lack of identifiable dead plants as the soft foliage is quickly lost as the plant dies.

4.1.5 Notable sites

Sites with high survivorship rates

The Grey & Mundoo, Mason Midway infill and Hartnett sites were notable for their high success rates.

Grey & Mundoo was a Hindmarsh Island site with infill plantings that proved difficult to survey, but the areas surveyed showed excellent plant health and planting method. Guards were intact and there was little evidence of grazing. There was a small sample size of 113 plants at this site.

Only 3 species were planted at Mason Midway Infill, but they were all suited to the site and surviving well. The terrain was sandy and sloping with a heavy cover of *Ehrharta calycina*. Corflute guards were used to restrict kangaroo grazing. There was a small sample size of 120 plants at this site.

Hartnett was a large and diverse site with only *Allocasuarina verticillata* low woodland plantings. Control efforts had successfully supressed weeds and plants have established well. There were a large number of plants counted (1135), giving confidence in the survival count.

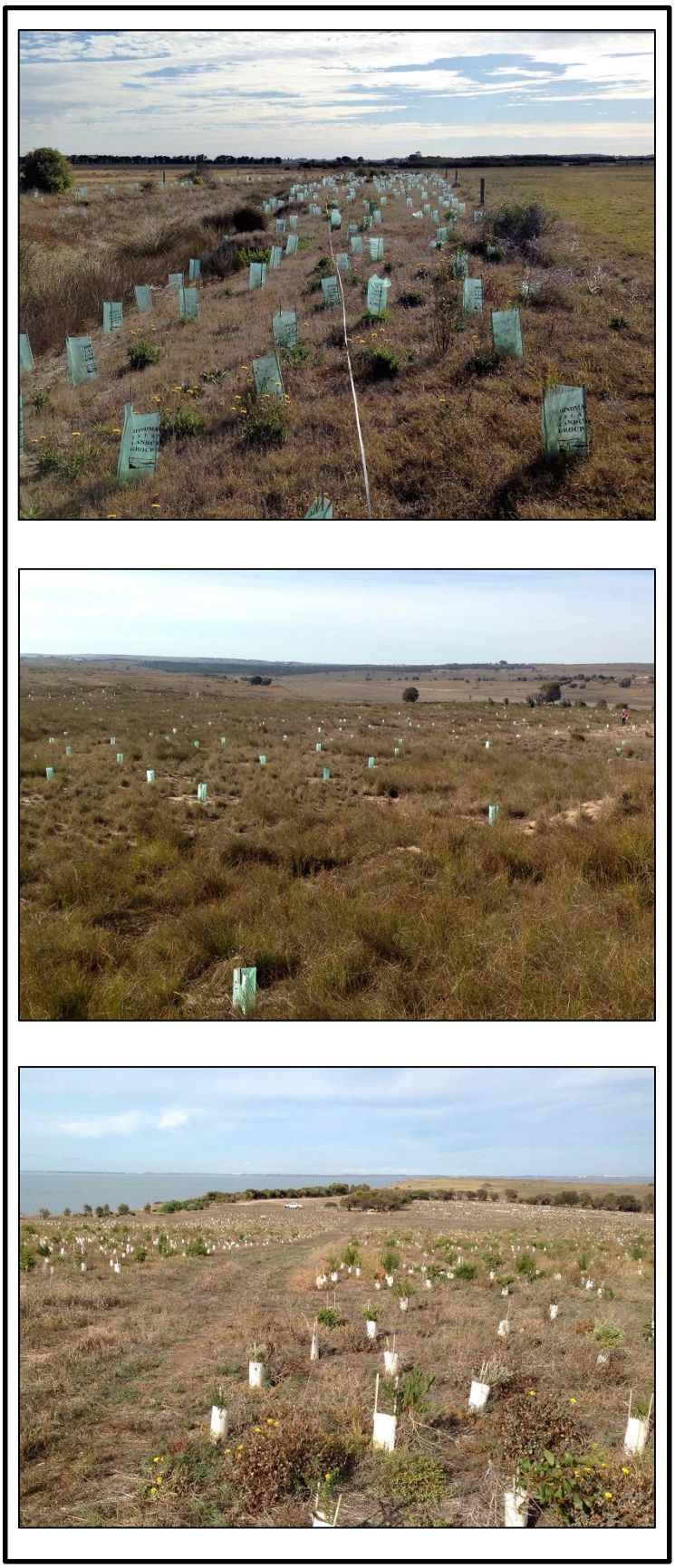


Figure 4 - The three highest survivorship sites in autumn 2014

TOP – Grey & Mundoo: 97% survivorship

MID – Mason Midway Infill: 95% survivorship

BELOW – Hartnett: 87% survivorship

Sites with low survivorship rates

Sites with survivorship of less than 50% included Warrengie, Kindaruar Farm, Gunner Samphire, Poltalloch Inland Dunes Infill and Sanders Samphire. All other sites had more than 50% survivorship.

Warrengie appeared to suffer from poor weed control, with innocent weed, caltrop and 3-corner jack all present. The quality of planting method was patchy, and many plants were unguarded.

Kindaruar Farm had two distinct planting areas. The Pink Gum woodland area had plantings amongst remnant trees and success was very poor – perhaps due to competition from remnant vegetation. The other area was sandy and open and had better (but still modest) success.

Gunner Samphire had substantial competition from problematic weeds, including lucerne, couch grass and kikuyu. There were also patches with poor success close to existing remnant vegetation, and competition may again have been a factor in the poor survival.

Figure 5 - Three sites with the lowest survivorship levels in autumn 2015

TOP – Warrengie: 25% survivorship

MID – Kindaruar Farm: 26% survivorship

BELOW – Gunner Samphire: 35% survivorship

In looking for possible reasons for failure at these sites, there was no clear trend in terms of zone or ecosystem type. However, each of the sites had specific characteristics that appeared to have a bearing on planting success.

The Warrengie site could have benefitted from more coordination between weed control and planting. While the site was structured in rows that would have made weed control and planting easier, site preparation and planting method appeared to be poor in many areas. Some of the plants were not guarded, and the remaining plants were affected by the lack of site preparation and weed control.

At Kindaruar Farm, competition from the existing remnant vegetation would have been a factor in the poor success seen in that area. However, survival in the other sandy loam patch was also poor and could point to other influences on revegetation success that were not immediately apparent during monitoring. Weed control appeared to be adequate in the rows, and guarding used mesh guards which were largely intact, but may have offered less protection from drying winds.

At Gunner Samphire, the competitive pressure of remnant vegetation was again perceived to have been a factor, as well as the sandy soils and competition from dense weeds in open areas, including lucerne, and couch and kikuyu grasses.

Competition from the existing remnant vegetation is recognised as a factor that can have negative effect on revegetation results, especially in low rainfall areas and dry years (Barron et.al. (1996)). Seedling planting within or adjacent to remnant vegetation or established trees are likely to need extra input to improve establishment reliability – this may include watering (with basins and/or irrigation), root-ripping (see Barron et.al. (1996)) and earlier timing. Obviously these treatments would need to be considered 'culturally appropriate' for any given site.

It appears therefore that local factors at these three sites, including physical site characteristics, weed control and planting method, along with the long, dry period after planting, are most likely to have influenced revegetation survivorship success. This low rainfall (discussed below) may have exacerbated the impact of late or poor site-preparation and planting on some sites as well.

4.1.6 Low rainfall

Low rainfall after July 2015 contributed to drier site conditions than in the previous year and will be a major factor in seedling survival at many sites. Rainfall measured at nearby locations (refer to Table 11) was above average during early winter before dropping substantially below the long term average in the August to December period.

Dry conditions were particularly severe on sandy hills and cracking clay soils, and may have offset improvements made in planting technique and higher rates of guarding, and on some sites may have exacerbated the impact of late or poor site-preparation and planting.

Table 11 - Monthly total rainfall (mm) across CLLMM planting region
April 2015 to March 2016

		2015									2016		
		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Meningie	2015-16	62.8	54.4	20.4	75.0	43.2	20.4	1.8	34.6	12.2	39.8	48.4	26.0
	Mean 1961-90	41.6	50.5	55.9	65.9	62.3	40.7	39.3	28.3	26.8	23.6	16.8	24.0
Goolwa	2015-16	86.0	75.0	26.6	77.2	50.0	18.4	4.8	8.8	4.8	19.0	65.4	23.6
	Mean 1961-90	39.2	48.6	56.1	66.0	62.0	44.8	40.4	25.5	21.2	21.5	20.8	19.5
Finniss	2015-16	108.6	65.8	21.0	71.0	37.6	23.4	3.4	12.0	7.8	25.4	44.8	19.6
	Mean 1961-90	43.1	52.2	54.3	65.2	66.9	47.0	42.8	26.1	22.7	22.6	21.2	24.4

Higher than mean
Lower than mean

4.1.7 Tree guards

Observations

The incidence of unguarded plants was low, with most plants protected by guards in a range of forms, including milk cartons, plastic film, plastic mesh and corflute. Most sites utilised milk carton guards, but 5 of the 15 sites were noted to be using sturdier corflute guards. The high usage of guards at most sites has helped to protect seedlings from weedy grasses and grazing animals.

Unguarded plants have been observed to have lower survivorship rates and plant health, particularly at sites where thick pasture grasses are present. These grasses often smother planted seedlings, substantially reducing their chances of survival.

Most sites use paper guards which are working effectively in most instances but were often knocked over, missing or degraded at sites with high wind exposure or intense browsing and grazing.

Figure 6 – Unguarded plants at Kindaruar Farm – a below-average survivorship site with heavy grazing

On Hindmarsh Island, most plants were guarded with plastic film guards, as in the previous year. While these can be susceptible to being blown away by wind in exposed sites, they have been installed with good technique and the guards were working well to provide some weed, weather and browsing protection, see Figure 7.

Figure 7 – A Hindmarsh Island site (Farrow)

Determined grazing animals may still gain access to plants, particularly with less sturdy milk carton guards, which can fairly easily be pushed over or removed by kangaroos, or dug under by rabbits or hares (Figure 8).

Figure 8 - Rabbit diggings around and under tree guards – the plant was gone in this instance

Guard removal

Some sites may benefit from earlier guard removal for some species, as guards were observed to be restricting their growth. This was seen in particular at the Hartnett, Meningie Lookout Road and Wellington Dairies sites.

Where plant growth rates are high and guards are intact, some plants are growing out of the top of the guards and becoming top-heavy. When guards at exposed sites are removed or blow away, the plants are likely to buckle in the wind and fall on their side. This could be partially mitigated by manually removing guards when plants reach the top of the guard, but this may be costly.

4.1.8 Weed management

Many sites contain high loads of weedy grasses such as *Erharta sp., Cynodon dactylon* and *Cenchrus clandestinus*, and these are competing with planted seedlings for moisture, nutrients and space. Most of the weedy biomass is from last year or earlier, but the higher than average summer rains will encourage regrowth and germination of these grasses.

Woody weeds such as *Lycium ferocissimum* have been controlled across most sites. Follow-up weed control will be required to control seedlings emerging from the soil seedbank or dropped by birds (see Table 12 for a list of site specific management recommendations).

4.1.9 Planting method

The sites surveyed did not appear to utilise the successful scalping and ripping method seen in previous years. However, only one site – Wellington Lodge Lake Edge Infill – approached the high growth rates seen at some sites in previous years, with plants growing over the top of guards (Figure 9). This site appeared to have been spot sprayed, with some patch spraying of larger areas of weedy grasses.

Strip and spot spraying were the most common site preparation methods seen. Planting layouts were mostly more natural, scattered layouts, rather than the highly-structured rows often seen at scalped sites in previous years.

There was no clear trend seen between sites that used spot spraying and scattered planting versus those that used strip spraying and a row based planting layout.

Figure 9 – Vigorous growth at the Wellington Lodge site

4.1.10 Comparison with the previous year's monitoring

While it can be difficult to make comparisons across planting years and sites due to the huge range of environmental variables at play, some useful observations can still be made.

Firstly, while survival is lower than in the previous two years, almost 60% of plants survived through a very dry spring and early summer. Sites generally showed good planting technique and site preparation was adequate in most instances.

The die-off of plants between the spring and autumn monitoring was higher than previous years, with a drop of 25%, compared to 20% in 2014 and 19% in 2013. However the drop was

not alarmingly high and likely points to difficult climatic conditions as the major reason for lower survivorship, rather than any wider issues with the revegetation method.

4.1.11 Survey limitations

Mixed-age and infill plantings

Some sites contained mixed age and infill plantings, and time had to be taken to differentiate 2015 plantings from older ones. In previous years, this was a particular problem at Hindmarsh Island sites, but these did not form a large proportion of the surveyed 2015 sites. In most cases it was resolved by checking a number of indicators, including the apparent age of seedlings and condition of tree guards if they were present.

At Hindmarsh Island, while the site maps showed the planned planting area, the actual area planted in infill sites was often not known from the mapping. Richard Owen from the Hindmarsh Island Landcare group again helped with identifying the 2015 plantings on-site and relocating transects where needed.

In the few cases where the age was not easily determined and transects could not be relocated, these areas were skipped and noted in the database.

Sites with few transects or plants

Some sites had relatively few plants counted and the information gathered at these sites may not accurately reflect the overall condition of the plantings in some cases. A single transect with low survivorship can have a large bearing on the overall survivorship for a site which may or may not reflect true trends across the site. This is difficult to remedy on small sites such as Henshell (6 transects) where there may not be sufficient room to run more transects.

5. RECOMMENDATIONS

5.1. General management recommendations

Based on the results of the survivorship monitoring, key recommendations proposed for consideration include:

1. Ensure that follow up weed control is maintained across sites, such as slashing of weedy grasses and removal or chemical treatment of problematic weeds. Effective implementation of this will involve regular checks on sites and reporting any emergent weed outbreaks for management, along with continuing control measures for existing weeds.

2. Control measures should be implemented immediately on spreading weeds such as *Emex australis* and *Cenchrus* sp., and control should be continued on transformative weeds such as *Lycium ferocissimum*. Refer to Section 5.2 for a list of site specific management issues.

3. Continue to use guards around plants wherever possible in future plantings to reduce grazing and competition from weedy grasses. Use of guards appeared to be high, although a stronger guard (i.e. corflute) may be of value at sites that are subject to high levels of grazing or the presence of large numbers of kangaroos.

4. Remove guards at some sites, where plants are growing out of the top of the guards.

5. Seedling planted within or adjacent to remnant vegetation or established trees are likely to need extra input to improve establishment reliability – this may include watering (with basins and/or irrigation), root-ripping (see Barron et.al. (1996)) and earlier timing. Obviously these treatments would need to be considered 'culturally appropriate' for any given site.

6. Continue to work with nearby landholders to report and manage the impacts of pest animals such as hares and rabbits to minimise impacts on plantings. These species have substantial impacts on site condition through diggings, and affect plant survivorship through grazing pressure.

7. For sites with markedly low survivorship rates, factors such as site preparation and planting method should be reviewed and recorded. This may result in some insight into the factors that may have contributed to plant death and help prevent similar problems occurring in future plantings.

8. Long-term monitoring: assess the sites after 3-5 years (and beyond) to track longer term survival and progress or trajectory against benchmarks for specific ecosystems. This

would help to indicate the longer-term success of the plantings and aid in planning adjacent and infill plantings to help continue the transition of sites to a species composition reflecting remnant native vegetation. Recognising that the methodology used in this case was specifically for short-term survival of the preceding year's planting, it may not be appropriate for this longer-term purpose, especially on sites with multiple years of infill planting, but a transect or quadrat based assessment could be used.

9. Where sites are subject to infill plantings, it is recommended that a different guard or a painted stake is used. Marking or painting the top of stakes could be done in bulk quite quickly before being used in planting, and using a particular colour for a given planting period would offer an easy way of identifying plants from other periods.

10. In reference to 9. above: If different guards or painted stakes are not practicable, a different method for monitoring infill sites needs to be designed. This may involve a more ad-hoc method that is not tied to the 50m transect, as it can be difficult to find such a long stretch of plants in some sites. Whatever the method chosen, it will remain dependent on finding the locations of the correct plantings from those who have planned and planted the sites. It should be noted that using a different survey method will limit the ability to compare restoration success between sites and across years.

11. Where justified, ground-truth planting areas post-planting to ensure monitoring waypoints are generated within the planted areas.

5.2. Site specific management recommendations

Site specific management recommendations resulting from autumn surveys are included in Table 12. Recommendations resulting from the spring surveys were not revisited during autumn monitoring due to time constraints, but are also included for reference in Table 13, as some actions may still be relevant.

Table 12 - Autumn 2016 monitoring - management recommendations

Site name	Location (E/N)	Issue/recommendation
Hartnett	Site	Some plants have outgrown their guards – remove guards where appropriate.
Hoopman Infill	Site	*Solanum linnaeanum* and *Lycium ferocissimum* infestation on neighbouring property. Monitor and/or liaise with neighbouring landholder to control.
Meningie Lookout Road	Site	Some plants have outgrown their guards – remove guards where appropriate.
		Asparagus asparagoides emerging.
		Xanthium spinosum on roadside near gates.
		Continue follow-up control of *Acacia saligna* and *Lycium ferocissimum*.

Poltalloch Inland Dunes Infill	Site	Two active rabbit warrens seen.
Sanders Remnant	Western side	*Emex australis* infestation.
	Eastern side	Kikuyu and lucerne re-invasion requires follow-up control.
Warrengie	Site	*Cenchrus* sp., *Tribulus terrestris* and *Emex australis* all require control.
Wellington Dairies	Site	Some plants have outgrown their guards – remove guards where appropriate.
Wellington Lodge	E 34952 N 6078526 E 34956 N 6078488 E 34957 N 6078450 E 34951 N 6078472 E 34932 N 6078520	Rabbit warrens.

Table 13 - Spring 2015 monitoring - management recommendations

Site name	Location (E/N)	Issue/recommendation
Alexandrina Dairies Remnant	Across site	Regenerating *Lycium ferocissimum* requires follow up.
Grey & Mundoo	Transect 5204	Juvenile *Lycium ferocissimum* seen on transect 5204.
Meningie Lookout Road	Across site	Follow up is needed for regenerating weeds, particularly *Lycium ferocissimum* and *Acacia saligna.*
Hindmarsh Island	Transects 4784 and 4790	Juvenile *Lycium ferocissimum* seen on transects 4784 and 4790.

6. REFERENCES

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7. APPENDIX A. SITE DATASHEET

Plan ID: *Site Name:*

Transects (WaypointID) completed:

Photo points taken:

Camera Ref #	***Easting***	***Northing***	***Bearing***	***Height***

Subjective Observation:

e.g. evidence of pest animals, general health/vigour of plants and weed/pest impacts.

8. APPENDIX B. TRANSECT DATASHEET

WaypointID:

Transect Direction (compass bearing)

Observer:

Date:

Time:

Survey:

Line A or B	Species	Alive	Dead

9. APPENDIX C. FULL SURVIVORSHIP RESULTS BY SPECIES

Species	Plants	Alive	Dead	Survival (%)
Acacia brachybotrya	30	27	3	90.0
Acacia calamifolia	11	6	5	54.5
Acacia cupularis	21	20	1	95.2
Acacia dodonaeifolia	37	32	5	86.5
Acacia hakeoides	4	0	4	0.0
Acacia leiophylla	46	37	9	80.4
Acacia ligulata	1	1	0	100
Acacia longifolia ssp. *sophorae*	96	43	53	44.8
Acacia microcarpa	3	3	0	100
Acacia myrtifolia	54	20	34	37.0
Acacia paradoxa	119	82	37	68.9
Acacia pycnantha	253	155	98	61.3
Acacia sp.	2	0	2	0.0
Acacia spinescens	15	14	1	93.3
Adriana quadripartita	18	18	0	100
Allocasuarina muelleriana ssp.	8	8	0	100
Allocasuarina pusilla	26	12	14	46.2
Allocasuarina verticillata	1000	645	355	64.5
Atriplex paludosa ssp.	165	151	14	91.5
Atriplex rhagodioides	101	98	3	97.0
Atriplex semibaccata	119	110	9	92.4
Austrostipa elegantissima	9	5	4	55.6
Austrostipa flavescens	49	16	33	32.7
Austrostipa sp.	129	105	24	81.4
Banksia marginata	2	0	2	0.0
Banksia ornata	71	43	28	60.6
Billardiera cymosa	253	210	43	83.0
Bursaria spinosa ssp.	110	78	32	70.9
Callitris gracilis	146	102	44	69.9
Calytrix tetragona	10	8	2	80.0
Carpobrotus rossii	108	42	66	38.9
Clematis microphylla	65	65	0	100
Correa reflexa var.	14	2	12	14.3
Cyperus gymnocaulos	14	14	0	100
Dianella brevicaulis	179	123	56	68.7
Dianella revoluta	11	9	2	81.8
Dianella sp.	22	20	2	90.9
Disphyma crassifolium ssp.	273	264	9	96.7
Dodonaea viscosa ssp. *cuneata*	62	40	22	64.5

Species	Plants	Alive	Dead	Survival (%)
Dodonaea viscosa ssp. *spatulata*	173	121	52	69.9
Duma florulenta	3	3	0	100
Einadia nutans ssp.	1	1	0	100
Enchylaena tomentosa var.	224	197	27	87.9
Eucalyptus cosmophylla	14	14	0	100
Eucalyptus diversifolia ssp. *diversifolia*	520	214	306	41.2
Eucalyptus fasciculosa	132	113	19	85.6
Eucalyptus incrassata	158	93	65	58.9
Eucalyptus odorata	98	87	11	88.8
Eucalyptus porosa	97	89	8	91.8
Eucalyptus sp.	67	0	67	0.0
Ficinia nodosa	220	159	61	72.3
Gahnia filum	173	110	63	63.6
Goodenia ovata	2	2	0	100
Hakea mitchellii	85	75	10	88.2
Hakea vittata	11	6	5	54.5
Juncus kraussii	28	9	19	32.1
Kennedia prostrata	14	12	2	85.7
Kunzea pomifera	264	173	91	65.5
Lasiopetalum baueri	6	2	4	33.3
Leptospermum lanigerum	4	3	1	75.0
Leptospermum myrsinoides	123	61	62	49.6
Leucophyta brownii	25	25	0	100
Leucopogon parviflorus	70	5	65	7.1
Lomandra leucocephala	6	6	0	100
Lomandra sp.	7	7	0	100
Maireana brevifolia	10	6	4	60.0
Maireana oppositifolia	56	55	1	98.2
Melaleuca acuminata ssp. *acuminata*	7	2	5	28.6
Melaleuca brevifolia	1	1	0	100
Melaleuca halmaturorum	619	471	148	76.1
Melaleuca lanceolata	337	168	169	49.9
Melaleuca uncinata	86	58	28	67.4
Muehlenbeckia adpressa	2	2	0	100
Muehlenbeckia gunnii	12	12	0	100
Myoporum insulare	151	120	31	79.5
Olearia axillaris	443	361	82	81.5
Olearia ramulosa	39	36	3	92.3
Pelargonium australe	109	102	7	93.6
Pittosporum angustifolium	17	14	3	82.4
Poa labillardieri var. labillardieri	16	16	0	100
Poa sp.	124	121	3	97.6
Pomaderris paniculosa ssp.	6	6	0	100

Species	Plants	Alive	Dead	Survival (%)
Puccinellia stricta	48	1	47	2.1
Rhagodia candolleana ssp.	294	281	13	95.6
Rytidosperma caespitosum	104	88	16	84.6
Rytidosperma sp.	9	0	9	0.0
Senecio odoratus	1	1	0	100
Senecio spanomerus	18	3	15	16.7
Solanum laciniatum	20	15	5	75.0
Tetragonia implexicoma	73	73	0	100
Themeda triandra	50	46	4	92.0
Threlkeldia diffusa	19	19	0	100
Vittadinia australasica var.	12	10	2	83.3
Vittadinia cuneata var.	8	7	1	87.5
Vittadinia sp.	73	66	7	90.4
Wahlenbergia sp.	10	8	2	80.0
Xanthorrhoea semiplana ssp.	10	10	0	100
Dead (unknown species)	1784	0	1784	0.0
Total	**10749**	**6394**	**4355**	**59.5**

10. APPENDIX D. INDIVIDUAL SITE SUMMARIES

10.1. Notes for referring to this section

Included sites

Only sites surveyed during autumn 2016 are included in this section. Details of sites surveyed in spring 2015 are included in the spring interim report (Tuck & Barron 2015).

Detailed site survivorship data

Plant counts by site are available in the tables in Section 3. In some cases, a site justifies further details to be included in this report due to poor survivorship or large changes between the spring and autumn counts; this is included with the site notes. This way, the most relevant data is highlighted.

Full survivorship count data for each site, including dead and alive by polygon, zone/ecosystem, transect, and species, is available in the database **survival_rel.accdb**.

10.1.1 Carol Block - PlanID 447

10.1.1.1 Site map

10.1.1.2 Site photo

10.1.1.3 Survivorship results

Carol Block	Spring 2015		Autumn 2016	
	Alive	**Dead**	**Alive**	**Dead**
	932	149	1220	887
Survival	**86.2%**		**72.7%**	

Planting areas were across both samphire and inland ecosystems. The samphire area showed good survivorship and plant vigour. Other areas were very patchy, with poor plant vigour in many areas and competition from weedy grasses.

Grazing pressure was low and guards were largely intact. Across the site, species such as *Melaleuca halmaturorum* and *Allocasuarina verticillata* were surviving well.

10.1.2 Grey and Mundoo - PlanID 552

10.1.2.1 Site map

10.1.2.2 Site photo

10.1.2.3 Survivorship results

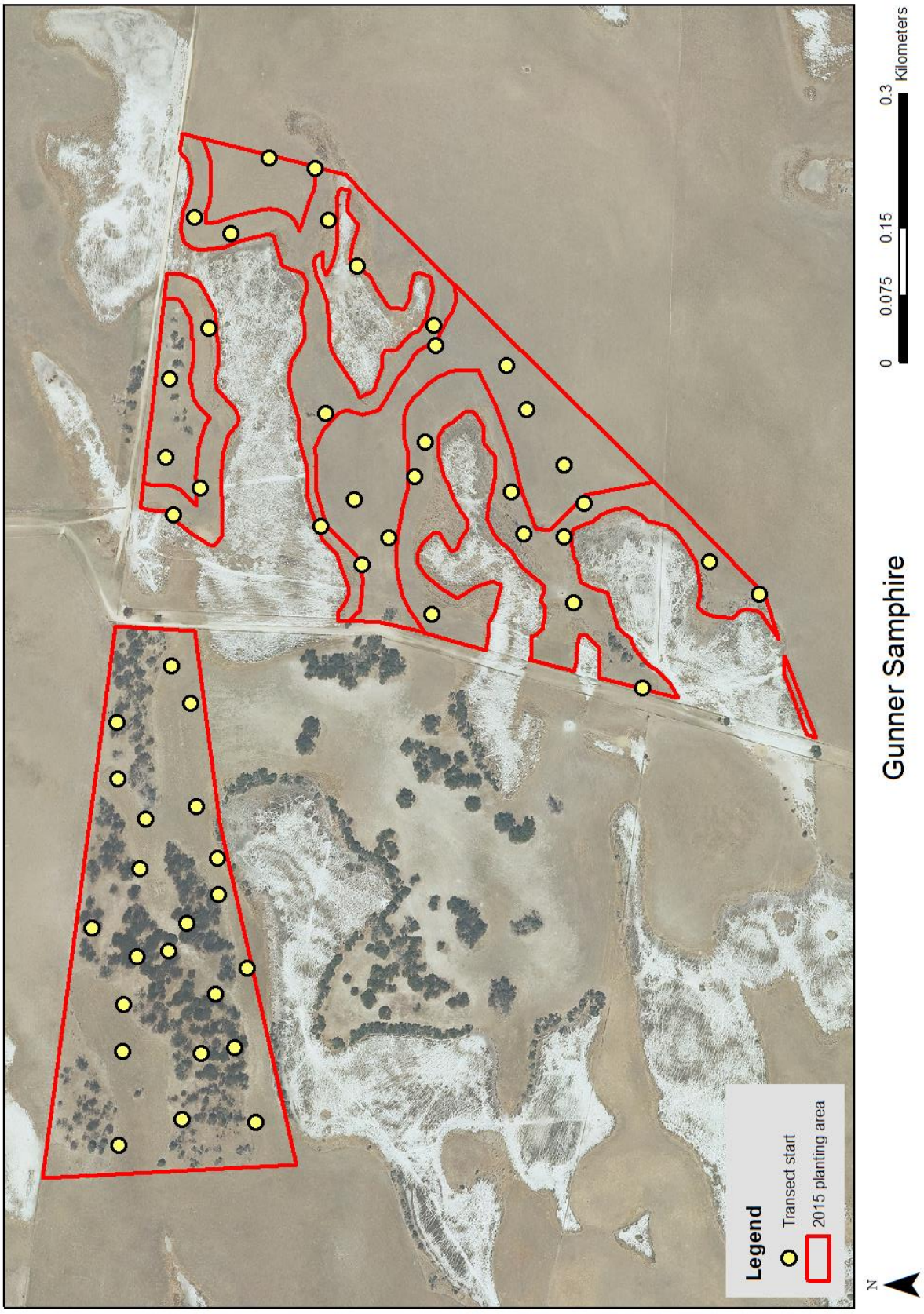
Grey and Mundoo	Spring 2015		Autumn 2016	
	Alive	Dead	Alive	Dead
	45	6	110	3
Survival	**88.2%**		**97.3%**	

Most transects were located in unplanted areas and only a small number were able to be surveyed. As a result, a small number of plants were counted and while survivorship was very high at 97%, the sample size was relatively small. The survival count in autumn 2016 was actually higher than the count in spring 2015, and – while unusual – was made possible by different transect locations and a relatively small sample size

The planted areas were mostly along saline watercourse and wetland edges, and the health and survival of seedlings was generally very good.

10.1.3 Gunner Samphire - PlanID 449

10.1.3.1 Site map



10.1.3.2 Site photo

10.1.3.3 Survivorship results

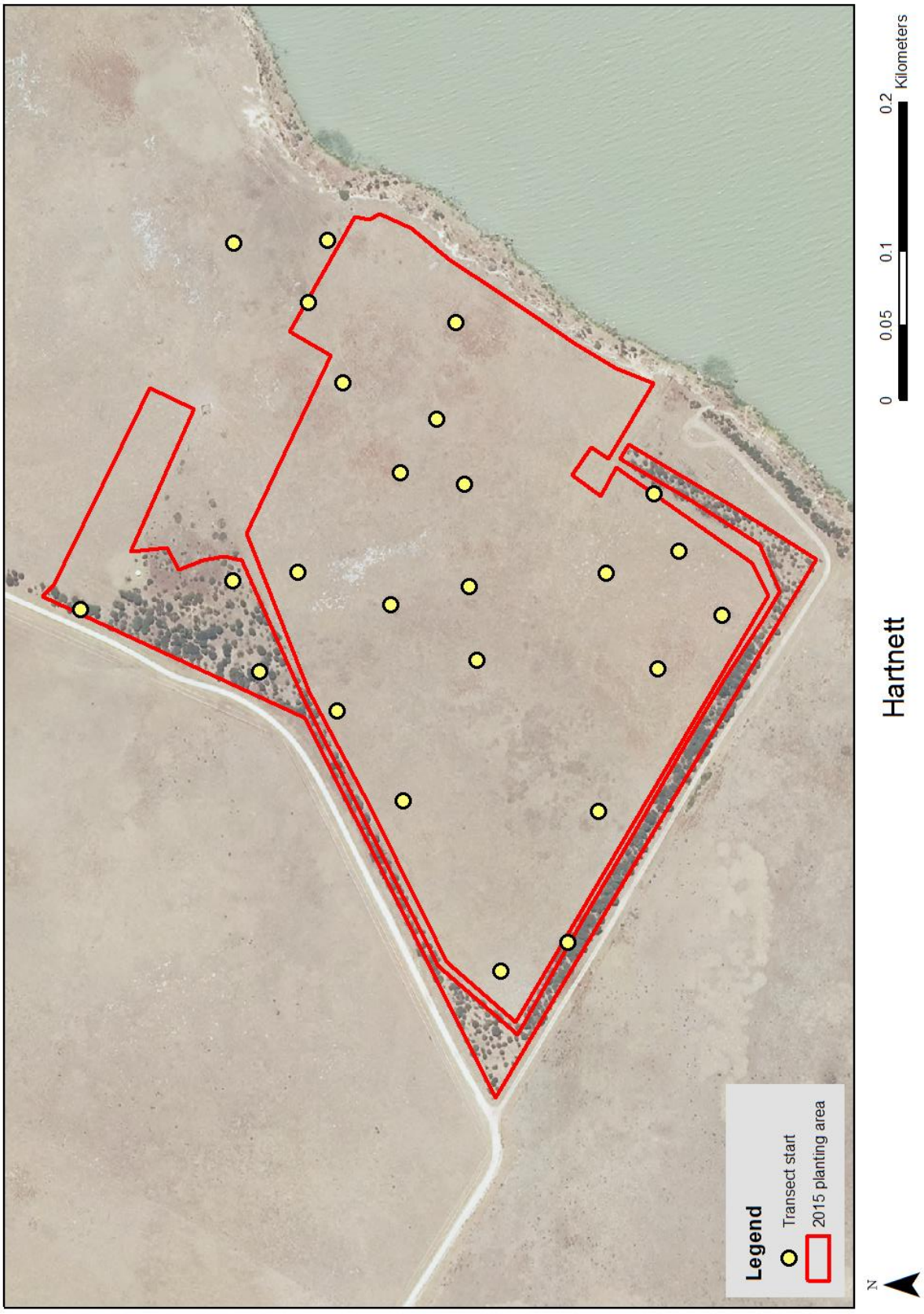
Gunner Samphire	Spring 2015		Autumn 2016	
	Alive	**Dead**	**Alive**	**Dead**
	743	247	340	646
Survival	**75.1%**		**34.5%**	

Survival was poor and patchy, with nearly all plants on some transects being dead. Overall survival at the site dropped by 40% from spring 2015 to autumn 2016. Competition from lucerne, couch and kikuyu in open areas has made survival difficult. It is also possible that pressure from remnant vegetation has also provided competition for the seedlings planted close by.

Two zones were planted, with the *Eucalyptus diversifolia* mallee zone recording substantially higher survival (47%) than the Samphire Shrubland zone (27%). *Melaleuca halmaturorum* was generally good across all autumn sites (76%) but struggled at Gunner Samphire with 50% survival.

10.1.4 Hartnett - PlanID 431

10.1.4.1 Site map



10.1.4.2 Site photo

10.1.4.3 Survivorship results

Hartnett	Spring 2015		Autumn 2016	
	Alive	**Dead**	**Alive**	**Dead**
	1283	105	979	156
Survival	**92.4%**		**86.3%**	

Survival across the Hartnett site was excellent given the dry summer conditions. While fairly high loads of weeds were present, the earlier weed control noted in the Spring surveys has been beneficial and plants have established well. Plant health and growth levels were high and excellent species diversity was seen – with more than 40 species recorded.

Grazing pressure appeared to be low and most guards were still intact. Some plants have outgrown their guards and would benefit from guard removal.

10.1.5 Henshell - PlanID 433

10.1.5.1 Site map

10.1.5.2 Site photo

10.1.5.3 Survivorship results

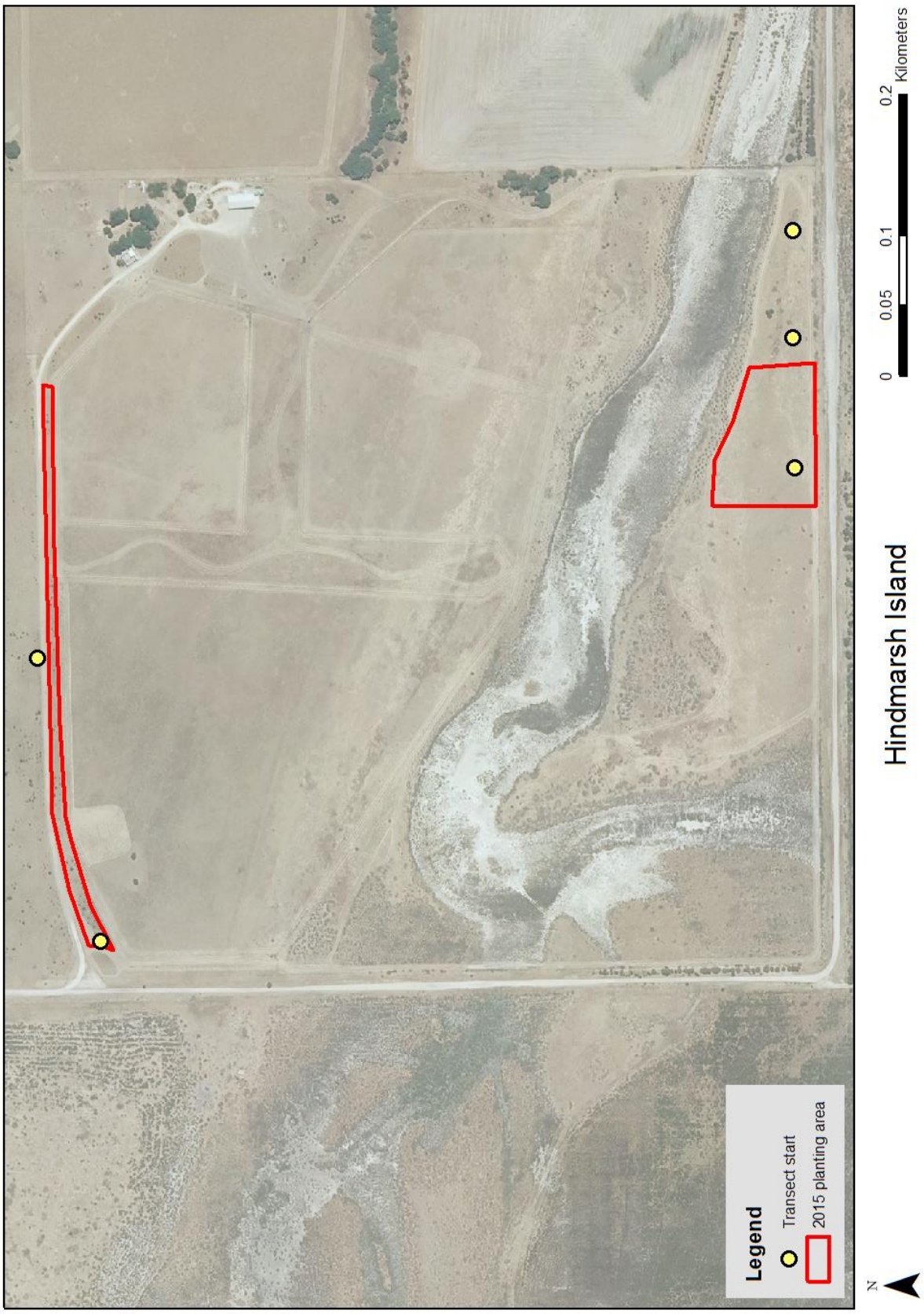
Henshell	Spring 2015		Autumn 2016	
	Alive	**Dead**	**Alive**	**Dead**
	450	139	290	210
Survival	**76.4%**		**58.0%**	

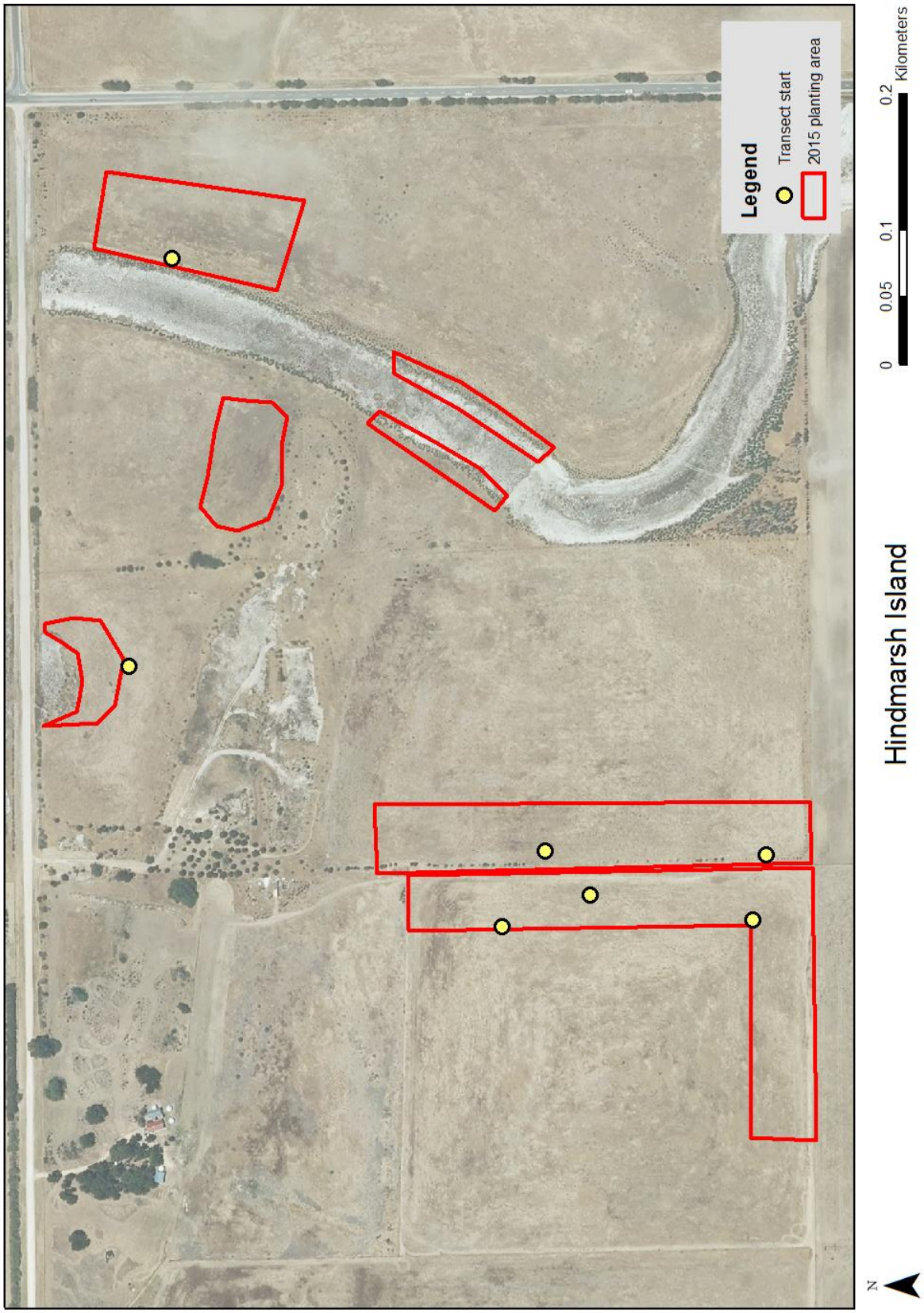
Survivorship was moderate at 58% and plant health was generally poor in the remaining seedlings. The impact of hot dry weather was compounded by the cracking clay soils at this site. Weed loads are generally high and there is a particular issue with rye grass.

Plantings in the south-western planting zone showed better health than those in the north-east. Some signs of grazing by kangaroos were noted.

10.1.6 Hindmarsh Island - PlanID 434

10.1.6.1 Site maps




Legend
Transect start
2015 planting area
0
0.05
0.1
0.2
Kilometers
Hindmarsh Island
N

10.1.6.2 Site photo

Farrow

Gilbert & Lane

10.1.6.3 Survivorship results

Hindmarsh Island	Spring 2015		Autumn 2016	
	Alive	**Dead**	**Alive**	**Dead**
	157	12	161	57
Survival	**92.9%**		**73.9%**	

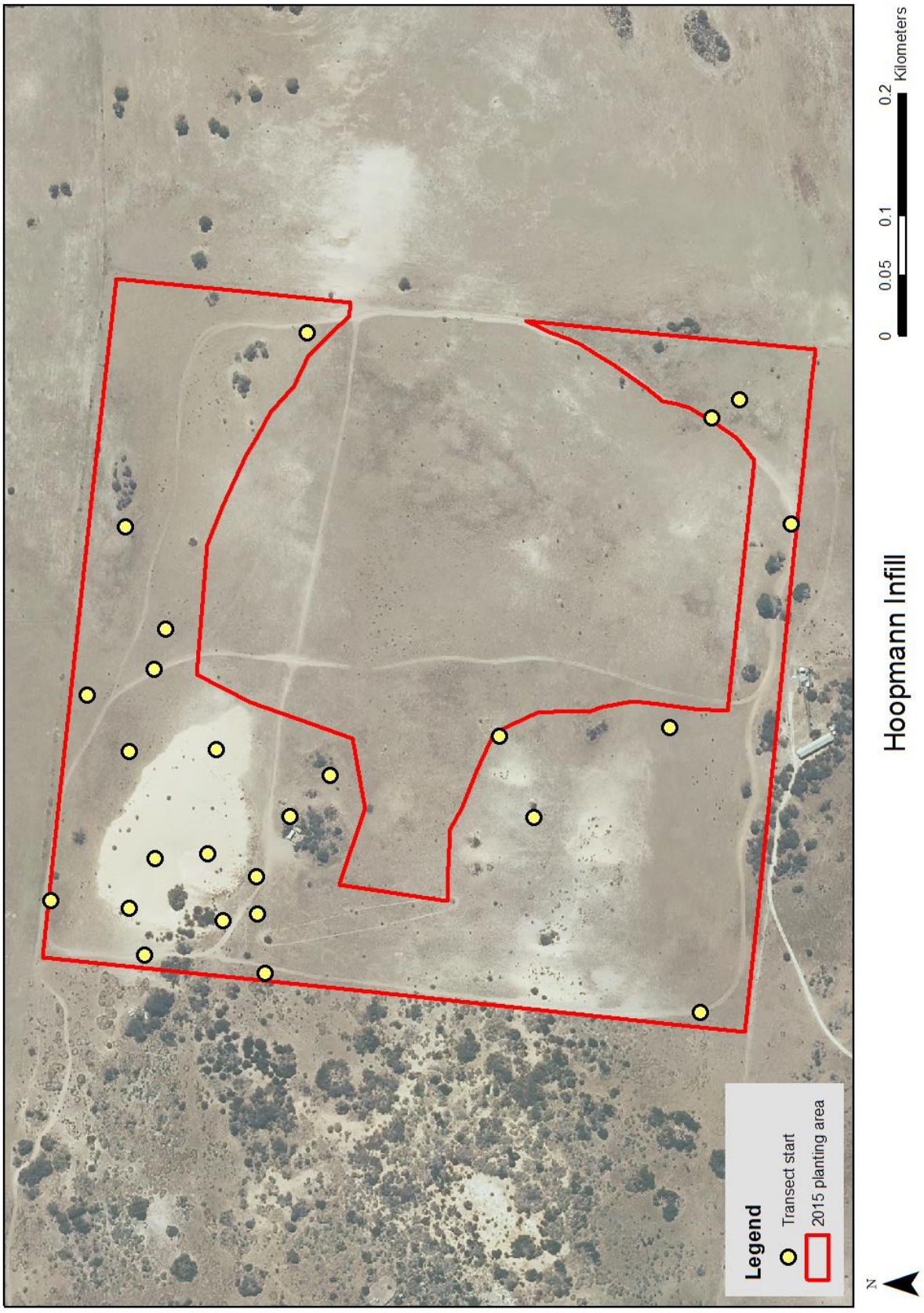
A small number of plants were counted across the Hindmarsh Island sites, but seedlings were generally surviving well and showing good vigour.

At the Gilbert and Lane site, survivorship was patchy on areas with cracking clay soil, but was otherwise good. The northern transects were not planted and 2015 plantings were too difficult to distinguish from other plantings in the area.

At the Farrow site, all transects in the southern area had to be moved as the planting area was west of the polygon. This is common in the Hindmarsh Island plantings where planting areas are moved to suit the conditions.

10.1.7 Hoopmann Infill - PlanID 469

10.1.7.1 Site map



10.1.7.2 Site photo

10.1.7.3 Survivorship results

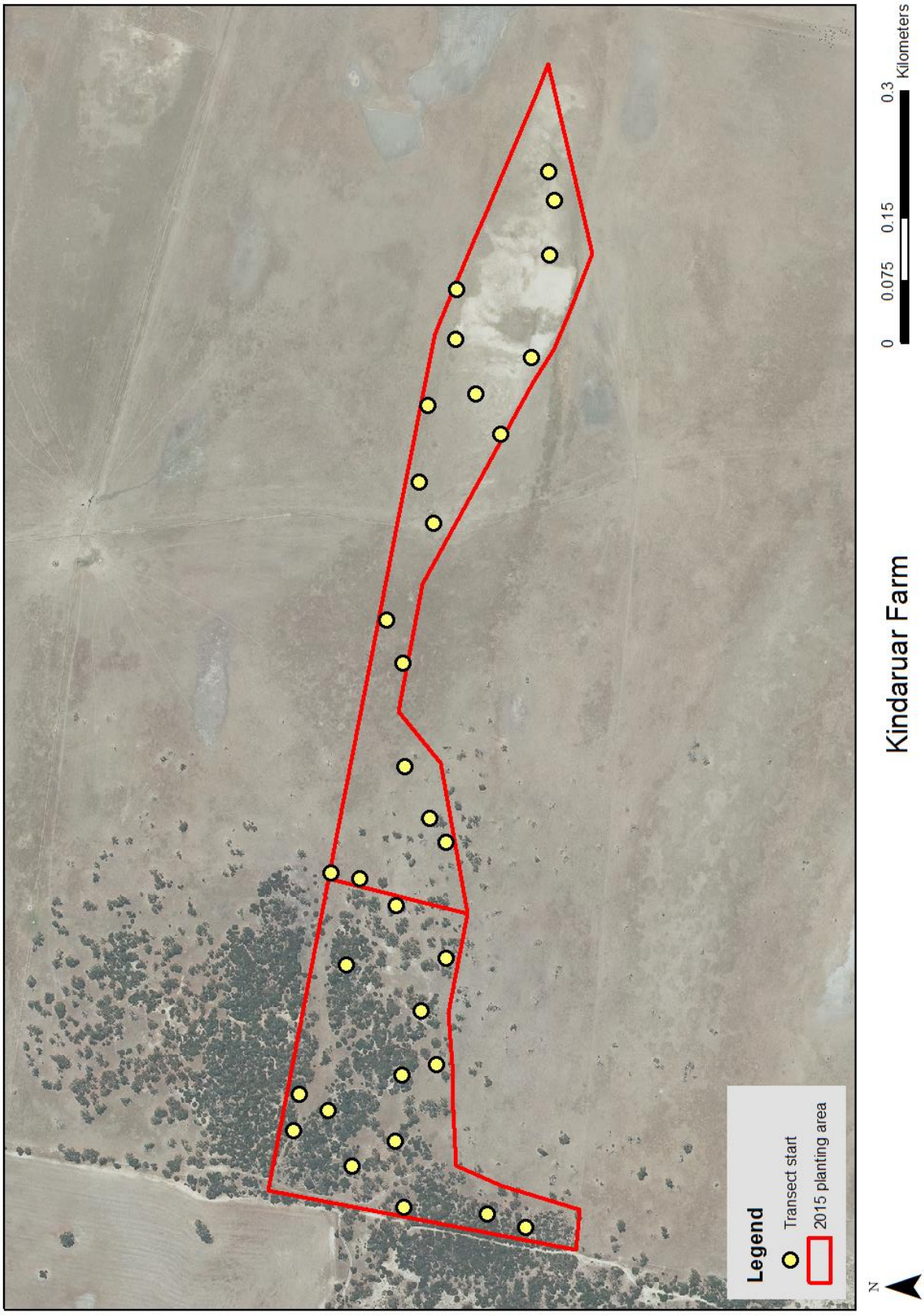
Hoopmann Infill	Spring 2015		Autumn 2016	
	Alive	**Dead**	**Alive**	**Dead**
	Not surveyed		306	305
Survival	**-**		**50.1%**	

A dry and sandy site with below-average survivorship of 50%. *Allocasuarina verticillata* was widely planted but struggled on the sandy rises with 53% survival (not including plants that couldn't be identified). Many dead *Leucopogon parviflorus* seedlings were also counted, with just 5 survivors from 70 plants identified.

There was competition from weedy grasses, but no other major weed or grazing issues on site. However, there is a severe Apple of Sodom (*Solanum linnaeanum*) and African Boxthorn (*Lycium ferocissimum*) issue on a neighbouring property which should be monitored, as it has the potential to spread into the plantings over time.

10.1.8 Kindaruar Farm - PlanID 454

10.1.8.1 Site map



10.1.8.2 Site photo

10.1.8.3 Survivorship results

Kindaruar Farm	Spring 2015		Autumn 2016	
	Alive	**Dead**	**Alive**	**Dead**
	428	188	180	512
Survival	**69.5%**		**26.0%**	

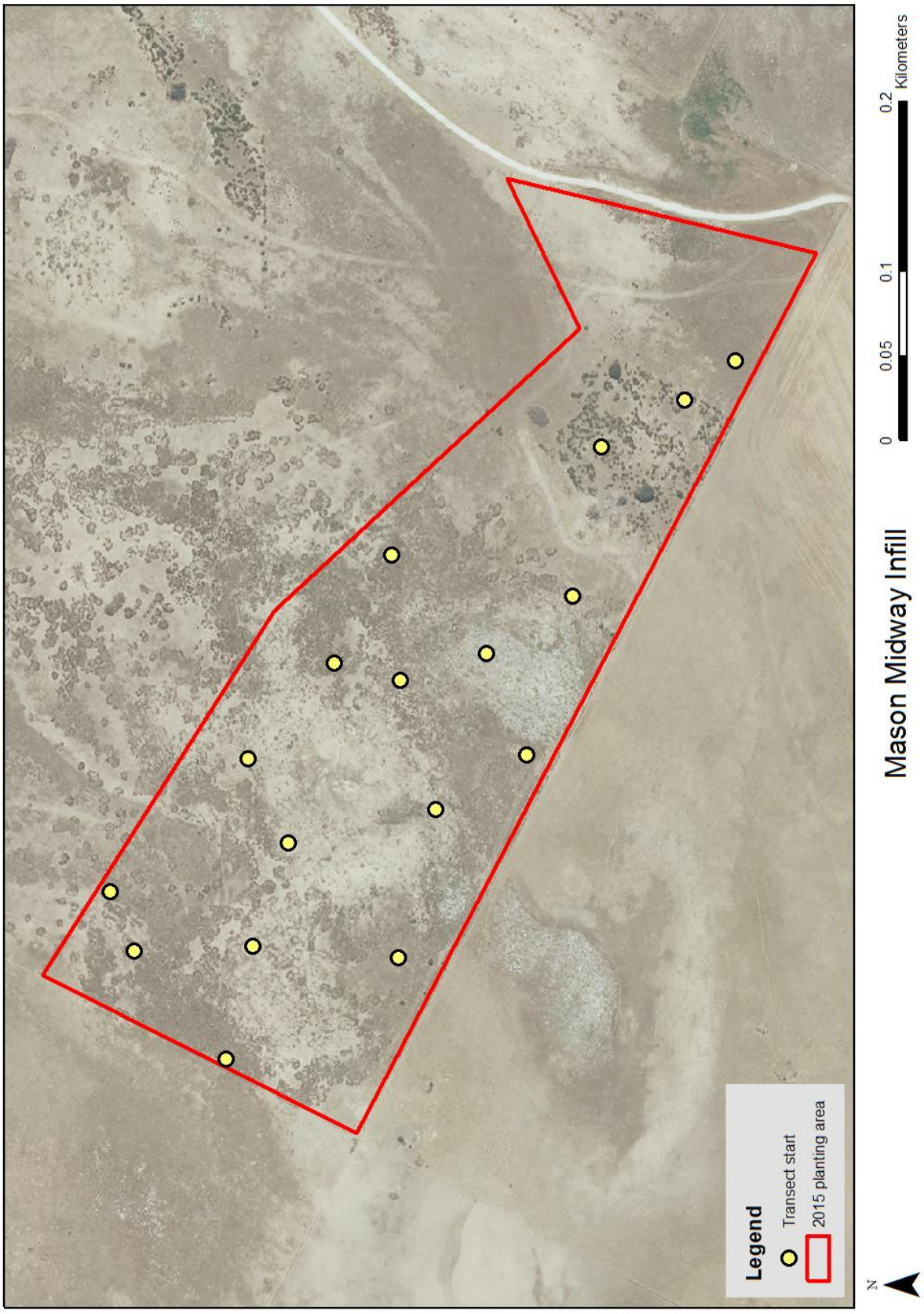
Kindaruar Farm had the lowest plant survival at the time of the spring 2015 counts, and the low survival continued in autumn 2016 with 26% survival.

The site was planted as one ecosystem - *Eucalyptus fasciculosa* woodland (1) - but distinction could be made between open and remnant planting areas. The open areas in the east of the site generally showed poor survival, with pockets of couch grass giving some competition. Weed control in the planting areas was evident and appeared to be adequate, and grazing pressure was low.

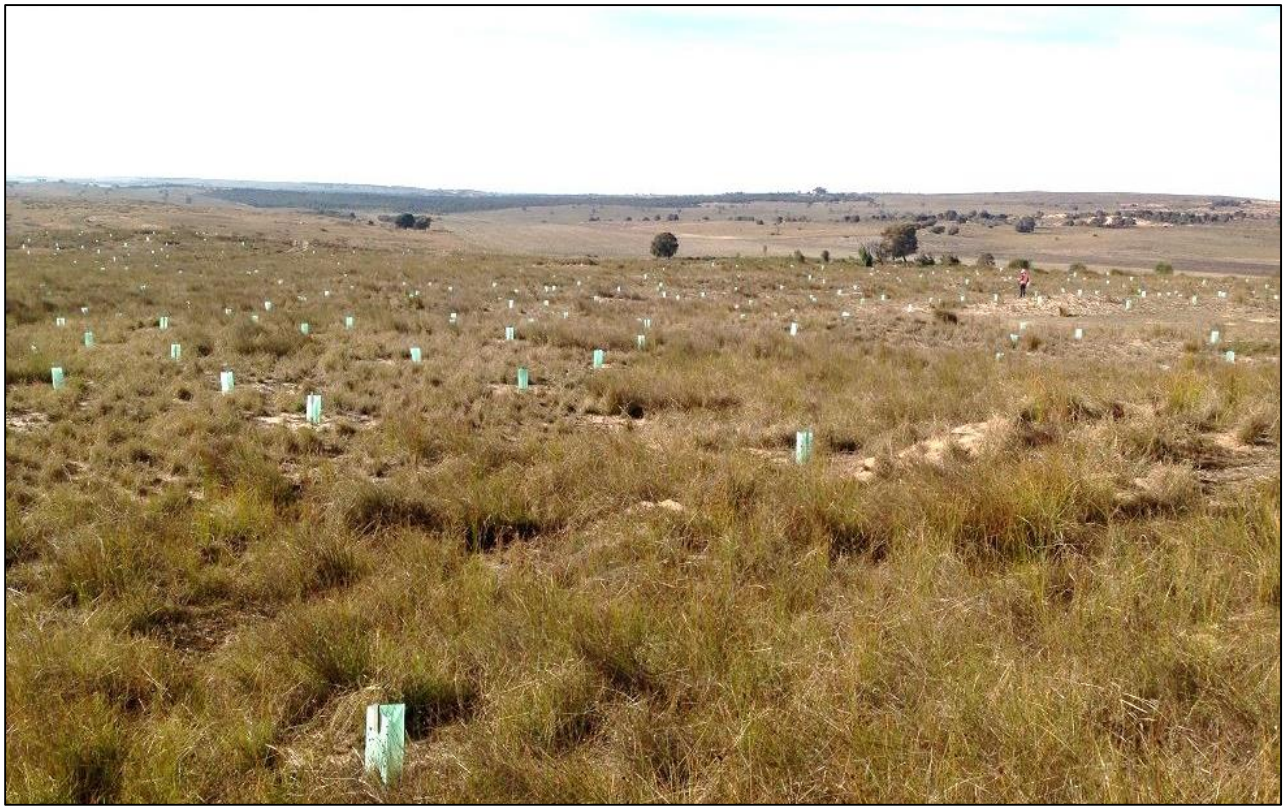
The remnant areas in the west of the site had very poor survival at 8% and surviving plants had poor health. This could be attributed to a combination of high grazing pressure and poor soils, and in addition, many seedlings were staked but were either not guarded or the guards were gone, and as a result most of these plants had been eaten. Some good control of mature *Lycium ferocissimum* was noted.

10.1.9 Mason Midway Infill - PlanID 558

10.1.9.1 Site map



10.1.9.2 Site photo



10.1.9.3 Survivorship results

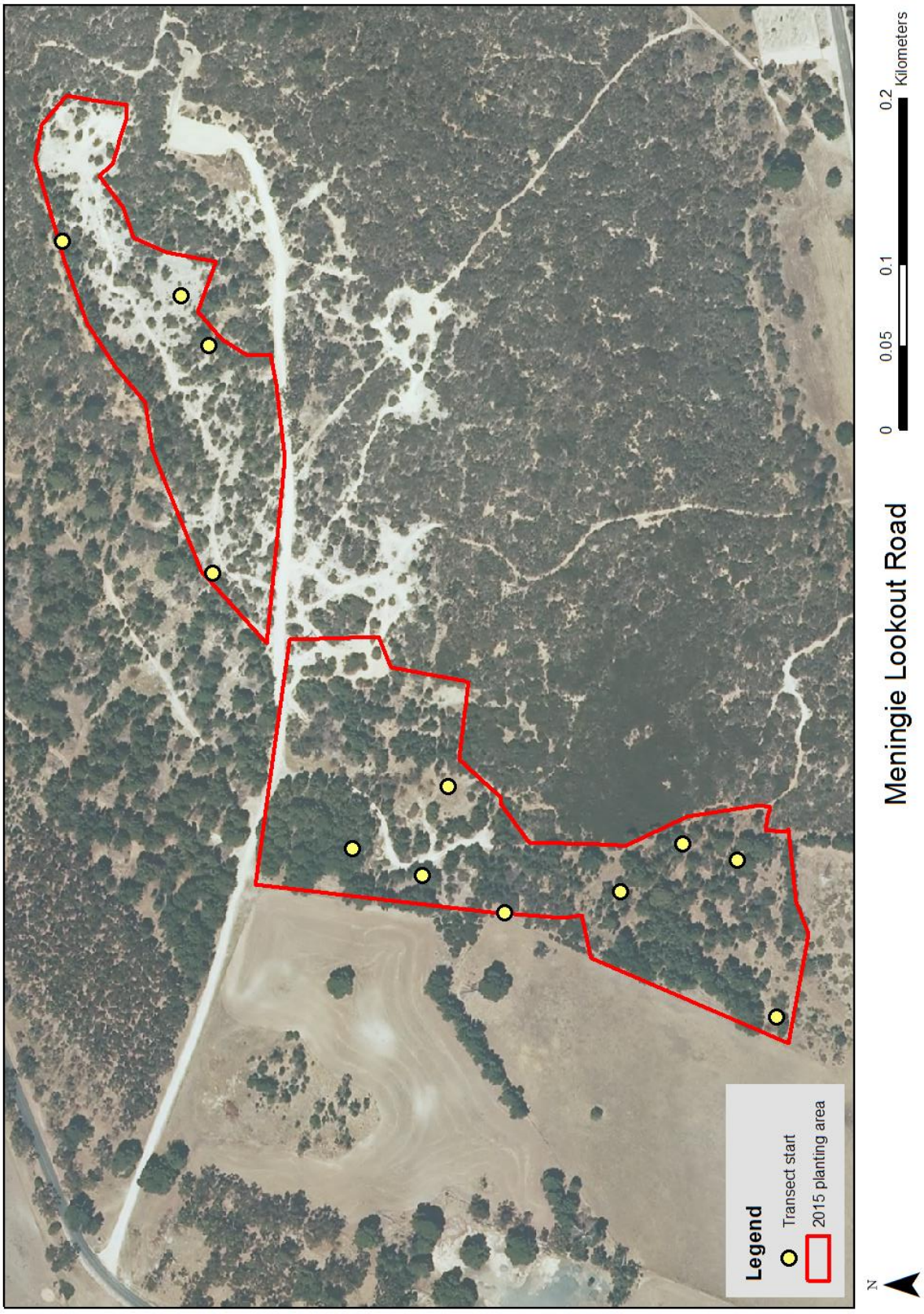
Mason Midway Infill	Spring 2015		Autumn 2016	
	Alive	Dead	Alive	Dead
	166	14	114	6
Survival	**92.2%**		**95.0%**	

Survivorship was generally excellent and had held well from the high survivorship seen in spring 2015. This was despite sandy soils and reasonably strong competition from weedy grasses.

Apart from two *Callitris gracilis* seedlings, all plants were either *Allocasuarina verticillata* or *Eucalyptus diversifolia* ssp. *diversifolia*, and all showed excellent survival and growth. Some large kangaroos were seen on site but browsing was not noted, and may have been helped by the use of corflute guards. Many signs of regenerating understorey were seen, giving indications that the site may be on a positive trajectory, subject to longer term success of the overstorey plantings.

10.1.10 Meningie Lookout Road - PlanID 459

10.1.10.1 Site map



10.1.10.2 Site photo

10.1.10.3 Survivorship results

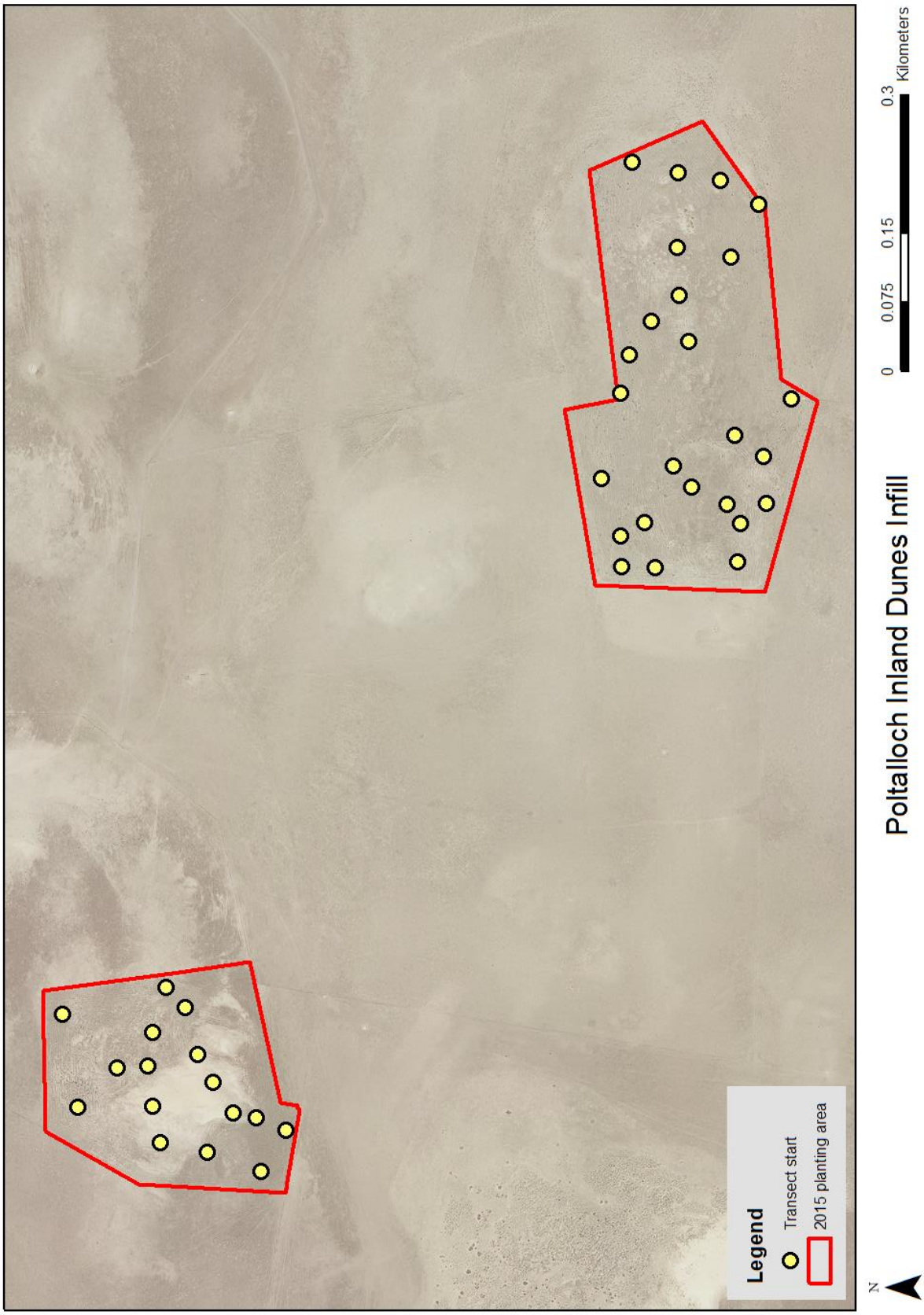
Meningie Lookout Road	Spring 2015		Autumn 2016	
	Alive	**Dead**	**Alive**	**Dead**
	441	36	319	59
Survival	**92.5%**		**84.4%**	

The site was planted in the *Eucalyptus diversifolia* mallee ecosystem, over rocky and sandy terrain. Survivorship was generally excellent at 84% for the site, with north-eastern transects recording 94% survival and to south-western transects 78%. The diverse range of species planted showed good growth and vigour, and with the vigorous growth of seedlings, many plants would benefit from guard removal to allow them the space to take a more natural form. There was also some good natural regeneration of many local species.

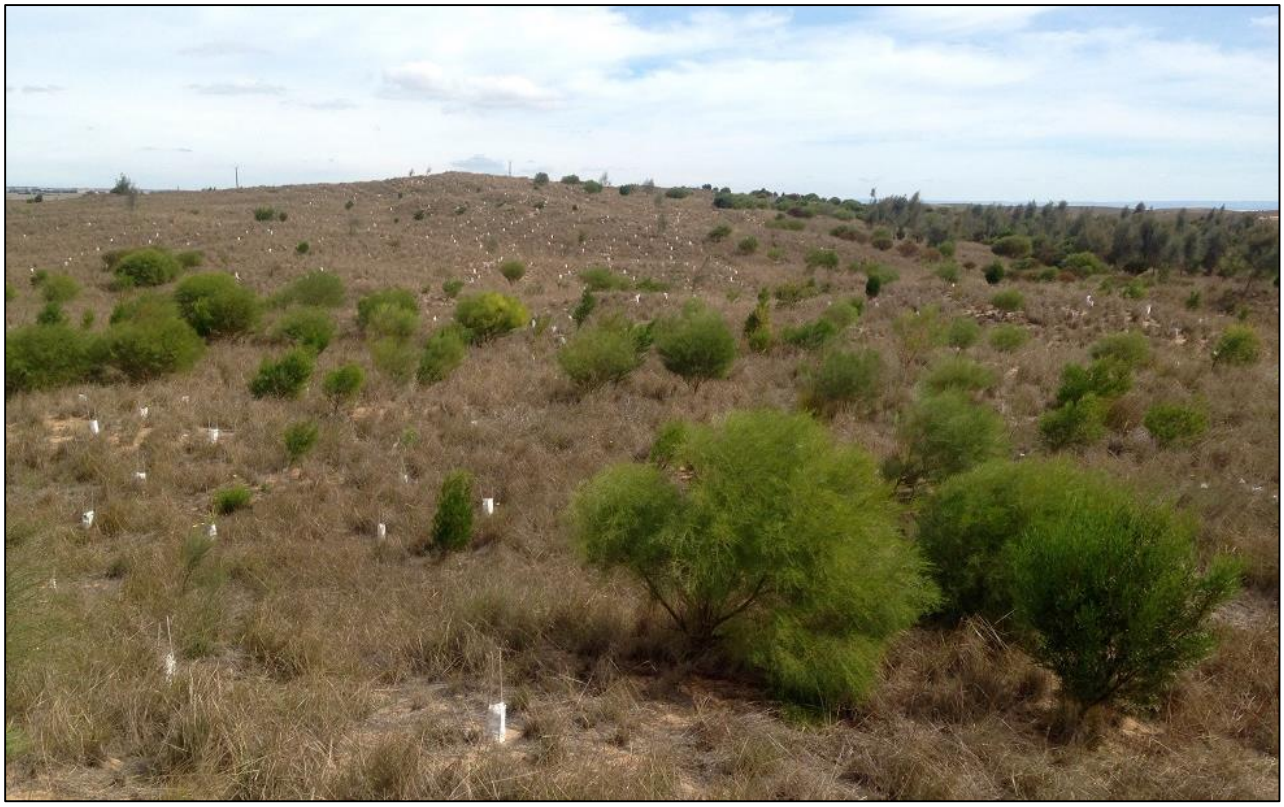
Asparagus asparagoides was emerging across the site, and some *Anthoxanthum spinosum* was noted on the roadside near the gates. There is also some emergent *Acacia saligna* and *Lycium ferocissimum*.

10.1.11 Poltalloch Inland Dunes Infill - PlanID 464

10.1.11.1 Site map



10.1.11.2 Site photo



10.1.11.3 Survivorship results

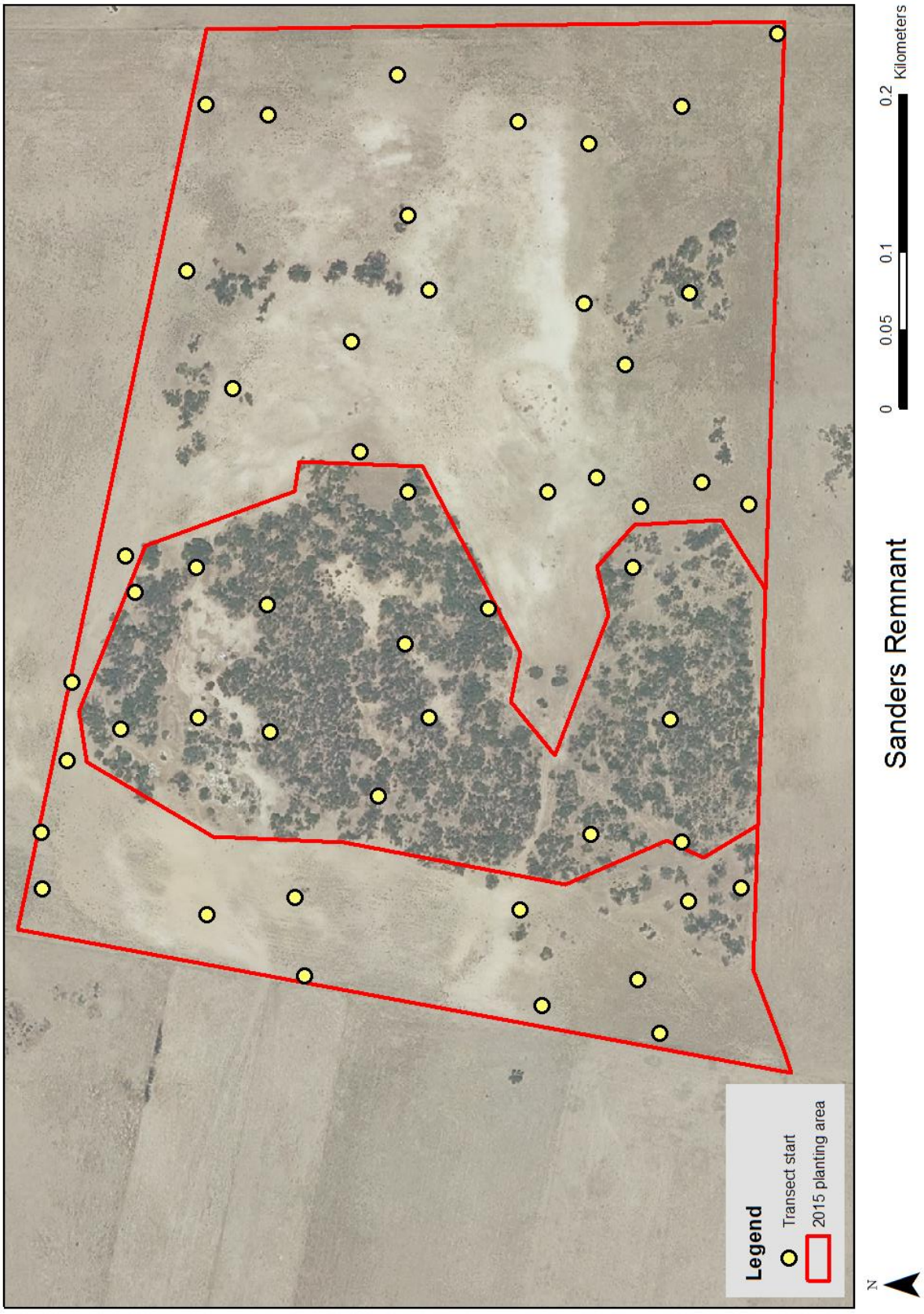
Poltalloch Inland Dunes Infill	Spring 2015		Autumn 2016	
	Alive	**Dead**	**Alive**	**Dead**
	Not surveyed		254	312
Survival	**-**		**44.9%**	

The Poltalloch Inland Dunes Infill site was not surveyed in spring 2015, but survival in autumn 2016 was relatively poor. Less than half of the widely-planted Eucalypt species survived, and competition from weedy grasses (especially *Ehrharta calycina*) was substantial. The dry, deep sand soils may have also been a factor in survival.

It was noted that grazing pressure from kangaroos was high and there were also one or two active rabbit warrens on the site.

10.1.12 Sanders Remnant - PlanID 479

10.1.12.1 Site map



10.1.12.2 Site photo

10.1.12.3 Survivorship results

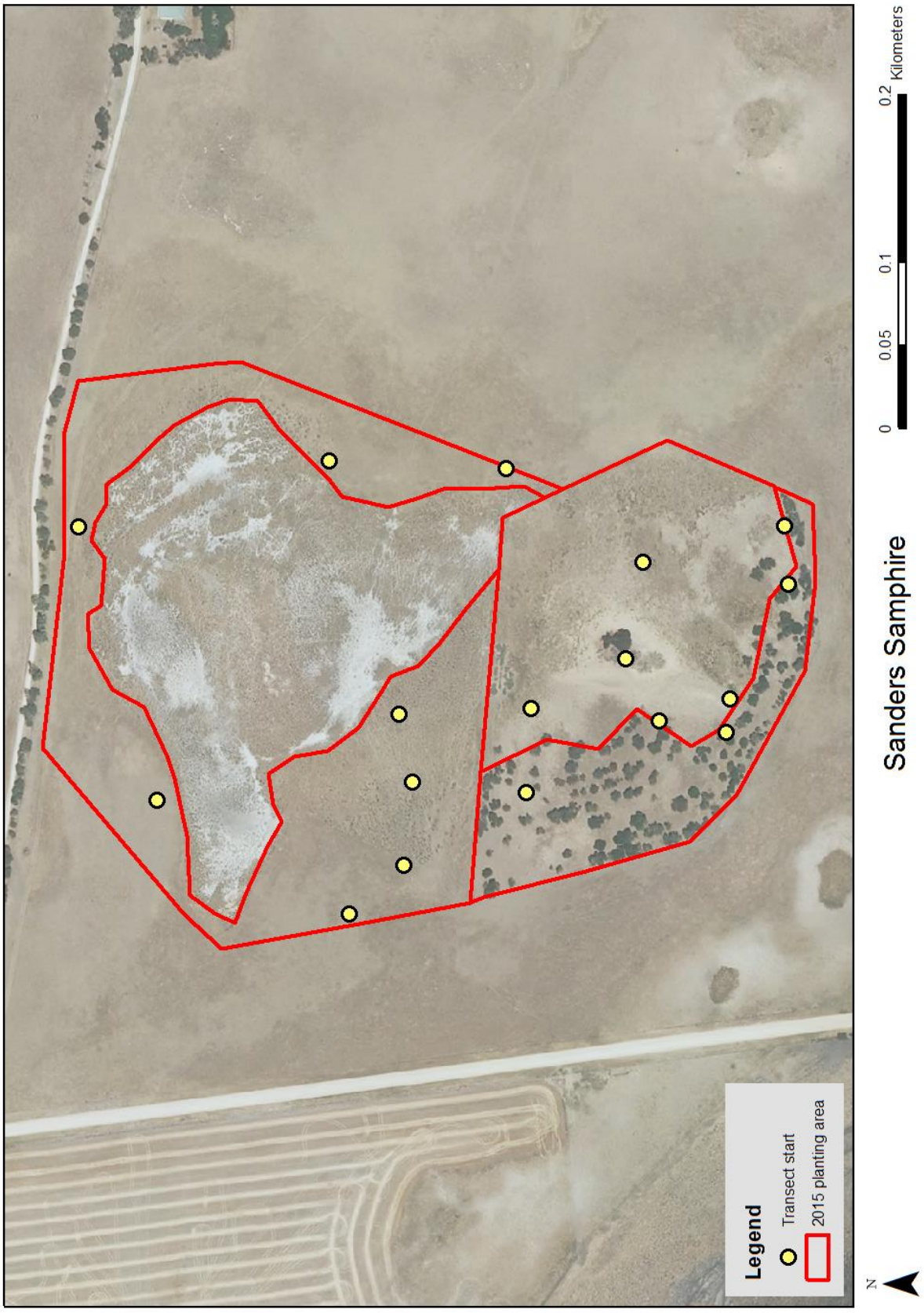
Sanders Remnant	Spring 2015		Autumn 2016	
	Alive	**Dead**	**Alive**	**Dead**
	1338	154	779	436
Survival	**89.7%**		**64.1%**	

The site was planted as a *Eucalyptus porosa* grassy woodland ecosystem, and survivorship was above average at 64%. *Allocasuarina, Acacia* and *Eucalyptus* species showed good survival.

Kikuyu and lucerne re-invasion was severe on the eastern side of the site and *Emex australis* was seen on the west. Control measures are advised to limit the spread of these weeds. Two hares were seen on the site.

10.1.13 Sanders Samphire - PlanID 461

10.1.13.1 Site map



10.1.13.2 Site photo

10.1.13.3 Survivorship results

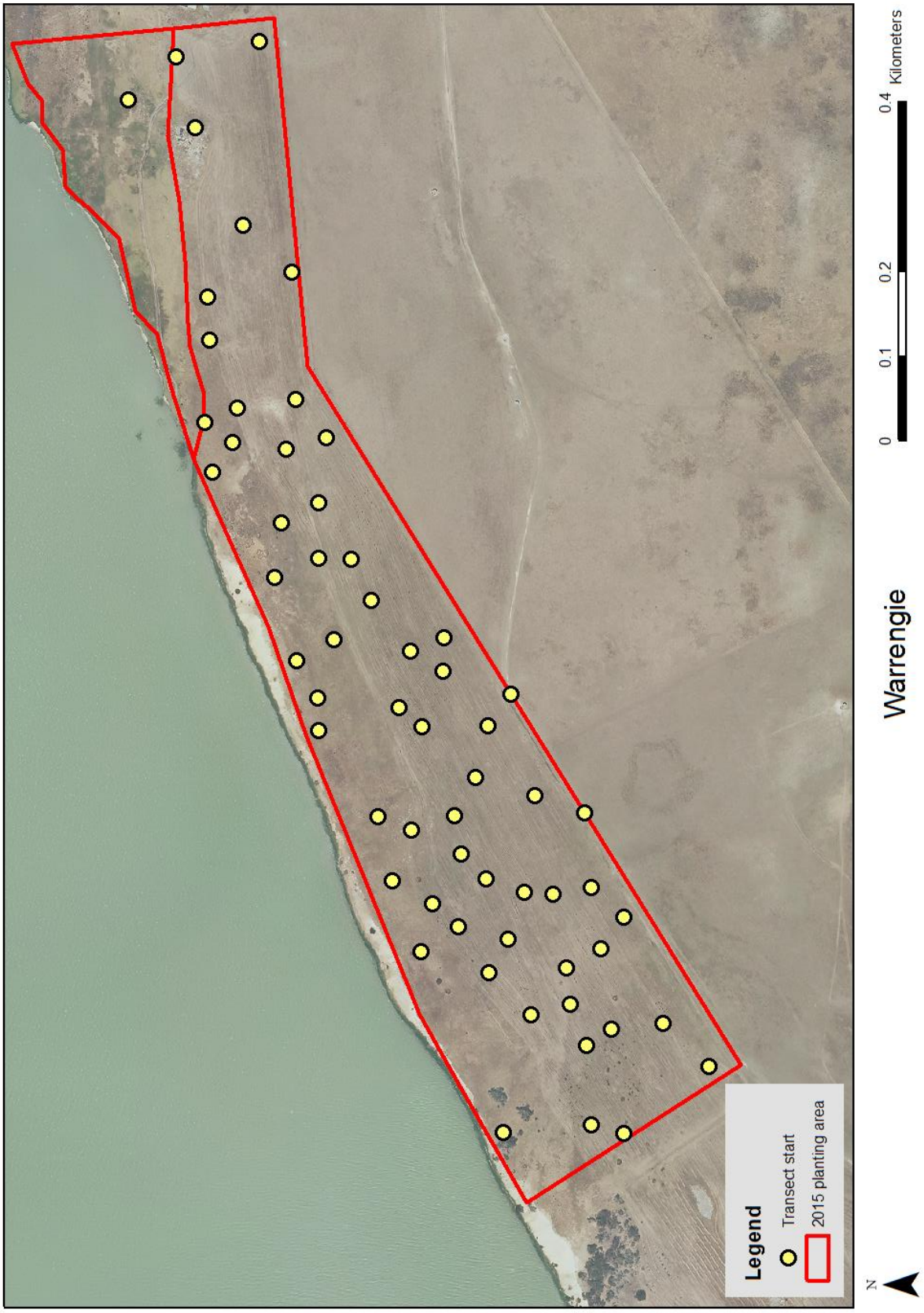
Sanders Samphire	Spring 2015		Autumn 2016	
	Alive	**Dead**	**Alive**	**Dead**
	509	166	272	291
Survival	**76.8%**		**48.3%**	

Both Samphire Shrubland (9) and *Allocasuarina verticillata/Callitris gracilis* woodland (10.4) zones were planted at the site. Saline edge plantings had high survival at 73%, with the saline-tolerant species such as *Melaleuca halmaturorum* and *Atriplex* p*aludosa* showing reasonable growth.

The *Allocasuarina verticillata*/*Callitris gracilis* woodland plantings were in sandy areas with high cover of *Ehrharta calycina*. Weed control was generally reasonable, however late planting may have been an issue and not allowed plants enough time to establish before the long dry summer. Some of the plants in close proximity to native vegetation may also have faced additional competitive pressure. *Allocasuarina verticillata* and *Kunzea pomifera* showed particularly poor survival.

10.1.14 Warrengie - PlanID 556

10.1.14.1 Site map



10.1.14.2 Site photo

10.1.14.3 Survivorship results

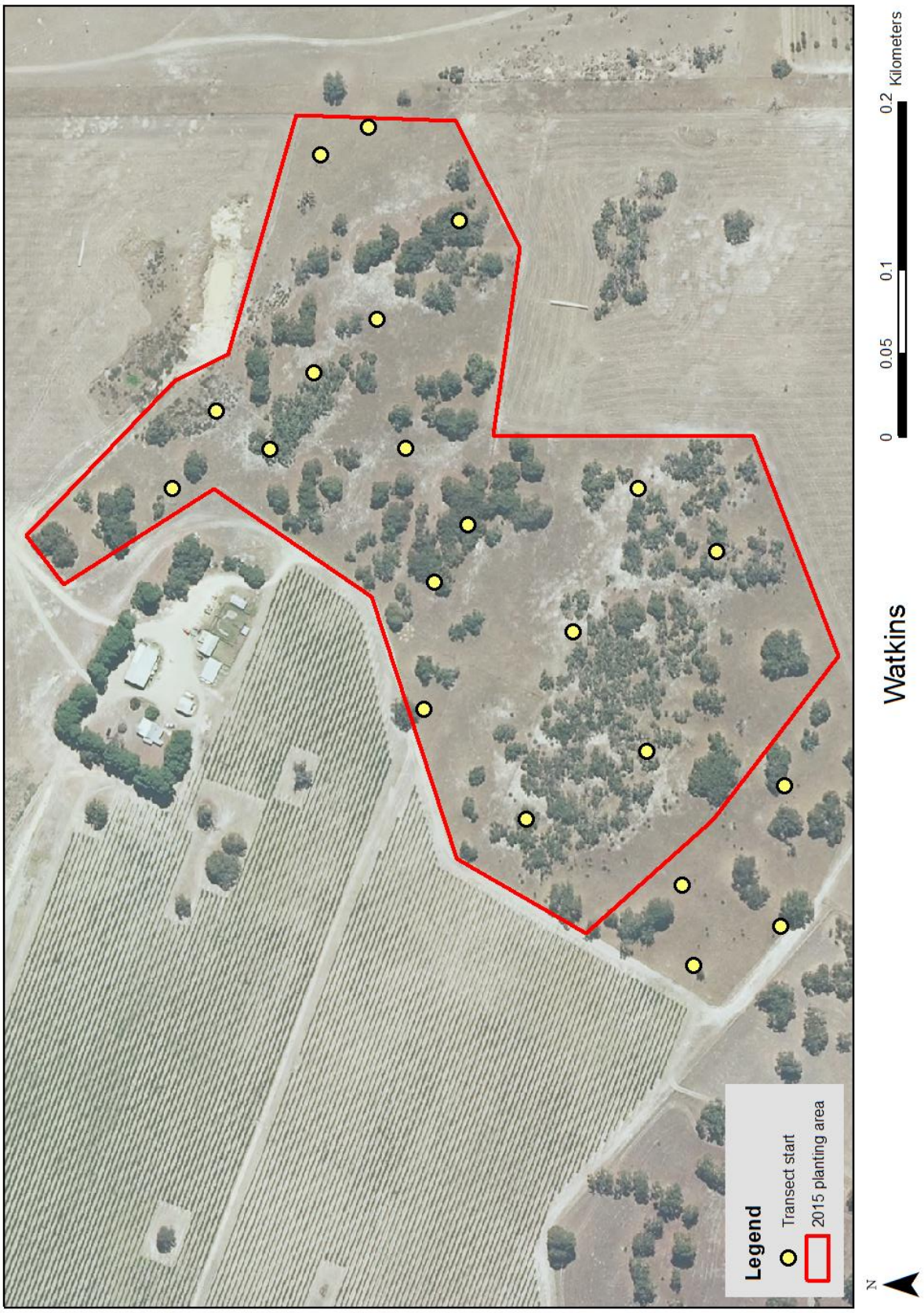
Warrengie	Spring 2015		Autumn 2016	
	Alive	Dead	Alive	Dead
	192	49	188	553
Survival	**79.7%**		**25.4%**	

Plantings were mostly infill, and were planted as a *Eucalyptus diversifolia* mallee ecosystem. Survival was generally poor at 25% with low growth rates. The site was difficult to survey as many seedlings had been unguarded in spring 2015, and this would have influenced survival.

Weeds were an issue, with innocent weed (*Cenchrus* sp.), caltrop (*Tribulus terrestris*) and 3-corner jack (*Emex australis*) all present. It appeared that weed control during site preparation had been poor.

10.1.15 Watkins - PlanID 442

10.1.15.1 Site map



10.1.15.2 Site photo

10.1.15.3 Survivorship results

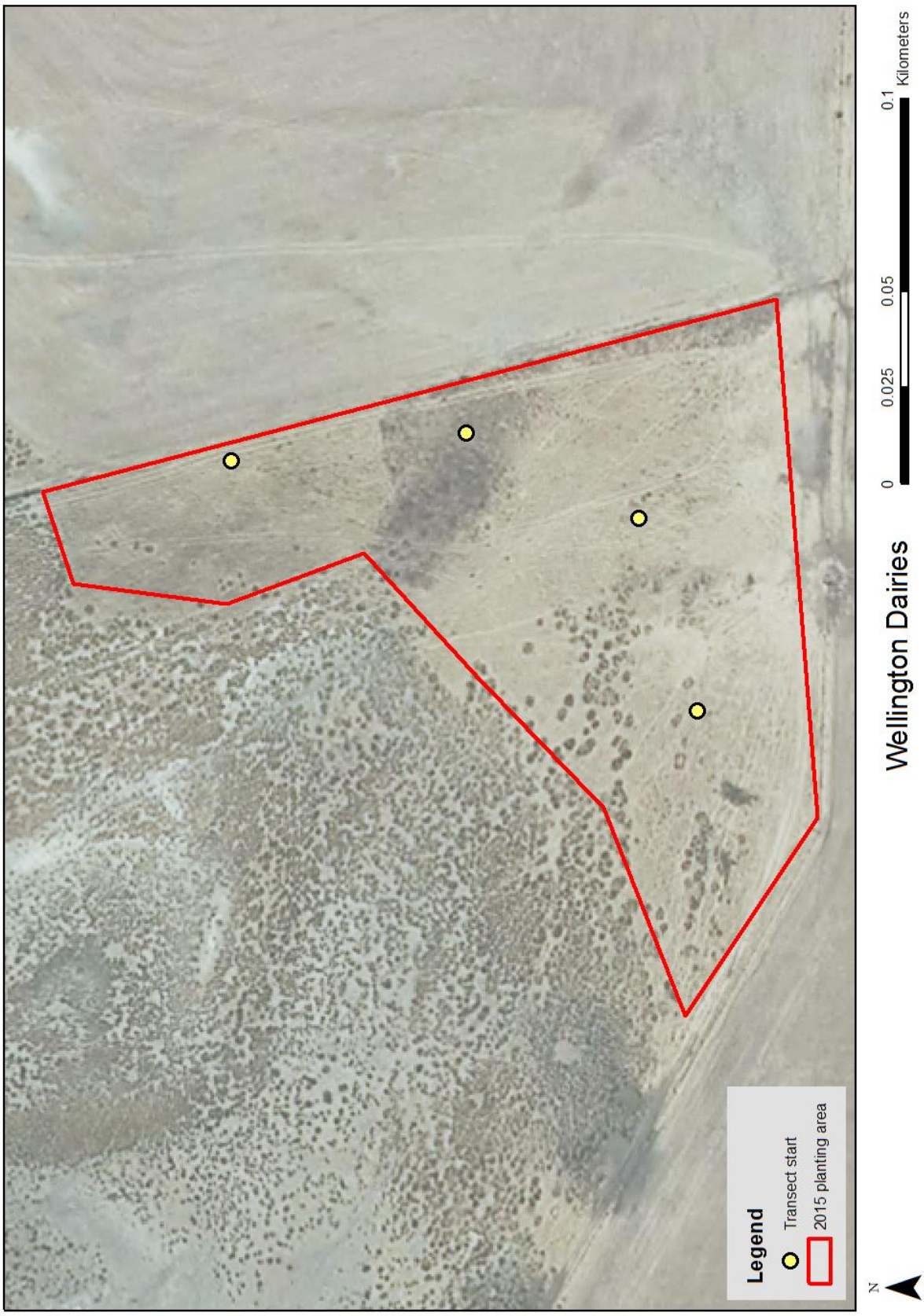
Watkins	Spring 2015		Autumn 2016	
	Alive	**Dead**	**Alive**	**Dead**
	585	98	418	202
Survival	**85.7%**		**67.4%**	

While survival was moderate to good across the site, vigour of plants tended to be excellent. A wide range of species were planted and survivors were establishing well – particularly given the sandy soils and proximity to remnant vegetation. This may be due to good site preparation, planting and maintenance methods and, especially, timing. Favourable local prevailing climatic conditions may have also assisted, however (eg. this site may have received more rain than others in the region, etc.). Corflute guards were used and may have been giving more protection from grazing animals. Grasses such as *Themeda triandra* were noted to be growing much taller and stronger than in other sites.

Survival was patchy closer to remnant vegetation and rabbits and kangaroos were providing above-average grazing pressure.

10.1.16 Wellington Dairies – PlanID 443

10.1.16.1 Site maps




Wellington Dairies
0
0.05
0.1
0.2
Kilometers
N
Legend
Transect start
2015 planting area

10.1.16.2 Site photo

10.1.16.3 Survivorship results

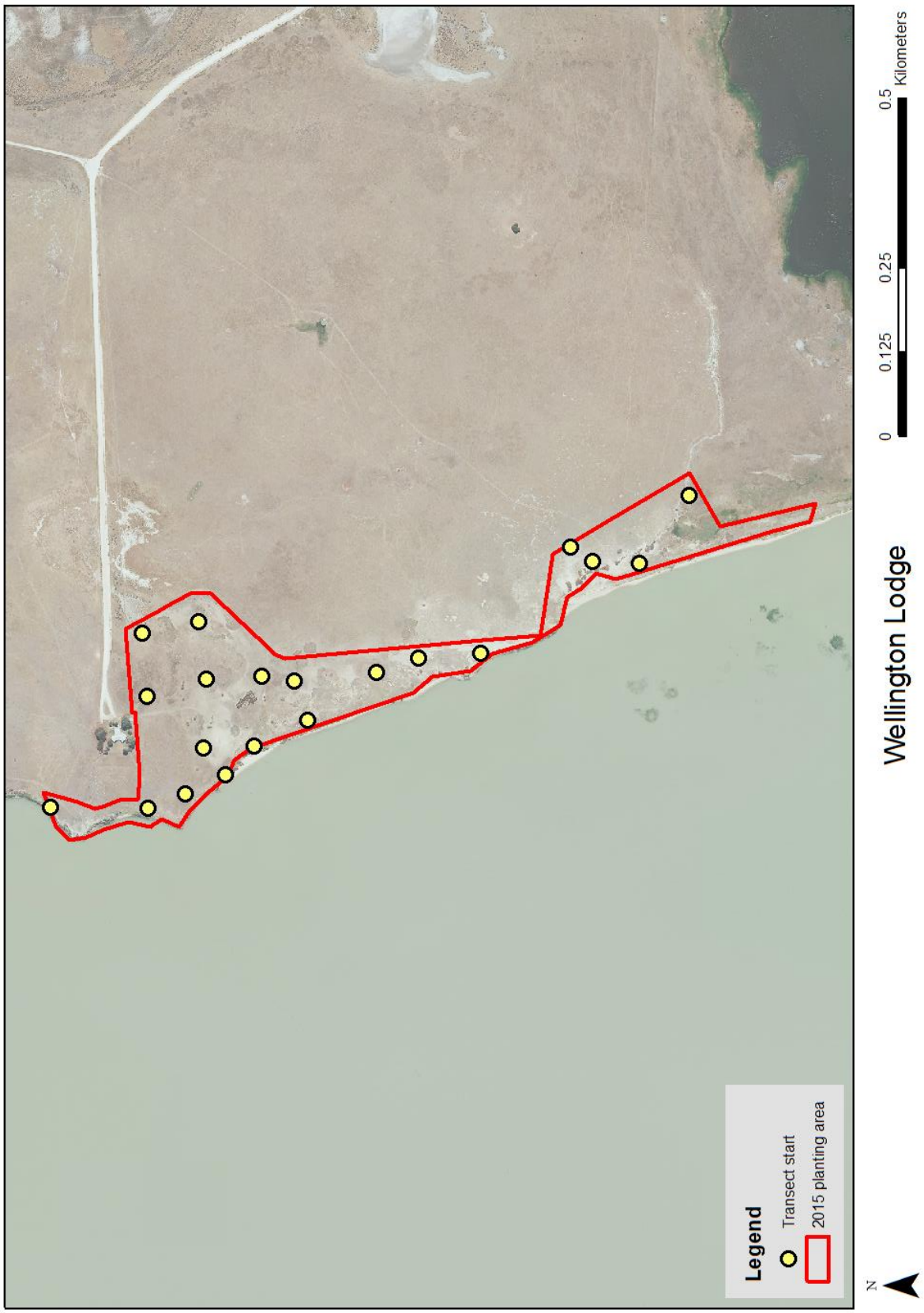
Wellington Dairies	Spring 2015		Autumn 2016	
	Alive	Dead	Alive	Dead
	476	101	434	89
Survival	**82.5%**		**83.0%**	

Plant growth and survival were highly variable in patches but overall survival was very good at 83% and plant growth was fairly good. Guards should be removed soon, especially for understorey species.

In spring 2015 there were many rabbits seen on the site, and in autumn 2016, there were still signs of activity from high rabbit numbers. However, calicivirus may have affected any resident rabbits – with a notable smell and no fresh droppings seen.

10.1.17 Wellington Lodge Lake Edge Infill - PlanID 472

10.1.17.1 Site map



10.1.17.2 Site photo

10.1.17.3 Survivorship results

Wellington Lodge Lake Edge Infill	Spring 2015		Autumn 2016	
	Alive	Dead	Alive	Dead
	568	175	363	185
Survival	**76.4%**		**66.2%**	

Survival was above average with a moderate drop of 10% from spring 2015 to autumn 2016. Plant health and growth was the highest seen across all sites. In many cases, plants were far advanced than would be expected at 9 months since planting. Corflute guards were working well and most were intact and protecting plants from grazing.

There were signs of rabbits across the site but few signs of recent activity, suggesting that baiting and possibly calicivirus had made an impact, evidenced by the large amounts of green growth seen above the top of guards. Grazing pressure had been high in previous years, and a large number of rabbits had been seen in the spring 2015 surveys. No other major pest or weed issues were noted, and woody weed control appeared to be adequate.

11. APPENDIX E. Survival_rel database and site photographs in digital format (see attached disk)