Regional, Focussed, On-ground

CLLMM Grass Trial Monitoring (2015 Plantings)

FINAL Project Report

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

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1. INTRODUCTION

1.1. Background to 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 program has undertaken extensive habitat restoration activities, including planting local native species across the CLLMM region.

The Vegetation Program undertakes research and monitoring activities in order to continually improve the delivery of restoration activities. One area identified as requiring further research was the use of site preparation techniques to improve the survival of native grasses in revegetation sites.

1.2. Treatment selection

At most restoration sites, the combined issues of elevated soil nutrients and high weed loads favour the establishment of exotic rather than native groundcover (Groves, *et al.* 2003). As such, site preparation is required before planting in order to 'tip the balance' in favour of native species and aid the establishment of a native vegetation community.

Of the various site preparation methods available, two methods were chosen for evaluation in this study: *spraying* and *scalping*. The *spraying* method involves treating the revegetation area with herbicide before planting, with the aim of reducing weed cover and therefore reducing competition for planted native species.

The *scalping* method involves removing topsoil to a predetermined depth across the revegetation area, with the aim of removing a large proportion of the nutrient-rich topsoil containing the weedy seedbank, as well as existing weedy plants. Scalped areas are typically then sown with native seed or planted with seedlings. A number of studies have found scalping to be more effective than traditional weed control (cultivation combined with herbicide spraying) at reducing weed numbers and biomass in restoration settings (Gibson-Roy, *et al.* 2010).

1.3. Project scope

In September 2015, Barron Environmental partnered with NGT Consulting to carry out the CLLMM Grass Trial Monitoring (2015 plantings) project. This project involved conducting vegetation survival monitoring at five grass trial sites that had been established and planted in 2015. Each site contained one or more paired plots (a total of 18 paired plots overall) which were treated using two site preparation techniques: herbicide spraying and soil scalping. The monitoring aimed to assess the effect of site preparation on grass survival. It should be noted that two of the sites (PlanID 452 and PlanID 480) were not accessible for the autumn assessment, rendering nine plots unavailable for analysis.

1.4. 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 grass trial sites in spring and autumn.
- Estimating the survivorship of the planting within the grass trial.
- Providing a basic photographic record of sites.

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 grass trial monitoring, including a discussion of the results.

2. METHODOLOGY

2.1. Monitoring sites

The five grass trial monitoring sites were situated within the CLLMM region, with two sites on the Narrung Peninsula, two north of Meningie, and one near the Finniss River (refer to Figure 1).

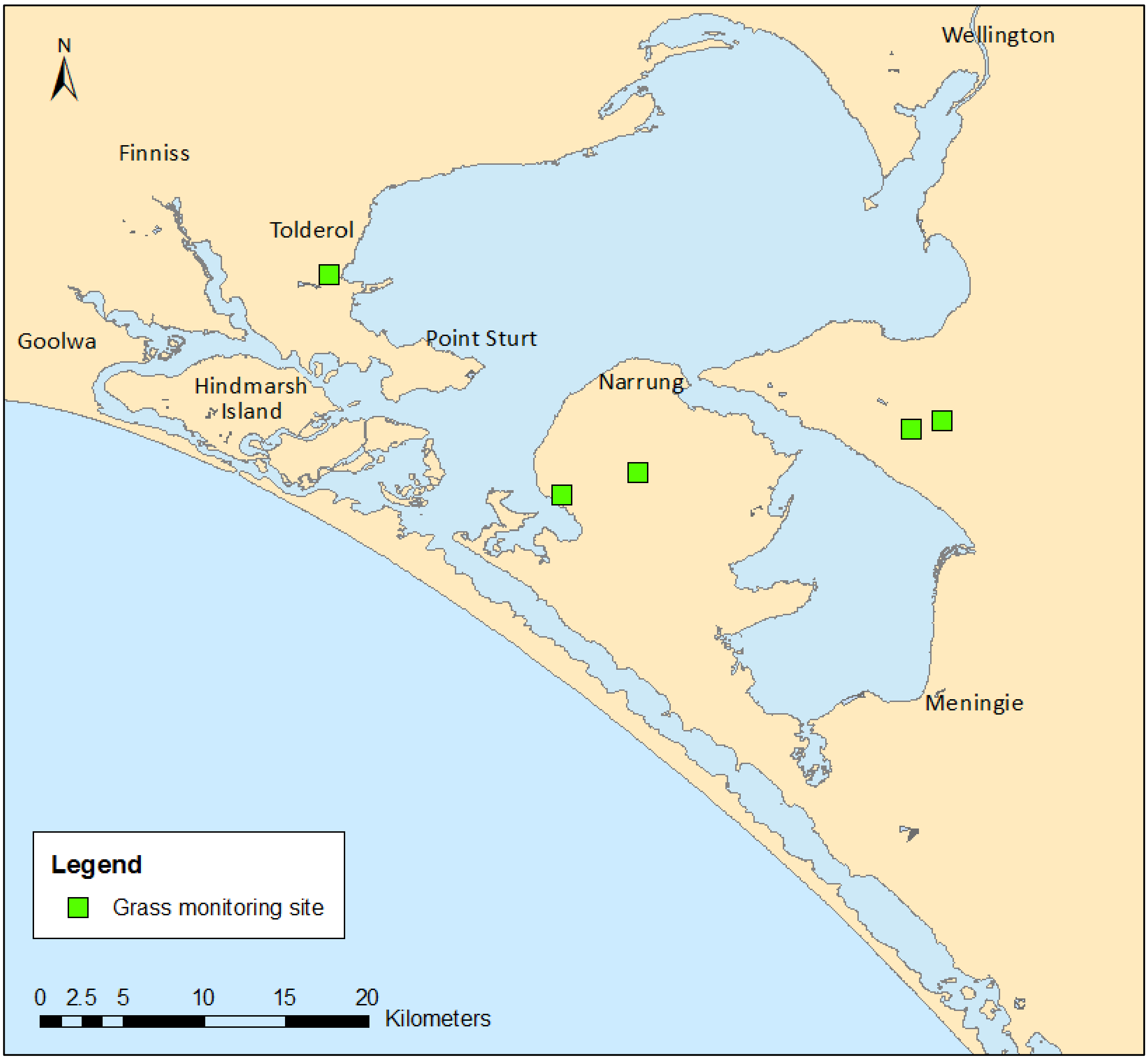

Figure 1 - Map of the CLLMM region showing grass trial monitoring locations

Sites were first surveyed in spring 2015 (18 paired plots across five sites - refer to Table 1) approximately three months after planting, to assess survivorship due to planting technique and grazing.

Table 1 – Spring 2015 monitoring sites (sites not revisited in autumn 2016 marked with an asterisk)

Site no.	Site name	Paired plots
1	PlanID 447	3
2	PlanID 461	1
3	PlanID 479	5
4	PlanID 452 *	6^
5	PlanID 480 *	3
Total		**18**

^ Only a sprayed plot was surveyed at one paired plot

Nine paired plots (across three sites) were then surveyed in autumn 2016 (Table 2) to assess survivorship after the plants experienced their first summer season. Importantly, and as mentioned in the Introduction, two sites (PlanID 452 and PlanID 480) were unavailable for the autumn count, resulting in half of the plots from the spring monitoring not being surveyed in the autumn counts.

Table 2 - Autumn 2016 monitoring sites

Site no.	Site name	Paired plots
1	PlanID 447	3
2	PlanID 461	1
3	PlanID 479	5
Total		**9**

2.2. Field survey methodology

Each of the five monitoring sites contained a number of paired plots. In each pair, one plot was sprayed with glyphosate herbicide to reduce competition from weedy exotic species. The other plot had the top 10 cm of soil removed (scalped) before planting in order to reduce competition from weedy species, and to remove accumulated weed seeds in the seed bank. Each plot consisted of three 9 m x 2.5 m rows. Each plot was planted with 550 randomly distributed grasses, containing 10 different species. Each grass seedling was guarded with a cardboard guard held in place by two bamboo stakes. Planting occurred from June to August 2015, using locally-sourced native grass tubestock.

To monitor the grass trials, a quadrat was monitored in each row (six surveys at each paired plot). At each row a 1 m x 2.5 m quadrat was randomly selected, using a random number generator in Microsoft Excel.

Measuring tapes were run along both sides of each row, and a 1 x 2.5 m quadrat was marked by placing two wooden rods across the row (see Figure 2). There were approximately 21 grasses planted in each quadrat.

A total of 105 quadrats (35 plots / 18 paired plots) were monitored in spring 2015, followed by 54 quadrats (18 plots / 9 paired plots) in autumn 2016.

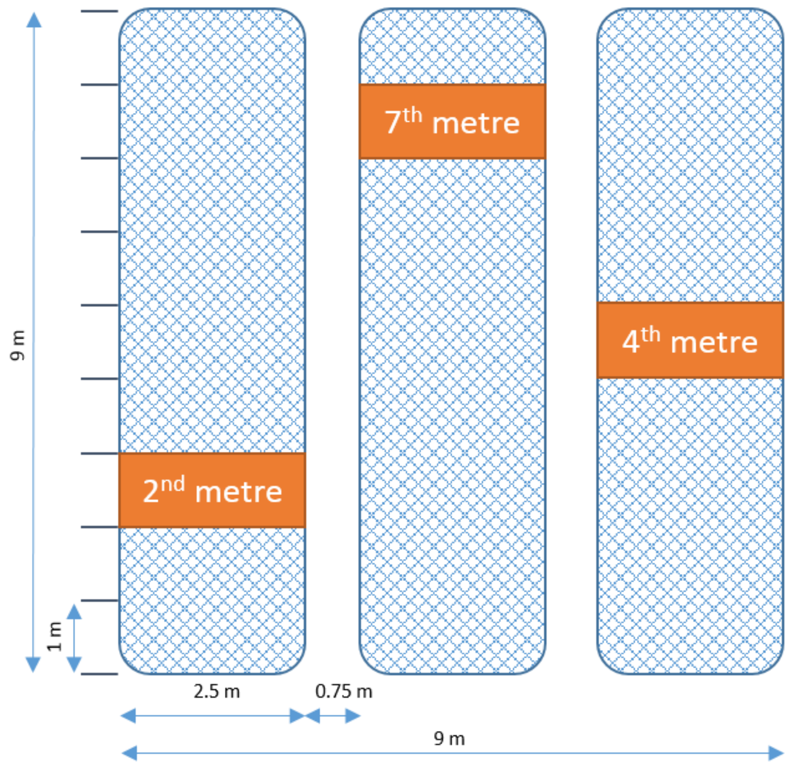

Figure 2 - Example of grassland quadrat delineation

2.3. Survivorship scoring

Each guarded plant was identified to species level, or if that was not possible to genus, and recorded as either dead or alive. Dead plants that could not be identified were recorded as "Dead (unknown species)".

2.4. Statistical analysis

A statistics analysis of results was undertaken in R. Survival for each treatment/site was calculated using the mean of each individual plot's seedling number and percentage survival (+/- standard deviation). Significance was based at the 95% confidence level, as calculated using the lme4 package in R (R Core Team 2014, Bates *et al*. 2015).

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. Spring 2015

In spring 2015, a total of 2156 grass seedlings were inspected across five different sites, with a mean of 88% survival across all monitoring plots at the time of monitoring (Table 3). Across all sites, mean survival in scalped plots was 7.8% higher than in sprayed plots.

Table 3 - Spring 2015 grass trial results across all sites, by plot

Treatment	Number of plots	Plants surveyed	Mean Survival (%)	Std Dev (%)
Scalped (G)	18	1054	92.0	16.9
Sprayed (P)	18	1102	84.2	17.1
Total		**2156**	**87.9**	**17.2**

Amongst individual sites, four of the five sites recorded a high mean survivorship within plots of between 84% and 98% (Table 4), while PlanID 461 recorded a mean survivorship within plots of 29.5%.

Table 4 - Spring 2015 grass trial results, by plot within site

Site	Paired plots	Treatment	Mean Survival %	Std Dev %	Site mean survival %	Site Std Dev %
PlanID 447	3	Scalped (G)	100	0	97.9	3.8
		Sprayed (P)	95.8	4.8		
PlanID 452	6	Scalped (G)	91.8	4.1	84.4	11.2
		Sprayed (P)	78.2	11.7		
PlanID 461	1	Scalped (G)	28.3	-	29.5	1.6
		Sprayed (P)	30.6	-		
PlanID 479	5	Scalped (G)	98.4	2.4	96.1	3.4
		Sprayed (P)	93.7	2.6		
PlanID 480	3	Scalped (G)	93.0	93.1	89.9	7.9
		Sprayed (P)	86.8	10.8		
Total	**18**				**87.9**	**17.2**

3.2. Autumn 2016

Bearing in mind that two of the sites (PlanID 452 and PlanID 480) were not accessible, three sites were revisited for monitoring in autumn 2016, resulting in 1130 grass seedlings inspected. Overall mean survival within plots remained high at 74.1% (Table 5).

Across all sites, mean survival in scalped plots was 12.1% higher than in sprayed plots.

Table 5 - Autumn 2016 grass trial results across all sites, by plot

Treatment	Number of plots	Plants surveyed	Mean survival (%)	Std Dev (%)
Scalped (G)	9	579	80.2	29.3
Sprayed (P)	9	551	68.1	26.8
Total		**1130**	**74.1**	**27.9**

Of the three sites that were visited, two performed well, with 79% survival at PlanID 447 and 85% at PlanID 479 (Table 6). There was a large die-off of plants at the third site (PlanID 461). However, as this site had only one paired plot comprising 11% of total plants counted, there was not a strong influence on the survival rate across all sites.

Table 6 - Autumn 2015 grass trial results, by plot within site

Site	Paired plots	Treatment	Mean survival %	Std Dev %	Site mean survival %	Std Dev (%)
PlanID 447	3	Scalped (G)	83.2	9.2	79.4	9.8
		Sprayed (P)	75.7	10.6		
PlanID 461	1	Scalped (G)	4.8	-	2.4	3.4
		Sprayed (P)	0.0	-		
PlanID 479	5	Scalped (G)	93.4	5.1	85.3	10.9
		Sprayed (P)	77.1	8.8		
Total	**9**				**74.1**	**27.9**

3.3. Further analysis by site and survey

Survivorship results were also analysed to determine the random effect of site and survey to try and further detect any significant differences between treatments. The analysis used a generalised linear mixed model (glmm) with a binomial distribution (R Core Team 2014, Bates *et al*. 2015). Treatment type (scalped or sprayed) was a fixed effect with a random effect of row and site nested within location.

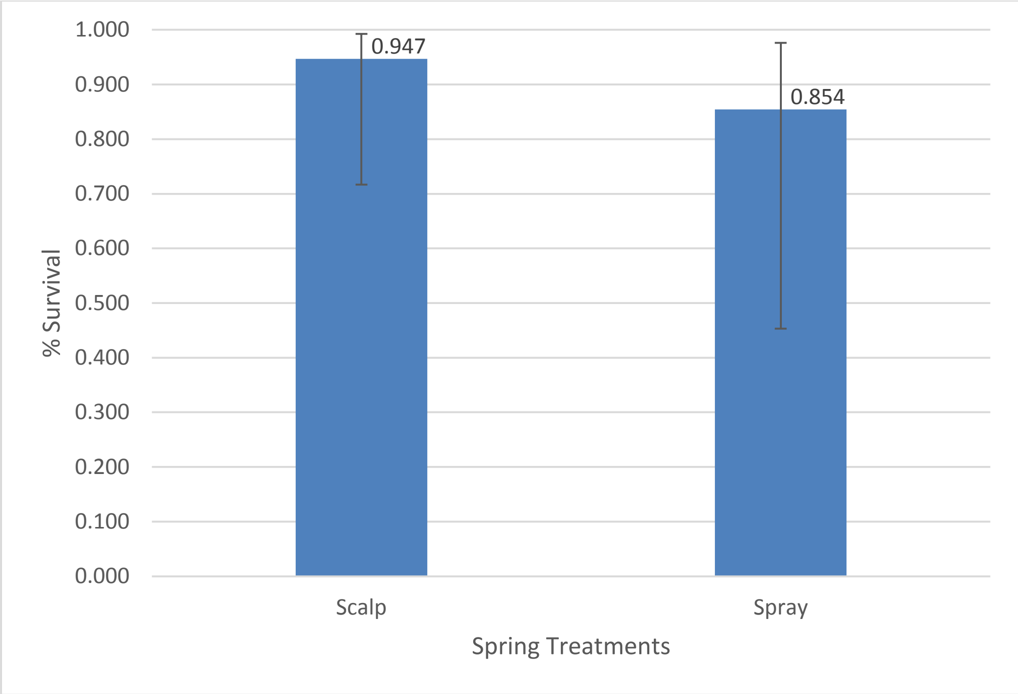

Figure 3 - Graph showing the % survival difference between treatments in spring 2015 (no significant difference at the 95% confidence level). Survival data were combined (sites and locations) and converted to a scale between 0 and 1, where 1 is 100% survival.

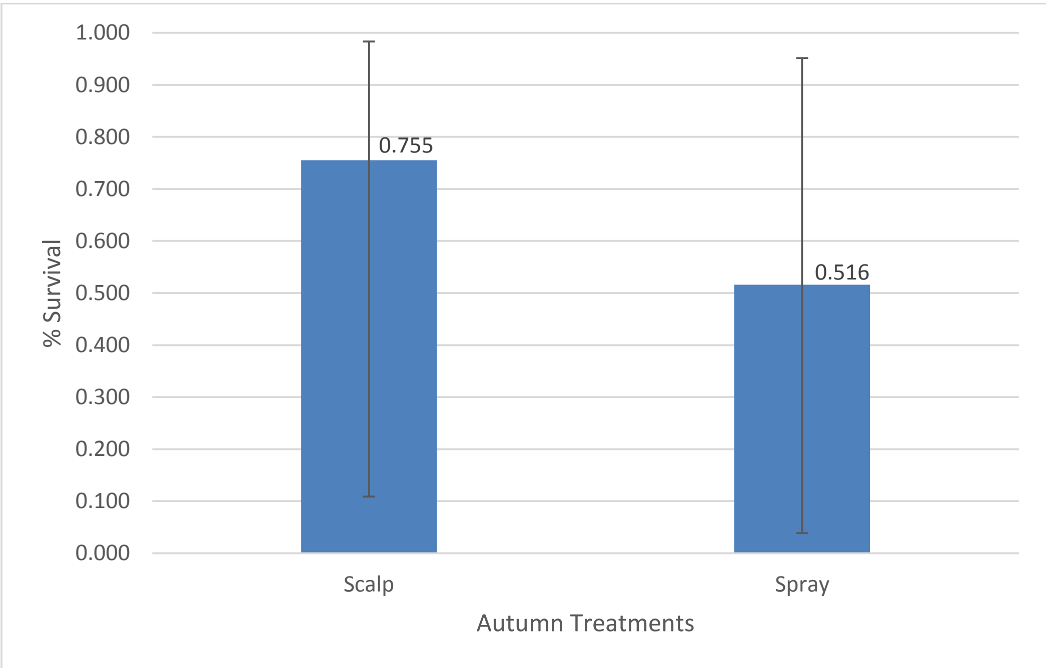

Figure 4 - Graph showing the % survival difference between treatments in autumn 2016 (no significant difference at the 95% confidence level). Survival data were combined (sites and locations) and converted to a scale between 0 and 1, where 1 is 100% survival.

As seen in Figure 3 and Figure 4, the spring and autumn analysis showed that plots treated by scalping have better survival, but overall they are not significantly different to spray treatments, possibly due to the high variability in results. This is likely to be due to the relatively low level of replication in autumn.

This analysis suggests that scalping provides greater survival for grass species over spring and autumn; however more replication is needed over a number of years/sites to ensure this is the case. Also note that analysis of individual species during the autumn monitoring was not possible due to the lack of replication (mainly due to PlanID 452 and 480 not being included).

4. DISCUSSION

4.1. Overall survival

Overall, mean survivorship in monitoring plots was high in both spring 2015 (87.9%) and autumn 2016 (74.1%).

Aside from PlanID 461, survival at individual sites was consistently high across spring and autumn surveys, and particularly so for scalped plots. In autumn, the site with the highest survivorship – PlanID 479 – recorded a mean survival rate of 93.4% in scalped plots.

At the site with the poorest survivorship – PlanID 461 – survival dropped further from the poor results seen in spring 2015, to a mean of 2.4% in autumn 2016. There was no visible indication of why survival had been so poor, suggesting that perhaps late timing of site preparation and/or planting may have been a factor.

4.2. Changes in spring and autumn survival

Due to half of the 18 paired plots not being surveyed in autumn 2016, there is a necessary reduction in confidence in the post-summer results. However, the three spring sites that were revisited in autumn are discussed below.

At the sites monitored in both seasons, mean plant survival in plots dropped by 13.8%, to 74.8% (Table 7). All sites recorded a drop in survival of more than 10%, with PlanID 461 suffering the highest percentage loss at 27%. It should be noted that a general drop in survival from spring to autumn is expected, due to increased temperatures and decreased moisture availability over summer.

Table 7 - Survival change between spring 2015 and autumn 2016, by site

Site	Paired plots	Treatment	Mean Survival %		% change	Site change %
			Spring 2015	Autumn 2016		
PlanID 447	3	Scalped (G)	100	83.2	-16.8	-18.5
		Sprayed (P)	95.8	75.7	-20.1	
PlanID 461	1	Scalped (G)	28.3	4.8	-23.5	-27.1
		Sprayed (P)	30.6	0.0	-30.6	
PlanID 479	5	Scalped (G)	98.4	93.4	-5.0	-10.8
		Sprayed (P)	93.7	77.1	-16.6	
Total	**9**		**87.9**	**74.8**		**-13.8**

4.3. Differences between scalped and sprayed plots

Referring to Table 3-Table 7 and **Error! Reference source not found.**-6, the spring and autumn results show better survival at plots with scalping treatments, but are not significantly different to spray treatments. This may be due to the high variability between sites, as well as the relatively low replication in autumn due to unavailable plots. As shown in Table 7, all three sites visited in both spring 2015 and autumn 2016 demonstrated higher survival with the scalping method.

While the two site preparation methods were not significantly different in this study, other similar (and more comprehensive) studies have demonstrated advantages in scalping compared to spraying, particularly by creating bare ground for a long enough time for sown native species to germinate and establish (Gibson-Roy, *et al.* 2010). In addition, scalping removes at least some of the high-nutrient topsoil, somewhat mitigating that barrier to the establishment of native species.

The expected lower weed germination that was observed at scalped plots may continue to advantage the establishment of native grass seedlings across the next few months, providing less competition for space, moisture and nutrients. However, as most sites have substantial surrounding weed loads, wind-blown seeds are making their way into scalped areas, and the scalping method is likely not deep enough to remove rhizomatous grasses such as kikuyu (*Pennisetum clandestinum*) and to a lesser extent, couch grass (*Elymus repens*).

While the scalping method demonstrated better survival, it was not significantly better than that of spraying, and spraying may still be an economical and relatively effective method of site preparation – particularly in the first year. However, due to the long-term weed suppression effect of scalping, the method can be nearly as economical as the multiple years of spraying treatment required to produce a similar effect (Gibson-Roy, *et al.* 2010).

Figure 5 - Autumn: scalped plot at PlanID 479

Figure 6 – Autumn: sprayed plot in foreground with scalped plot in background at PlanID 479

4.4. Influence of a single poor-performing site

In both spring and autumn monitoring, overall results were substantially influenced by the failure of plantings at PlanID 461, which recorded a mean of 29.5% survival in plots in spring and just 2.4% survival in autumn. Site-specific factors may have prompted this failure, including later planting than at other sites, sandy soils, the slope of the planting area, and possible competition from remnant vegetation.

Table 8 and Table 9 show the overall results with PlanID 461 removed. In spring, survival was 8.2% higher in scalped plots than in sprayed plots. In autumn the gap increased, with survival 13% higher in scalped plots than in sprayed plots.

Table 8 - Spring 2015 grass trial results across all sites, by plot (PlanID 461 removed)

Treatment	Plants surveyed	Mean Survival (%)	Std Dev (%)
Scalped (G)	994	95.6	4.4
Sprayed (P)	1040	87.4	10.9
Total	**2034**	**91.4**	**9.3**

Table 9 - Autumn 2016 grass trial results across all sites, by plot (PlanID 461 removed)

Treatment	Plants surveyed	Mean Survival (%)	Std Dev (%)	Mean survival % change from spring
Scalped (G)	517	89.6	8.2	-6.0
Sprayed (P)	494	76.6	9.1	-10.8
Total	**1011**	**83.1**	**10.6**	**-8.1**

4.5. 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 10) was above average during early winter, before dropping significantly below the long term average in the August to December period. Low rainfall during that period would have contributed to particularly challenging conditions for seedlings at PlanID 461, which was planted in mid-August 2015.

The above-average rainfall in summer may be contributing to earlier emergence of weeds within the plots, but excessive weed cover was not noticed in most plots.

Table 10 - Monthly total rainfall (mm) across CLLMM planting region April 2015 to March 2016

		2015 Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**2016** 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

4.6. Recommendations and future research

As discussed above, two of the grass trial sites could not be accessed in the autumn 2016 surveys, resulting in 54 of the 105 quadrats not being monitored in that season. It is recommended that if the current plots are revisited for surveying, these sites be included.

It was noted that it could be difficult at times to ascertain whether a grass plant was dead or dormant. A short follow-up survey in spring 2016 would allow this to be easily detected from green growth on plants, and give further information on the effectiveness of scalping and herbicide spraying preparation methods.

Due to variable form, grazing pressure (browsing of grasses as they emerged from the guards) and differing growth rates, it was at times difficult to identify plants to species level, and in some cases, to genus level – particularly for dead plants. For that reason, there was not sufficient confidence to compare results for individual species or genus; however, this information is contained in the delivered database. To avoid this scenario in future, tags on rows could indicate the species contained in that row. While time intensive, this would allow gathering of detailed species survival information.

Although the analysis suggests that scalping provides greater survival for grass species over spring and autumn, we believe that more replication is needed over several years and sites to try to improve the confidence in this outcome.

5. REFERENCES

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