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Establishment success and benefits to the aquatic plant community of planting *Schoenoplectus tabernaemontani* around the shorelines of lakes Alexandrina and Albert - 2015

Jason Nicol, Susan Gehrig and Kate Frahn

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Cover Photo: Shoreline of Lake Alexandrina at Raukkan showing *Ceratophyllum demersum, Phragmites australis, Typha domingensis* and *Schoenoplectus tabernaemontani* (Regina Durbridge).

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EXECUTIVE SUMMARY

Schoenoplectus tabernaemontani is a large, native, perennial, rhizomatous sedge that grows to 2–3 m high in water up to 1.5 m deep and is a common emergent species around the edges of the Lower Lakes (lakes Alexandrina and Albert). Unlike other large emergent species present in the Lower Lakes, (e.g. *Phragmites australis* and *Typha domingensis*) it does not form dense monospecific stands and usually grows in deeper water than the aforementioned species, often in association with aquatic taxa such as *Myriophyllum* spp., *Potamogeton* spp. *Ceratophyllum demersum* and *Vallisneria australis. Schoenoplectus tabernaemontani* is a robust species; often growing on shorelines subjected to wave action and provides a sheltered area between the stand and shoreline where less robust species can persist. These characteristics have resulted in *S. tabernaemontani* being planted extensively around the edges of lakes Alexandrina and Albert, primarily to reduce shoreline erosion.

Despite *S. tabernaemontani* being extensively planted there has been little monitoring to evaluate the survivorship, density and extent of the planted stands. Furthermore, vegetation surveys were not undertaken at planting sites prior to planting and there is little information regarding the benefits of planting *S. tabernaemontani* on the aquatic plant community. This project was designed to address these data deficiencies and had four aims:

- To compare the survivorship, density, height and extent of *S. tabernaemontani* plantings in lakes Alexandrina and Albert between 2013, 2014 and 2015.
- To compare the density, height and extent of *S. tabernaemontani* between shorelines that were planted and areas where it occurs naturally.
- To investigate the effect of *S. tabernaemontani* planting on the aquatic plant community by comparing the plant community in planted and control shorelines and where *S. tabernaemontani* is naturally present.

Survivorship, stand width, stem density and maximum and mean stem height of *S. tabernaemontani* were assessed at seven planted shoreline sites (n = 4 old plantings (8 to 9.5 years old), n = 3 new plantings (2.5 to 3.5 years old) in lakes Alexandrina and Albert in autumn 2013 and 2014, and at three shoreline sites where *S. tabernaemontani* is present naturally in autumn 2014 (age unknown, herein referred to as “natural shorelines”; n = 3). An additional three new planted sites (two of which were surveyed before they were planted in autumn 2014) were established in 2015 (0.5 years old). These parameters were compared between old

plantings, new plantings and natural shorelines in autumn 2014 and 2015, whilst changes in these parameters between autumn 2013, 2014 and 2015 were assessed at all planted sites established in 2013. The benefits of planting to the aquatic plant community were assessed by comparing the plant community at planted, adjacent unplanted (control) shorelines (in 2013, 2014 and 2015), natural shorelines (in 2014 and 2015) and shorelines planted in 2014 (in 2015).

Between autumn 2013 and 2015, there were significant increases in stand width and stem density at most planted sites. There was an increase in the calculated total number of stems present at each 100 m surveyed section of shoreline at all sites between 2013 and 2014 and all sites between 2014 and 2015, except the old planted site at Nurra Nurra Point (where there was a decrease in the number of stems) and Wellington Lodge (where the number of stems were similar in 2014 and 2015). In autumn 2014, *S. tabernaemontani* stands at the natural sites were characterised by greater stand width than planted sites (old and new) and stem densities lower than shorelines planted prior to 2007, but similar to shorelines planted after 2010. Stand width, stem density and the total number of stems changed at natural sites between 2014 and 2015 with an increase in extent and density at the Bremer River Mouth and Hindmarsh Island Bridge but a decrease at Loveday Bay. Stem height was similar at natural and all planted shorelines and generally did not change through time.

A diverse aquatic plant community was generally present at shorelines planted prior to 2007, compared to the control sites, which were often devoid of aquatic vegetation. The aquatic plant community at shorelines planted after 2010 was similar to the control shorelines, with the exception of Meningie Foreshore, which was similar to sites planted before 2007. Vegetation at sites planted in 2014 was also similar to control shorelines. The plant community at natural shorelines was distinct but most similar to shorelines planted prior to 2007. When the plant community was divided into high (+0.8 and +0.6 m AHD) and low (+0.4, +0.2 and 0 m AHD) elevations the differences between the planted, natural and unplanted shorelines at the high elevations was less distinct but the shorelines planted prior to 2007 were still most similar to the natural shorelines. At low elevations there were distinct differences between the plant community at the natural, planted and unplanted shorelines with shorelines planted prior to 2007 becoming more similar to the natural shorelines between autumn 2013 and 2015.

Results showed that planted *S. tabernaemontani* survived at all sites and there was evidence that it was expanding at all but two sites due to the increase in the calculated number of stems recorded, even in areas where no statistically significant increases in stand width or stem density were detected. Comparisons between planted and natural stands suggested that the planted stands could expand a considerable distance into lakes Alexandrina and Albert and it is unlikely that the maximum stem density has been reached at planted sites.

Data collected in autumn 2015 further supported the hypothesis that *S. tabernaemontani* provides a “breakwater” protecting the shoreline from waves and creating a low energy environment where aquatic, amphibious, floating and submergent plants can establish. There is also evidence that the plant communities at shorelines planted prior to 2007 are becoming more similar to the plant community at natural shorelines through time. Therefore, the natural shorelines may be used as a target to evaluate the success of the planting program.

1. INTRODUCTION

1.1. Background

Schoenoplectus tabernaemontani is a large, native, perennial, rhizomatous sedge that grows 2–3 m in height (up to 5 m in favourable conditions) in water up to 1.5 m deep (Cunningham *et al.* 1992; Sainty and Jacobs 2003). Ecosystem services provided by *S. tabernaemontani* include erosion control, waterbird and fish habitat, sediment and water column aeration and water quality improvement (Sainty and Jacobs 2003). It is a common emergent species around the edges of lakes Alexandrina and Albert but unlike the other two large emergent species present in the Lower Lakes, *Phragmites australis* and *Typha domingensis*, it does not form dense monospecific stands (Gehrig *et al.* 2011; 2012; Frahn *et al.* 2013; 2014). *Schoenoplectus tabernaemontani* usually grows in deeper water than *T. domingensis* and *P. australis* (Sainty and Jacobs 2003) and in the Lower Lakes is often associated with submergent taxa such as *Myriophyllum* spp., *Potamogeton* spp., *Ceratophyllum demersum* and *Vallisneria australis* (Gehrig *et al.* 2011; 2012; Frahn *et al.* 2013; Nicol *et al.* 2013; 2014).

The ability of *S. tabernaemontani* to tolerate wave action has resulted in it being planted extensively around the edges of lakes Alexandrina and Albert in water depths up to 80 cm, primarily to control shoreline erosion (Goolwa to Wellington Local Action Planning Board *et al.* no date). Nearly all aquatic (and riparian) erosion control planting programs involve planting trees or shrubs on shorelines or river banks (e.g. Abernethy and Rutherfurd 1998; Raulings *et al.* 2007; Watson 2009); hence, planting an emergent aquatic species in the water is a novel approach.

Results of monitoring undertaken in autumn 2013 showed that planted stands persisted during the period of low water levels (2007 to 2010), probably as rhizomes, and established once water levels were reinstated (Nicol *et al.* 2013). In autumn 2014, monitoring results showed that all planted stands had persisted for a further 12 months and the total number of stems had increased in each of the 100 m of shoreline that was surveyed (Nicol *et al.* 2014). Furthermore, there was evidence that plantings of *S. tabernaemontani* benefitted the aquatic plant community by providing a sheltered area where submergent and less robust emergent species could establish (Nicol *et al.* 2013). In 2014, the plant community in areas where *S. tabernaemontani* grows naturally was surveyed and the plant community in these areas was different to planted sites (Nicol *et al.* 2014). However, the change in the plant community composition at sites planted prior to 2007, between autumn 2013 and 2014 showed that the vegetation at planted sites were becoming more similar to areas where *S. tabernaemontani* occurs naturally (Nicol *et al.* 2014).

1.2. Objectives

Despite *S. tabernaemontani* being planted extensively around the shorelines of lakes Alexandrina and Albert, there have been only two monitoring events (autumn 2013 and autumn 2014) to evaluate the survivorship, density and extent of the planted stands. Furthermore, vegetation surveys were not undertaken prior to planting (except at the stands planted at Wellington Lodge and Poltalloch in 2014). Therefore, only data collected in autumn 2013 and 2014 are available to assess the impacts of planting *S. tabernaemontani* on the aquatic plant community. Finally, quantitative comparisons of the aquatic plant community between shorelines planted with *S. tabernaemontani* and shorelines where the species occurs naturally were only undertaken in autumn 2014. This project was designed to address these data deficiencies and had four aims:

- To compare the survivorship, density, height and extent of *S. tabernaemontani* plantings in lakes Alexandrina and Albert between 2013, 2014 and 2015.
- To compare the density, height and extent of *S. tabernaemontani* between shorelines that were planted and areas where it occurs naturally.
- To investigate the effect of *S. tabernaemontani* planting on the aquatic plant community by comparing the plant community in planted and non-planted areas (without *S. tabernaemontani*) and where *S. tabernaemontani* is present naturally.
- To establish and monitor paired planted and control sites at Poltalloch and Hartnett's (Point Sturt) and establish an additional site at Wellington Lodge in the area planted in 2014.

2. METHODS

2.1. Study sites

A total of 11 locations with 21 sites (each 100 m of shoreline surveyed) were surveyed in 2015 (Table 1, Figure 1). Seven were established in 2013 at locations where *S. tabernaemontani* had been planted (two in Lake Alexandrina; Wellington Lodge and Raukkan and five in Lake Albert; Dumandang, Lake Albert Rd, Meningie Foreshore and Nurra Nurra Point) (Figure 1) and surveyed in autumn (to correspond with The Living Murray monitoring) 2013, 2014 and 2015 (Table 1). Control sites, for assessing changes in the aquatic plant community, were established adjacent to all planted sites except Lake Albert Road and Meningie foreshore (Figure 1). At Lake Albert Road the planting extended a considerable distance along the shoreline, resulting in the adjacent shoreline being too close to the Narrung Narrows at the western end of the planting and at the eastern end at the inlet of Waltowa Swamp. Both these areas were considerably different to the planted area; hence, a control site was established at the northern end of Brown Beach (on the eastern shoreline of Lake Albert) (Figure 1). The shoreline adjacent to the Meningie Foreshore site was also different to the planted shoreline. The shoreline to the south was highly modified (jetties and the boat ramp) and extensive erosion control works had been undertaken on the shoreline to the north hence a control site was established at the southern end of Brown Beach (Figure 1). In 2014 three potential future planting sites (Wellington Lodge, Poltalloch and Point Sturt) and three sites where *S. tabernaemontani* grows naturally (Hindmarsh Island Bridge, Loveday Bay and Bremer Mouth) (Figure 1) were established and surveyed (Table 1). However, the proposed planting site at Point Sturt was abandoned and replaced with a site nearby at Hartnett's, where planting occurred in 2014 (Table 1). Planting was undertaken at Wellington Lodge and Poltalloch and these shorelines were surveyed in 2015 (Table 1). All sites where *S. tabernaemontani* grows naturally were surveyed again 2015 (Table 1). At Wellington Lodge *S. tabernaemontani* was planted at the 2013 and 2014 control site and the 2014 proposed planting site is now the control site. Whilst this was unfortunate in terms of data continuity at this site, it means that we have two years of vegetation data prior to planting that we do not have for any other sites and will enable changes in the plant community before and after planting to be compared. GPS coordinates of sites, the year *S. tabernaemontani* was planted and the years monitoring was undertaken at each location are presented in Appendix 1.

Table 1: List of locations, their planting status, stand age category and when the stands were planted and surveyed.

Location	Planting Status	Age	Year Planted	Years Surveyed
Dumandang	Planted (+Control)	Old	2003, 2004 and 2006	2013, 2014 and 2015
Raukkan	Planted (+Control)	Old	2006	2013, 2014 and 2015
Wellington Lodge	Old Planted, New Planted (+Control)	Old and New	2007 and 2014	2013, 2014 and 2015
Nurra Nurra Point	Old Planted, New Planted (+Control)	Old and New	2006, 2012 and 2013	2013, 2014 and 2015
Meningie Foreshore	Planted (+Control)	New	2012	2013, 2014 and 2015
Lake Albert Road	Planted (+Control)	New	2013	2013, 2014 and 2015
Poltalloch	Planted (+Control)	New	2014	2014 and 2015
Hartnett's	Planted (+Control)	New	2014	2015
Loveday Bay	Natural	NA	NA	2014 and 2015
Bremer Mouth	Natural	NA	NA	2014 and 2015
Hindmarsh Island Bridge	Natural	NA	NA	2014 and 2015

Figure 1: Aerial photograph of lakes Alexandrina and Albert showing the survey locations.

2.2. Density, height and extent of *Schoenoplectus tabernaemontani* stands

At each site, a 100 m section of shoreline in the centre of the planted stand was selected where the survivorship, stem density, stem height and extent (stand width) of planted or natural *S. tabernaemontani* and the aquatic plant community were assessed.

Stem density (no. stems m^{-2}), stem height (maximum and mean) and extent (stand width) of planted *S. tabernaemontani* stands was assessed at each of the planted sites (*n* = 10) (Table 1, Figure 1). Measurements were undertaken at five random points along the 100 m section of surveyed shoreline (determined using a random number generator between 0 and 99 and taking measurements at the corresponding metre mark on a 100 m measuring tape) (Figure 2) in autumn 2013, 2014 and 2015 (Table 1). Random numbers were generated for each survey to avoid repeated measures. The same measurements were undertaken on natural *S. tabernaemontani* (*n* = 3) stands in autumn 2014 and 2015.

Stem density was measured by recording the number of stems in a 1 x 1 m quadrat and stand width measured along the left hand edge (facing the shoreline) of the quadrat (Figure 2). The tallest stem in the quadrat and the height of ten random stems were measured from the lake bed. In addition, water depth was measured at each quadrat to determine emergent height, although this was not reported because planting depth was consistent across sites (<5 cm range between sites).

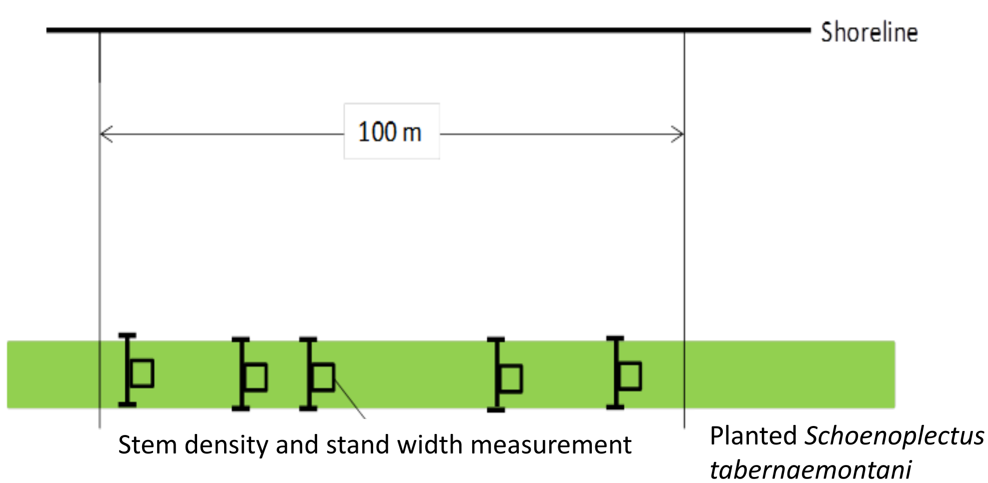

Figure 2: Plan view of a planted shoreline section showing the stand width measurement and quadrats within which stem density and height measurements were undertaken.

2.3. Benefit of *Schoenoplectus tabernaemontani* plantings for the aquatic plant community

The vegetation monitoring protocol used the same methods as TLM (*The Living Murray*) lake shore vegetation condition monitoring for lakes Alexandrina and Albert (Frahn *et al.* 2014). This will enable quantitative comparison of data with that collected as part of the TLM vegetation condition monitoring program, if required. At each location, three transects were established perpendicular to the shoreline, at each end and in the middle of the 100 m shoreline section at planted and control sites (Figure 3). At Wellington Lodge and Nurra Nurra point two planted sites and one control site are present and at locations where *S. tabernaemontani* occurs naturally one site was established at each location as controls were not required (Figure 1).

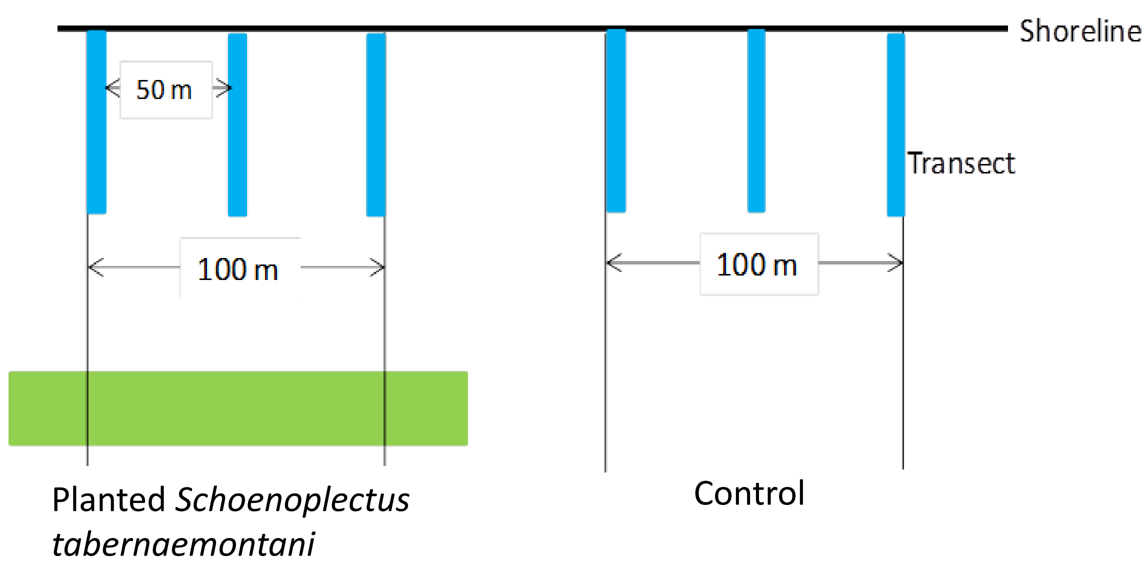

Figure 3: Plan view of planted and control shoreline sections showing the placement of vegetation monitoring transects. Potential future planting sites were also established following the same design.

Along each transect, three 1 x 3 m quadrats, separated by 1 m, were established at +0.8, +0.6, +0.4, +0.2, and 0 m AHD (Figure 4). Quadrats at lower elevations were not surveyed due to the absence of vegetation at all sites. Cover and abundance of each species present in the quadrat were estimated using the method outlined in Heard and Channon (1997) except that N and T were replaced by 0.1 and 0.5 to enable statistical analyses (Table 2).

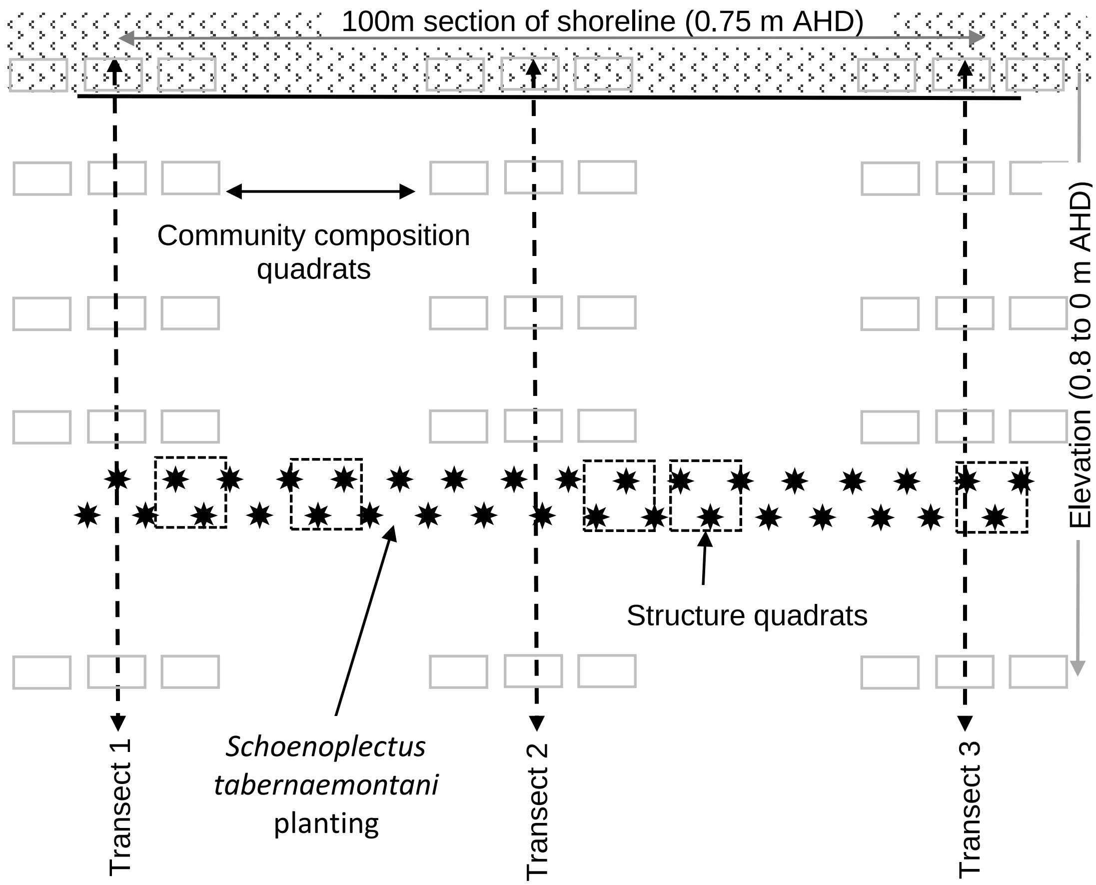

Figure 4: Vegetation surveying protocol for each transect: plan view showing placement of quadrats relative to the shoreline, planted *S. tabernaemontani* and transects.

Table 2: Modified Braun-Blanquet (1932) scale estimating cover/abundance as per Heard and Channon (1997).

Score	Modified Score	Description
N	0.1	Not many, 1-10 individuals
T	0.5	Sparsely or very sparsely present; cover very small (less than 5%)
1	1	Plentiful but of small cover (less than 5%)
2	2	Any number of individuals covering 5-25% of the area
3	3	Any number of individuals covering 25-50% of the area
4	4	Any number of individuals covering 50-75% of the area
5	5	Covering more than 75% of the area

2.4. Plant identification and nomenclature

Plants present were identified to species where possible using keys in Sainty and Jacobs (1981), Jessop and Tolken (1986), Prescott (1988), Dashorst and Jessop (1998), Romanowski (1998), Sainty and Jacobs (2003) and Jessop *et al.* (2006). In some cases due to immature individuals or lack of floral structures, plants were identified to genus only. Nomenclature follows the Centre for Australian National Biodiversity Research and Council of Heads of Australasian Herbaria (2015).

2.5. Data Analysis

An estimate of the total number of stems (over the 100 m of shoreline where measurements were taken) at the planted and natural shorelines was calculated using the following equation (Equation 1):

Equation 1: Total number of *S. tabernaemontani* stems = (mean stand width x 100) x mean stem density

Stand width, stem density, mean and maximum height and calculated stem number data were presented graphically and the relationship between stand age (time since planting) and stem density, stand width and calculated stem number analysed with regression analysis using Microsoft Excel. Stand width, stem density and mean stem height at each planted shoreline were compared between 2013, 2014 and 2015 with univariate PERMANOVA (Anderson 2001; Anderson and Ter Braak 2003) using the package PRIMER 6.1.15 (Clarke and Gorley 2006). Euclidean distances were used to calculate the similarity matrices for all univariate PERMANOVA tests.

Plant community data (all species present) collected at the different elevations at each site were pooled and the difference in floristic composition in 2013, 2014 and 2015 between shorelines where *S. tabernaemontani* has been planted, control shorelines and natural shorelines were assessed with non-metric scaling (NMS) ordination (McCune *et al.* 2002). A dummy variable (equal to 1) was added to enable quadrats with no plants present to be included in the analysis (*sensu* McCune *et al.* 2002). In addition, the same analyses were performed separately on plant community data from high (+0.8 and +0.6 m AHD) and low elevations (+0.4, +0.2 and 0 m AHD) (McCune *et al.* 2002). Species with a Pearson Correlation Coefficient of greater than 0.5 were overlaid on the ordination plots as vectors. In addition to the MDS ordinations, two factor PERMANOVA comparing the plant communities through time and between control and planted sites was undertaken at the newly planted sites at Wellington Lodge and Poltalloch. All multivariate anayses were undertaken using the package PRIMER version 6.1.15 (Clarke and Gorley 2006). Bray-Curtis (1957) similarities were used to calculate the similarity matrices for all multivariate analyses and α=0.05 for all statistical analyses with the Bonferroni correction used for multiple comparisons (Quinn and Keogh 2002).

3. RESULTS

3.1. Survivorship, density, height and extent of *Schoenoplectus tabernaemontani* stands

Live *S. tabernaemontani* was present and established at all planted sites indicating it survived the previous 12 months (or previous 6 months for the newly planted sites at Poltalloch, Wellington Lodge and Hartnett's). The widest stands of planted *S. tabernaemontani* were at Raukkan (where the stand width exceeded 10 m in places) and Wellington Lodge (Figure 5). The width of natural *S. tabernaemontani* stands at the Bremer River Mouth and Hindmarsh Island Bridge were greater than any of the planted stands; however, the natural stand at Loveday Bay was a similar width to the stands at Raukkan and Wellington Lodge (Figure 5). There was no significant change in stand width at any of the naturally occurring stands between 2014 and 2015 except at the Bremer River Mouth, where there was a significant increase (Table 3). The only planted sites where there was a significant change in stand width between autumn 2013 and autumn 2015 were the newly planted stand at Nurra Nurra Point, Dumandang (where there was a significant increase between 2013 and 2014 but no change between 2014 and 2015) and Raukkan (where there was no significant change between 2013 and 2014 and a significant increase between 2014 and 2015) (Table 3, Figure 5). Whilst there were no significant increases in stand width at the other planted sites, there were increasing trends in stand width at all planted sites except the old planted site at Nurra Nurra Point (Figure 5). Furthermore, there was a significant positive relationship between stand age and width (R^2=0.3626; P=0.002) (Figure 6).

Table 3: PERMANOVA results comparing the changes in stand width, stem density and mean stem height at the shorelines planted with *S. tabernaemontani* between 2013, 2014 and 2015 and shoreline where *S. tabernaemontani* occurs naturally between 2014 and 2015.

Shoreline	**Stand Measurements**	***Pseudo-F***	***DF***	***P***	**Annual comparisons**
Meningie Foreshore (new)	Stand Width	2.25	2,14	0.144	NA
	Stem Density	4.91	2,14	**0.015**	2013<2014=2015
	Mean Stem Height	0.20	2,149	0.811	NA
Nurra Nurra Point (new)	Stand Width	6.29	2,14	**0.013**	2013<2014=2015
	Stem Density	15.50	2,14	**0.003**	2013<2014<2015
	Mean Stem Height	0.06	2,149	0.945	NA
Lake Albert Rd (new)	Stand Width	1.96	2,14	0.143	NA
	Stem Density	32.79	2,14	**0.002**	2013=2014<2015
	Mean Stem Height	28.97	2,149	**0.001**	2013=2015<2014
Dumandang (old)	Stand Width	14.06	2,14	**0.001**	2013<2014=2015
	Stem Density	1.46	2,14	0.270	NA
	Mean Stem Height	12.08	2,149	**0.001**	2013>2014=2015
Nurra Nurra Point (old)	Stand Width	2.04	2,14	0.166	NA
	Stem Density	0.60	2,14	0.548	NA
	Mean Stem Height	1.55	2,149	0.219	NA
Raukkan (old)	Stand Width	4.62	2,14	**0.027**	2013=2014<2015
	Stem Density	1.27	2,14	0.336	NA
	Mean Stem Height	6.96	2,149	**0.004**	2013>2014=2015
Wellington Lodge (old)	Stand Width	1.97	2,14	0.182	NA
	Stem Density	0.18	2,14	0.842	NA
	Mean Stem Height	2.26	2,149	0.101	NA
Bremer Mouth (natural)	Stand Width	7.45	1,9	**0.027**	2014<2015
	Stem Density	1.12	1,9	0.347	NA
	Mean Stem Height	0.06	2,149	8.819	NA
Loveday Bay (natural)	Stand Width	1.27	1,9	0.279	NA
	Stem Density	3.86	1,9	0.121	NA
	Mean Stem Height	7.91	2,149	**0.007**	2014>2015
Hindmarsh Island Bridge (natural)	Stand Width	2.36	1,9	0.234	NA
	Stem Density	11.41	1,9	0.026	2014<2015
	Mean Stem Height	37.20	2,149	**0.001**	2014<2015

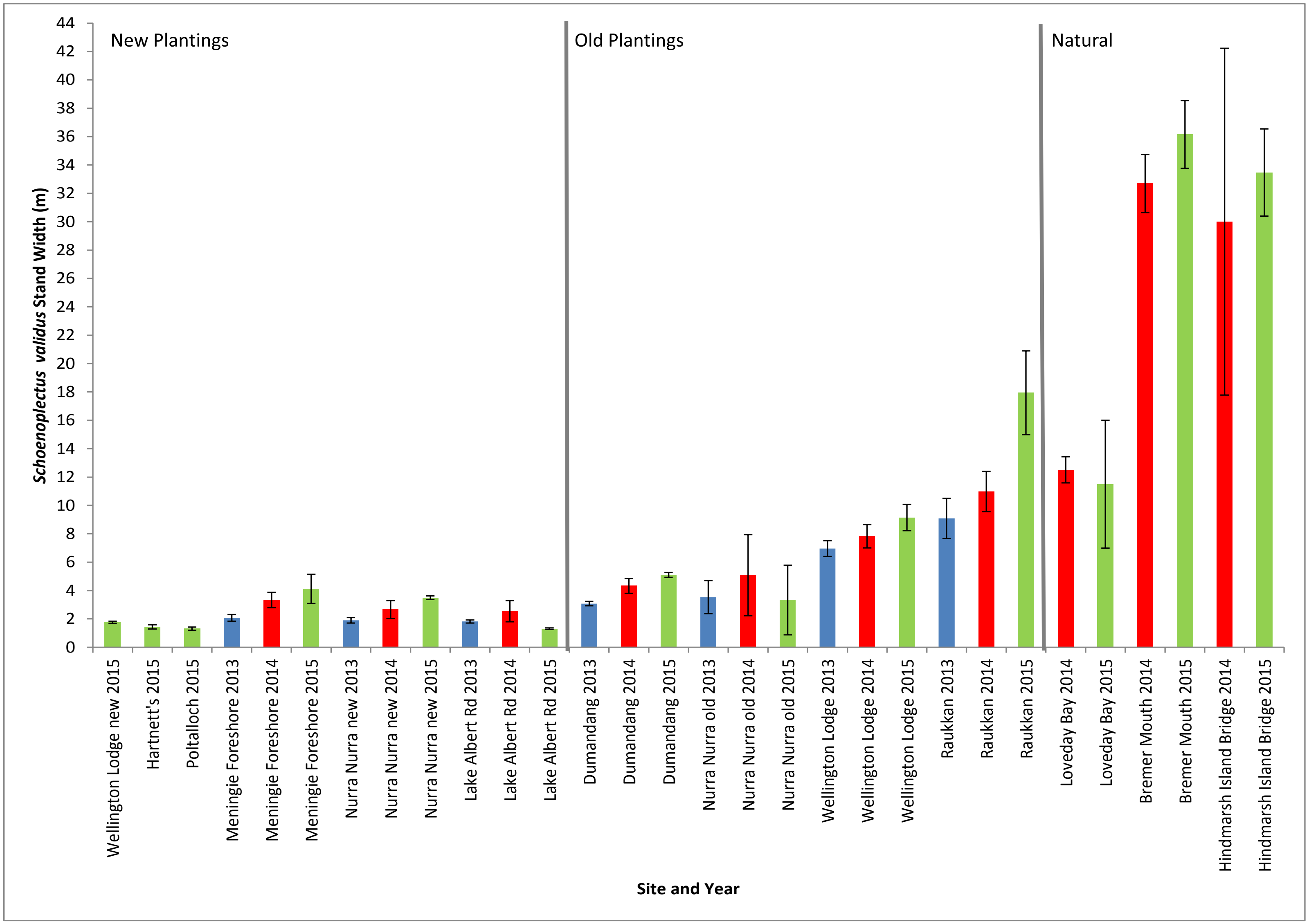

Figure 5: *Schoenoplectus tabernaemontani* stand width for each planted and natural shoreline in lakes Alexandrina and Albert in autumn 2013 (blue), 2014 (red) and 2015 (green) (error bars=±1 SE).

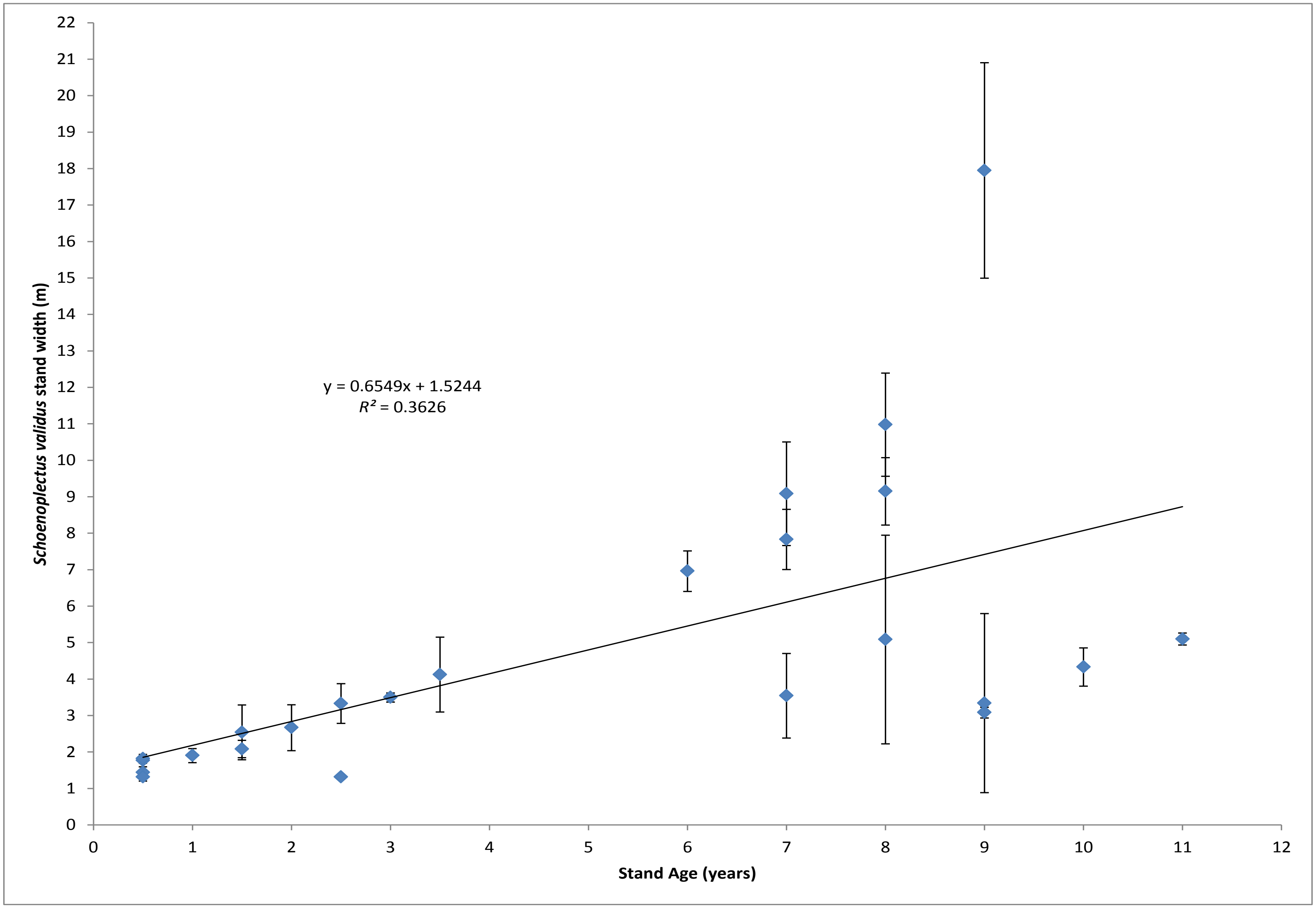

Figure 6: Relationship between *S. tabernaemontani* stand width and stand age, for each planted site in lakes Alexandrina and Albert for autumn 2013, 2014 and 2015 (error bars=±1 SE).

The change in stem density through time was variable between sites (Figure 7). At sites planted after 2007 there were significant increases between 2013 and 2015 but when the significant increase occurred was different between sites. At Meningie Foreshore there was a significant increase between 2013 and 2014 but no significant change between 2014 and 2015. At the young planting site at Nurra Nurra Point there was a significant increase each year and Lake Albert Road there was no significant change between 2013 and 2014 but a significant increase between 2014 and 2015 (Table 3, Figure 7). There was no significant change in stem density at sites planted prior to 2007 (Table 3, Figure 7).

Stem density at the natural shorelines was variable within and between sites with the highest density at Loveday Bay in 2014, which was comparable to the densities recorded at the shorelines planted prior to 2007 (except the old planting at Nurra Nurra) and the densities recorded at Meningie Foreshore, the new planting at Nurra Nurra Point and Lake Albert Road in 2015 (Figure 7). There was no significant change in stem density at the Bremer River Mouth and Loveday Bay between 2014 and 2015 and a significant increase at the Hindmarsh Island Bridge (Table 3, Figure 7).

Linear regression analysis showed a weak (albeit significant) positive relationship (R^2=0.2329; P=0.017) between stand age and stem density (Figure 8). However, if the data from the old planted site at Nurra Nurra Point are removed there was a strong positive, significant relationship between stand age and stem density (R^2=0.5986; P<0.0001).

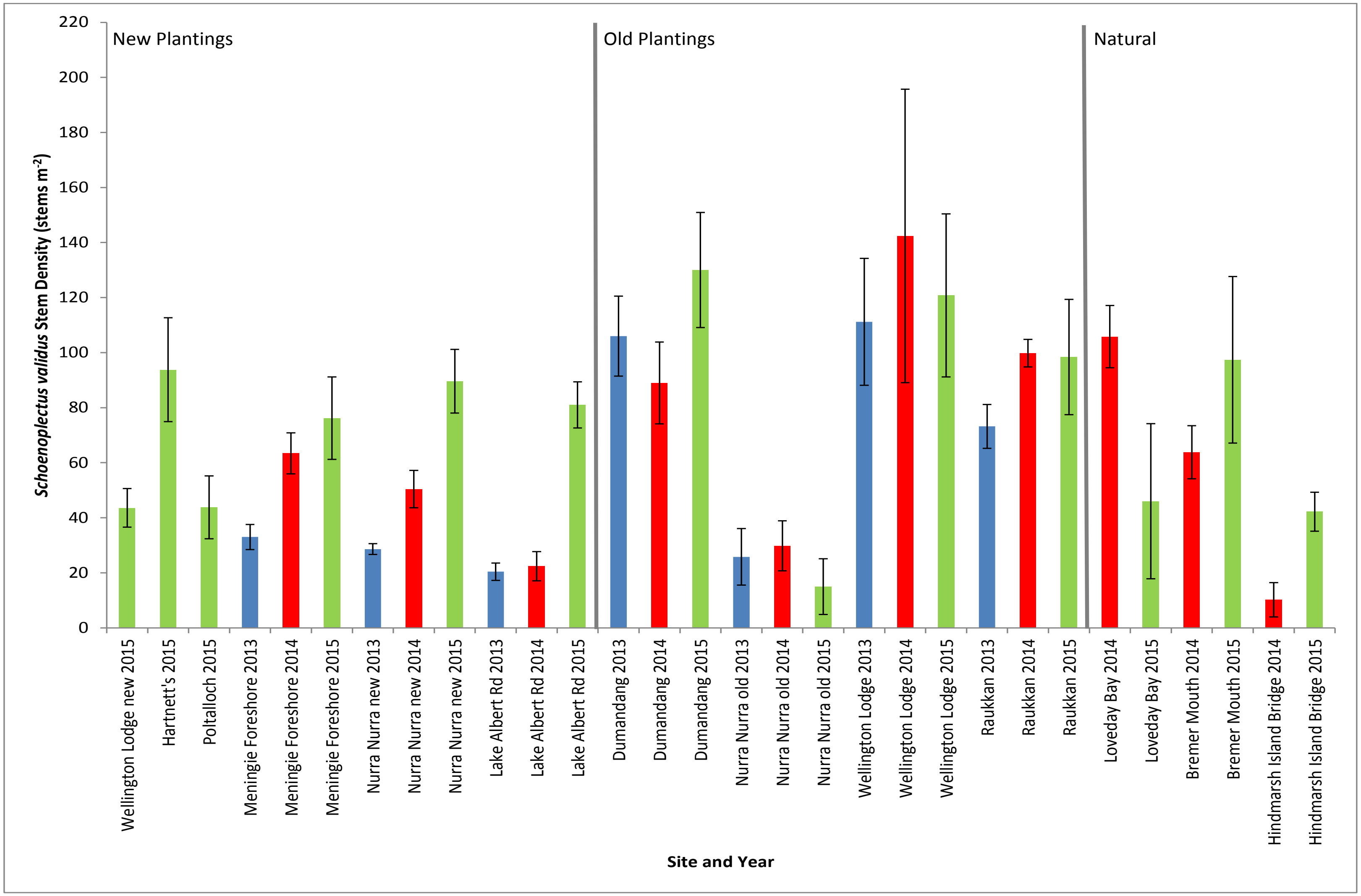

Figure 7: *Schoenoplectus tabernaemontani* stem density for each planted and natural shoreline in lakes Alexandrina and Albert in autumn 2013 (blue), 2014 (red) and 2015 (green) (error bars=±1 SE).

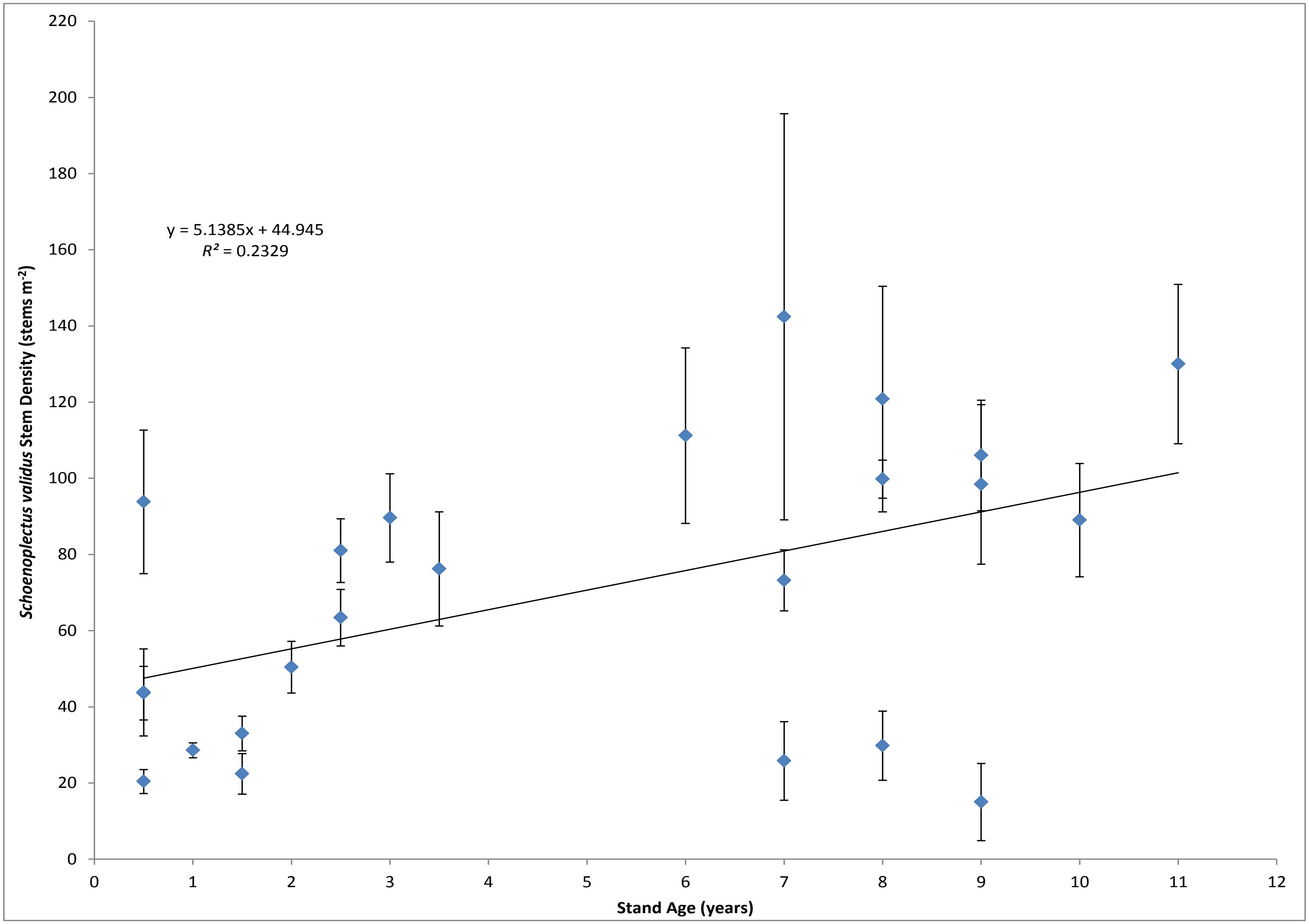

Figure 8: Relationship between *S. tabernaemontani* stem density and stand age, for each planted site in lakes Alexandrina and Albert for autumn 2013, 2014 and 2015 (error bars=±1 SE).

The height of the tallest stem present in each quadrat was relatively consistent between planted shorelines and surveys (autumn 2013, 2014 and 2015) with heights ranging from 118 (at the newly planted site at Wellington Lodge) to 238 cm (at Raukkan) (Figure 9). At the old planting at Nurra Nurra Point the maximum height of stems was lower and more variable (Figure 9). Maximum stem height was also consistent for the natural stands but stems were generally taller (Figure 9). Due to the consistent maximum height of stems there was no relationship between stand age and maximum stem height (R^2=0.0216; P=0.496) (Figure 10).

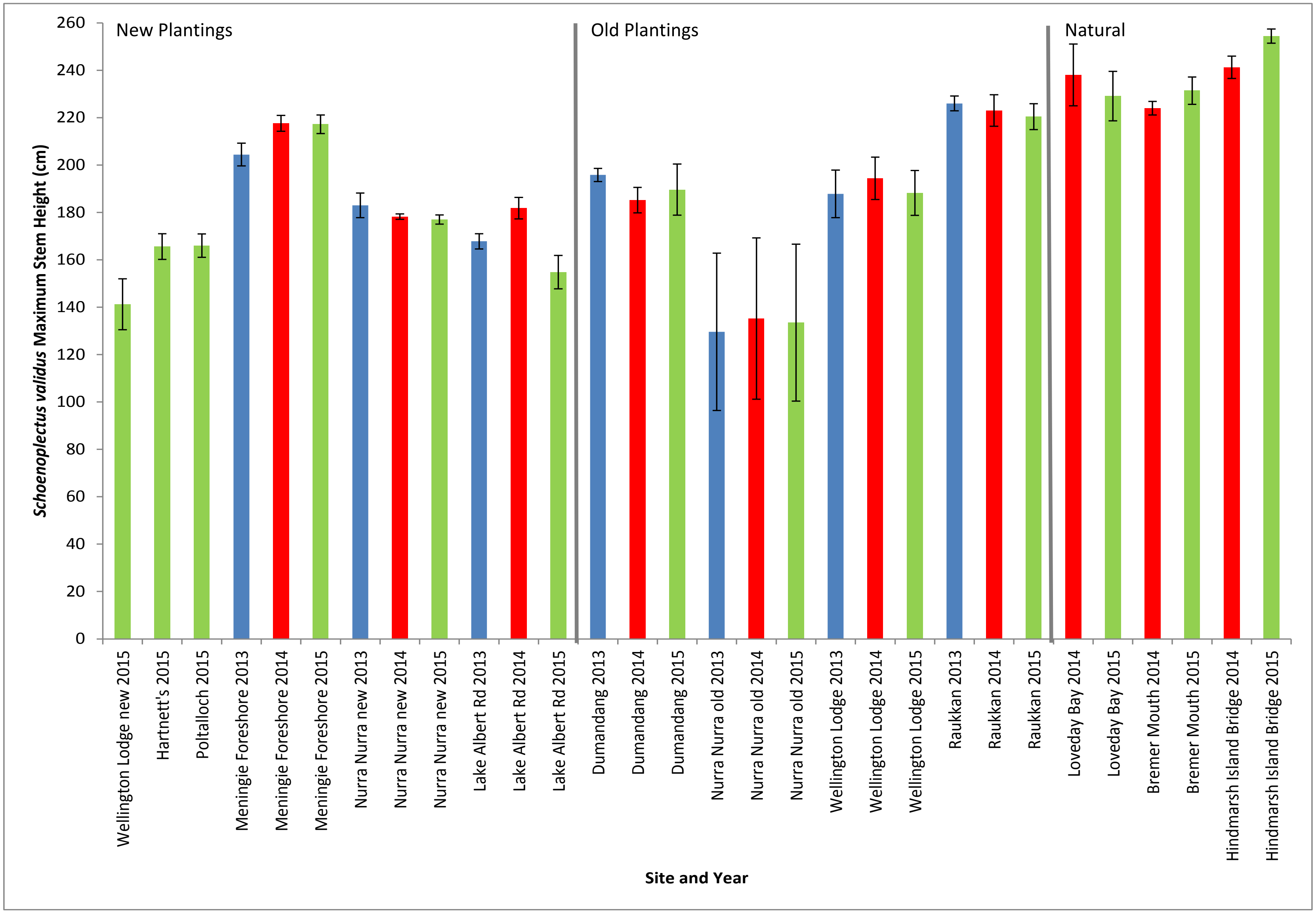

Figure 9: *Schoenoplectus tabernaemontani* maximum stem height for each planted and natural shoreline in lakes Alexandrina and Albert in autumn 2013 (blue), 2014 (red) and 2015 (green) (error bars=±1 SE).

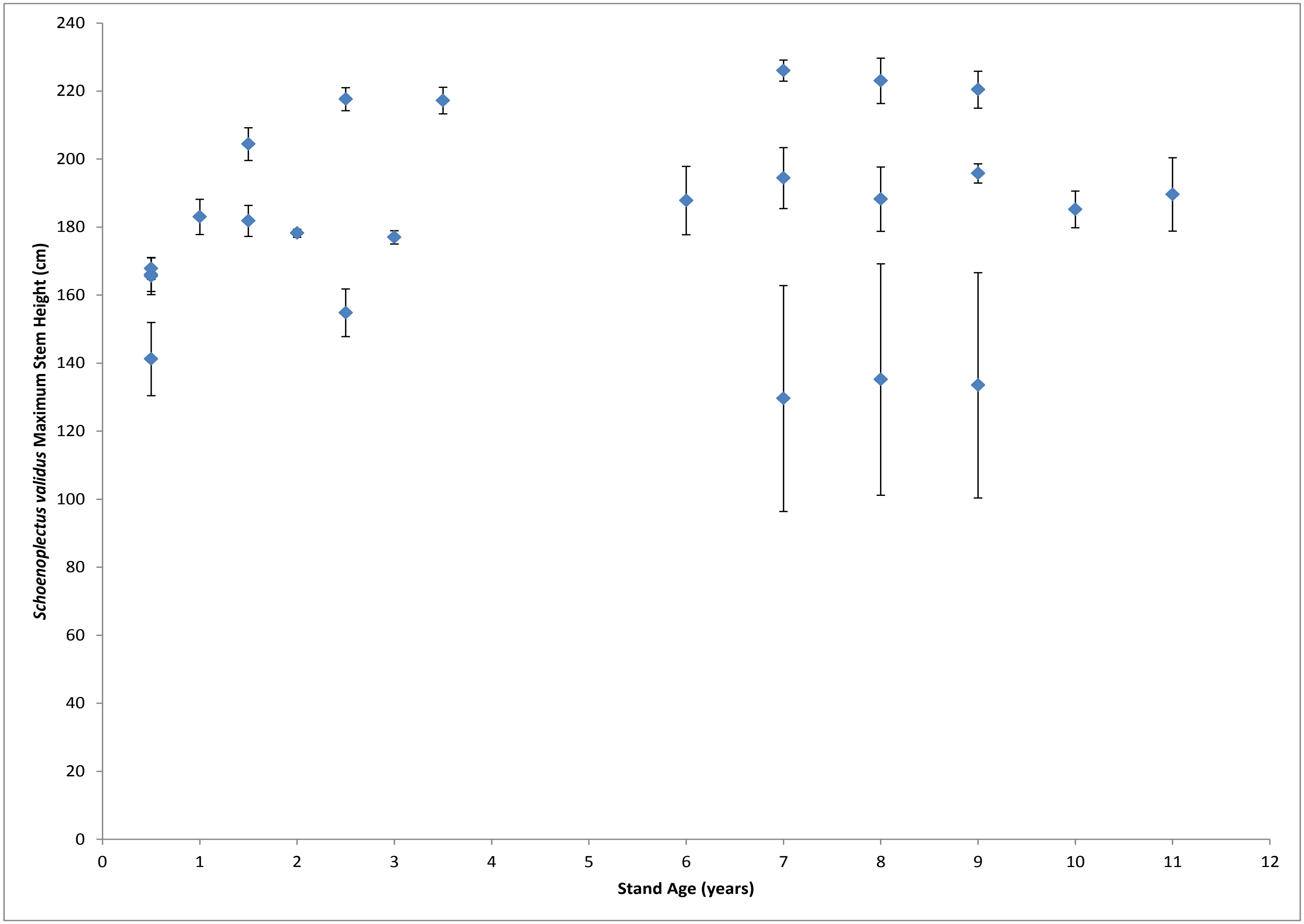

Figure 10: Relationship between *S. tabernaemontani* maximum stem height and stand age, for each planted site in lakes Alexandrina and Albert for autumn 2013, 2014 and 2015 (error bars=±1 SE).

Mean stem height generally did not change significantly between 2013 and 2015 at planted sites except at Lake Albert Road (stems were significantly taller in 2014), Dumandang and Raukkan (stems were significantly taller in 2013) (Table 3, Figure 11). At the natural sites stems were significantly taller in 2014 at Loveday Bay, significantly taller in 2015 at Hindmarsh Island Bridge and there was no significant change at the Bremer River Mouth (Table 3, Figure 11). Similar to maximum stem height, there was no relationship between stand age and mean stem height (R^2=0.041; P=0.3427) (Figure 12).

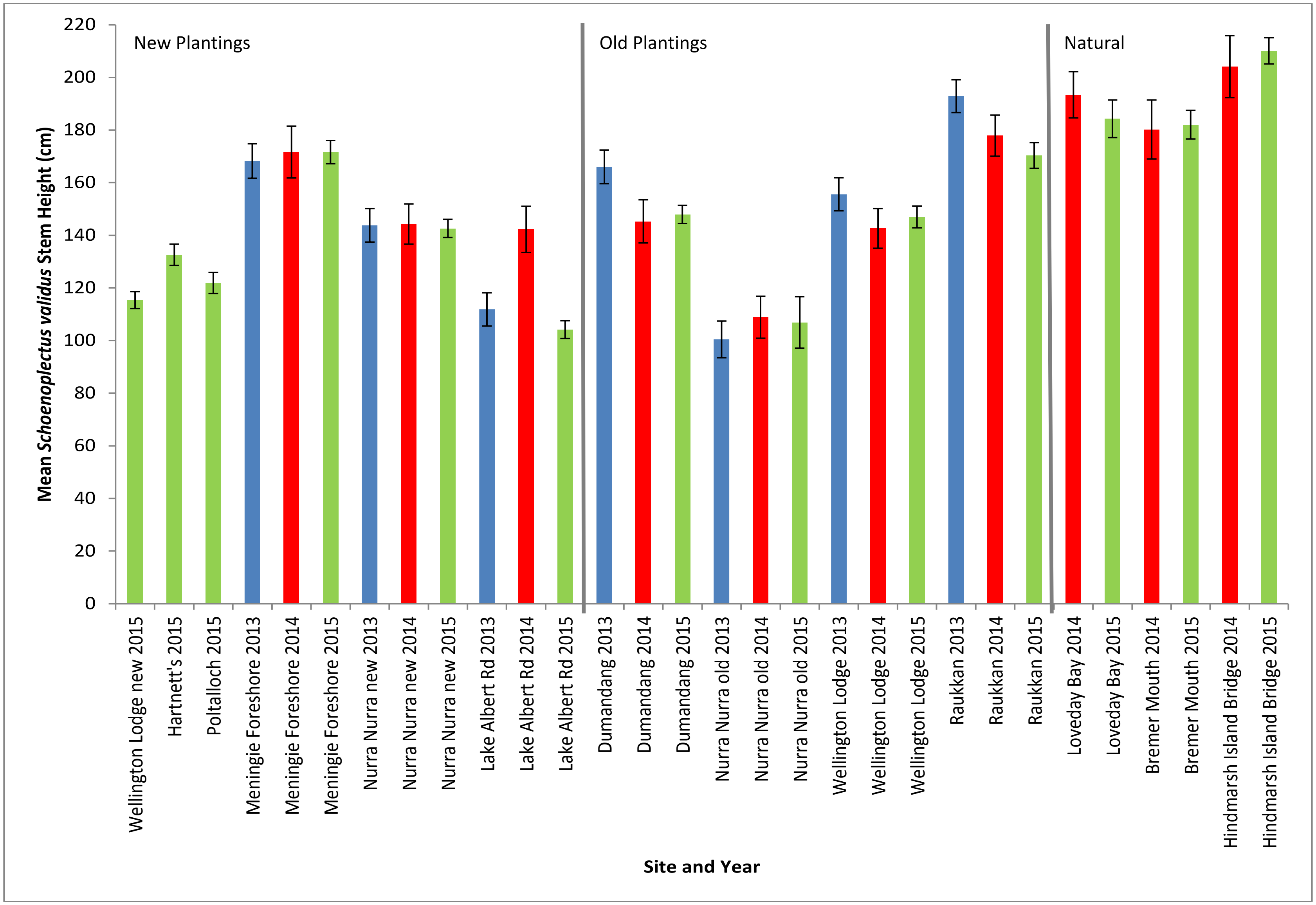

Figure 11: *Schoenoplectus tabernaemontani* mean stem height for each planted and natural shoreline in lakes Alexandrina and Albert in autumn 2013 (blue), 2014 (red) and 2015 (green) (error bars=±1 SE).

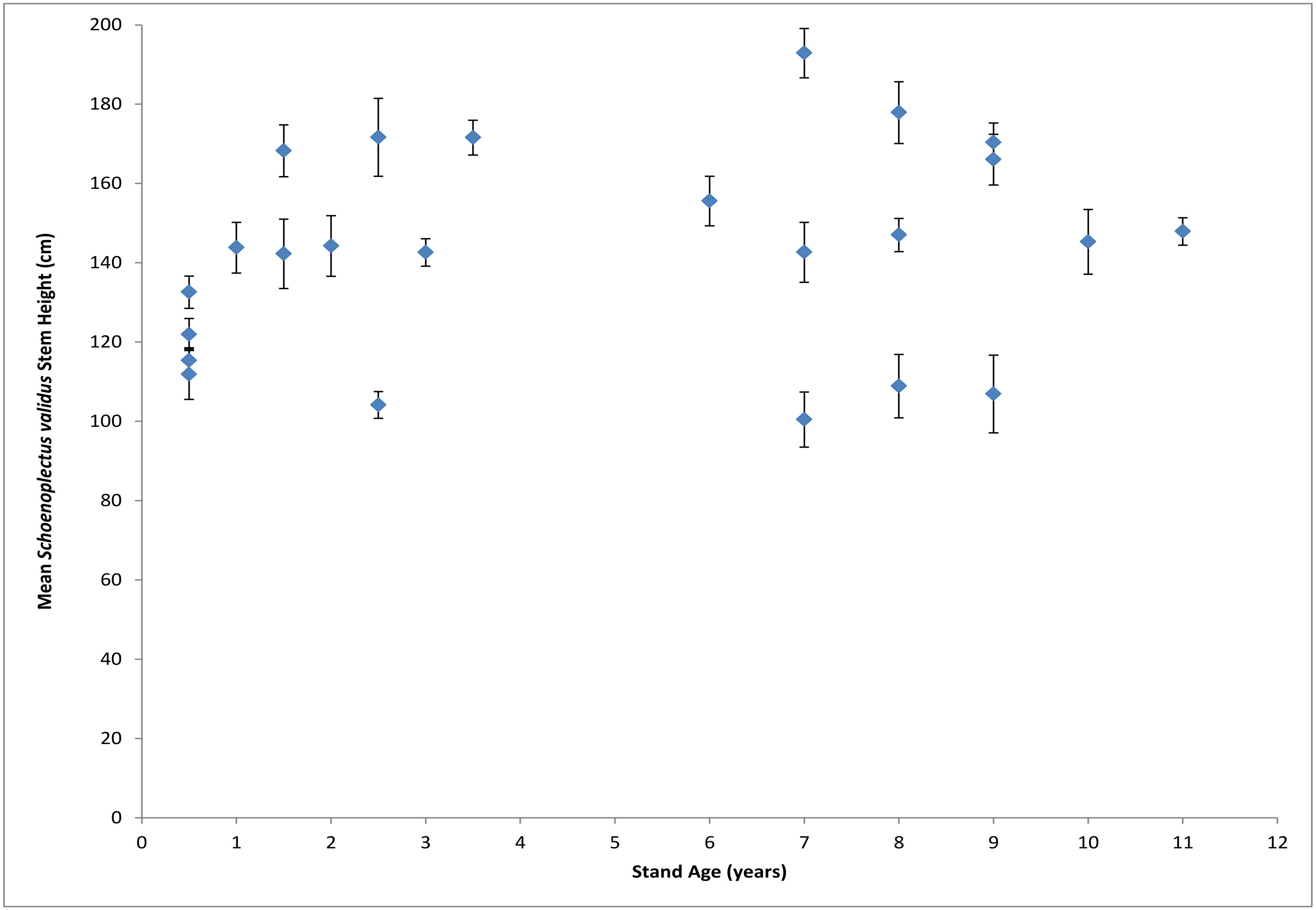

Figure 12: Relationship between *S. tabernaemontani* mean stem height and stand age, for each planted site in lakes Alexandrina and Albert for autumn 2013, 2014 and 2015 (error bars=±1 SE).

At all planted sites there was an increase in the total number of *S. tabernaemontani* stems present at each shoreline except the old planted site at Nurra Nurra Point (where there was a decrease between 2014 and 2015) and Wellington Lodge (where numbers remained similar between 2014 and 2015) (Figure 13). Wellington Lodge and Raukkan had the highest number of stems present at planted shorelines in 2015. At shorelines where *S. tabernaemontani* occurs naturally there was a decrease in the total number of stems at Loveday bay but increases at the other sites (Figure 13). The highest number of stems occurred at the Bremer River Mouth (Figure 13). Linear regression showed a significant positive relationship (R^2=0.3412; P=0.003) between stand age and total number of stems (Figure 14).

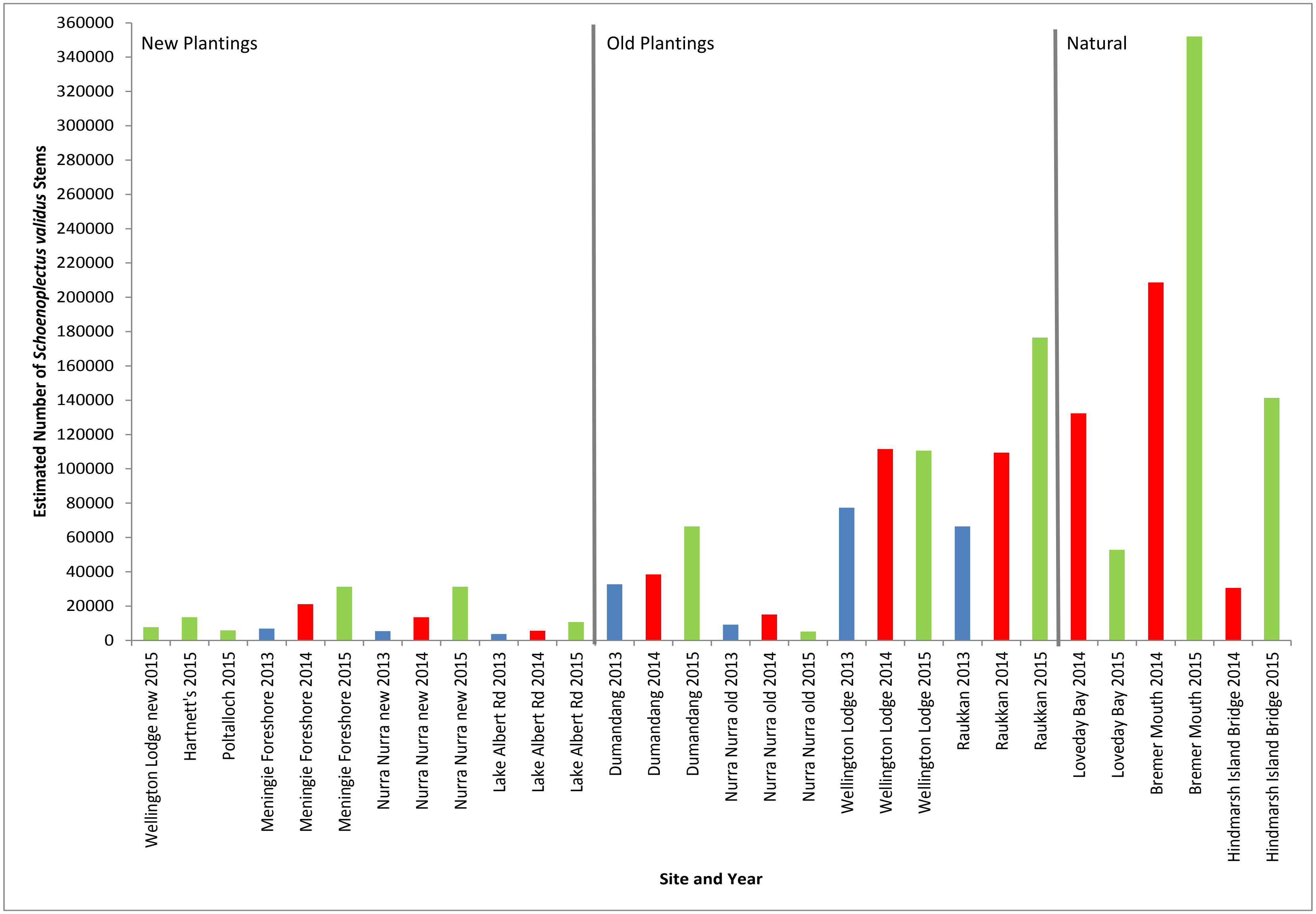

Figure 13: Estimated number of *S. tabernaemontani* stems for each planted and natural shoreline in lakes Alexandrina and Albert in autumn 2013 (blue), 2014 (red) and 2015 (green).

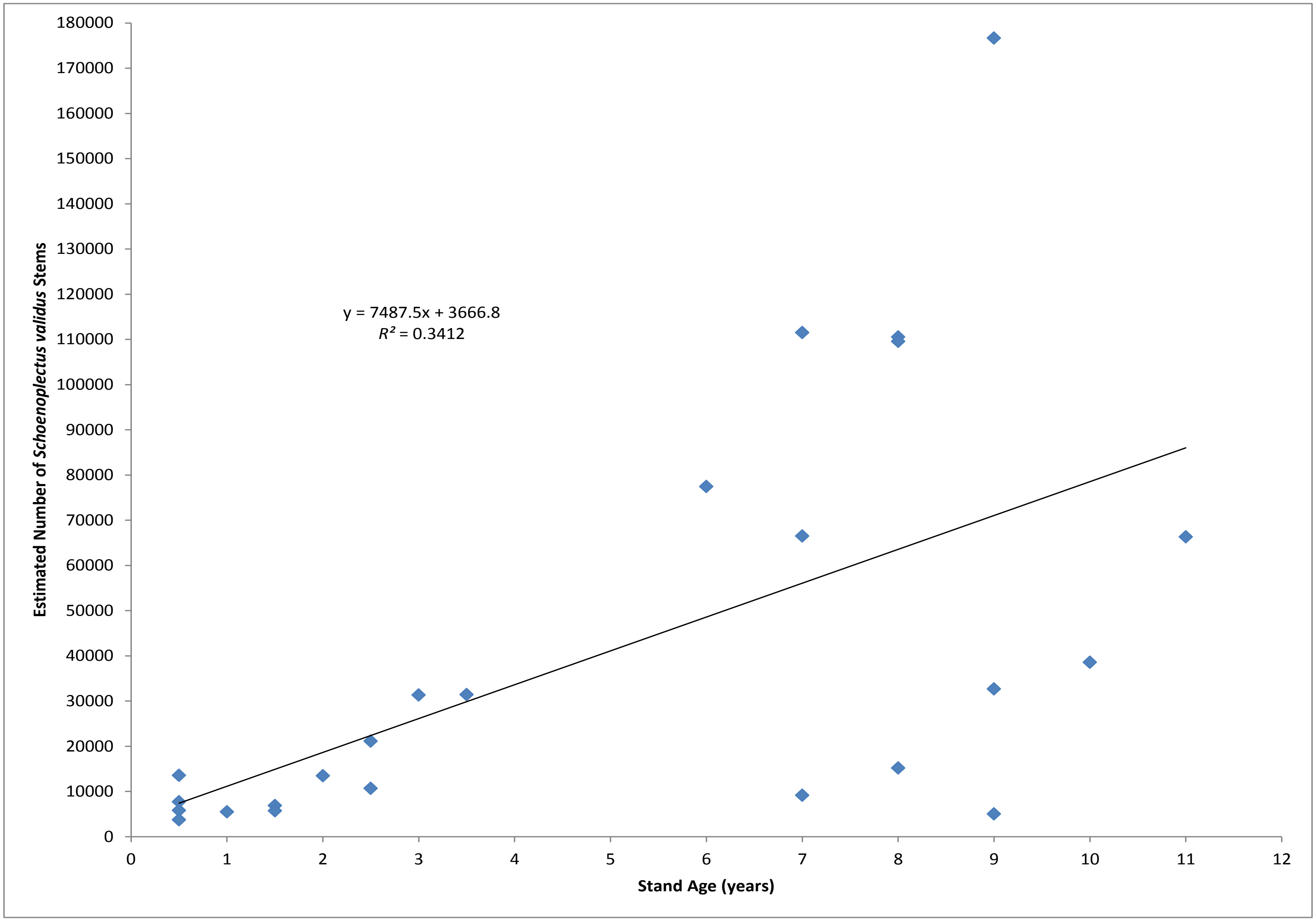

Figure 14: Relationship between the estimated number of *S. tabernaemontani* stems and stand age, for each planted site in lakes Alexandrina and Albert for autumn 2013, 2014 and 2015.

3.2. Benefit of *Schoenoplectus tabernaemontani* plantings for the aquatic plant community

NMS ordination comparing the plant community at all shorelines across all elevations showed that the natural shorelines were distinct from all other shorelines (Figure 15). A diverse assemblage of emergent (e.g. *T. domingensis, P. australis, S. tabernaemontani*) and amphibious (e.g. *Mentha* spp*., Calystegia sepium*) taxa was present at these shorelines in autumn 2014 and 2015 (Figure 15). The plant community was highly variable in autumn 2013, 2014 and 2015 at shorelines where *S. tabernaemontani* was planted and control shorelines (Figure 15). Quadrats at control sites were often completely devoid of vegetation; however, *Paspalum distichum* and *Cenchrus clandestinus* were often abundant (Figure 15, Appendix 2). Shorelines planted in 2014 and first surveyed in autumn 2015 (Poltalloch, Hartnett's and the new planting at Wellington Lodge) had plant communities similar to control shorelines (Figure 15). This observation was supported by two factor PERMANOVA that showed there was no significant differences in the plant community at Poltalloch and the newly planted site at Wellington Lodge, the control sites and there was no significant interaction (Table 4). The plant community at Lake Albert Road was also similar to control shorelines (Figure 15). At planted shorelines the plant community was generally more similar to shorelines where *S. tabernaemontani* grows naturally and there is a general trend that the plant community at planted shorelines is becoming more similar to these sites through time (Appendix 2).

Table 4: PERMANOVA results comparing the changes in plant community from 2014 to 2015 and between control and planted sites at Poltalloch and the newly planted site at Wellington Lodge.

Factor	*Pseudo-F*	*DF*	*P*
Planting status	2.07	1,23	0.105
Survey year	0.34	1,23	0.829
Planting status x Survey year	1.12	1,23	0.342

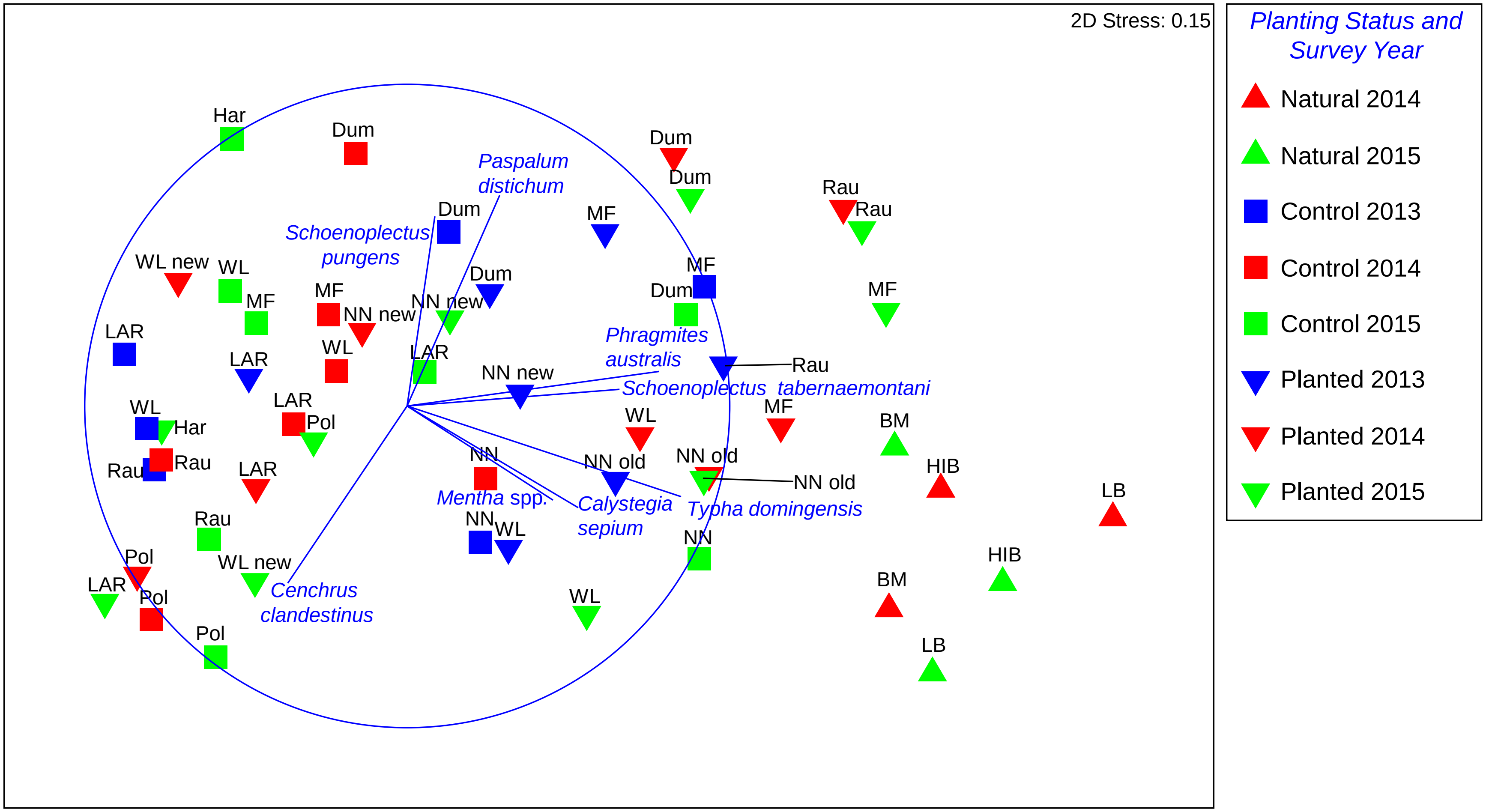

Figure 15: NMS ordination comparing the plant community (all elevations) at each shoreline in autumn 2013, 2014 and 2015 (LB=Loveday Bay, HIB=Hindmarsh Island Bridge, BM=Bremer River Mouth, Rau=Raukkan, MF=Meningie Foreshore, NN=Nurra Nurra Point, Dum=Dumandang, WL=Wellington Lodge, LAR=Lake Albert Road, Har=Hartnett's, Pol=Poltalloch).

There were less differences in vegetation between natural shorelines, planted shorelines and controls at high elevations (Figure 15, Figure 16). This was due to species such as *C. clandestinus* and *P. distichum* (clonal low growing grasses) often being abundant at many shorelines (irrespective of planting status) at high elevations (Appendix 2). Shorelines planted in 2014 and first surveyed in autumn 2015 (Poltalloch, Hartnett's and the new planting at Wellington Lodge) had plant communities at high elevations similar to control shorelines, as did Lake Albert Road between 2013 and 2015 (Figure 16). Nevertheless, amphibious (*Berula erecta, C. sepium, Mentha* spp. and *Persicaria lapathifolia*) and emergent (*T. domingensis* and *P. australis*) taxa were associated with planted and natural shorelines at high elevations (Figure 16).

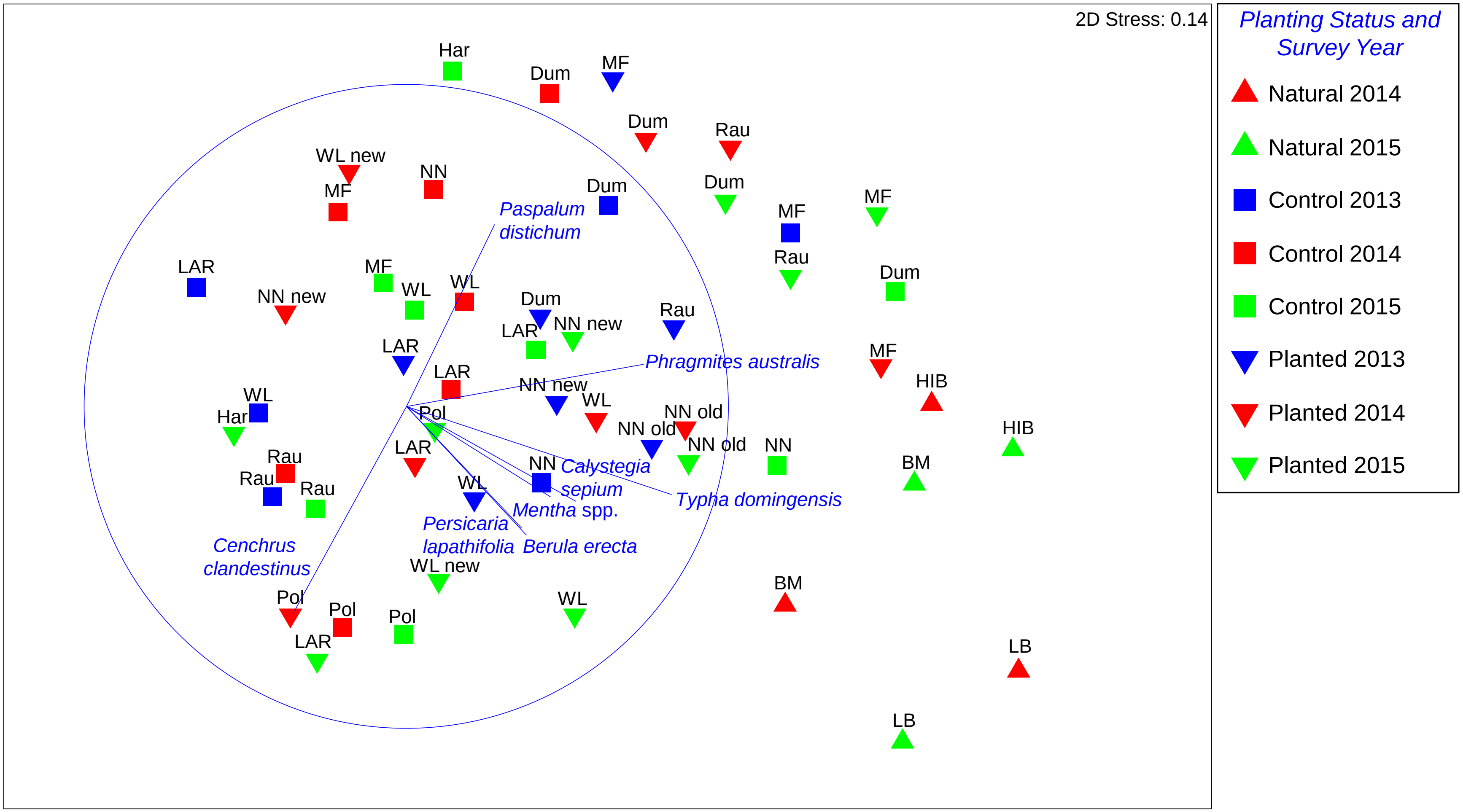

Figure 16: NMS ordination comparing the high elevation plant community (+0.8 and +0.6 m AHD) at each shoreline in autumn 2013, 2014 and 2015 (LB=Loveday Bay, HIB=Hindmarsh Island Bridge, BM=Bremer River Mouth, Rau=Raukkan, MF=Meningie Foreshore, NN=Nurra Nurra Point, Dum=Dumandang, WL=Wellington Lodge, LAR=Lake Albert Road, Har=Hartnett's, Pol=Poltalloch).

At low elevations, the plant community at natural shorelines and the shorelines planted prior to 2007 were dominated by emergent species (*T. domingensis, S. tabernaemontani* and *P. australis*) and *Azolla filiculoides* (Figure 17). The group of points on the left of the ordination was dominated by open water with very few plants present (most points represent control shorelines); however, the planted shoreline at Lake Albert Road and shorelines planted in 2014 and first surveyed in 2015 are also present in this group (Figure 17). The plant community at low elevations at all shorelines planted before 2007 and Meningie Foreshore became more similar to the plant community at natural shorelines between autumn 2013 and 2015 (Figure 17).

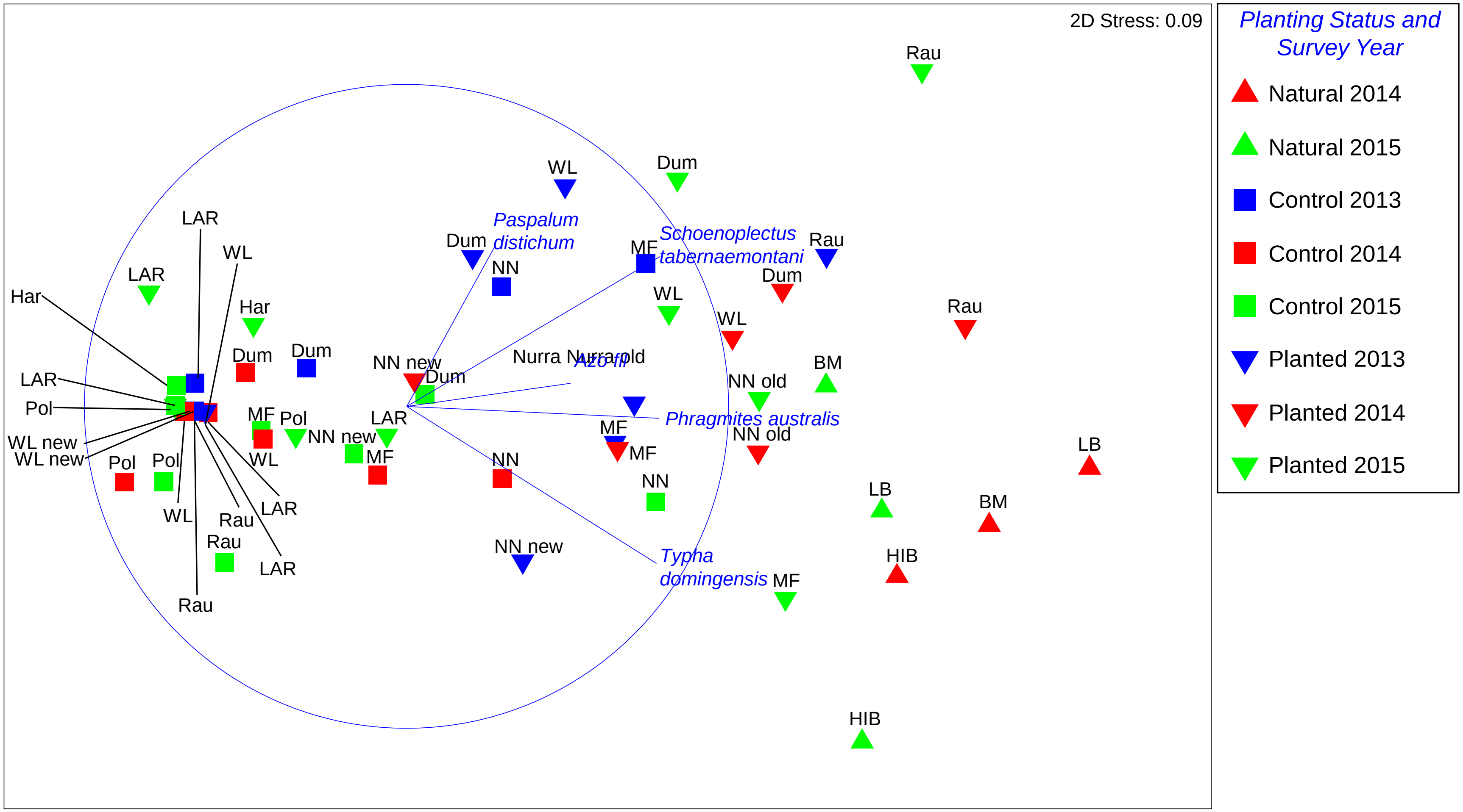

Figure 17: NMS ordination comparing the low elevation plant community (+0.4, +0.2 and 0 m AHD) at each shoreline in autumn 2013, 2014 and 2015 (LB=Loveday Bay, HIB=Hindmarsh Island Bridge, BM=Bremer River Mouth, Rau=Raukkan, MF=Meningie Foreshore, NN=Nurra Nurra Point, Dum=Dumandang, WL=Wellington Lodge, LAR=Lake Albert Road, Har=Hartnett's, Pol=Poltalloch).

4. DISCUSSION

Results from the autumn 2015 surveys provided further evidence that *S. tabernaemontani* is an appropriate species for planting around the edges of the Lower Lakes, not only to control erosion but provide greater lakeshore habitat diversity. Planted stands are increasing in extent and density (with the exception of the old planting at Nurra Nurra Point) and the plant community associated with old planted stands is becoming more similar to the community present in naturally occurring stands.

Results from the first year of the monitoring program and TLM vegetation condition monitoring showed that *S. tabernaemontani* was resistant to drying because it survived through the drought and subsequent low water levels and sprouted from rhizomes after water levels were reinstated (Frahn *et al.* 2013; Nicol *et al.* 2013). Results from 2013, 2014 and 2015 indicated that at most planted shorelines (even recently planted ones) *S. tabernaemontani* created a 'breakwater' providing a sheltered area where less robust species could establish and persist (Nicol *et al.* 2014). This generally resulted in planted shorelines having a larger number of native emergent, submergent, floating and amphibious species compared to unplanted shorelines, which tended to be sparsely vegetated or dominated by *P. australis* or *T. domingensis* monocultures. Furthermore, Fairweather *et al.* (2013) reported higher diversity and abundance of macroinvertebrates and finer, more organic rich sediments at shorelines planted prior to 2007.

The second and third years of the monitoring program demonstrated that *S. tabernaemontani* persisted at all planted shorelines, which was expected due to permanent inundation between 40 and 80 cm of planted stands (*sensu* Sainty and Jacobs 2003). Furthermore, the current monitoring program allowed comparisons of stand characteristics between autumn 2013, 2014 and 2015 at planted shorelines, along with comparisons of planted and natural stands.

The data collected in autumn 2013, 2014 and 2015 provided evidence that Meningie Foreshore, the young planting at Nurra Nurra Point and Lake Albert Road are expanding, albeit at different rates. There was an increase in the total number of stems at all of the aforementioned sites; however, the pattern of increase through time was different between sites. There were no significant increases in stand width at Meningie Foreshore and Lake Albert Road, but there were significant increases in stem density. At the new planting at Nurra Nurra Point there was a significant increase in both stand width and density. These results indicated that the stands have established well and are expanding and will probably continue to expand for several years.

The total number of stems is much lower at Lake Albert Road and increasing at a slower rate than the new planting at Nurra Nurra Point and Meningie Foreshore, which is probably due to the site being on a lee shore exposed to the prevailing southerly and south-westerly winds and subsequent wave action. The increase in stem density observed between 2014 and 2015 at Lake Albert Road may consolidate this stand and increases in stand width may occur in the future. Interestingly, there was a significant increase in stem height between 2013 and 2014 and subsequent decrease in 2015 at Lake Albert Road. This result is unexplained because emergent macrophytes, when subjected to wave action, generally produce a larger number of shorter stems (e.g. Coops and Van der Velde 1996).

There was an increase in the total number of stems present along the 100 m of surveyed shoreline at Raukkan and Dumandang between 2014 and 2015 providing evidence that these stands are also expanding. However, at Wellington Lodge the number of stems did not increase between 2014 and 2015 and at the old planting at Nurra Nurra point there was a decrease. It is unclear why the planted stands at Wellington Lodge and Nurra Nurra Point did not increase between 2014 and 2015. It is unlikely that these stands have reached their maximum extent as natural stands were generally much wider than the planted shorelines and extended into deeper water (the maximum depth at natural stands was 95 cm compared to 80 cm for planted stands). These data suggest that the planted stands could expand a considerable distance into lakes Alexandrina and Albert; however, *S. tabernaemontani* may be occupying deeper water at the natural sites due to being outcompeted by *T. domingensis* and *P. australis* in shallow water. *Typha domingensis* and *Phragmites australis* were not generally present at shorelines planted after 2010 and probably not present when the shorelines planted before 2007 were established, which gave the planted *S. tabernaemontani* an opportunity to establish in shallow water in the absence of competition from other large emergent species.

The reason for the lower stem density, stand width and subsequent lower total number of stems at the old planting at Nurra Nurra Point compared to other sites planted prior to 2007 is unclear. This stand is the same age as the stand at Wellington Lodge and older than the stand at Raukkan, which both recovered well after water levels were reinstated after the drought in 2010. Therefore, it is probably not a case of the stand being less well established (and less able to recover when water levels were reinstated) when water levels declined in 2007. Nurra Nurra Point is also more protected from the prevailing winds than Raukkan and Wellington Lodge and the newly planted stand increased in density and extent between 2013 and 2015 indicating that conditions at the site are favourable for *S. tabernaemontani*. One hypothesis for the poor performance of *S. tabernaemontani* at Nurra Nurra point is that rhizomes were not buried as deeply and subjected to greater desiccation compared to more exposed locations. Between 2007 and 2010 small dunes formed at Raukkan and Loveday Bay where *S. tabernaemontani* occurred (natural and planted) (J. Nicol pers. obs.), which buried rhizomes protecting them from desiccation and maintained viability in the absence of favourable hydrological conditions. This did not occur at Nurra Nurra Point and the shallower burial depth of rhizomes may have resulted in lower viability and slower recolonisation after water levels were reinstated.

Natural *S. tabernaemontani* stands were generally wider than planted stands. Stem density was variable with the lowest density recorded at the Hindmarsh Island Bridge in 2014 and the highest at Loveday Bay in 2014, which was comparable to the highest densities recorded at all shorelines planted prior to 2007. There was a large amount of variation in stem density and stand width (and subsequently the total numbers of stems) between 2014 and 2015 at sites where *S. tabernaemontani* naturally occurs. There were increases at Hindmarsh Island Bridge and Bremer Mouth and a decrease at Loveday Bay, which indicates that these stands are dynamic and large changes between years are a natural occurrence in a dynamic ecosystem such as the Lower Lakes, which is a contrast to planted stands that almost all increased.

Maximum and mean stem height showed no relationship with stand age, which was expected because full grown plants were usually planted. There was a decrease in mean stem height at Loveday Bay between 2014 and 2015, an increase at Hindmarsh Island Bridge and no significant change at the Bremer River Mouth. The reason for these changes is unclear but the decrease in stem height corresponds to a decrease in extent and density at Loveday Bay and an increase at Hindmarsh Island Bridge with the increase in extent and density.

The aquatic and littoral plant community of planted shorelines where three years of data have been collected (except the newly planted site at Nurra Nurra Point and Lake Albert Road) were generally more similar to the natural shorelines rather than the controls. When only the high elevation (+0.8 and +0.6 m AHD) plant community was compared there was a similar pattern; however, the distinction of planted and natural shorelines from controls was less clear. This was due to the planted and unplanted shorelines at high elevations both often being dominated by low growing clonal grasses such as *P. distichum* and *C. clandestinus*. Nevertheless, amphibious species such as *P. lapathifolia, B. erecta, Centella asiatica* and *Hydrocotyle verticillata* were present at planted shorelines and natural shorelines, whereas these species tended to be absent at control shorelines (Appendix 2).

Floating species such as *A. filiculoides* and *Lemna minor* were also present at high elevations at the planted and natural shorelines, which was probably due to the breakwater effect. *A. filiculoides* and *L. minor* are able to reproduce asexually and their expansion rates under favorable conditions are exponential (Cheng *et al.* 2010; Fernandez-Zamudio *et al.* 2010) and can rapidly colonise large areas (Sainty and Jacobs 1981; 2003). At high energy shorelines floating species will probably be dispersed but when a plant fragment arrives into a localised area of calm water it is able to colonise and reproduce rapidly asexually.

Differences in plant communities between planted and natural shorelines and control shorelines were most evident at the low elevations. This was in part due to the presence of *S. tabernaemontani* at the planted and natural shorelines; however, submergent and emergent species were usually present at the low elevations at the aforementioned shorelines, whereas the unplanted shorelines were generally devoid of vegetation. This provides further evidence for the breakwater effect provided by *S. tabernaemontani* because submergent species are not generally found at high energy shorelines in the Lower Lakes and are restricted to wetlands (e.g. Dunn's Lagoon and Clayton Bay), lower reaches of the Finniss River and Currency Creek, Goolwa Channel and narrow channels (e.g. Hunters Creek) (Gehrig *et al.* 2011; 2012; Frahn *et al.* 2013).

Surveys in 2014 and 2015 showed there was evidence to suggest that the plant communities at low elevations at locations planted prior to 2007 and Meningie Foreshore were becoming similar to natural locations. These data showed that the plant community at these sites changed over this period and the vegetation at planted sites was becoming more similar to natural sites. The aquatic plant community at the natural shorelines should be used as a target for the aquatic plant community at planted sites to evaluate the success of the planting program. Shorelines planted after 2010 probably require several years for the stands to become sufficiently wide and dense to provide a breakwater effect that will facilitate the development of a diverse aquatic plant community similar to a natural shoreline. However, the change in the plant community observed at Meningie Foreshore showed that this is already occurring with the vegetation resembling sites planted prior to 2007. If natural sites are to be used as targets for planted shorelines it will likely require a long-term (e.g. 10 years) monitoring program to assess whether targets are being attained, especially for shorelines planted after 2010.

Undertaking vegetation surveys at two shorelines (Poltalloch and Wellington Lodge) in 2014 where *S. tabernaemontani* was planted later that year provided baseline information regarding the plant community prior to planting, which was unavailable at other sites. Another paired planted control site was established at Hartnett's on the northern shoreline of Point Sturt in autumn 2015, where *S. tabernaemontani* was planted in 2014. This enabled a BACI design (*sensu* Underwood 1992) at Wellington Lodge and Poltalloch that will evaluate the benefit of planting to the aquatic plant community in the future and gain information regarding the time taken for plant communities to develop at these sites. The plant community at the aforementioned planted sites was not significantly different to the control sites, which was expected as there has been insufficient time for planted *S. tabernaemontani* to increase density and extent to provide a breakwater effect.

We conclude that planting *S. tabernaemontani* around the shorelines of lakes Alexandrina and Albert has benefits for the aquatic plant community and provides greater regional aquatic habitat diversity. Future plantings should target shorelines where erosion is occurring to provide suitable conditions for submergent and emergent plant recruitment. However, planning for future plantings need to consider the ecosystem services provided by sparsely vegetated shorelines (e.g. mudflats that are water bird foraging habitat) and ensure that these habitats are not planted.

Future research and monitoring

- Continue the monitoring program to gain further information regarding planted *S. tabernaemontani* stand dynamics and the benefit to shoreline plant communities.
- Assess seed banks in planted and control areas and in areas where species rich wetland plant communities are present to determine if there is local capacity for a species rich wetland plant community to develop or whether sediment transplant is an option to accelerate the establishment of an aquatic plant community
- Further expand the monitoring program to include other planted shorelines (e.g. north of Point Malcolm) and additional potential planting sites.
- Mesocosm and field studies to investigate tolerances of common macrophytes in the Lower Lakes to wave action.

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APPENDICES

Appendix 1: GPS coordinates (UTM format; map datum WGS 84) of survey sites, planting status, when *S. tabernaemontani* was planted and when each site was surveyed.

Site	Easting	Northing	Planting Status	Year Planted	Years Surveyed
Bremer Mouth	323061	6081991	Natural	NA	2014 and 2015
Dumandang	339058	6053687	Planted	2003, 2004 and 2006	2013, 2014 and 2015
Dumandang Control	340594	6054244	Control	NA	2013, 2014 and 2015
Hartnett’s	319449	6081919	Planted	2014	2015
Hartnett’s Control	320978	6081950	Control	NA	2015
Hindmarsh Island Bridge	299349	6081493	Natural	NA	2014 and 2015
Lake Albert Road	350743	6060734	Planted	2013	2013, 2014 and 2015
Lake Albert Road Control	350313	6054328	Control	NA	2013, 2014 and 2015
Loveday Bay	326167	6082052	Natural	NA	2014 and 2015
Meningie Foreshore	349673	6049720	Planted	2012	2013, 2014 and 2015
Meningie Foreshore Control	350237	6053018	Control	NA	2013, 2014 and 2015
Nurra Nurra Point Control	341547	6063414	Control	NA	2013, 2014 and 2015
Nurra Nurra Point Old	341723	6063637	Planted	2006	2013, 2014 and 2015
Nurra Nurra Point New	341808	6063808	Planted	2012 and 2013	2013, 2014 and 2015
Poltalloch	339761	6082305	Planted	2014	2014 and 2015
Poltalloch Control	342616	6082355	Control	NA	2014 and 2015
Raukkan	327643	6067143	Planted	2006	2013, 2014 and 2015
Raukkan Control	327414	6082076	Control	NA	2013, 2014 and 2015
Wellington Lodge	349440	6079043	Planted	2007	2013, 2014 and 2015
Wellington Lodge Control	349278	6082469	Control	NA	2013, 2014 and 2015
Wellington Lodge New	349469	6079117	Planted	2014	2014 and 2015

Appendix 2: Species list for a. sites planted after 2007, b. sites planted before 2007 and c. natural sites (*denotes exotic species, **denotes proclaimed pest plant in South Australia, # denotes listed as rare in South Australia).

a.

Site	**Hartnett's**		**Lake Albert Rd**						**Meningie Foreshore**						**Nurra Nurra new**			**Poltalloch**				**Wellington Lodge new**	
Planting	**Control**	**Planted**	**Control**			**Planted**			**Control**			**Planted**			**Planted**			**Control**		**Planted**		**Planted**	
Year	**2015**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**
Taxon																							
*Aster subulatus**	*											*	*	*				*					
*Atriplex prostrata**											*												
Atriplex spp.												*			*								
Bolboschoenus caldwellii												*	*	*					*				
Brassica spp.*															*								
Calystegia sepium												*	*	*	*		*		*				
*Cenchrus clandestinus**	*	*		*	*	*	*	*		*	*			*	*	*	*	*	*	*	*		*
*Centaurea calcitrapa**															*								
Chara sp.																			*				
Cotula coronopifolia	*											*			*								
Crassula helmsii							*											*					
Cyperus gymnocaulos		*			*							*	*	*				*			*		
Distichlis distichophylla																			*				*
Duma florulenta				*	*			*										*	*		*		
Eleocharis acuta												*		*									
*Festuca arundinacea**							*																
*Ficinia nodosa**																						*	*
*Fumaria bastardii**												*											
Hydrocotyle verticillata														*									
*Hypochoeris glabra**						*																	
Isolepis producta	*						*					*	*										
*Juncus acutus**							*						*	*									
Juncus kraussii						*		*						*									
Lachnagrostis filiformis								*						*									
Lilaeopsis polyantha							*											*					
Limosella australis	*																						
Lobelia alata														*					*				
*Lycium ferocissimum****																			*				
Medicago sp.*				*										*				*					
*Melilotus indicus**						*																	
Mimulus repens	*			*	*	*						*	*	*			*	*					
Myriophyllum salsugineum	*					*													*				*
Nitella spp.																	*						
*Oxalis pes caprae***															*								
*Paspalum distichum**	*	*	*	*	*	*	*		*	*	*	*	*	*	*		*	*	*		*	*	*
Phragmites australis			*	*	*	*	*		*	*	*	*	*	*	*	*	*				*	*	*
*Plantago coronopus**						*						*											
*Polypogon monspeliensis**	*											*			*			*					
Potamogeton pectinatus		*				*											*						
*Ranunculus trilobis**												*		*									
*Riechardia tingitana**																		*					
Rumex bidens	*							*			*				*		*				*		*
*Scaeveola atropuroura**												*											
Schoenoplectus pungens	*		*		*	*		*				*		*	*	*	*				*		*
Schoenoplectus tabernaemontani		*							*			*	*	*		*	*						
*Silybum marianum***						*																	
*Sonchus asper**															*								
*Sonchus oleraceus**						*		*				*		*	*		*						
Trifolium spp.*	*					*						*	*	*	*		*				*	*	*
Triglochin procera	*																						
Typha domingensis												*	*	*	*		*						
Vallisneria australis						*																	

b.

Site	**Dumandang**						**Nurra Nurra**						**Raukkan**						**Wellington Lodge**					
Planting	**Control**			**Planted**			**Control**			**Planted**			**Control**			**Planted**			**Control**			**Planted**		
Year	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
Taxon																								
*Apium graveolens**			*			*																		
*Aster subulatus**	*	*	*			*	*		*	*							*	*						
*Atriplex prostrata**		*	*																*					
Atriplex spp.										*														
Azolla filiculoides						*										*	*	*	*				*	*
Berula erecta																	*	*						
Bolboschoenus caldwellii					*					*						*	*	*						
Brassica spp.*													*											
*Brassica tournifortii**					*																			
Calystegia sepium			*						*			*						*					*	*
*Cenchrus clandestinus**				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
*Centaurea calcitrapa**	*	*					*														*			
Centella asiatica			*			*										*	*							
Ceratophyllum demersum#					*											*	*	*						
Chara sp.				*		*																		
*Conyza bonariensis**						*																		
Cotula coronopifolia	*	*	*				*																	
Cyperus gymnocaulos		*				*								*		*		*	*			*		*
Distichlis distichophylla																								*
Duma florulenta				*	*	*																		*
Epilobium pallidiflorum																*								
*Euphorbia terracina***									*															
Ficinia nodosa																*	*	*			*			
Helichrysum luteo-album							*																	
Hydrocotyle verticillata	*								*															
*Hypochoeris radicata**																	*							
Isolepis producta																			*					
*Juncus acutus**	*				*	*													*					
Juncus holoschoenus																			*					
Juncus kraussii				*													*							
Juncus subsecundus																			*					
Juncus usitatus																				*				
Lachnagrostis filiformis						*																		
*Lactuca serriola**			*																					
*Lagurus ovatus**																*	*							
Lemna minor																*	*							
Lilaeopsis polyantha																								*
Limosella australis																			*					
Lobelia alata						*																		
Lolium spp.*	*	*																						
Ludwigia peploides																		*						
*Lupinus cosentini**																								*
Lycopus australis																							*	
Lythrum salicaria	*																							
*Malva parviflora**		*					*																	
Medicago spp.*		*																						
*Melilotus indicus**										*														
Mimulus repens																								*
Myriophyllum salsugineum						*	*								*	*			*	*		*	*	*
Nitella sp.						*													*					
*Oxalis pes-caprae***							*			*														
*Paspalum distichum**	*	*	*	*	*	*	*	*	*	*	*	*		*		*	*	*	*	*	*	*	*	*
Persicaria lapathifolia						*												*				*		
Phragmites australis	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
*Plantago coronopus**	*																		*					
*Polypogon monspeliensis**	*	*																						
Potamogeton crispus																							*	*
*Ranunculus tribolus**						*																		

Site	**Dumandang**						**Nurra Nurra**						**Raukkan**						**Wellington Lodge**					
Planting	**Control**			**Planted**			**Control**			**Planted**			**Control**			**Planted**			**Control**			**Planted**		
Year	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
Taxon																								
*Riechardia tingitana**		*							*															
Runes bidens		*	*		*	*						*				*	*				*			*
Ruppia tuberosa						*																		
Schoenoplectus pungens	*	*	*	*	*	*	*		*	*			*		*	*	*	*	*	*				
Schoenoplectus tabernaemontani	*	*	*	*	*	*	*	*	*	*	*	*				*	*	*	*	*		*	*	*
*Senecio pterophorus**																*								
*Solanum nigrum**			*																					
*Sonchus asper**	*		*			*			*															
Sonchus oleraceus	*	*	*				*			*			*			*		*	*				*	
Tecticornia pergranulata	*																							
Trifolium spp.*	*		*		*	*	*		*	*						*	*	*			*			*
Triglochin striatum						*																		
Typha domingensis	*		*		*	*	*	*	*	*	*	*				*	*	*				*	*	*
*Urtica urens**									*															
Vallisneria australis																			*			*		
Wolffia sp.																		*						

c.

Site	**Bremer Mouth**		**Hindmarsh Island Bridge**		**Loveday Bay**	
Planting	**Natural**		**Natural**		**Natural**	
Year	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**
Taxon						
*Aster subulatus**		*			*	*
Azolla filiculoides	*				*	*
Berula erecta	*				*	*
Bolboschoenus caldwellii						*
*Brassica tournifortii**					*	
Calystegia sepium	*	*	*	*	*	*
*Cenchrus clandestinus**	*	*				*
Centella asiatica	*					
Ceratophyllum demersum#		*			*	*
Chara sp.						*
Cyperus gymnocaulos	*					
Duma florulenta					*	
Eleocharis acuta	*					
Epilobium pallidiflorum	*					*
Ficinia nodosa		*				*
Hydrocotyle verticillata	*				*	
Juncus holoschoenus					*	
Lachnagrostis filiformis		*				
*Lactuca serriola**	*					
*Lagurus ovatus**					*	
Lemna minor	*				*	
Ludwigia peploides					*	
Lycopus australis	*	*				*
Mentha australis					*	
Mentha spp.*	*	*	*	*		*
Myriophyllum salsugineum	*			*		*
*Paspalum distichum**	*	*	*	*	*	*
Persicaria lapathifolia	*	*			*	*
Phragmites australis	*	*	*	*	*	*
Potamogeton pectinatus					*	
*Ranunculus tribolus**		*			*	*
Rumex bidens	*					*
Schoenoplectus pungens	*	*			*	
Schoenoplectus tabernaemontani	*	*	*	*	*	*
Trifolium spp.*					*	*
Typha domingensis	*	*	*	*	*	*
Urtica urens		*				*
Vallisneria australis	*	*				
Wolffia sp.						*