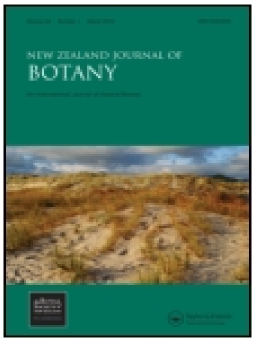

New Zealand Journal of Botany

ISSN: 0028-825X (Print) 1175-8643 (Online) Journal homepage: https://www.tandfonline.com/loi/tnzb20

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New Zealand Journal of Botany, 1988, Vol. 26: 183–192
0028–825X/88/2602–0183$2.50/0

The use of field transplants in determining environmental tolerance in salt marshes of Otago, New Zealand

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Abstract Reciprocal transplants of species from different salt marsh zones were performed in a number of areas in coastal Otago. The general pattern was that most species transplanted successfully to all zones at higher elevation, but to only a short distance below the species natural lower elevation limit. Plants at the lower limit of the salt marsh did not, however, survive at sites below the salt marsh. This pattern closely matches one of increasing salt-tolerance with decreasing elevation. Exceptions can be related to some species being intolerant of habitats such as depressions within the marsh or where there are salinity extremes in a variable salinity habitat. It is considered that competition with more salt-tolerant species limits spread to lower elevations, whereas competition with faster growing species of less salt-tolerance limits spread to higher elevations.

Keywords salt marsh; salt tolerance; salinity; reciprocal transplants; waterlogging; competition; Otago, New Zealand

INTRODUCTION

By examining the salt-tolerance of salt marsh species, Partridge & Wilson (1987) indicated that, ideally, the responses of the species to all environmental factors should be known. This, however, is a very demanding task and, as an alternative, they focused on salinity as one of a number of correlated factors. Reciprocal field-transplant experiments, on the other hand, measure response to all environmental factors acting together, but these factors cannot be separated into individual components as they can in glasshouse experiments, where they are controlled or varied as desired. When used in conjunction, though, the two techniques can provide particularly useful information. The transplants indicate the response of the species to different environments, and this response can be compared with the known growth characters of the species to the factors in question.

This has not been the usual aim of transplant experiments, even those in salt marshes. For instance Hiesey & Nobs (1970) looked at genetic variation within a species using transplants only within its known range. Salt marsh transplants, however, have been studied (Statler & Baston 1969, Boorman 1971, Statler 1973) and have produced interesting results worthy of comparison. A rather unusual form of transplant experiment was that of Clarke & Hannon (1971) who transplanted between simulated environmental zones in the glasshouse. In this paper, we examine the response of various salt marsh species to field transplants and discuss the ecological implications, especially in relation to salinity.

METHODS

The reciprocal transplant experiments were set up at 65 sites in 11 areas described briefly in Table 1. Detailed descriptions of the communities are presented in Appendix 1, and the locations of the areas are indicated in Fig. 1. Sites were selected to represent both typical and some atypical salt marsh communities found in each area.

At each site a zone of marsh was selected for homogeneity of the vegetation and a 0.5 m × 0.5 m grid with 25 squares was laid down. Circular cores of 2.5 cm radius and 10 cm depth were extracted from the centre of each square. Three replicate cores were transplated to randomly allocated holes within each of the other sites chosen for the area and within the original site itself.

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Received 14 January 1987; accepted 28 August 1987

Table 1 Brief descriptions of vegetation patterns of the transplant sites.

Location	Transplant code	Description
Aramoana East	AE1	Lower (*Samolus repens*) to upper marsh sequence including shallow upper marsh depressions (*Leptocarpus similis*).
	AE2	Sand flat (*Zostera muelleri*) to upper marsh dry sandy sequence including wave splash marsh edge (*Suaeda novae-zelandiae*).
Aramoana Central	AC	Sand flat (*Zostera muelleri*) to wet upper marsh (*Leptocarpus similis*) sequence.
Aramoana West	AW1	Lower (*Samolus repens, Sarcocornia quinqueflora*) to upper marsh (*Leptocarpus similis*) sequence including deep upper marsh depressions (*Mimulus repens, Cotula coronopifolia*).
	AW2	Sand flat (*Schoenoplectus pungens*) to wet upper marsh sequence.
Purakanui	PU1	Lower (*Sarcocornia quinqueflora*) to dry upper marsh (*Poa cita*) sequence.
	PU2	Lower marsh (*Sarcocornia quinqueflora*) to *Juncus maritimus* to upper marsh dominated by *Juncus maritimus*.
Cherry Farm	CF1	*Spartina anglica* to lower (*Sarcocornia quinqueflora, Puccinellia novae-zelandiae*) to wet modified upper marsh (*Festuca*) sequence including depressions (*Leptocarpus similis, Schoenoplectus pungens*).
	CF2	Lower (*Sarcocornia quinqueflora*) to dry upper marsh sequence.
Karitane South	KA	*Spartina anglica* to lower (*Sarcocornia quinqueflora*) to dry sandy upper marsh sequence.
Evansdale	EV	Lower (*Sarcocornia quinqueflora*) to modified (*Agrostis stolonifera*) upper marsh sequence.

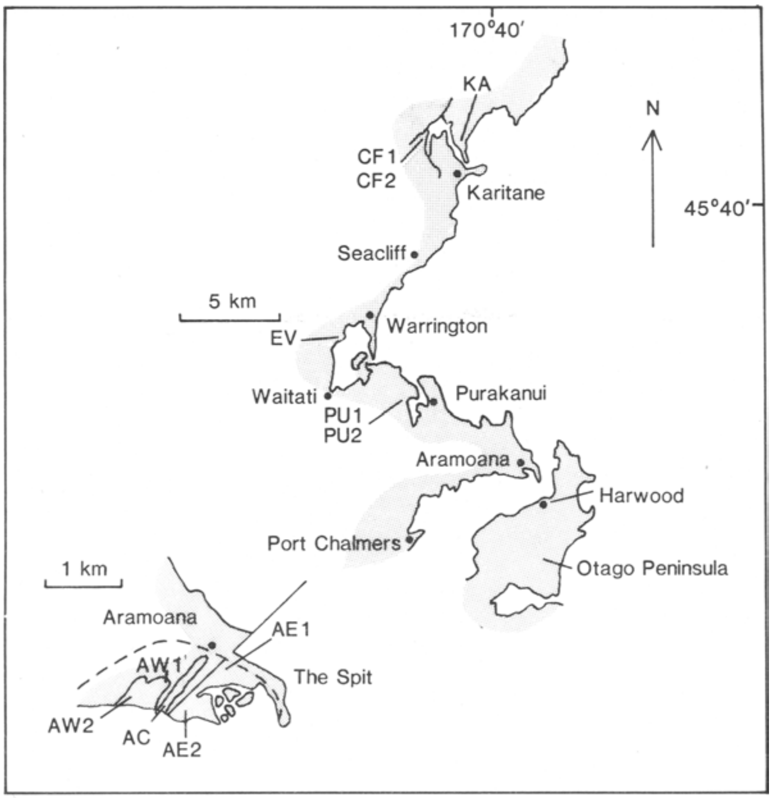

Fig. 1 Map of coastal Otago showing location of areas where transplants were made.

Each month the performance of each transplant was subjectively assessed relative to the untransplanted plants of the original zone, starting in October 1978, one month after transplanting. The experiment was continued until April 1979, after which seasonal die-back of many of the species made interpretation difficult.

RESULTS AND DISCUSSION

The results of all 11 reciprocal transplants are presented in Table 2.

The transplants involve a series of sites located on a typical lower to upper marsh fringe sequence, along with atypical communities encountered in any of the areas. Table 2f is an example in which there are no especially chosen atypical communities. Within areas, transplants were made to both higher and lower elevation. When moved to higher elevation, plants usually survived in all zones, whether already there or not. Failure in these situations can usually be attributed to habitat peculiarities and will be discussed later. When moved to lower elevations, the results are different. If the origin of the plants is above their natural lower limit (e.g., *Selliera radicans* in Table 2a) they generally transplant successfully within that range. However, most species also survive below their lower limit when transplanted there, providing it is not very far below. In the case of Table 2f, with its simple four zones, each species transplanted successfully only one zone down the marsh. The notable exceptions are those species growing at the lower limit of the salt marsh itself (e.g., at Aramoana Central, AC). These species appear to be at their tolerance limit already, as they fail when transplanted to the *Zostera muelleri* or bare sand and mud flats below. All species failed when transplanted to a deep unvegetated pan found within one of the marsh areas (Table 2d).

Zostera muelleri is the only species incapable of growing further up the marsh than it naturally does (Table 2b, c). For the salt marsh species the reverse is true, with none surviving in the *Zostera muelleri* zone. *Zostera* has an essentially aquatic physiology and is therefore restricted to a marine environment of long periods of inundation, while salt marsh species with land plant physiology are restricted to areas with much shorter periods of inundation. Where these two physiologies meet there is, therefore, a very important change.

Interesting comparisons can be made by assembling rankings for species performance within each area, using the hypothesis that salt tolerance decreases with elevation. Three rankings can be prepared for each area based on different criteria; lower limit of species, lower transplanted limit and performance, and salt tolerance (from Partridge & Wilson 1987). These are summarised in Table 3. Sites outside the normal marsh sequence (depressions, sand mounds) have been excluded. Species for which no salt tolerance data is available (e.g., *Zostera muelleri*, *Juncus gerardii*) are also excluded.

Although the overall patterns both within and between areas are similar, there are some interesting differences. Within the lower marsh, it is not always the most salt tolerant species that are at the lowest elevation (e.g., at Karitane, KA). Partridge & Wilson (1987) pointed out that in variable environments, species often had to tolerate salinity extremes. At the lowest elevations however, long periods of inundation produce a constant salinity without extremes. For instance, in mud and sand flats flooded regularly by the tide (e.g., at Karitane, KA), *Spartina anglica* occupies a lower marsh habitat of constant salinity, whereas *Suaeda novae-zelandiae* occurs in a more elevated but sandy habitat of variable salinity. In such a habitat, its tolerance of the occasionally extremely high salinities is important. Indeed, the extreme dry sand mound site at Aramoana East (AE2 Table 2b) was too harsh for species other than *Suaeda novae-zelandiae* and *Sarcocornia quinqueflora*. The death of the other species transplanted there was probably a result of occasionally high salinities or of drought.

Schoenus nitens performed more poorly in the transplants than its salt tolerance suggests, especially when compared to the often associated *Selliera radicans* (Table 2d, i, k). It is, however, a species naturally restricted to higher elevations and may not be able to extend to lower marsh elevations for other reasons.

The performance of the more salt-tolerant species varied considerably when transplanted to the marsh depressions where water frequently ponds. Some, especially those of drier areas, performed poorly in these depressions—*Samolus repens*, *Schoenus nitens* and, to a lesser extent, *Selliera radicans* (Table 2d). Others, most notably *Sarcocornia quinqueflora* (Table 2a), showed no sign of reduced growth. A number of species of low salt tolerance also performed poorly in these sites, these being *Poa cita* (= *Poa laevis* of Partridge & Wilson 1987), *Apium prostratum*, and *Festuca arundinacea* (Table 2a). Conversely, most species

Table 2 Performance of species transplanted between sites at each of the eleven areas. Performance codes are:
5 = all live and healthy as before transplant
4 = all live but not as healthy as before transplant
3 = some live, some dead at end of experiment
2 = all dead, but all survived for at least three months
1 = all dead, death occurring between one and three months
– = all dead within one month.
The sites are named as in Appendix 1. The letter after the species name is the site of origin, those along the top are the sites transplanted to. Underlining indicates that that species is present at the particular site.

2a. Aramoana East 1 (AE1)

		Lower A	Lower B	Middle C	Meadow D	Upper E	Fringe F	Depression G	Depression H
Samolus repens	A	5	5	5	5	5	4	1	1
Samolus repens	B	5	5	5	5	5	5	1	1
Samolus repens	C	5	5	5	5	5	5	1	1
Sarcocornia quinqueflora	B	5	5	5	4	4	4	5	5
Sarcocornia quinqueflora	G	5	5	5	5	5	5	5	5
Selliera radicans	C	4	5	5	5	5	5	5	5
Selliera radicans	D	4	4	5	5	5	5	5	5
Selliera radicans	E	4	5	5	5	5	5	5	5
Schoenus nitens	D	1	1	3	5	5	4	1	1
Apium prostratum	E	–	–	1	5	5	4	2	2
Poa cita	F	–	–	–	1	4	5	–	–
Triglochin striatum	G	2	4	5	5	5	5	5	5

2b. Aramoana East 2 (AE2)

		Flat A	Sand mound B	Lower C	Middle D	Meadow E	Fringe F
Zostera muelleri	A	5	–	–	–	–	–
Suaeda novae-zelandiae	B	–	5	5	5	3	3
Samolus repens	C	–	1	5	5	5	5
Sarcocornia quinqueflora	D	–	5	5	5	4	5
Selliera radicans	D	–	–	4	5	5	5
Selliera radicans	E	–	–	4	5	5	5
Schoenus nitens	E	–	–	2	3	5	5
Juncus gerardii	F	–	–	–	1	2	4

2c. Aramoana Central (AC)

		Flats A	Flats B	Lower C	Middle D	Upper E	Fringe F
Zostera muelleri	A	4	–	–	–	–	–
Samolus repens	C	–	1	5	5	5	5
Samolus repens	D	–	1	5	5	5	5
Selliera radicans	D	–	–	4	5	5	5
Atriplex prostrata	E	–	–	–	3	5	4
Poa cita	F	–	–	–	–	3	5

2d. Aramoana West 1 (AW1)

		Lower A	Lower B	Meadow C	Depression D	Depression E	Depression F	Upper G	Pan H
Samolus repens	A	5	5	5	4	2	1	5	–
Samolus repens	B	5	5	5	4	1	1	5	–
Sarcocornia quinqueflora	B	5	5	5	5	5	2	5	1
Selliera radicans	C	4	5	5	5	5	3	5	1
Selliera radicans	G	3	5	5	5	5	3	5	–
Schoenus nitens	C	2	2	5	2	–	–	5	–
Triglochin striatum	D	4	5	5	5	5	4	5	1
Triglochin striatum	E	3	5	5	5	5	5	5	1
Puccinellia stricta	D	5	5	5	5	5	2	5	–
Cotula coronopifolia	E	2	2	2	5	5	5	5	1
Mimulus repens	F	–	–	–	3	5	5	5	–

2e. Aramoana West 2 (AW2)

		Flats A	Lower B	Lower C	Upper D
Zostera muelleri	A	4	1	–	–
Schoenoplectus pungens	B	1	3	2	2
Schoenoplectus pungens	C	–	2	3	2
Samolus repens	C	–	1	5	1

2f. Purakanui 1 (PU1)

		Lower A	Middle B	Meadow C	Fringe D
Sarcocornia quinqueflora	A	5	5	5	5
Selliera radicans	B	4	5	5	5
Samolus repens	B	5	5	5	5
Cotula dioica	C	–	4	5	5
Schoenus nitens	C	–	5	5	5
Agrostis stolonifera	D	–	1	4	5

2g. Purakanui 2 (PU2)

		Lower A	Lower B	Depression C	Depression D	Upper E
Sarcocornia quinqueflora	A	5	5	5	4	5
Samolus repens	B	5	5	4	2	5
Samolus repens	E	5	5	5	3	5
Juncus maritimus	C	2	1	2	1	1
Schoenoplectus pungens	D	–	–	1	1	–
Selliera radicans	E	4	5	4	2	5

2h. Cherry Farm 1 (CF1)

		Flats A	Flats B	Lower C	Depression D	Depression E	Middle F	Upper G	Fringe H
Spartina anglica	A	5	5	5	5	5	5	5	5
Puccinellia novae-zelandiae	B	4	5	5	5	5	5	4	5
Sarcocornia quinqueflora	C	4	4	5	5	5	5	5	5
Triglochin striatum	D	5	5	5	5	5	5	5	4
Selliera radicans	F	–	1	3	3	5	5	5	5
Selliera radicans	G	–	–	3	2	2	5	5	5
Samolus repens	F	–	–	3	3	3	5	5	5
Schoenus nitens	G	–	–	1	–	–	4	5	4
Festuca arundinacea	H	–	–	–	–	–	3	5	5

2i. Cherry Farm 2 (CF2)

		Lower A	Lower B	Meadow C	Fringe D
Sarcocornia quinqueflora	A	5	5	5	5
Samolus repens	B	4	5	5	5
Selliera radicans	C	3	5	5	5
Selliera radicans	D	3	5	5	5
Schoenus nitens	C	1	3	5	5
Carex flagellifera	D	–	–	3	5

2j. Karitane (KA)

		Flats A	Lower B	Sand mound C	Lower D	Middle E	Upper F	Meadow G	Upper H	Fringe I
Spartina anglica	A	5	5	4	5	2	3	2	1	–
Sarcocornia quinqueflora	B	5	5	5	5	5	5	4	5	3
Suaeda novae-zelandiae	C	1	5	5	5	5	5	2	5	4
Samolus repens	D	1	2	5	5	5	5	5	5	5
Plantago coronopus	E	1	2	4	4	5	5	5	5	5
Selliera radicans	E	1	3	5	4	5	5	5	5	5
Selliera radicans	G	1	2	4	5	5	5	5	5	5
Selliera radicans	H	1	3	5	5	5	5	5	5	5
Festuca arundinacea	F	–	–	–	1	5	5	2	3	5
Schoenus nitens	G	–	1	1	2	5	5	5	3	4
Disphyma australe	H	–	1	2	2	5	5	1	5	5
Poa cita	I	–	–	–	–	3	5	2	2	5

2k. Evansdale (EV)

		Lower A	Meadow B	Fringe C
Sarcocornia quinqueflora	A	5	5	5
Selliera radicans	B	3	5	5
Schoenus nitens	B	2	5	5
Atriplex prostrata	C	1	3	5
Agrostis stolonifera	C	–	5	5

naturally occurring in these depressions performed poorly in dry soils. *Mimulus repens* and *Cotula coronopifolia*, in particular, did not grow well outside depressions (Table 2d). *Triglochin striatum*, however, which is typical of depressions but is also found scattered elsewhere, could grow in most sites (Table 2a, d, h).

Where transplants of the same species were made from different zones at a site, the results were usually very similar. The only exception was *Selliera radicans* at Cherry Farm (Table 2h). This could have been because the shorter plants from salt meadow, when transplanted into tall *Leptocarpus similis*, were usually under ponded water, whereas those taller plants from other sites were not. Two species, *Juncus maritimus* and *Schoenoplectus pungens*, did not transplant well at all, even to their own sites, probably as a result of damage to the plants during transplanting (Table 2e, g).

Within salt marshes, similar patterns following transplanting have been shown by Statler & Baston (1969). It is interesting to note that, in their experiments, *Spartina alterniflora* had a similar pattern to *Spartina anglica* at Karitane (Table 2j), in that it failed when transplanted to the upper marsh. This can be explained in both cases as a result of the dry conditions found in the upper marsh. In contrast, at Cherry Farm (Table 2h) water ponds in the upper marsh and *Spartina anglica* survived at all sites. Similar patterns of response of other transplanted species were found by Boorman (1971). The successful transplanting of so many species both up and down the marsh suggests that many salt marsh species have realised niches considerably narrower than their fundamental niches.

The transplant experiment results pose the question of why so many species do not occur in lower zones in which it has been shown they can survive. A possible explanation is a requirement for lower salinities for germination or establishment. Many of the species involved, however, grow vegetatively and would be capable of this form of spread to lower elevations. This does not appear to happen as these species have the same performance when transplanted as those which do not spread vegetatively. It is probable that reduced competitive ability against the more tolerant species stops many species spreading to lower elevations of the marsh. Competition cannot be limiting, however, at the lower marsh boundary as there are no species to compete with, so adult tolerance limits or seedling establishment requirements probably do limit spread. In the few transplants into bare areas or mats of *Zostera muelleri*, there was death of all species except *Spartina anglica*, a plant renowned for its ability to spread to such places (Hubbard 1969, Hubbard & Partridge 1981).

Although a small number of species are restricted to parts of the tidal salt marsh, most can be found in the upper marsh fringe and sometimes in habitats above this. The transplant experiment demonstrated that most salt marsh species can survive and grow in habitats at higher elevations. Habitats beyond the salt marsh which contain halophytes are almost always saline (Chapman

Table 3 Rankings of salt tolerance as suggested by distribution in sample sites (L), performance in transplant experiments (T), and salt tolerance (S) at each transplant area. Lower salt marsh limits are used for both distribution and transplants. The half-growth salinity (Partridge & Wilson 1987) was used for the salt tolerance and the order in which the species are listed. A ranking of 1 is for the most salt tolerant. Site codes are given in Table 1.

	AE1			AE2			AC			AW1			AW2			PU1			PU2			CF1			CF2			KA			EV		
	L	T	S	L	T	S	L	T	S	L	T	S	L	T	S	L	T	S	L	T	S	L	T	S	L	T	S	L	T	S	L	T	S
Suaeda novae-zelandiae																												3	3	1			
Sarcocornia quinqueflora	2	1=	1	2=	1=	1				2	1=	1				1	1=	1	1	1=	1	3	3	1	1	1	1	2	1=	2	1	1	1
Juncus maritimus																			3	1=	2												
Schoenoplectus pungens													1	1	1																		
Spartina anglica																						1	1=	2				1	1=	3			
Puccinellia novae-zelandiae																						2	1=	3									
Samolus repens	1	1=	2	1	1=	2	1	1	1	1	1=	2	2	2	2	2=	1=	2	2	1=	3	4=	5	4	2	2	2	4	4=	4			
Puccinellia stricta										3	1=	3																					
Schoenus nitens	4	4	3	4	4	3				5	5	4				4=	4=	3				6	6	5	4	4	3	8	7=	5	2=	3	2
Cotula dioica																4=	4=	4															
Selliera radicans	3	3	4	2=	1=	4	2	2	2	4	4	5				2=	1=	5	4	4	4	4=	4	6	3	3	4	6	4=	6	2=	2	3
Plantago coronopus																												5	4=	7			
Atriplex prostrata							3	3	3																						4=	4	4
Carex flagellifera																									5	5	5						
Poa cita	6	6	5				4	4	4																			9	9	8			
Apium prostratum	5	5	6																														
Festuca arundinacea																						7	7	7				7	7=	9			
Agrostis stolonifera																6	6	6															

1974), even though most species of the salt marsh grow best in fresh water. The absence of halophytes from non-saline habitats may be the result of an inability to compete with glycophytes in areas without any salt, resulting in the restriction of halophytes to places such as salt marsh fringes, where they are the more successful competitors.

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Appendix 1

List of sample sites according to vegetation type. The sequence is from low to high elevation with important variants such as depressions and sand mounds following. Salt meadow is a very short dense vegetation that may be classified as either middle or upper marsh. An asterisk in the final column indicates that further species are also present.

Community/ Sites		Species transplanted	Species not transplanted	Other species in community
Sand and mud flats				
AE2	A	*Zostera muelleri*		
AC	A	*Zostera muelleri*		
AC	B			
AW2	A	*Zostera muelleri*		
CF1	A	*Spartina anglica*		*Zostera muelleri*
CF1	B	*Puccinellia novae-zelandiae*		*Spartina anglica, Zostera muelleri*
KA	A	*Spartina anglica*	*Zostera muelleri*	
Lower marsh				
AE1	A	*Samolus repens*		*Puccinellia stricta*
AE1	B	*Samolus repens, Sarcocornia quinqueflora*		*Puccinellia stricta, Suaeda novae-zelandiae*
AE2	C	*Samolus repens*		*Puccinellia stricta*
AC	C	*Samolus repens*		
AW1	A	*Samolus repens*		*Puccinellia stricta*
AW1	B	*Samolus repens, Sarcocornia quinqueflora*	*Suaeda novae-zelandiae*	*Puccinellia stricta*
AW2	B	*Schoenoplectus pungens*		*Zostera muelleri*
AW2	C	*Samolus repens, Schoenoplectus pungens*		
PU1	A	*Sarcocornia quinqueflora*		
PU2	A	*Sarcocornia quinqueflora*		
PU2	B	*Samolus repens*		
CF1	C	*Sarcocornia quinqueflora*		
CF2	A	*Sarcocornia quinqueflora*		*Puccinellia stricta*
CF2	B	*Samolus repens*	*Sarcocornia quinqueflora*	*Puccinellia stricta*
KA	B	*Sarcornia quinqueflora*	*Spartina anglica*	*Puccinellia novae-zelandiae*
KA	D	*Samolus repens*	*Sarcocornia quinqueflora*	*Puccinellia fasciculata*
EV	A	*Sarcornia quinqueflora*		*Puccinellia stricta*
Middle marsh				
AE1	C	*Samolus repens, Selliera radicans*	*Sarcocornia quinqueflora, Puccinellia stricta*	*Suaeda novae-zelandiae*
AE2	D	*Sarcocornia quinqueflora, Selliera radicans*	*Samolus repens, Puccinellia stricta*	*Suaeda novae-zelandiae*
AC	D	*Samolus repens, Selliera radicans*	*Sarcocornia quinqueflora, Puccinellia stricta*	
PU1	B	*Samolus repens, Selliera radicans*	*Sarcocornia quinqueflora, Puccinellia stricta*	
CF1	F	*Samolus repens, Selliera radicans*	*Sarcocornia quinqueflora*	*Puccinellia stricta*
KA	E	*Plantago coronopus, Selliera radicans*	*Sarcocornia quinqueflora*	*Samolus repens, Suaeda novae-zelandiae*

Community/ Sites		Species transplanted	Species not transplanted	Other species in community
Salt meadow				
AE1	D	*Selliera radicans, Schoenus nitens*	*Samolus repens, Lachnagrostis* sp.	*Puccinellia stricta*
AE2	E	*Selliera radicans, Schoenus nitens*	*Samolus repens, Lachnagrostis* sp.	*Puccinellia stricta, Sarcocornia quinqueflora**
AW1	C	*Selliera radicans, Schoenus nitens*	*Samolus repens*	*Puccinellia stricta, Sarcocornia quinqueflora**
PU1	C	*Schoenus nitens, Cotula dioica*	*Selliera radicans*	*Puccinellia stricta, Sarcocornia quinqueflora**
CF2	C	*Selliera radicans, Schoenus nitens*		*Cotula dioica*
KA	G	*Selliera radicans, Schoenus nitens*		*Sarcocornia quinqueflora, Cotula dioica**
EV	B	*Selliera radicans, Schoenus nitens*	*Samolus repens*	*Sarcocornia quinqueflora*
Upper marsh				
AE1	E	*Selliera radicans, Apium prostratum*	*Leptocarpus similis*	*Samolus repens, Sarcocornia quinqueflora**
AC	E	*Atriplex prostrata*	*Leptocarpus similis*	*Apium prostratum, Sarcocornia quinqueflora**
AW1	G	*Selliera radicans*	*Leptocarpus similis*	*Apium prostratum, Triglochin striatum**
AW2	D		*Leptocarpus similis*	*Agrostis stolonifera*
PU2	E	*Selliera radicans, Samolus repens*	*Juncus maritimus*	*Sarcocornia quinqueflora, Apium prostratum**
CF1	G	*Selliera radicans, Schoenus nitens*	*Cotula dioica*	*Apium prostratum, Agrostis stolonifera**
KA	F	*Festuca arundinacea*	*Plantago coronopus*	*Sarcocornia quinqueflora, Suaeda novae-zelandiae**
KA	H	*Selliera radicans, Disphyma australe*	*Samolus repens*	*Sarcocornia quinqueflora, Suaeda novae-zelandiae**
Marsh fringe				
AE1	F	*Poa cita*	*Selliera radicans, Phormium tenax*	*Leptocarpus similis, Apium prostratum**
AE2	F	*Juncus gerardii*	*Selliera radicans*	*Leptocarpus similis, Sarcocornia quinqueflora**
AC	F	*Poa cita*	*Hypochaeris radicata*	*Agrostis stolonifera, Leptocarpus similis**
PU1	D	*Agrostis stolonifera*	*Selliera radicans*	*Cotula dioica, Apium prostratum**
CF1	H	*Festuca arundinacea*	*Selliera radicans*	*Leptocarpus similis, Cotula dioica**
CF2	D	*Selliera radicans, Carex flagellifera*	*Leptocarpus similis*	*Cotula dioica, Poa cita**
KA	I	*Poa cita*	*Festuca arundinacea, Agrostis stolonifera*	*Leptocarpus similis, Disphyma australe**
EV	C	*Atriplex prostrata, Agrostis stolonifera*		*Leptocarpus similis, Cotula dioica**
Marsh depressions				
AE1	G	*Sarcocornia quinqueflora, Triglochin striatum*		*Apium prostratum*
AE1	H		*Leptocarpus similis*	*Apium prostratum, Atriplex prostrata*
AW1	D	*Puccinellia stricta, Triglochin striatum*	*Selliera radicans*	*Apium prostratum, Juncus gerardii*
AW1	E	*Triglochin striatum, Cotula coronopifolia*	*Sarcocornia quinqueflora*	*Mimulus repens, Leptocarpus similis**
AW1	F	*Mimulus repens*	*Leptocarpus similis, Cotula coronopifolia*	*Apium prostratum, Sarcocornia quinqueflora**
PU2	C	*Juncus maritimus*		
PU2	D	*Schoenoplectus pungens*		
CF1	D	*Triglochin striatum*		*Leptocarpus similis, Sarcocornia quinqueflora*
CF1	E		*Leptocarpus similis*	*Schoenoplectus pungens*
Sand mounds				
AE2	B	*Suaeda novae-zelandiae*	*Sarcocornia quinqueflora*	
KA	C	*Suaeda novae-zelandiae*	*Sarcocornia quinqueflora, Puccinellia fasciculata*	
Bare pans				
AW1	H			*Samolus repens* (around edge)