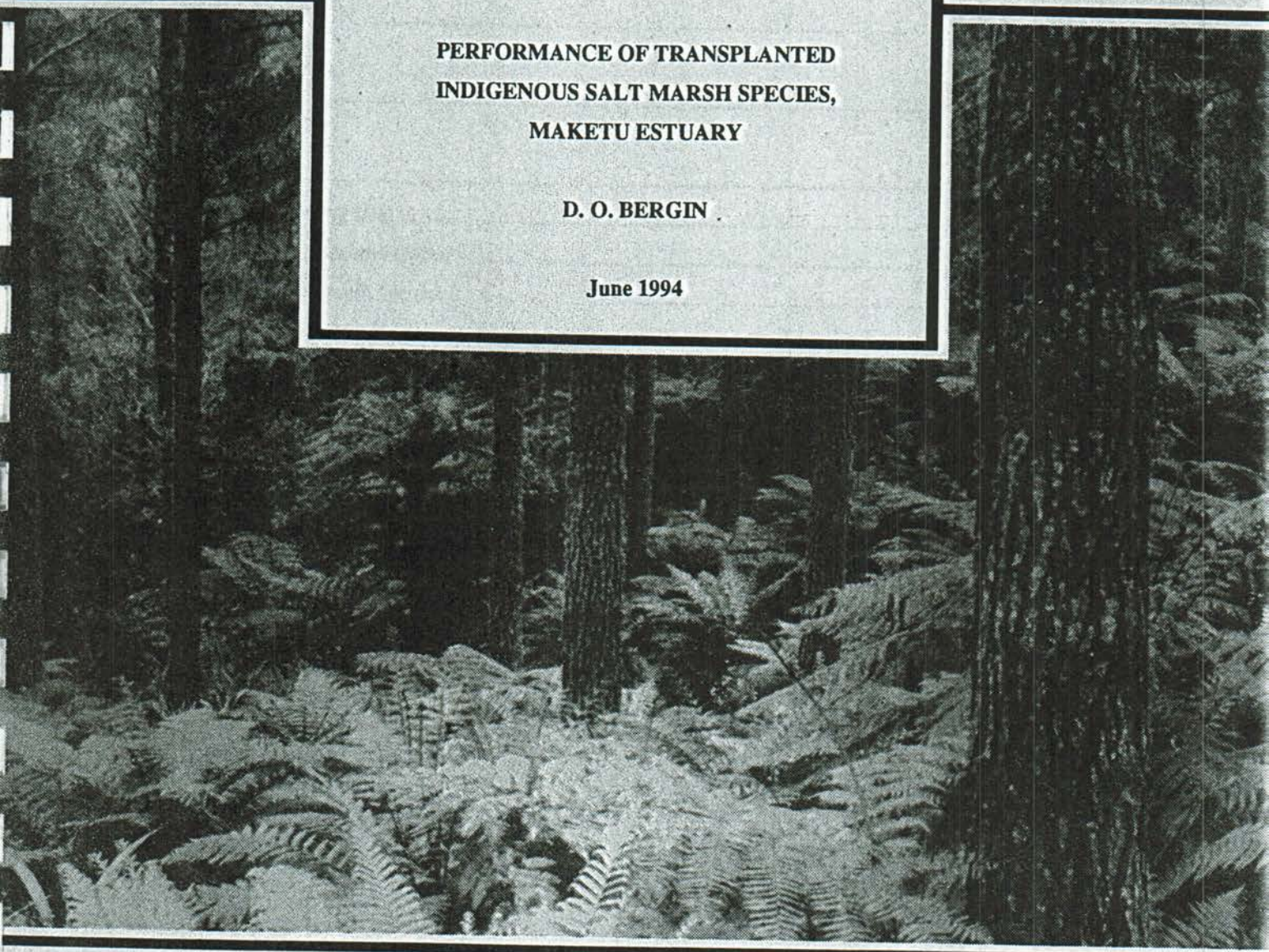
PERFORMANCE OF TRANSPLANTED INDIGENOUS SALT MARSH SPECIES, MAKETU ESTUARY

D. O. BERGIN

June 1994



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CONTENTS

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New Zealand Forest Research Institute Contract Report

PREPARED FOR:
Bay of Plenty Conservancy
Department of Conservation
Rotorua

DATE: June 1994

EXECUTIVE SUMMARY

INVESTIGATION TITLE: Performance of transplanted indigenous salt marsh species, Maketu Estuary

STUDY VENUE: Bay of Plenty

INVESTIGATION LEADER: D. O. Bergin

CLIENT: Bay of Plenty Conservancy, Department of Conservation, Rotorua

INVESTIGATION SUMMARY:

In 1990 the Forest Research Institute investigated factors affecting the status of an indigenous salt marsh and set up a transplanting trial using indigenous salt marsh species at Maketu Estuary, Bay of Plenty. In 1994, the Indigenous Forest Management section of the NZ Forest Research Institute, Rotorua, assessed the performance of the transplanting trial and briefly inspected the adjacent salt marsh remnant.

OBJECTIVES:

- To remeasure transplanting trials established in the vicinity of the main vegetation remnant testing selected salt marsh species transplanted onto mudflat.
- To describe any major changes to remnant salt marsh vegetation.
- To provide recommendations for restoration of salt marsh vegetation based on results from assessment of transplanting trials and changes to the remnant vegetation.

METHODS:

- Over 2500 transplants of *Juncus maritimus* and *Leptocarpus similis* were planted on one sheltered and one exposed site adjacent to existing salt marsh vegetation in late 1991. Treatment factors tested were clump-size, spacing, and application of fertiliser at planting. Several plots of mangroves were also established.
- Performance of transplants, including mangroves, was first assessed 5 months after planting and again in June 1994. In the latest measurement, transplant groups were assessed for survival, health, unthriftiness, height and canopy cover.
- The margins of the existing salt marsh remnant was inspected. Distances between datum pegs established in 1990 and margins of the remnant salt marsh vegetation were remeasured in June 1994 to determine retreat or advance of vegetation.

RESULTS:

- There were no surviving plants of *J. maritimus* on the exposed site 3.5 years after planting.
- On the sheltered site there were highly significant differences in survival between all clump-sizes of *J. maritimus* but no difference in survivals with plant spacing. Large, medium and small clump-sizes had 89%, 70% and 24% survivals respectively. The larger clump-size was consistently taller and achieved canopy closure sooner than the smaller clump-sizes.

- There was a significant correlation between canopy closure and spacing of plants for *J. maritimus*; larger clump-sizes planted at close spacings achieved canopy closure significantly sooner than small clumps at wide plant spacing combinations.
- The large clump-size of *L. similis* has survived significantly better than the smaller clump-sizes 3.5 years after planting.
- Survival of transplanted mangroves had reduced to 30% of the original number planted.
- Of the 14 datum pegs remeasured nearly 4 years after they were positioned around the edges of the remnant, 11 indicate that the vegetation has retreated from 70 cm to 1.5 m.

CONCLUSIONS:

- This trial demonstrates that two major indigenous rush species at Maketu Estuary, *J. maritimus* and *L. similis*, can be successfully transplanted to sheltered mudflats with most succuss using the larger clump-sizes.
- At the close spacing of 4 plants/m^2 (plants 50 cm apart) and using large transplants (100 x 100 x 150 mm depth) of *J. maritimus*, complete vegetation cover was achieved at Maketu within 3.5 years of establishment.
- The low survival of medium and small clump-sizes of *L. similis* indicate that large clump-size is the only option for successful establishment of this species.
- If the salt marsh remnant at Maketu Estuary continues to retreat at the present rate, it is likely to be reduced to discontinuous patches of vegetation within 50 years and to disappear within a century.

RECOMMENDATIONS:

- For revegetation of sheltered mudflats using *J. maritimus*, managers have the option, depending on resources, of choosing either large or medium clump-sizes for transplanting. Where large scale transplanting is considered and resources are limited, medium size clumps could be planted at wide spacing. However, where resources are sufficient, and rapid revegetation of mudflats is desirable, the preferred option is to plant large transplants at close spacing.
- Where restoration of previously vegetated sites is considered, the relative proportions of species that once existed or in nearby natural areas should be used to determine appropriate species mix and planting pattern.
- As most of the salt marsh vegetation decline of the Maketu Estuary is occurring along the exposed seaward side of the remnant, and as this is the last major salt marsh remnant in the estuary, further investigation of techniques for transplanting indigenous vegetation to exposed mudflats is urgently required.

2. INTRODUCTION

In 1990, the Forest Research Institute investigated techniques for re-establishing salt marsh vegetation on mudflats at Maketu Estuary, Bay of Plenty, where salt marsh has been declining over the last 50 years. This involved planting of over 2500 transplants of *Juncus maritimus* and *Leptocarpus similis* on one sheltered site and one exposed site adjacent to the last major salt marsh remnant. Only about 5 ha of salt marsh remained in 1990 on the inland side of the estuary (Fig. 1). Monitoring of some factors that could be affecting the status of salt marsh vegetation was also initiated including determining salinity gradients of surface and subterranean water, an examination of degraded plants and root decay along margins of the salt marsh remnant, and placement of datum pegs for monitoring the long term rate at which the salt marsh vegetation is retreating. The results of the initial monitoring programme and the performance of the transplanting trial 5 months after planting are given in Bergin (1991).

In 1994, the Indigenous Forest Management section of the NZ Forest Research Institute, Rotorua, assessed the performance of the transplanting trial since planting 3.5 years earlier. Changes to the status of the salt marsh remnant were also briefly inspected.

3. OBJECTIVES

- To remeasure transplanting trials established in the vicinity of the main vegetation remnant testing selected salt marsh species transplanted onto mudflat.
- To describe any major changes to remnant salt marsh vegetation.
- To provide recommendations for restoration of salt marsh vegetation based on results from assessment of transplanting trials and changes to the remnant vegetation.

4. METHODS

4.1 Transplanting trial

4.1.1 Species and layout

The two main species tested in the trial were *J. maritimus* and *L. similis*. Over 2500 transplants were planted in 20 seedling groups in November 1990. The planting pattern was designed to blend in with the natural vegetation as much as possible.

The trial was located at two sites, one on the exposed side of the main salt marsh remnant where wave action could be a major problem in uprooting plants during stormy conditions, and the second site on the inland side of the estuary between the vegetation remnant and Maketu Road. Placement of transplanted seedlings was influenced by four site factors: salinity levels of surface water that covered planting sites during high tides, proximity to existing vegetation, type of substrate covering planting sites, and degree of exposure to wave action and wind.

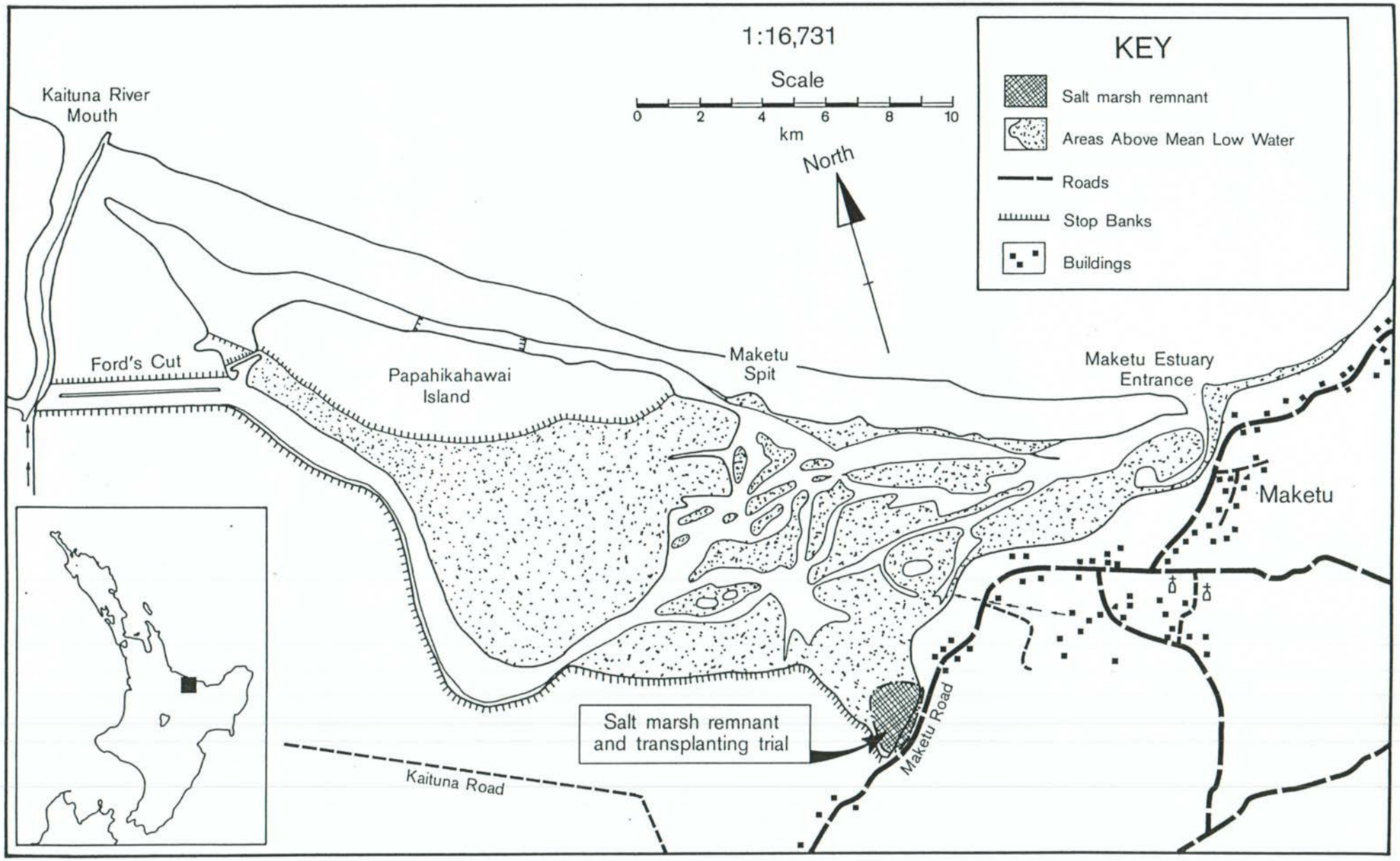

Figure 1: Location of trial area and main features of Maketu Estuary

4.1.2 Treatment factors

The treatment factors tested at each trial site for *J. maritimus* were clump-size (small medium, large), fertiliser (present, absent), and spacing of clumps within plots (wide, medium, close).

Clumps were taken from healthy plants along the edge of the main salt marsh remnant adjacent to planting sites. The effect of removing transplants from the edge of the main remnant was minimal. The technique involved separating large sections of healthy plant from the main remnant using a spade and removing at least a spade depth of mud containing the roots. Sections of plant material were then dragged over to each planting site and clumps of the appropriate size cut by spade.

The large clumps were 100 x 100 x 150 mm depth, medium size clumps 50 x 50 x 150 mm depth, and small clumps were bare-root transplants with a few leaves and attached roots. The large and medium clumps had intact root systems with substrate still attached. Large clumps took twice as long to prepare for planting and consumed a greater quantity of plant material than small clumps. Time to prepare transplants and plant each plot took a minimum of 15 minutes using small clumps and 25 minutes using larger clumps.

Spacing was determined by marking 5 m, 3.6 m or 2.5 m diameter circles for the wide, medium and close spacings respectively, ie., wide - 4 plants/m^2 or 50 cm between plant centres; medium - 2 plants/m^2 or 70 cm between plant centres; close - 1 plant/m^2 or 1 m between plant centres. Seedlings were then planted at a relatively even spacing within and up to the edge of marked circles.

Fertilised plants were given an application of 25 g of a slow release NPK fertiliser (Magamp coarse granules). This involved placing fertiliser granules in the planting hole before the transplant was inserted. With fertiliser placed into the base of planting holes where there was less chance of it being washed away by tidal water.

4.1.3 Trial design

At each site, three replicate blocks were planted with one block located on mudflat at least 10 m away from the existing salt marsh remnant (S2 & E3) and the other two located along the margins of the remnant (S1 & S3; E1 & E2) (Fig. 2). For *J. maritimus*, all treatment combinations were tested at each site. For *L. similis*, only the sheltered site was used, and only the clump-size treatment factor tested at medium spacing, without fertiliser. Seedlings were planted in plots of 20 transplants with a single treatment combination assigned randomly to each plot.

4.1.4 Monitoring

The transplanting trial was first assessed for survival five months after planting. Transplant groups were rated for health, based on the proportion of live shoots (good - > 50% live leaves, intermediate - 25-50% live leaves, poor - < 25% live leaves). The number of plants within each group that were considered unthrifty was also recorded.

Transplant groups were assessed in June 1994 on the sheltered site for survival, health and unthriftiness as in the first assessment. Mean top height was also measured for each transplant group and canopy cover rated as closed (plant shoots overlapping obscuring ground), intermediate or open (> 50% ground cover within plots visible between plants).

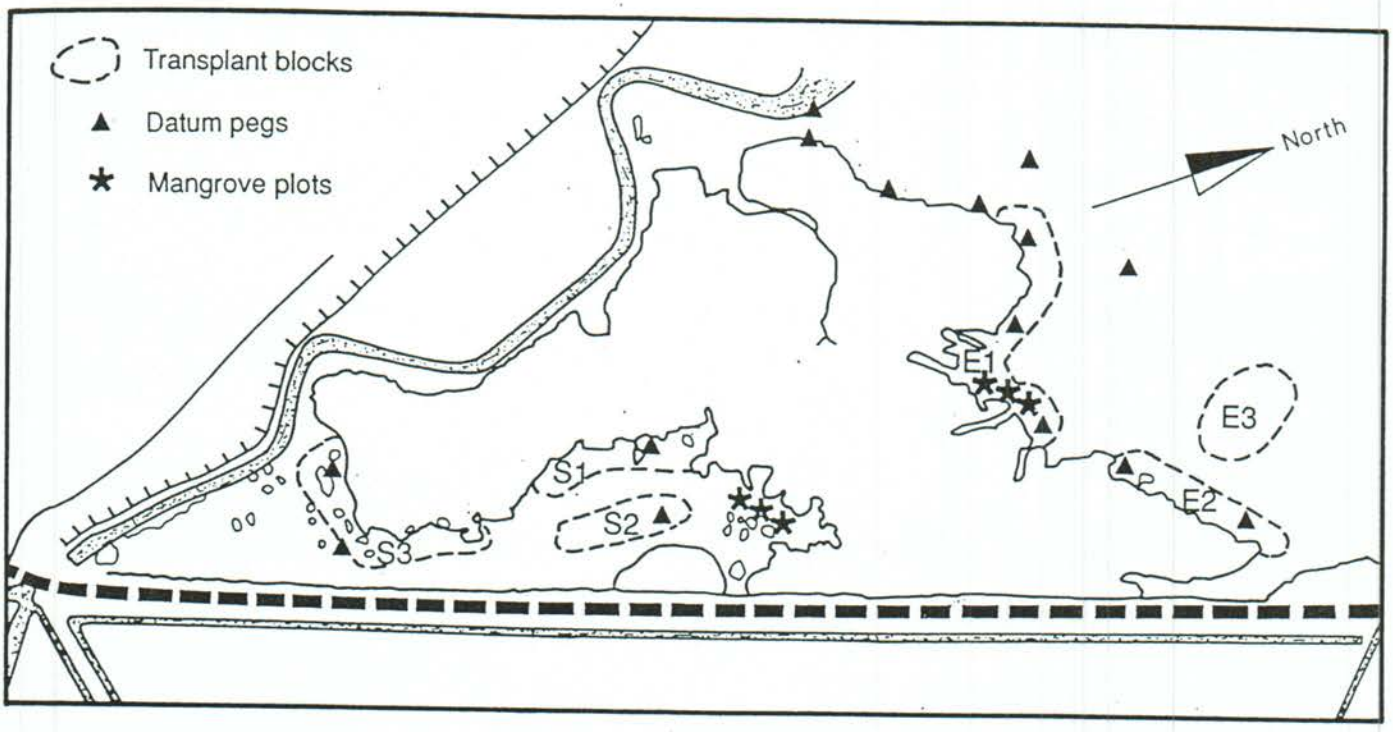

Figure 2: Location of blocks of transplanted **Juncus maritimus** *and* **Leptocarpus similis**, *mangrove plots and datum pegs. Three blocks were located on the sheltered site - S2 and S3 adjacent to the existing salt marsh remnant and S1 located in an open mudflat area. A further three blocks were located on the exposed side of the salt marsh remnant (E1-E3).*

4.1.5 Analysis

Analysis of variance methods were used to test the significance of treatment and site effects on survival, health, height and canopy closure of transplants.

4.1.6 Transplanting of mangroves

A mangrove (*Avicennia resinifera*) pilot trial was established in mid-1990, involving transplanting 10, 50-cm high mangrove plants from Tauranga Harbour. Additional plots of freshly collected small propagules of mangrove were established in January 1991, two plots at both the exposed and sheltered sites. Propagules with roots less than 3 cm long and propagules with roots longer than 3 cm were planted in separate plots. Survival and height were assessed in June 1994.

4.2 Salt marsh retreat

In order to determine the rate at which the salt marsh vegetation is retreating in the long term, 15 two metre long treated pegs were placed in permanent positions around the existing margin (Fig. 2). Distances were measured along a compass bearing to the nearest live plant on the edge of the remnant in order to measure any future retreat or advance of salt marsh vegetation. The datum pegs were also used to establish a reference mark so that any increase or decrease in substrate level could be identified. Distances between datum points and margins of the vegetation remnant and differences in substrate level were remeasured in June 1994.

5. RESULTS

5.1 Transplanting trial

After only five months, there was significant loss of *J. maritimus* transplants on the exposed site compared to the sheltered site where up to 95% of the medium and large clump-sizes had survived. However, 3.5 years after planting, there were no surviving plants on the exposed site.

On the sheltered site there were highly significant differences in survival between all clump-sizes of *J. maritimus* 3.5 years after planting (large 89%, medium 70%, small 24%) (Fig. 3; Appendix). However, within treatments (clump-sizes) there was no significant difference in survivals with plant spacing suggesting that transplants do not require the support of neighbouring plants. The larger clump-size was consistently taller and achieved canopy closure sooner than the smaller clump-sizes (Appendix). The large and medium clump-sizes were significantly healthier than the small clump-size. However, there was no effect of plant spacing, block or fertiliser on survival, health and height growth of *J. maritimus*.

There was a significant correlation between the canopy closure rating and spacing of plants for *J. maritimus*. Clump-size and plant spacing interactions clearly indicate that larger clump-sizes planted at close spacings achieve canopy closure significantly sooner than small clumps at wide plant spacing combinations (Fig. 4, Appendix). Large clumps at the close plant spacing of 4 plants/m^2 (planted 50 cm apart) have a completely closed canopy with individual clumps only discernible around the outside margin of planted groups (Plate 1). With increased spacing, canopy closure has not yet occurred (Plate 2).

The large clump-size of *L. similis* has survived (78%) significantly better than the medium (5%) or small clump-sizes (22%) 3.5 years after planting (Appendix). There were no significant differences in health, height growth or canopy closure on clump-size. There was no block effect with any of the parameters assessed for this species.

Sites along margins and within the existing remnant from which transplants were taken recovered within the first year after extraction.

5.2 Transplanting mangroves

As indicated in the first assessment 5 months after planting (Bergin 1991), transplanting of mangroves was not very successful with high mortality of larger seedlings (roots greater than 3 cm) within a few weeks of planting. However, most of the survivors 5 months after planting (25%) were still growing over 3 years later with an average height of 50 cm (range 26-65 cm). Although 80% of small seedlings (5-10 cm propagules with roots less than 3 cm long had survived 5 months after planting, survival had reduced to 30% of the original number planted with height ranging from 30-42 cm.

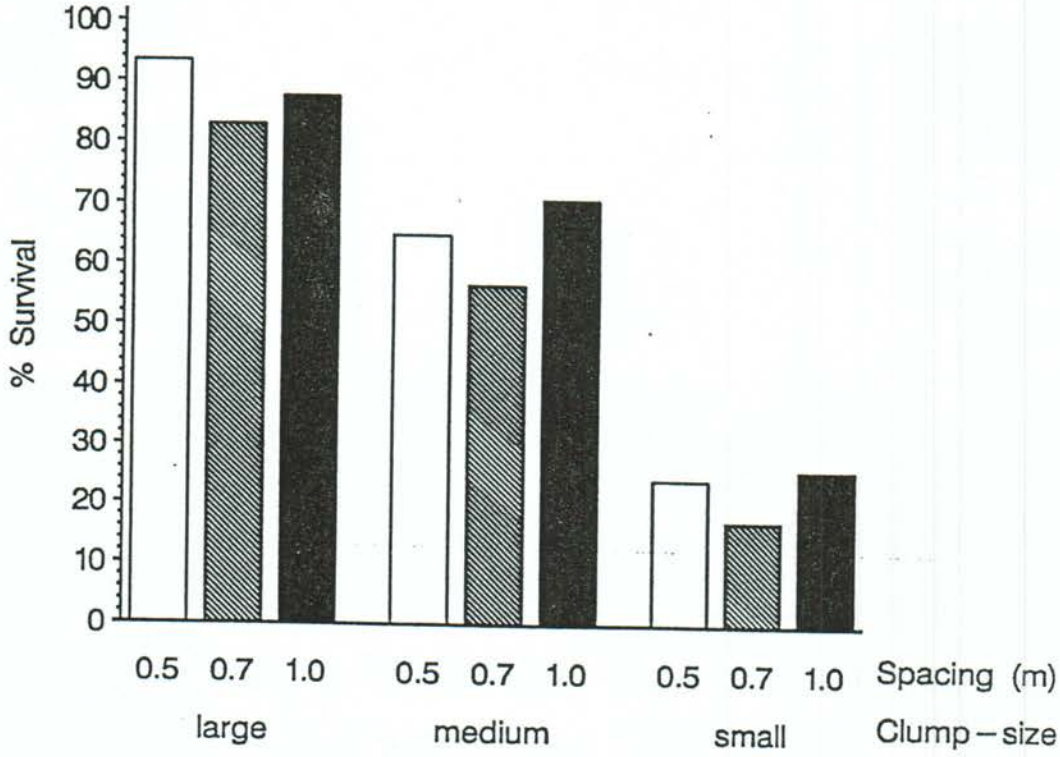

Figure 3: Effect of plant spacing and clump-size on % survival of Juncus maritimus.

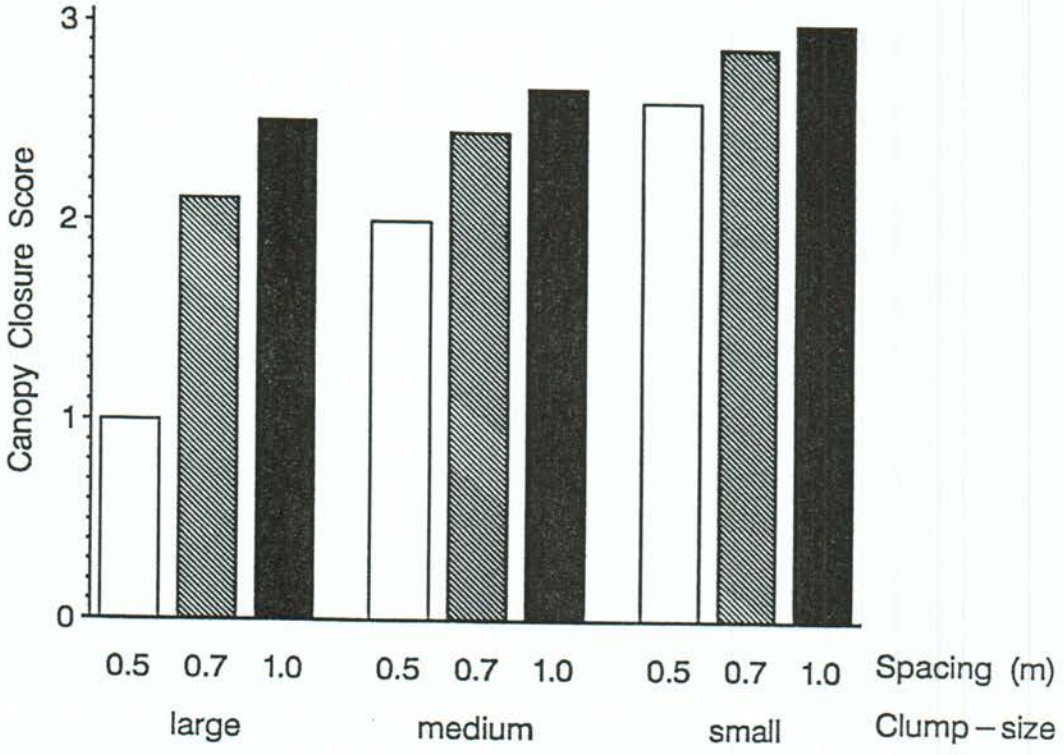

Figure 4: Effect of plant spacing and clump-size on canopy closure of Juncus maritimus. *Canopy closure score: 1 - closed canopy; 2 - intermediate; 3 - open canopy.*

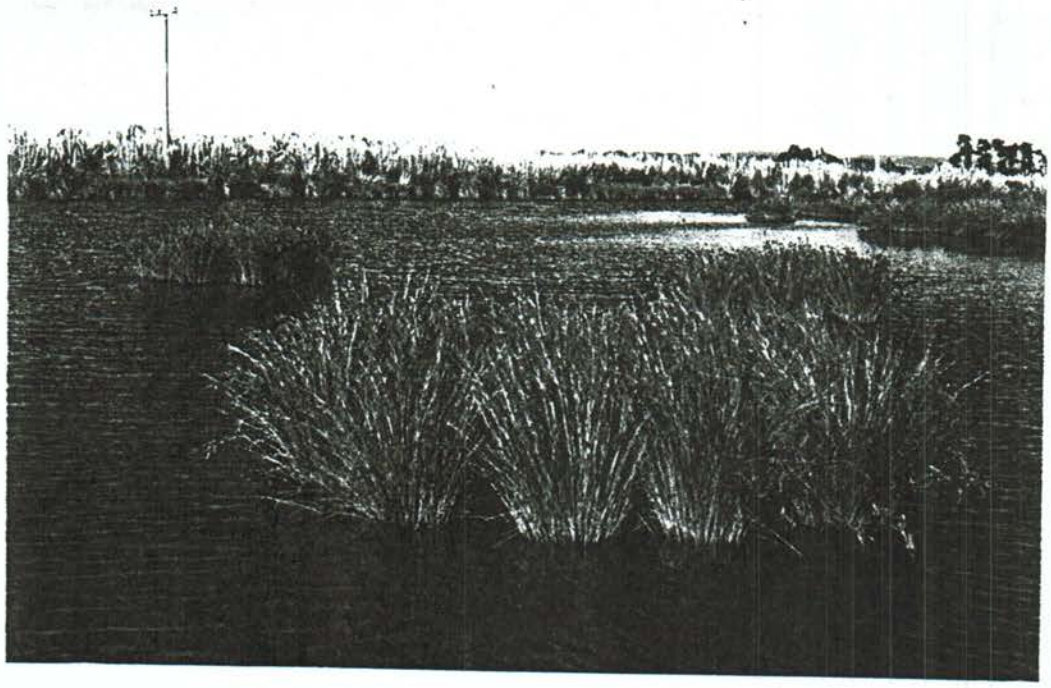

Plate 1: *Large clumps of* **Juncus maritimus** *planted at close spacing (50 cm apart) have coalesced to form a closed canopy within 3.5 years of planting.*

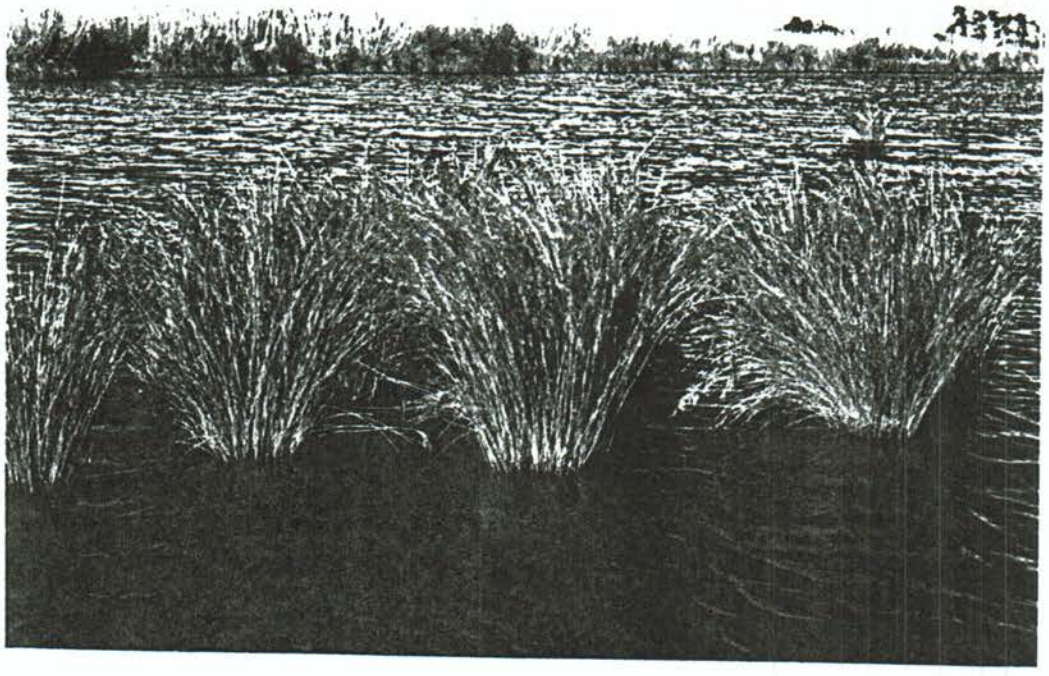

Plate 2: *Canopy closure has not yet occurred where large clumps of* **Juncus maritimus** *have been planted at medium (70 cm apart) plant spacing (as above) or at wide spacing (1 m apart).*

5.3 Salt marsh retreat

On the seaward side of the remnant, salt marsh vegetation has continued to retreat generally toward the east. Of the 14 datum pegs remeasured nearly 4 years after they were positioned around the edges of the remnant, 11 indicate that the vegetation has retreated from 70 cm to 1.5 m (Plate 3). The level of the substrate has decreased by 10 cm (Plate 4). However, at one inland site, there was expansion of the salt marsh vegetation by 60 cm.

6. CONCLUSIONS

6.1 Transplanting trial

This trial demonstrates the two major indigenous rush species at Maketu Estuary, *J. maritimus* and *L. similis* can be successfully transplanted to sheltered mudflats. The assessment 3.5 years after planting confirms general conclusions reached at the first assessment 5 months after planting (Bergin 1991). On a sheltered site *J. maritimus* can be successfully transplanted using a medium clump-size and *L. similis* using a large clump-size. The trial confirmed earlier work of Partridge and Wilson (1988) who found that transplanting of small clumps of *J. maritimus* results largely in failure.

On a sheltered mudflat, transplants planted at a close spacing or immediately adjacent to the existing salt marsh remnant do not benefit from the extra protection afforded by neighbouring plants at close proximity. It is only at the close spacing and using large transplants that complete vegetation was achieved at Maketu within 3.5 years of establishment. Gillespie (1988) suggested that transplants at wide spacing (1 m between plants) may take up to three years for clumps to coalesce into a uniform marsh. However, the Maketu trial clearly indicates that transplants at wide spacing will take considerably longer.

A major disadvantage is that large clump-sizes require considerably more planting effort than smaller clump-sizes. Although sites where transplant material was sourced for the trial recovered quickly, large scale revegetation programmes using large clump-sizes could cause unreasonable damage to source areas. This is likely to be a major practical concern to managers. For *J. maritimus*, managers have the option of choosing either large or medium clump-sizes for transplanting, although results show that there are nearly 20 percentage points difference in survivals between the two clump-sizes. The choice of clump-size for *J. maritimus* however, is also influenced by plant spacing and the urgency for getting complete canopy closure. Larger clump-sizes planted at close spacings will give the quickest canopy closure compared with other combinations using smaller clump sizes and wide plant spacings.

As predicted in the 5 month assessment, transplanting of *J. maritimus* on the exposed site has completely failed. The most likely cause for this is the severe exposure on the seaward side of the estuary where wave action from open water constantly buffets transplants during wind at high tides. If transplanting is to be considered on such sites, then temporary artificial barriers should be considered in an attempt to reduce wave action on newly planted areas. In contrast to sheltered sites, mutual protection of plants at close spacing could enhance establishment on exposed sites and is one of the many treatments that requires further investigation on these difficult sites.

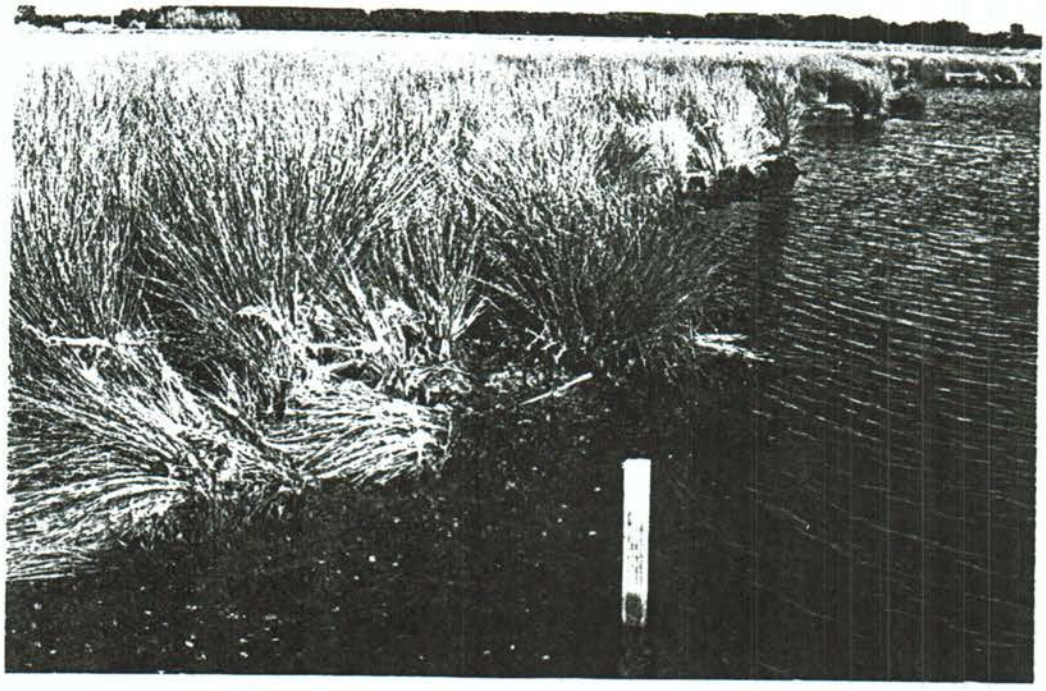

Plate 3: On the exposed seaward side of the salt marsh remnant, the margin of the vegetation has continued to retreat at a significant rate (0.7-1.5 m over 4 years). This datum peg was placed 4 years earlier at the edge of the vegetation but wave action and other factors during this period has resulted in the vegetation retreating by over 1 m. Parts of the original soil horizon are also evidence of the salt marsh retreat.

Plate 4: The level of the estuary has decreased around parts of the salt marsh remnant by 10 cm over the last 4 years. Consequently, edge plants particularly on the exposed side of the remnant are undermined by wave action, exposing root systems, and plants are washed out resulting in loss of salt marsh vegetation.

The low survival of medium and small clump-sizes of *L. similis* indicate that large clump-size is the only option for successful establishment of this species. Unfortunately, plant spacing was not tested with this species with all plots planted at only medium spacing (70 cm apart). It is likely to be a further year or more before even the larger *L. similis* transplants coalesce into uniform salt marsh vegetation (Plate 5). However, in a pilot planting of *L. similis* established a few months before the main transplanting trial was established, a dense uniform stand has formed indicating that although it is slower to expand than *J. maritimus*, *L. similis* will eventually occupy the site (Plate 6). All transplants in the pilot trial were equivalent to the large clump-size and were planted at the close spacing of 4 plants/m^2 (plants 50 cm apart).

6.2 Salt marsh retreat

Clearly, the salt marsh remnant at Maketu Estuary is still retreating at a significant rate. If at least 1 m of erosion of vegetation occurs each year along exposed margins, then the present remnant is likely to be reduced to discontinuous patches of salt marsh vegetation within 50 years and to disappear within a century.

The abrupt differences in levels between the salt marsh and the lower adjacent mudflat remains a significant feature. Suggestions that decline of the salt marsh is the result of the reducing elevation of the area, exposing marginal vegetation root systems to constant wave abrasion, and a possible link to the diversion of the Kaituna River nearly 40 years ago is discussed in Bergin (1991).

7. RECOMMENDATIONS

Where large scale transplanting is considered and resources are limited, medium-size clumps should be planted at wide spacing, with some mortality inevitable. However, where resources are sufficient, including adequate labour and a nearby source of healthy transplant material, and rapid revegetation of mudflats is desirable, the best option is to plant large transplants (100 x 100 x 150 mm depth) at close spacing (50 cm between plants).

Further work should include determining the optimum plant spacing for *L. similis*. Transplanting mixed species clusters of both *J. maritimus* and *L. similis* may also be worth evaluating.

Where restoration of previously vegetated sites is to be considered, it is prudent to consider, where possible, the relative proportions of species that once occurred on the site and their spatial patterns. The Maketu trial tested a greater range of treatments and sites using *J. maritimus* as it dominated both sheltered and exposed sites in contrast to *L., similis* which occurred only on the inland side of the remnant. Close examination of local vegetation composition and pattern of natural stands can often be a useful indicator of any habitat preferences and an appropriate mix of species before embarking on a revegetation programme of nearby degraded sites.

As most of the salt marsh vegetation decline of the Maketu Estuary is occurring along the exposed seaward side of the remnant, further investigation of techniques for transplanting indigenous vegetation to exposed mudflats is , urgently required.

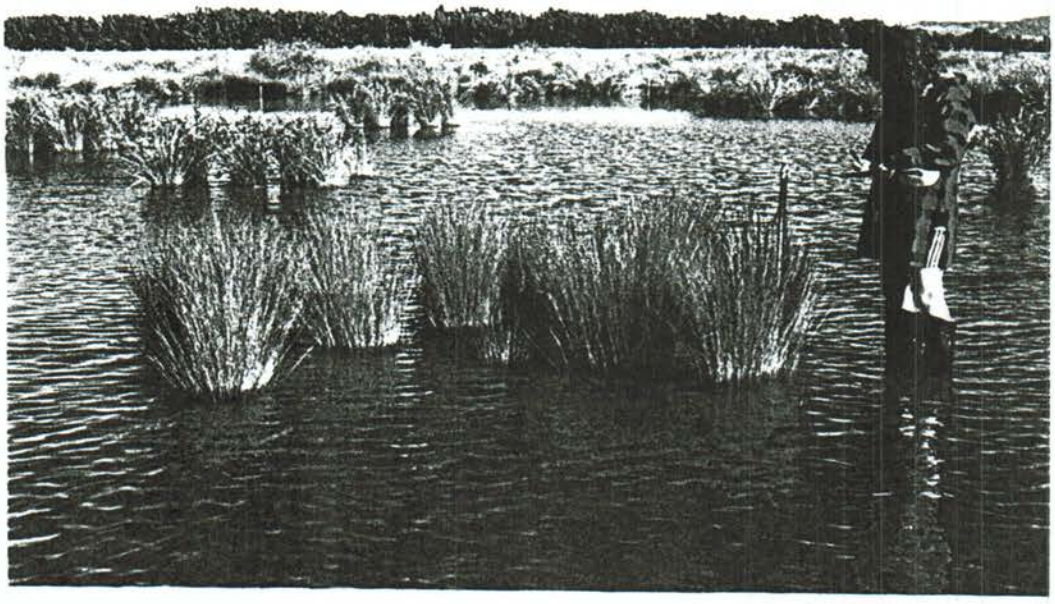

Plate 5: Large clumps of **Leptocarpus similis** *have not expanded as fast as* **Juncus maritimus.** *It will be at least a further year before this medium-spaced cluster (planted 70 cm apart 4 years earlier) of* **L. similis** *will have a closed canopy.*

Plate 6: **Leptocarpus similis** *established in a pilot trial has expanded in 4 years to fully occupy the site. Large clumps (100 x 100 x 150 mm depth) were transplanted at close spacing (50 cm apart). Although not tested in the main trial, the pilot trial does indicate that large clump-size and close plant spacing is the preferred option for this species. Growth of* **L. similis** *is not as fast as* **Juncus maritimus.**

8. ACKNOWLEDGMENTS

Greg Steward and Jessamy Herbert assisted with fieldwork. Mark Kimberley carried out the data analysis and John Herbert commented on the manuscript.

9. REFERENCES

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10. APPENDIX - Survival, mean top height, health score and canopy closure of transplant groups for major salt marsh species planted on the sheltered mudflat site, Maketu Estuary. Figures with the same letters are not significantly different.

Species	Treatments	No. of transplants	Survival of transplants (%)	Mean Group Height (cm)	Group* Health Score (1, 2, 3)	Group** Canopy Closure Score (1,2,3)
Juncus maritimus	Clump size					
	— large	180	89 a	98.9 a	1.0 a	1.8 a
	— medium	180	70 b	88.2 b	1.0 a	2.3 b
	— small	180	24 c	83.6 b	1.3 b	2.8 c
	Spacing					
	— wide	180	61 a	87.1 a	1.1 a	2.7 a
	— medium	180	61 a	93.2 a	1.1 a	2.3 b
	— close	180	61 a	90.9 b	1.1 a	1.8 c
	Block No.					
	— S1	180	55 a	92.7 a	1.1 a	2.2 a
	— S2	180	61 a	95.4 a	1.1 a	2.3 a
	— S3	180	67 a	82.2 b	1.1 a	2.4 a
	Fertiliser					
	— absent	270	62 a	90.2 a	1.2 a	2.4 a
	— present	270	60 a	90.6 a	1.0 a	2.2 a
	Clump-size x spacing					
	— large x close	60	93 a	100.7 a	1.0 a	1.0 a
	— large x medium	60	85 ab	101.7 a	1.0 a	1.8 b
	— large x wide	60	88 ab	95.0 ab	1.0 a	2.5 cde
	— medium x close	60	65 b	84.1 bc	1.0 a	2.0 bc
	— medium x medium	60	74 ab	94.2 ab	1.0 a	2.2 bcd
	— medium x wide	60	71 ab	84.2 bc	1.0 a	2.7 de
	— small x close	60	24 c	81.6 c	1.2 ab	2.6 de
	— small x medium	60	23 c	85.5 b	1.3 b	2.8 e
	— small x wide	60	26 c	82.2 c	1.3 b	3.0 e
Leptocarpus similis	Clump size					
	— large	60	78 a	76.7 a	1.0 a	2.7 a
	— medium	60	22 b	63.3 a	1.7 a	3.0 a
	— small	40	5 b	50.0 a	2.0 a	3.0 a
	Block No.					
	— S1	60	33 a	68.3 a	1.0 a	2.7 a
	— S2	60	42 a	56.7 a	2.3 a	3.0 a
	— S3	40	30 a	72.5 a	1.0 a	3.0 a

* Health score — 1-good; 2-intermediate; 3-poor

** Canopy closure score — 1-closed; 2-intermediate; 3-poor