NEW ZEALAND FOREST RESEARCH INSTITUTE LIMITED

PROJECT RECORD NO.: 6219

PORTFOLIO: RISK AND SUSTAINABILITY

PROJECT: MODIFYING THE ENVIRONMENT WITH PLANTS

CODE: 97 / 98 (Financial Year) | 145 (Old Resource Centre No.) | 2102 (Project) | (Sub-project) | (FRST Contract) | (Obj.)

WORK PLAN NO.: 2604 **EXPERIMENT NO.:**

TITLE: PERFORMANCE OF INDIGENOUS COASTAL PLANTS ON SAND COUNTRY, AWHITU PENINSULA

AUTHOR(S): D. O. BERGIN, D. HICKS & D. CRAIG **DATE:** 1998

KEYWORDS: MARRAM GRASS, INDIGENOUS SPECIES, SAND DUNES, EROSION, REVEGETATION

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A planting trial using indigenous tree and shrub species were established in mid-1996 by the Awhitu Peninsula Land Group to determine practical and cost-effective techniques for establishing an indigenous vegetation cover on erosion-prone sand country retired from grazing. Performance was best on the sheltered dense marram grass site. Of the five species tested, karo, pohutukawa, and harakeke have performed best with good survival and growth on the dense marram grass site and to a lesser extent in the kikuyu grass site. All species performed poorly on the more exposed, recently planted marram grass site where significant sand movement had continued to occur. Akeake performed poorly on all sites especially where seedlings were exposed to on-shore winds and virtually all knobby club rush had died out. Early results indicate that a cover of marram grass or dense kikuyu grass is providing shelter for planted trees and shrubs as long as planted gaps are kept small. Intensive weed control has been necessary to keep seedlings free of grass within the first year of planting. If growth continues with ongoing maintenance, the indigenous species may eventually suppress the grass cover.

PERFORMANCE OF INDIGENOUS COASTAL PLANTS ON SAND COUNTRY, AWHITU PENINSULA

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ABSTRACT

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KEYWORDS: Marram grass, indigenous species, sand dunes, erosion, revegetation

INTRODUCTION

The Awhitu Peninsula on the south head of the Manuka Harbour is dominated by high sand cliffs along the coast and extensive sand dune country landward of the cliffs which is for the most part in pasture. The sand country is either older relatively stable Redhills Sand or the more recent Pinaki Sand which is prone to serious erosion. The unstable sand dunes on the latter sand type can be extensive in area and spectacular. They impact on pasture growth with significant losses of livestock carrying capacity for some farmers (Lambrechtsen & Hicks 1995a).

With support from the Auckland Regional Council, local landowners formed the Awhitu Peninsula Land Care Group with an initial objective to reduce erosion of the coastal sand country. The intention of the group is to carry out a range of activities leading to a

sustainable management plan for their area and to carry out these activities primarily by involving landowners, and other interest groups in the district including Ngaati Te Ata. As part of a research programme developed for the Group (Hicks 1995), one priority area of research identified was an investigation of appropriate indigenous species to use on erosion-prone sites which are to be retired permanently from grazing.

A collaborative planting trial using indigenous tree and shrub species and monocots was established on a problem erosion site at Awhitu Peninsula in mid-1996 by the Awhitu Peninsula Land Group, Ecological Research Associates and the ***Forest Research***.

PREVIOUS WORK

Although there are guidelines for planting of indigenous species, most previous research has concentrated on revegetation of relatively sheltered inland sites and planting of upland forest sites (eg., Evans 1983; Pollock 1986; Beveridge *et al.* 1985, 1987). Existing information on techniques for stabilisation of sand country using indigenous tree and shrub species relevant to the Awhitu Peninsula has recently been compiled by Lambrechtsen & Hicks (1995a, 1995b).

Indigenous coastal species screening trials established at Whitianga Beach on a modified backdune (Bergin *et al.* 1995) and on marram grass (*Ammophila arenaria*) dominated backdune sites at South Brighton and Waimairi Beaches in Christchurch (Bergin, Herbert & White 1996). The North Island trial was part of a large dune nourishment project using local indigenous species. The South Island trial was aimed at the determination of appropriate strategies for establishing mainly indigenous vegetation on backdunes currently dominated either by marram grass (*Ammophila arenaria*) or ice plant (*Carpobrotus edulis*). Several thousand nursery raised seedlings were planted at both sites. The range of species trialed included coastal ground cover, shrub and tree species. Fully replicated trials were used to evaluate the effects of seedling quality and size, site characteristics, and application of bark mulch and Magamp fertiliser.

The Whitianga trial has shown high survival rates and good growth for most of the 26 indigenous species planted (Bergin & Herbert 1997). Application of a Magamp fertiliser at planting has boosted growth of seedlings. Some species have benefited from artificial shelter. No improvement was apparent where a bark mulch had been placed around seedlings. The trial has identified at least 10 hardy indigenous species with high survival and good growth rates. These were flax (*Phormium tenax*), the woody ground covers pohuehue (*Muehlenbechia complexa*) and sand coprosma (*Coprosma acerosa*) and the coastal shrub and tree species akeake (*Dodonea viscosa*), coastal five finger (*Pseudopanax lessonii*), pohutukawa (*Metrosideros excelsa*), ngaio (*Myoporum laetum*), karo (*Pittosporum crassifolium*), taupata (*Coprosma repens*) and tauhinu (*Cassinia leptophylla*). The height response to fertiliser treatment is shown for five of these better performing coastal species in Figure 1. Of 16 indigenous species planted in the South Island trials, only three, tauhinu (*Cassinia leptophylla*), *Euphorbia glauca* and flax (*Phormium tenax*), have shown reasonable survival and growth on the marram grass-dominated site. Performance of all species planted on ice plant dominated dunes at Christchurch has been poor.

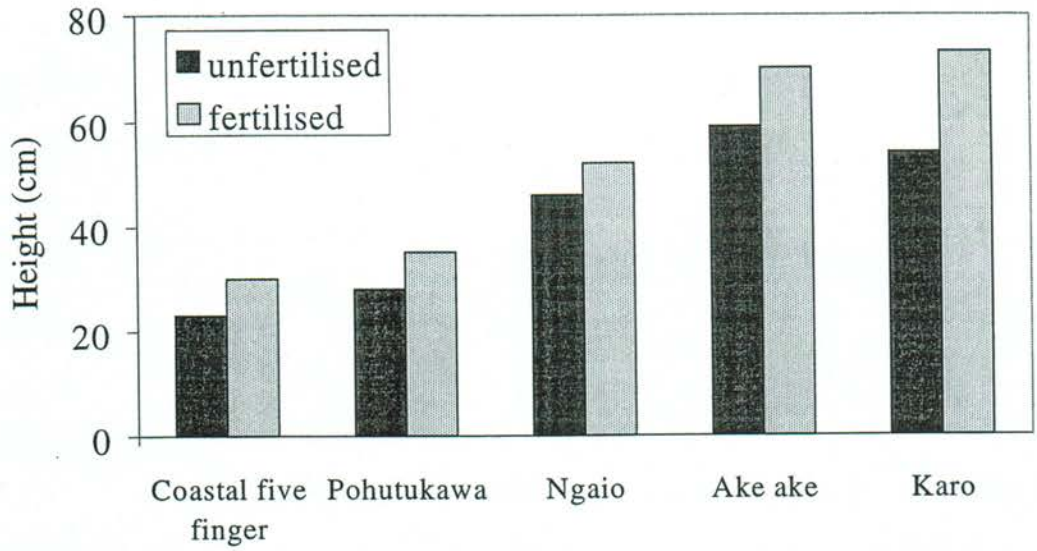

Figure 1: Height of nursery-raised seedlings of indigenous coastal trees and shrubs 12 months after planting on a modified backdune site at Whitianga, Coromandel Peninsula. Magamp fertiliser (30g/seedling) was applied at time of planting to seedlings in fertilised plots.

Although these beaches are substantially different to the Awhitu sand country, results clearly indicate a range of hardy indigenous species that are likely to have reasonable performance when planted on a backdune site. It was therefore necessary to evaluate the performance of these species where they were locally appropriate and stock could be sourced for the Awhitu Peninsula site so that the most appropriate species and the most effective techniques for large scale revegetation could be determined.

OBJECTIVES

The overall objective of a revegetation trial at Awhitu Peninsula is to determine practical and cost effective techniques for establishing an indigenous vegetation cover on erosion-prone sand country.

Specific aims include:

- To evaluate performance of planted seedlings of a limited range of appropriate local indigenous species.
- To evaluate a range of treatment options including up to three site types, and site preparation treatments.
- To provide the Awhitu Peninsula Land Group, other local interest groups and local authorities with guidelines for revegetation of unstable sand dunes using indigenous species.

METHOD

Trial design and treatments

Five indigenous plant species were tested based on results of previous work and availability of stock. These were:

Pittosporum crassifolium (karo)
Metrosideros excelsa (pohutukawa)
Dodonea viscosa (akeake)
Phormium tenax (harakeke)
Isolepis nodosus (knobby club rush)

Planting stock of the hardwoods was sourced from local nurseries. Divisions of harakeke split off nearby mature plants and clumps of knobby club rush were obtained from established plants using a spade.

Three different site types were also tested. The planting site types were typical of areas retired from grazing that were eroding or had the potential to be major problem erosion areas on sand country along the exposed western side of Awhitu Peninsula. Three sites with different vegetation types on David Craig's property on the Pinaki Sand type were planted:

1. Dense marram grass site - dunes dominated by a tall continuous cover of marram with limited gaps between clumps.
2. Recently planted marram grass site - recently planted marram grass on irregular dune areas with a high proportion of exposed sand.
3. Ungrazed kikuyu grass (*Pennisetum clandestinum*) site - ungrazed pasture of rank grass that had been recently retired.

At all site types, the trial was a Randomised Complete Block design consisting of 8 replicates each with 5 plots. Each plot consisted of 5 seedlings of the same species and each treatment consisted of 40 seedlings (8 reps x 5 seedlings).

All sites had been permanently retired from grazing and fenced to exclude stock. The trial was established in autumn 1996 (late May/early June) by the Awhitu Peninsula Land Group.

Site preparation

Due to the exposed nature of the site and the importance of retaining an almost continuous cover of vegetation to prevent sand erosion, site preparation involved creating small planting spots for the planting of small groups of 5 seedlings each. Grass sites were spot-sprayed with Roundup and Pulse to create 60 cm diameter spots for the planting of a single seedling. For the recently planted marram grass site, there was sufficient bare sand available between marram grass clumps to plant indigenous seedlings with no clearance of marram grass. For the dense marram grass site, natural gaps were used where possible with expansion of gaps by cutting back overtopping vegetation and minimal removal of marram grass clumps only where necessary by spade.

Application of fertiliser

Approximately 30 - 40g of Magamp medium granule slow-release fertiliser (small-medium handful) was applied to all seedlings. Results from previously established sand dune trials using the same species (Fig. 1) consistently indicated that fertiliser boosts growth and

improves vigour compared to unfertilised seedlings (Bergin & Herbert 1997). Fertiliser was incorporated into the sand at planting.

Monitoring

Planting height and cover were measured for all seedlings soon after planting and one year after planting with survival and any factors affecting plant performance such as browsing by rabbits or hares, and in particular, growth of grass, marram grass and weeds monitored by the landowner at greater frequency within the first year. A subjective assessment of plant vigour and health was also completed 12 months after planting.

INTERIM RESULTS

Seedling performance

The full range of parameters used to assess performance of the planted seedlings at the Awhitu Peninsula trial are given in the Appendix. Most parameters assessed show consistently better survival and growth for akeake, harakeke, karo and pohutukawa over the first 12 months since planting on the dense marram grass and kikuyu grass sites compared to the more exposed sparse marram grass site. With the exception of knobby club rush, survival, height growth and increment, plant spread and increment, and the subjective assessment of plant vigour were all significantly greater in the dense marram grass site compared to the other sites. Increment in height is relatively small even on the better sheltered sites ranging from 7 to 24 cm. For most species planted on the sparse marram grass site, there was a decrease in height and plant cover since planting. Knobby club rush had worst survival on all sites tested with virtually all transplanted clumps having died out within 12 months of planting.

Survival and height of planted seedlings 12 months after planting are shown in Figure 1 and Figure 2 respectively and clearly show a consistent trend for most species with decreasing performance of planted indigenous seedlings with increasing exposure on the kikuyu grass site and the sparse marram grass site. For all species except knobby club rush, survival was close to or exceeded 90% on the sheltered dense marram grass site. Harakeke was the most consistent on all sites with high survival and good growth on all sites. Of the five species planted, performance of akeake varied the most with very poor survival and growth on the exposed sparse marram grass site, less than 50% survival on the kikuyu grass site and almost full survival and good growth on the dense marram grass site. In general, seedlings are still relatively small even on the sheltered sites with average heights ranging from about 50-60 cm for akeake, karo and pohutukawa.

Field observations

Dense marram grass site

Overall, seedlings planted on the dense marram grass site are performing best compared to the more exposed sites. On this site, the marram grass is up to 90 cm tall site and well above the height of most planted seedlings even one year after planting. All species appear to be benefiting from the increased shelter of the tall marram grass but all planted groups have been released several times to keep tops of surrounding marram grass clumps from overtopping planted seedlings. Releasing involved cutting back the foliage of overhanging marram grass tops with shears. The possible vigorous root competition of surrounding marram grass is probably outweighed by the shelter provided by the tall vegetation.

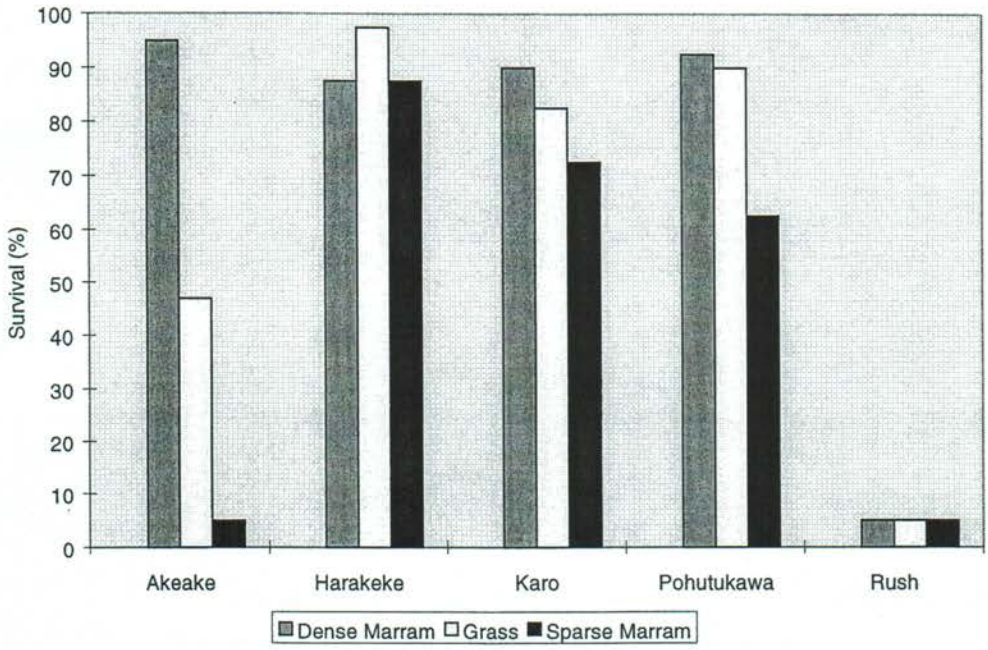

Figure 3: Survival of planted indigenous seedlings 12 months after planting on the three sites, Awhitu Peninsula.

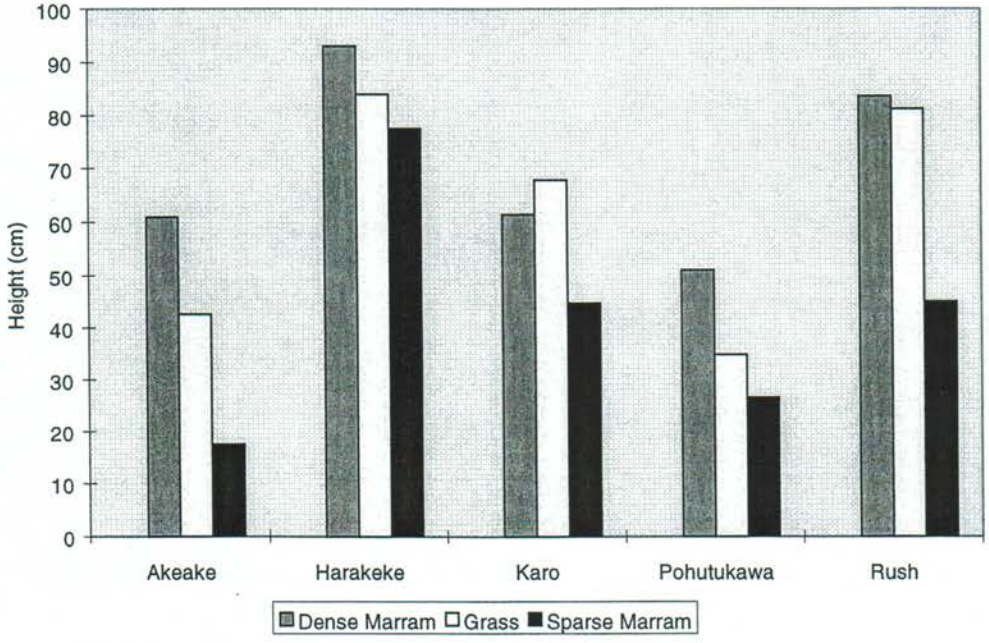

Figure 3: Total height of planted indigenous seedlings 12 months after planting on the three sites, Awhitu Peninsula.

Most dramatic evidence of the effects of exposure is shown with akeake which are growing vigorously within planted gaps but where tops of taller plants which have grown above the height of the surrounding marram grass have been burnt off with defoliation and blackened stems. This has also occurred in the Whitianga backdune planting trial where akeake up to 1.5 m high have become severely wind shorn due to strong on-shore winds with similar defoliation and blackening of exposed tops (Bergin & Herbert 1997).

Most losses of plants have been in plots located near the top of the dune especially on the seaward facing slope where there has been 15 to 60 cm sand accumulation even though the site is covered in dense marram grass. Source of sand is an adjacent blowout immediately seaward of this part of the site. Increased sand levels would therefore have masked growth increment for seedlings on this site.

Sparse marram grass site

Of the three sites, this is clearly the worst site for performance of planted seedlings for all species. High mortality has occurred due to high exposure to wind and decreases or increases in sand levels. Survivors tend to be amongst existing clumps of marram grass or in the lee of sand ridges. Wind funnelling throughout the site is complex and would make choosing suitable planting sites very difficult. Most knobby club rush and Akeake have disappeared from exposed sites with only occasional seedlings of the other species present in poor condition. Harakeke which have been undermined by wind action are occasionally hanging on by straggly roots.

Kikuyu grass site

Despite a dense cover of rank kikuyu grass over all plots, there is generally good survival and growth for all species except knobby club rush. The pre-plant spot spraying gave adequate control of kikuyu for a maximum of 6 months after seedlings were planted. Harakeke have not been released since planting but the planted tree and shrub species were hand released at least three times during the period 6-12 months after planting. This involved pulling grass away from the base of each seedling but not opening up the gap too much. Akeake in particular has been worst affected by dieback of exposed tops.

CONCLUSIONS

In general, growth rates within the first year of planting at the Awhitu Peninsula trial on the sheltered dense marram grass site are similar to growth rates of the same species in planting trials established at Whitianga on the east coast at close to the same latitude (Bergin & Herbert 1997). As with the east coast trials, the most critical factor determining performance is degree of shelter from on-shore winds and is most apparent with the effects of top dieback and wind shear of akeake in trials at both Awhitu and at Whitianga. Initial results at Awhitu demonstrate the need to provide shelter for planted indigenous species.

There are likely to be few practical alternatives to planting exposed bare sandy sites with marram grass to provide an initial cover crop. Marram grass is a more vigorous sand binder than any indigenous sand binding species on these sites (eg., Partridge 1992) and there are unlikely to be practical alternative exotic species that could be used as a temporary nurse crop while indigenous species became established.

Plate 1: Dense marram grass site planted on retired farmland where vigorous plants are over 1 m in height. Gaps between clumps of marram grass have been enlarged to allow planting of small groups of indigenous seedlings 12 months previously including karo (foreground) and harakeke (background). Most seedlings are still below the nurse crop canopy. Dieback of exposed tops of akeake has occurred where they have grown above the marram grass canopy.

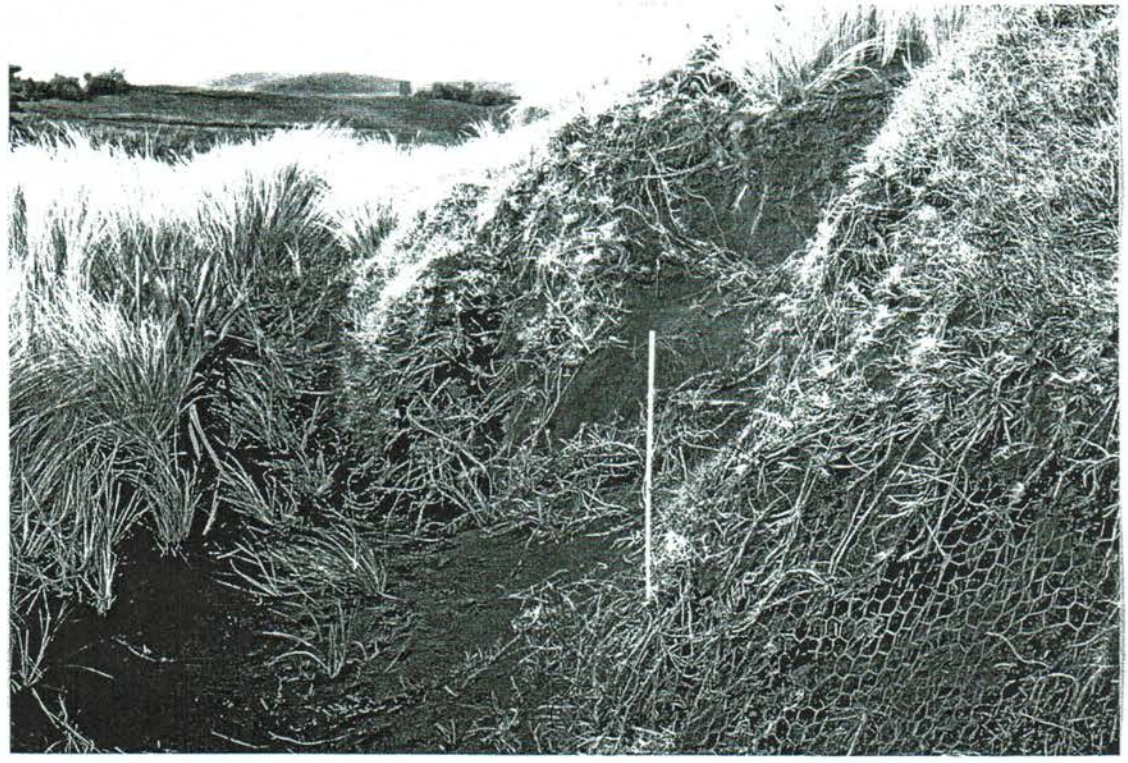

Plate 2: Sparse marram grass site where most planted seedlings have died or are unthrifty due excessive exposure and sand movement especially in the vicinity of wind channels and major blow-outs. Note previous attempts at controlling sand movement with netting.

Plate 3: Kikuyu grass site with small groups of planted indigenous seedlings identified by centrally located wooden pegs. There has been good survival and growth of pohutukawa, karo and harakeke but planted seedlings have required hand releasing to keep seedlings free of dense kikuyu once the effects of pre-plant herbicide spray diminished about 6 months after planting.

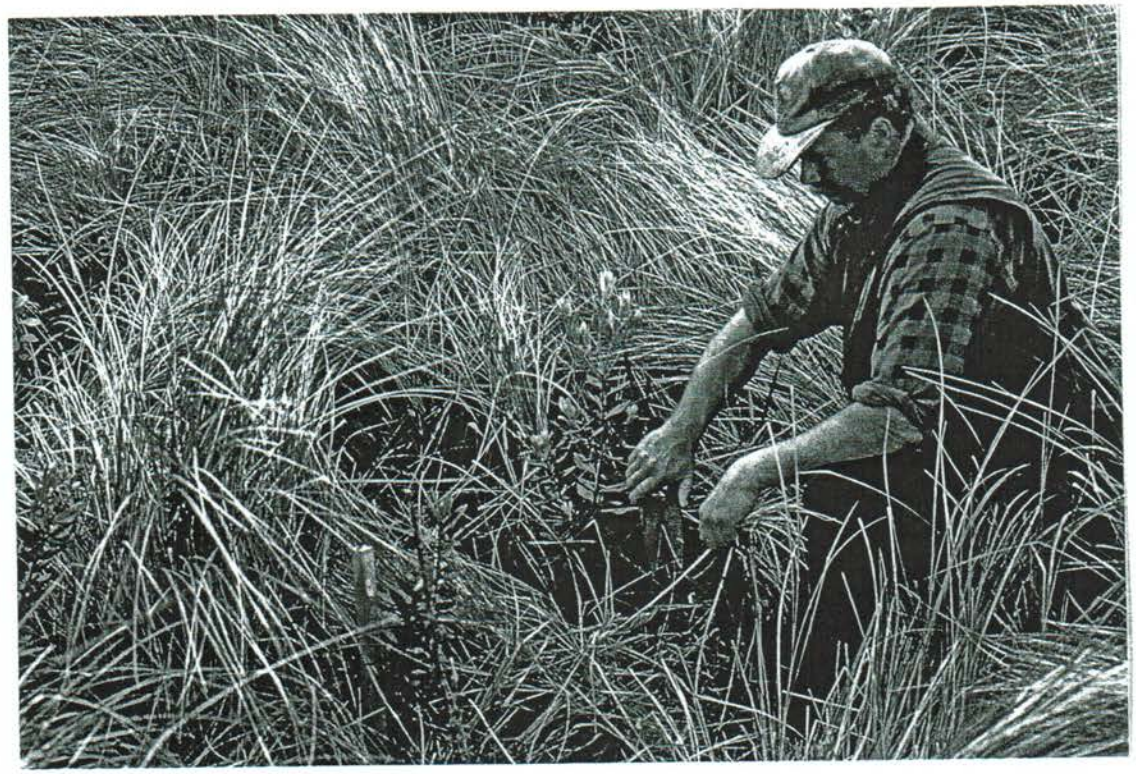

Plate 4: Releasing of planted seedlings in the dense marram site has been necessary several times since planting a year ago. Shears have proved effective in clipping back overtopping marram grass while still maintaining a sheltered gap for growth of indigenous seedlings.

Where planted seedlings are kept free of overtopping nurse vegetation, indigenous trees and shrubs should overtop surrounding grass cover eventually. Suppression of the grass cover may only be possible however in the vicinity of planted groups unless areas are densely planted. The rationale for planting small groups is to establish clumps of vegetation that will create sheltered sites between planted clumps that will encourage natural regeneration of a wide range of locally indigenous trees and shrubs. Large-scale blanket planting of such sites is likely to be too expensive for most owners and impractical to keep seedlings free of competing nurse vegetation in early years.

Where marram grass is performing a nurse crop role in providing some sand stability and shelter, there are likely to be other indigenous species that could be tried on these difficult sites at Awhitu in addition to those tested in this trial. Since the trial was started, cabbage tree (*Cordyline australis*) has been planted by the landowner David Craig. Other species that have performed well in ***Forest Research*** trials on backdunes include tauhinu (*Cassinia leptophylla*), houpara (*Pseudopanax lessonii*) and taupata (*Coprosma repens*). However, further investigation is required to determine whether these species are local to Awhitu Peninsula and whether there are other local species that should be evaluated.

INTERIM RECOMMENDATIONS

Based on the early performance of selected indigenous species planted on an exposed sand country site at Awhitu Peninsula, some interim recommendations are given:

- A dense cover of marram grass or to a lesser extent dense kikuyu grass will provide adequate shelter for planted trees and shrubs as long as planted gaps are kept small.
- The small gaps will require constant maintenance to ensure planted seedlings within dense covers are not suppressed.
- Best performing species tested in the trial to date are harakeke, karo and pohutukawa; akeake is prone to dieback of foliage exposed to salt-laden winds and therefore would be more suited to sites further inland.
- Areas planted with indigenous species need to permanently fenced off; some indigenous seedlings are highly palatable to rabbits and hares so control may be necessary.
- It is not worthwhile planting any indigenous species in exposed sites in sand country where there is no vegetation or sparse vegetation; densely plant exposed bare sand areas with marram grass to provide a dense nurse crop.
- Plant small groups of indigenous seedlings in dense marram grass to utilise natural gaps where possible, to maximise shelter effects of surrounding vegetation and to allow easier relocation of a compact seedling group that has some degree of mutual protection.

ACKNOWLEDGMENT

Mark Kimberley (***Forest Research***) assisted with trial design, data analysis and production of graphs.

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APPENDIX - Performance of the five indigenous coastal species planted on three different sites on erosion-prone sand country, Awhitu Peninsula.

Species	Site	Survival (%)	Height (cm)	Height increment (cm)	Plant spread[1] (cm)	Plant spread[1] increment (cm)	Vigour[2]
Akeake	Dense marram	95.0 a	60.8 a	23.7 a	34.7 a	19.1 a	3.9 a
	Kikuyu grass	46.9 b	42.8 b	16.6 b	20.8 ab	9.1 a	2.7 b
	Sparse marram	5.0 c	17.5 c	-8.9 c	9.7 b	-2.1 b	2.4 c
Harakeke	Dense marram	87.0 a	93.0 a	17.4 a	72.0 a	33.8 a	4.4 a
	Kikuyu grass	97.0 a	84.0 ab	14.7 a	74.0 a	22.3 b	4.7 a
	Sparse marram	87.0 a	77.5 b	-4.4 b	65.1 b	14.6 c	3.2 b
Karo	Dense marram	90.0 a	61.3 a	8.8 a	25.0 a	9.7 a	4.2 a
	Kikuyu grass	82.0 a	67.8 a	10.8 a	21.7 b	6.7 b	3.8 ab
	Sparse marram	72.0 a	44.7 b	-2.6 b	14.6 c	1.3 c	3.0 b
Pohutukawa	Dense marram	92.5 a	51.0 a	6.9 a	36.3 a	16.8 a	4.5 a
	Kikuyu grass	90.0 a	34.8 b	-3.7 b	24.9 b	3.9 b	3.5 b
	Sparse marram	62.5 b	26.6 b	-12.9 c	16.6 c	-2.5 b	2.1 c
Rush	Dense marram	5.0 a	83.7 a	50.0 a	23.4 a	12.7 a	3.4 a
	Kikuyu grass	5.0 a	81.2 a	59.7 b	26.8 a	21.2 b	3.1 a
	Sparse marram	5.0 a	45.0 b	21.4 c	24.1 a	11.0 a	2.9 b

[1] Plant spread - square root of length x breadth

[2] Vigour of plants within species assessed as 1 - poor, 2- unthrifty, 3 - average, 4 - good, 5 - excellent

Within groups, values followed by the same letter are not significantly different (5% probability level)