COASTAL DUNE VEGETATION NETWORK

PROCEEDINGS OF THE COASTAL DUNE VEGETATION NETWORK 2002 CONFERENCE

'THE WILD WEST COAST'

compiled by

Greg Steward

forest research

Massey University
COLLEGE OF HUMANITIES & SOCIAL SCIENCES

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The Coastal Dune Vegetation Network Coordinating Committee is grateful to Bernie Salmon for the wonderful artwork on the front cover of the Proceedings.

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The Coastal Dune Vegetation Network would like to acknowledge and thank the following organisations who have sponsored this 5th Conference of the Coastal Dune Vegetation Network

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COASTAL DUNE VEGETATION NETWORK MISSION STATEMENT

To provide a forum for the free exchange of information on sustainable management of coastal dune ecosystems with emphasis on the use of vegetation to restore natural character, form and function.

NETWORK OBJECTIVES

The objectives of the Network are:

1. **To provide direct funding support, from Financial Members, for prioritised research projects.**

2. **To provide leverage through Members contributions to attract Public Good Science Funds and optimise returns to the Coastal Dune Vegetation Network.**

3. **To respond to coastal resource managers and user-sourced research priorities through a process of mutual prioritisation in consultation with collaborators.**

4. **To provide high quality, timely, research-based information and management outcomes to Coastal Dune Vegetation Network membership through field trips, meetings, workshops, and by other appropriate means.**

AGENDA

Venue: The Science Centre, 396 Main St, Palmerston North

Wednesday 13th February

8.30 - 10.00am	**Registration**		Display set-up	
9.45 - 10.15am	**Morning tea**			

Formal Welcome

10.15 - 11.00am				**(Chaired by Harley Spence)**
		5 min	Welcome	Annette Main (Councillor, horizons.mw)
		15 min	History of sand country land use	Denis Hocking
		30 min	Geomorphology and coastal dynamics of sand country	Patrick Hesp

Technical Session 1.

11.00 - 12.15pm	**Santoft**			**(Chaired by Lachie Grant)**
		20 min	Sand country forestry	Pat McCarthy
		15 min	Trial site - vegetation	Diana Gainsford
		10 min	Trial site - dune dynamics	Patrick Hesp
		30 min	Discussion on future management	
12.15-1.15	**Lunch**			

Technical Session 2.

1.15-3.00	**West Coast Trials**			**(Chaired by Don Clark)**
		15 min	Te Henga (Bethells Beach), West Auckland	David Bergin
		15 min	Awhitu Peninsula	David Craig
		15 min	New Plymouth	Ken Schischka, Paul Jamieson
		15 min	Waikawa	Aaron Madden
		30 min	Panel Discussion	
3.00 - 3.30pm	**Afternoon tea**			

Technical Session 3.

3.30 - 5.15pm	**Regional Roundup**		Karen Baverstock - Auckland Justin Cope - Canterbury Jason Roberts - Christchurch Paul Pope - Dunedin Sarah Flavall - Northland Greg Jenks – Bay of Plenty Dave Harrison Jnr – Manawatu	**(Chaired by Jim Dahm)**

5.45pm Cocktails

Thursday 14th February 2002

Field Trip.

8.00 am	**Depart Science Centre**	**Issues**
9.30 am	**Paki Paki Bush**	• Remnant dune forest
11.15 am	**Waitarere Beach**	• Introduction to an accreting beach • Foredune re-development • Access & surf-club issues • Resource consent requirements
12.30 pm	**Foxton Beach (lunch)**	• Carpark development • Pro-grading & accreting coastline
1.30 pm	**Fox-Tangi parabolics**	• Dynamics of parabolic dunes • First principles of secondary plantings • Managing off-road vehicles • Options for managing foredune blowouts
3.30 pm	**Himatangi beach**	• Foredune reshaping • Introducing Spinifex to a marram dominated dune • Stream management • The invasion of *Acacia sophorae*
4.30 pm	**Tangimoana**	• Challenges of coastal exotic forestry • DOC reserve
5.00 - 5.30 pm	**Return to Palmerston North**	

7.30pm Conference dinner at the Loaded Hog, Coleman Pl, Palmerston North

Friday 15th February

David Bergin to introduce. Long.

Technical Session 4.

8.30 - 10.00am	**Coastal Plants and Dune management**			**(Chaired by Dave Harrison Jnr)**
		30 min	Rare and endangered coastal plants of the region	Colin Ogle
		20 min	Coastal zone management strategies and techniques	Lucy Brake
		15 min	*Acacia sophorae* invasion	Jim Campbell Range Mgr
		15 min	Managing animal pests in an urban environment	Greg Corbett
			Discussion	
10.00 – 10.30 am	**Morning tea**			

CDVN AWARDS will be held by

Annual General Meeting

10.30 – 12.30 pm			• Coordinators report • Financial statement • Presentation of workplans for new CDVN projects on - restoration of native plant communities on backdunes - propagation and establishment of *Euphorbia glauca* - control of rabbits/hares on sand dunes - panel discussion on future direction of present trials and new projects • Next years conference venue • General business

The Manawatu Dunefield: Environmental Change and Human Impacts

PATRICK A. HESP

ABSTRACT

Four stages of environmental change are apparent in the Manawatu coastal landscape: the first stage was that of a world wide sea level rise and initiation of the first major dune phase (Foxton or phase I) in the Manawatu. This was followed by a second dune-building phase (Motuiti or phase II), which was probably initiated by climate change. The second stage occurred in the last 600 to 1000 or so years when Maori first occupied the area, rapidly causing the extinction of a range of fauna, significantly altering the vegetation cover and potentially initiating or assisting the development of a new dune phase (Waitarere or phase III). The latter part of the Waitarere phase (phase IV) or episode may have been initiated by Europeans in the last 150 years. The third stage of environmental change occurred in the period 1940 to 1990 when large scale sand sheets and transgressive dunefields were significantly stabilised by humans, and parabolic dunes were created. A fourth stage is just beginning where an entirely new suite (or episode) of parabolic dunes has developed from blowouts within the foredune in the last 10 years. Overall, human impact has wrought major environmental changes to one of the greatest examples of Holocene dunefields in New Zealand.

ABOUT THE AUTHOR

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The parabolic and transgressive dunefield that extends from Patea to near Paekakariki is the largest in New Zealand, extending approximately 200 km north to south and 18 km wide at its widest point (at Rangiotu). It was formed over approximately 10,000 (the northwestern cliffton dunefield portion) to 7000 years in several phases. In the following pages, the evolution and structure of the dunefield is outlined, and the environmental, principally vegetational, conditions that pertained prior to human disturbance are briefly reviewed. The latest dune phase was initiated around 1000 years ago, but an accurate photographic record of environmental changes phase is only available for the last 60 years. This paper also provides a review of the record for the Himatangi to Foxton section of the dunefield, and some reflections on the implications of the observed changes.

The Holocene environment

There have been several dune building phases in the Manawatu. Cowie (1963) stated that the term "dune-building phase" was used in a time sense and included "the interval between the formation of the dune complex, either by accumulation of sand along a foreshore or by renewed wind erosion of previously stabilised dunes, and the stabilisation of the complex by vegetation and the initiation of soil development" (p. 269).

Cowie identified four dune building phases in the Manawatu, principally on the basis of soil development, three of which are considered here. According to Cowie, the most landward Foxton phase dunes are probably 2000 to 4000 years old. He considered that the Motuiti phase was younger than 1000 years and stabilized around 500 years ago. Cowie noted that the Waitarere phase covered European artifacts and introduced plants and was less than 120 years old (Figure 1).

Muckersie and Shepherd (1995) have since carried out further dating of the dune phases, and estimated dune ages based on rates of sand migration.

The first dune building phase (phase I of Muckersie and Shepherd, 1995) probably began at least 6500 years ago at or near the close of the Post-glacial Marine Transgression when the Manawatu coastline was approximately 4km

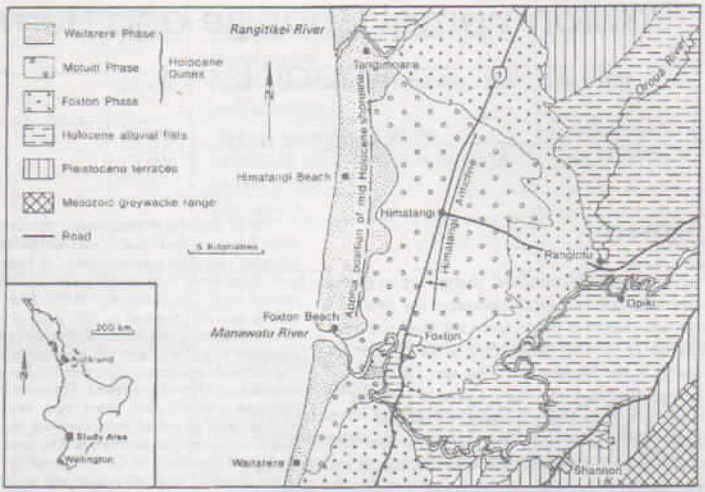

Figure 1: Geomorphology of the Manawatu Region. Cowie's (1963) three dune phases are indicated. Modified from various sources including Cowie (1963), Kingma (1967), Hesp and Shepherd (1978) and Muckersie and Shepherd (1995).

eastwards (landwards) of its present position (Shepherd et al., 1986; Muckersie and Shepherd, 1995). The timing of initiation of this first phase is in accord with the timing of the first Holocene dune phase development recorded in many places (e.g. Thom et al., 1992; Hesp, 1999). Parabolic and transgressive dunes (somewhat equivalent to the Foxton phase of Cowie, 1963) continued to be generated until around 4500 years BP, migrated 15km inland in several waves, and appear to have fully stabilised by around 1600 years BP ago (Shepherd, 1987).

The second dune phase began approximately 3500 years BP and ended around 1300 years ago, according to Muckersie and Shepherd (1995), so phase I and phase II dunes were active at the same time. Note, however, that Cowie (1963) reported that at the Whirokino cut, Motuiti phase dunes overlie Maori occupation remains believed to be younger than 1000 years. Phase II may have been initiated by continuing offshore profile adjustment, tectonism and landslide development and related sediment delivery via rivers, volcanism (the Motuiti phase dunes contain Taupo pumice dated at 1750 cal BP; Froggatt and Lowe, 1990), and climate change (greater windiness; aridity; increased storminess: higher rainfall in catchments resulting in increased sediment delivery; Hesp and Thom, 1990; Muckersie and Shepherd, 1995). Uplift of the Himatangi anticline (Figure 1) causing nearshore adjustments and progradation is a possible mechanism but that appears unlikely, given the stratigraphic position of mid-Holocene estuarine sediments in the Manawatu estuary (M. Shepherd, pers. comm.).

Cowie's (1963) third phase (Waitarere) has been split into two possible phases by Muckersie and Shepherd (1995), with phase III possibly initiated by Maori no more than 1000 years BP and phase IV initiated by Europeans and ongoing (Muckersie and Shepherd, 1995). McFadgen (1985) separated Cowie's Waitarere phase into two episodes, the older of these being initiated 300 – 550 years BP and (possibly) stable (at least on the eastern margin) by 1889. A discontinuous line of small lakes and swamps occurs along the eastern margin of the Waitarere phase (Figure 1).

It is important to note that the Manawatu coast is progradational and accreting at 0.5 to 1 metre per year, with foredunes accreting at around 20m³/m of dune width per year (Johnson, 1987). Despite this, parabolic dunes, and, to a lesser extent, transgressive dunes have completely dominated dunefield development. Foredunes only occur on the seaward margin and no relict foredunes exist within the Manawatu dunefield (Shepherd, 2000; Hesp, 2000; Shepherd and Hesp, in press).

McGlone (1989) and McGlone et al. (1997) indicate that the Manawatu region was vegetated, with tall conifer-broadleaf forest and small patches of beech forest 3000 years ago. The pollen and archaeological record indicates that forest was already well established on the Motuiti and

older Waitarere dunes by the time Maori arrived (Adkin, 1948; McFadgen, 1985, 1995). The McGlone maps are, of necessity, generalised. It is likely that while the landward dunefields were largely forested, the more seaward dunes would have a mosaic of kuhikatea, rotara and cabbage tree dominated swamp and deflation plain forest, Tawa dominated forest on drier sites, kanuka and manuka on the younger stabilised dune ridges, and toi toi and scrub on the recently active dunes. Those proposals are based on observations of bush remnants in the region (cf. McFadgen, 1985; 1995; Ravine, 1992)

Polynesian impact

Maori may have first moved into the Manawatu region 650 - 700 years ago (McGlone, 1983; Bussell, 1988; Anderson, 1991; McFadgen et al., 1994; McGlone and Wilmshurst, 1999) or possibly earlier (Holdaway, 1996; Matisoo-Smith, 1994; Flenley, 2000a). The natural vegetation cover in coastal Manawatu may well have been reduced or largely destroyed by Maori using fire to encourage the growth of bracken fern (Burton, 1968; McFadgen, 1985; cf. Bussell, 1988), timber felling for pa construction and housing, for fuel, and horticulture. Population size is difficult to determine, but Buick (1903) reports that by 1855 there were numerous *pa* along the Manawatu River near Foxton and they contained an estimated population of 3400. Records elsewhere in coastal New Zealand (e.g. Matakana Island, Northland region) indicate that significant forest clearance took place following Maori arrival, and dune initiation and/or mobilisation occurred (e.g. Enright et al., 1988; Enright and Anderson, 1988; Coster, 1989; Shepherd et al., 1997).

Cowie (1963) inferred that the latest dune (Waitarere) 'phase' was initiated after the 1840s, while Muckersie and Shepherd considered it likely that the earlier part of the Waitarere phase (their phase III) was initiated by Maori. While it is certainly possible that Maori burning and clearing of the vegetation may have initiated dune mobilisation, the 7000 year history of this coast is one of either semi-continuous or phase-like development of dunes which continues to this day. Therefore, Maori de-vegetation (partial or otherwise) of the dunes would have resulted in re-activation of existing dunes. While this is regarded as a new dune-building "phase" by Cowie (1963) in his definition above, the dune-building episode had either already begun or Maori were re-activating Motuin dunes. Since sediments were still being supplied to the coast at that time (Griffiths and Glasby, 1985) it may be that Maori disturbance merely assisted the mobilization of a coincidentally occurring dune development episode.

Similar comments apply to the later part of the Waitarere phase (phase IV). Under Cowie's definition of a 'phase', European destabilisation of the near-coastal dunes produced a new dune phase. Colonial and post-colonial clearing of catchments would have added sediment to the coastal system, but it is unknown if this, in conjunction with dune disturbance, *initiated* the latest dune phase (as indicated by Muckersie and Shepherd, 1995) or merely added to a naturally developing dune-building episode.

1800s to 1940 changes

A map of vegetation around 1840 shows that the Manawatu dune country was largely fernland, grassland, shrubland or swamp (Anderson and McGlone, 1997; McGlone et al., 1997). An 1840s to 1860s map indicates that most of the coastal dune terrain was 'open sandy country' and 'scrub and fernland' with a few small areas of bush remaining (Esler, 1978; Roche, 1997; Flenley, 2000b). Adkin (1948) indicates that the forest edge was roughly co-incidental with the inland edge of the dunefield when Europeans arrived.

Stock grazing began in the region by the 1840s, when Pakeha settlers began leasing land from Maori in the region (Ian Matheson, PNCC Historian pers. comm.; House of Representatives, 1864). In 1847 the Reverend John Inglis reported that there was a resident European population of approximately 50 persons along the Manawatu, noting that they were 'very immoral characters' (The Scottish Presbyterian, 1847; Owens, 1972). The National Government took over the land in the Foxton and Rangitikei-Manawatu regions in 1858 and 1866, respectively (I. Matheson pers. comm.). This Crown land was then sold to private ownership from the 1870s onwards. Stock grazing had a major impact on the coastal vegetation and dune terrain. It was typical to graze stock on the foredune and adjacent landward dunes. For example, in 1848 and 1856 the Ngati Awa people moved from Waikanae to the Tararuki region. Some travelled northward along the beach driving their animals before them (Macnorran, 1969; McKelvey, 1999). Some coastal farms had significant stock numbers; for example, Davies and Stuart were running 10,000 sheep in 1886 on a farm immediately south of the Manawatu river mouth (Dreaver, 1984). By 1881 Travers stated that the extensive mobile dunes existing between Paekakariki and Wanganui were a direct consequence of cattle and sheep grazing (Travers, 1881). McDonald and O'Donnell (1929) state the same. Wilson (1959) states that when he took over the property north of Himatangi in 1904 "it had been leased for 15 years, and large numbers of bullocks had been run in the winter, and they had completely eaten out the spinifex (*Spinifex sericeus*) on the coast between the Manawatu and Rangitikei Rivers; and had started many sand drifts" (p. 7).

Sambar deer were released in the Rangitikei district in 1875 (McKelvey, 1999), and rabbits were probably in the region by around 1870. Both contributed to the removal and/or reduction of native plant cover, particularly on foredunes where the palatable Spinifex, Pingao (*Desmoschoenus spiralis*) and Sand tussock (*Austrofestuca littoralis*) grew. Fire was also utilised to clear scrub and provide soil nutrients. Wetlands were drained and modified (Wilson, 1959).

The consequence of disturbance to the dunefields was that dune mobilisation increased and stabilisation works

became necessary. Probably the earliest dune stabilisation work carried out in the Manawatu was that conducted by the Railways Department in 1885. The railway line between Foxton and Himatangi was affected by mobile dunes and the "sand menace" was planted with radiata pine (McKelvey, 1999).

Marram grass (*Ammophila arenaria*) was introduced into New Zealand in the 1800s and had become 'naturalised' in some areas by the 1870s (Buchanan, 1872). In the Manawatu region, Walter Barber of Foxton may have been the first individual to stabilise dunes when he procured two cart-loads of marram from the Eulis district and planted them on his land in the 1840s (McKelvey, 1999). The first experimental dune stabilisation works were established on dunes at the Rangitikei and Waikato River mouths by the Lands Department with marram planting beginning in 1913 (on Run 24, later Tangimoana grazing lease) at the Rangitikei (McKelvey, 1999). Two-thirds of the plantings failed. By 1916, driftwood had been utilised to build sand trapping fences in dune hollows and blowouts to create a 4.8km long foredune. By 1917 manuka brush was being used to make sand trapping fences. The State Forest Service (later the NZ Forest Service) subsequently established the Rangitikei Sand-Dune Experiment Station at Run 24 in 1921. By 1930, 680 hectares of marram and 271 hectares of pine forest had been planted (McKelvey, 1999).

In 1932, during the Great Depression, the Public Works Department administered a relief scheme for the unemployed which included marram planting south of the Rangitikei river mouth, and over the next few years that expanded to include the Waitarere district (Fenton, 1948; Saunders, 1968; McKelvey, 1999). Tree lupin was sown after the marram had been growing two years, and pines were planted once the lupin was two to three years old (McKelvey, 1999).

Major R.A. Wilson and his partner, K. Dalrymple, took over 970 hectares of dune country in the Himatangi area in 1910 of which 485 ha were mobile dunes. Wilson (1959) kept stock off the active dunes and within 10 years 285 ha of bare sand had been naturally vegetated. He was a pioneer who planted spinifex along the backshore adjacent to his property in 1930, and stabilised the remainder of his active dune areas by planting marram, lupin, radiata pine and macrocarpa.

Many other exotic vegetation species were gradually introduced into the region. The Wanganui Acclimatisation Society was established in 1863, and by 1937 over 60 percent of the flora in the Manawatu was naturalised exotic species (Wynn and Richards, 1997).

By around 1910, significant areas of the Manawatu and New Zealand dunefields had been partially and, in some cases, fully activated by first Maori and later European activities (c.f. Saunders, 1968). Marram planting was widely carried out to stabilise dunes, pine forests were then established (Fenton, 1948), and a significant number of exotic plant and animal species were introduced.

1940s - 1990

Foredunes were present along the coast in the 1870s (McDonald and O'Donnell, 1929), and Cockayne (1909; 1911) indicated that foredunes ('sand grass dunes') were present along the Manawatu coast in 1909. However, by 1942 the foredune along the Foxton to Himatangi section of coast was highly erosional, being cut every few metres to tens of metres by blowouts (Aerial photographs, 16/5/42; Figure 2). By the 1960s there were areas where foredunes were barely present or absent (National Archives NZFS photograph collection, e.g. AAQA 6395, M 145; McKelvey, 1999). The Manawatu Catchment Board reported that there were 8000 acres of unstable sand between Waitarere and Tangimoana in 1948. Even in the 1970s, foredunes were obviously absent or highly erosional. Wendelken (1974) stated that by 1974 foredunes were being constructed at the rate of at least 3 kilometres per year in front of the larger forests.

The younger Waitarere phase (or phase IV) was largely active transgressive dunefield by 1942. These mobile

Figure 2: 1942 vertical aerial photograph of the coast between Himatangi (top) and 3 Mile Creek (3km south of Himatangi Beach). The foredune is highly erosional and an active transgressive dunefield dominates the region (NZ Aerial Mapping Survey Rangitikei Woodville Manakau, Run 218/2, 16th August, 1942. Crown copyright with permission).

dunelands were characterised by large, active sand sheets and dunefields. The latter comprised transverse and barchanoidal dunes on the surfaces, and sheets and dunefields both had extensive precipitation ridges along their downwind margins. Some parabolic dunes were evident, but relatively rare (Figure 2). Deflation plains were present throughout the dunefield.

Acacia was introduced into the region in 1945 (McKelvey, 1999), presumably to add a highly competitive, rapidly spreading, intermediate species capable of stabilising dune crests and lee faces and of withstanding salt spray and sand inundation.

By 1966 narrow strips of pine forest had been planted along the margins of some of the active dunes (Holland, 1983), and some areas of relatively low dunefields and sheets had been re-contoured and re-shaped by local farmers to reduce sand movement and increase the potential for pasture growth. In the area immediately north of Himatangi, for example, Major Wilson's actions had led to a ~ 50 percent reduction of the active dune area. However, this was not a universal result and the area between Himatangi and Foxton, while less active than in 1942, still had significant areas of active dunes (cf. Saunders, 1968; Holland, 1983).

Aerial photographs in 1979 show that the formerly widespread, transgressive dunefields were breaking up into parabolic dunes (Wilde, 1992; cf. Esler, 1978). There were still some rare, moderate size transgressive dunefields. The parabolic dunes occurred for two reasons. One, because landward portions of the former transgressive dunefields were vegetated and managed to various degrees by farmers. Two, there was apparently less grazing pressure on the near-coastal dunefield, so as dunes migrated landwards, deflation basins formed upwind of the advancing dunes and were partially stabilised by vegetation (Figure 3). The foredune/blowout complex was still highly erosional and unstable.

By 1985 (NZ Aerial Mapping photography, SN 11142 A; 28/3/85; 90019-22), further dune areas were stabilized, and parabolic dunes dominated the active dunefield. The NZ Forest Service was abolished in 1987 but by that time had planted 3347 hectares of forest at Santoft, 420 ha at Tangimoana, and 1652 ha at Waitarere. Quite large areas of private pine plantations between Tangimoana and Foxton had also been planted.

Recent changes 1990 – 2001

Parabolic dunes have continued to migrate landwards at rates varying from less than 5 metres per year, where the dunes are large and/or migrating into mature pine forest, to 100 metres per month in an extreme case (Holland, 1983) where the dunes are very low and/or migrating across low pasture. Several larger and older parabolic dunes present in the 1970s have been stabilised to varying extents by marram planting or largely stopped migrating as they moved up against pine plantations (Figure 4).

Figure 3: 1979 vertical aerial photograph of the Himatangi to 3 Mile Creek area. This transgressive dunefield has largely broken up into large scale parabolic dunes (Part of NZ Aerial Mapping Survey No. 5408, Run C12, Photo No. 830, 17th April, 1979. Crown copyright with permission).

A new episode of parabolic dune formation has begun in the last five years. Several blowouts present in the foredune in 1995 have evolved into low, long and narrow parabolic dunes migrating at average rates of around 20 to 25 metres per year. Some of the older parabolics, which developed in the period 1990 to 1995, display migration rates of 50 to 80 metres per year. These rates (including the 100m/month above) are the highest recorded in the world (see Table 2 in Muckersie and Shepherd, 1995) and testify to the high wind energy of the Manawatu roaring 40s coast.

Conclusion

Four stages of environmental change are apparent in the Manawatu coastal landscape. The first stage was that of late Pleistocene and Holocene climate change inducing a world wide sea level rise, sediments delivered shorewards as nearshore and shelf profiles adjusted, and initiation of the first major dune phase (Foxton or phase I) in the Manawatu. There is an apparent time gap of about 1000 years when dune initiation was absent (Muckersie and

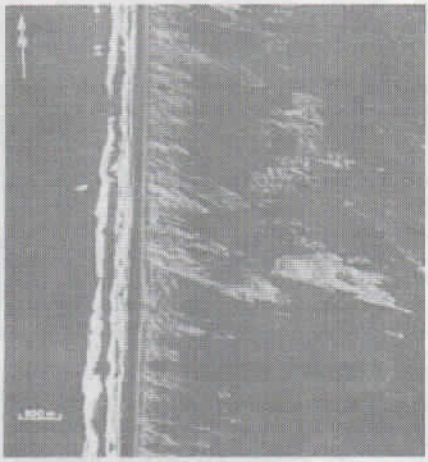

Figure 4: 2000 vertical aerial photograph of the 3 Mile Creek area. Some large scale parabolic dunes still exist, and while the seaward face of the foredune is relatively intact the crest and landward slope are cut by numerous blowouts, several of which have developed into long thin parabolic dunes in the last five years (Lawrie Cairns and Associates coastline aerial photography for Horizons.MW, Photo No. 55, Feb/Mar 2000 with permission).

Shepherd, 1995), then the second dune-building phase (Moturoa or phase II) occurred. This phase may have been initiated by a number of mechanisms, but climate change (periods of greater windiness, aridity or rainfall) is most likely.

The second stage of environmental change occurred in the last 600 to 1000 years when Maori first occupied the area, rapidly causing the extinction of a range of fauna (McFadgen, 1995) and significantly altering the vegetation cover. The first part of the Waitarere dune phase (phase III of Muckersie and Shepherd, 1995; early episode of McFadgen, 1985) may have been caused by this impact. From the 1800s onwards, burning and grazing by Europeans lead to widespread dune mobilisation, further forest and native vegetation disturbance, introduction of exotic species, marram planting, pine afforestation, and draining and modification of the wetlands. The latter part of the Waitarere phase (phase IV) may have been initiated by Europeans in the last 150 years. This phase resulted in changing the dunefield from one most probably dominated by parabolic dunes to one dominated by a widespread, active transgressive dunefield.

The third stage of environmental change occurred in the period 1940 to 1990. During this stage humans attempted and partially succeeded in taming "the sand menace" in the region. Large scale sand sheets and transgressive dunefields created by overgrazing and other activities prior to 1940 have been significantly stabilised and parabolic dunes created. Thus, a section of the dunefield was completely changed from transgressive, mobile dunefield to a largely vegetated parabolic dunefield by humans. Much of the rest of the dunefield is in forest, settlement and pasture.

A fourth stage is just beginning. Shepherd (1987) stated that it was unknown whether dune activity during the Foxton phase was episodic or occurred more or less continuously (p. 182). The latest (2000) photographs indicate that the modern (Waitarere) "phase" is indeed episodic. An entirely new suite (or episode) of parabolic dunes has developed from blowouts within the foredune in the last 10 years. There are 20 new parabolic dunes in just 10km of coast extending from Himatangi to Foxton. These are migrating downwind and landwards at rates up to 25 metres per year and herald a new stage, largely driven by natural forces (but aided to some degree by human recreational activity and, perhaps, rabbits).

The environmental impact of human colonisation on the dunefields of the region has been phenomenal. A significant portion of the dunefield was changed to a transgressive dunefield and back into a parabolic dunefield in the space of 150 years or less. Many wetlands were drained, pine afforestation has lowered water tables and reduced swamp and wetland areas, and some wetlands and lakes are severely polluted. Most of the natural vegetation of the region has been destroyed and a large number of exotic plants and animals have been introduced. Ogle (2001) states that in the entire southwest of the North Island there is only one remaining dry dune native forest patch with a closed canopy. It covers a mere 10 ha. Formal protection has just recently been applied for and the area has been fenced. It contains 102 native plant species, and in the last 30 years 28 species recorded earlier seem to have disappeared. In addition, few dune landforms in the region are in reserves and afforded any protection. Clearly our human impact has wrought major environmental changes to one of the greatest examples of Holocene dunefields in New Zealand, and reversal of the destructive trend of the last 600 years is long overdue.

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WEST COAST SANDS

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SANTOFT FOREST

HISTORY

Santoft started in 1951 under the Forests Act of 1949 which gave the Forest Service the authority to acquire, use or develop land for stabilisation of soil, including sand fixation Generally the inland limits of the land assigned to forestry coincide with the inner limits of the main area of unstable sand, but there were minor areas within the Santoft Farm Settlement assigned to forestry because of their potential instability and to provide access. The Crown's task of rehabilitating coastal sand country had been made easier by the fact that much of the land adjoining the beach had remained in Crown ownership.

Santoft Forest is approximately 4800 Hectares but 650 Hectares of this is protection. There is approximately 25km of coastline at Santoft. Coastal dunes are of easy terrain up to only about 30 metres above sea level. Winds are predominantly west to north-west, with occasional southerly gales. It has an annual rainfall of 800-900mm of rain. There is a mix of eroding and accreting shorelines. The accretion is demonstrated graphically at Santoft, where the old wreck of the Fusilier, stranded at the ocean edge in 1884, is now high and dry and a hundred metres or so inland. Like all coastal sand forests, especially on the western coasts, stable protective foredunes are pivotal to effective forest management. They extend from high-water mark to about 70 metres inland and require continual maintenance, comprising regular programmes of repairing breaches, and planting and fertilising marram. In the early days of Santoft *Acacia sophorae* was introduced near the foredunes to aid stabilisation. It has been too successful, having spread into the pine stands where it forms an impeding shrub storey. Extensive belts of Macrocarpa were established on the seaward forest edge, the enhanced shelter maximising the area of productive Radiata pine forest inland of them.

BACKGROUND OF ERNSLAW ONE LTD

In 1990 Ernslaw One Ltd purchased five Crown Forestry Licences granting cutting rights to plantation forests in the Coromandel, Rangitikei and Otago regions. The Crown Forestry Licences in the Rangitikei were Santoft, Tangimoana and Harakeke.

MANAGEMENT OF THE FOREDUNES

Since 1990 Ernslaw has continued to maintain the foredunes at Santoft and Tangimoana. The practice is to reshape the dunes that have blown out and plant with marram grass. Any areas of spinifex and pingao are left if practicable. Planting commences during May and continues till August. Approximately 5 hectares of dune maintenance is done each year. This could cover a third of the 25km of coastline Two applications of urea at 50kgs/ha are applied each year by helicopter. This is done in April and September. In 2002 we will be interplanting spinifex plants amongst marram on the seaward side to try and establish a complete spinifex dune system along the coast.

BASIC FACTS ON SAND BINDERS

Spinifex is found to be the dominant plant on the seaward side of the foredune, and showed itself to be superior to marram in that niche because it was more tolerant of sea water and also rapidly colonised fresh sand. Further, it formed more even foredunes, which were less inclined to blowouts. Pingao is present above the high water mark. The drawback of pingao is that it is a poor collector and binder of sand. Pingao is a precursor to spinifex, the seeds of the latter germinating in pingao swards and eventually replacing that species in a succession. Marram is the most effective stabiliser of the rear (transverse) dunes. There is probably no indigenous plant that is as effective for lee-slope stabilisation.

ESTABLISHMENT AND GROWTH OF SAND-BINDING SPECIES ON ERODIBLE FOREDUNES AT SANTOFT BEACH, RANGITIKEI
(Restoration of Exposed Sites Trial No. FR 360/1)

Conference Report: February 2002

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INTRODUCTION

The native species, spinifex (*Spinifex sericeus*), is potentially useful for revegetating and protecting highly erodible foredunes on the west coast of the lower North Island. Management of this ecosystem has traditionally involved the winter planting of exotic marram grass (*Ammophila arenaria*) on mechanically graded areas or natural dune slopes of foredunes and other dune types. In the first of four dune restoration trials across New Zealand, a trial was commenced at Santoft Beach in June 1999 to determine (i) whether marram could be co-planted with spinifex and act as a protective cover while the spinifex established a reasonable cover; (ii) the establishment and growth of spinifex and marram grass with various fertiliser combinations at planting and during establishment; and (iii) the potential of spinifex to establish from seed in the field. Results from two assessments conducted during 2001 and a topographic survey in 2002 are reported.

MATERIALS AND METHODS

The trial comprises six treatments, namely:

1: Marram + 50 kg/ha urea (46% nitrogen) in spring and autumn – normal operational practice
2: Marram + 30 g MagAmp (magnesium ammonium phosphate)/plant at planting
3: Marram + Spinifex + 50 kg/ha urea in spring and autumn
4: Marram + Spinifex + 30 g MagAmp/plant at planting
5: Marram + 30 g MagAmp/plant at planting + 50 kg/ha urea in spring and autumn
6: Marram + 50 kg/ha urea in spring and autumn; in middle section of plots, spinifex seed sown in holes with 30 g MagAmp

Plots of each treatment are 15 x 15 m and plants are spaced 1 x 1 m. In treatments comprising both species, marram grass and spinifex are planted in alternate rows. There are 2-4 replicate plots of each treatment arranged in randomised blocks. The trial was assessed in April and November 2001 for ground cover (%), height (cm), and vigour (scored 1 (low/poor) to 5) of marram grass and spinifex. The length of relatively long, well-developed runners was measured for selected spinifex plants in November. The height (cm) above ground of pegs (60 cm at start of trial) in transects in all plots was also measured.

RESULTS AND DISCUSSION

Sand movement

Initially nearly half of the trial area experienced erosion, particularly the mid to upper slopes. The principle reason was probably that wind speeds were highest in the mid to upper slope region (due to flow compression and speed-up up the foredune slope). In addition, marram culms were planted at relatively wide spacings (1 x 1 m) and wind erosion occurred between the plants. Note that this period was a La Nina period with relatively low regional wind speeds. As plant cover increased, the incipient blowout that was threatening to develop in about the first six months, did not eventuate.

By November 2001, it was estimated that 28 pegs remained of the 99 originally positioned in June 1999. The average height of these above ground in November was 49 cm, indicating that net sand accretion of 11 cm had occurred since trial commencement. However there was considerable variation between original peg heights within the trial, ranging from 9 cm (51 cm sand accretion) to 84 cm (24 cm sand loss). The fate of the missing 71 original pegs is largely unknown. Several were broken and it is suspected that most were buried, particularly on the lower seaward side of the foredune. Other pegs were removed by vandals, as indicated by several pegs lying on the ground away from the original transects.

The extent of sand accretion or loss around a peg was largely related to its position on the vegetated foredune slope (Figures 1 and 2). For example, exposed peg heights in a plot at the bottom of the slope increased over a transect of 9 m, from 18 cm closest to the beach to 62 cm farthest from the beach. This contrasted with plots mid-way on the slope and near the ridge of the foredune where peg heights were relatively constant over transect distances of 9 or 12 m, such as 46-53 cm and 51-62 cm. Figure 1 illustrates a transect across the middle of plots 15, 9 and 1 (northernmost plots) down the foredune. Most deposition has occurred on the seaward half of the slope and the vegetation has grown seawards by around 5 metres.

Figure 1: Relative sand surface height (m) at two times along a transect in Plots 1, 9 and 15.

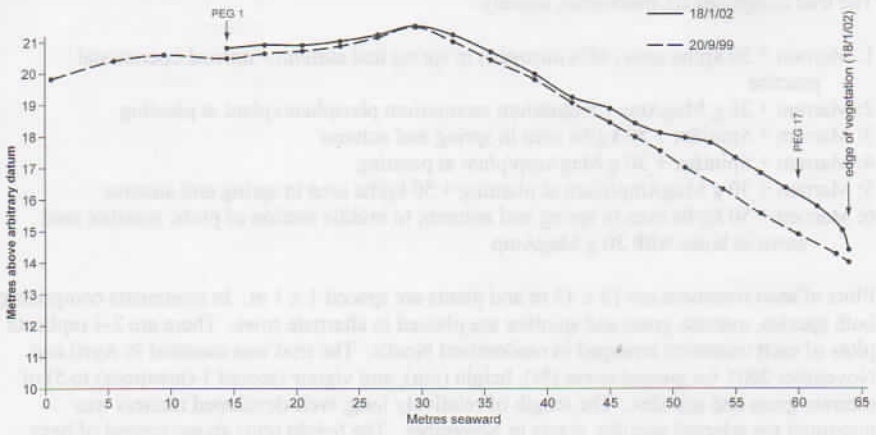
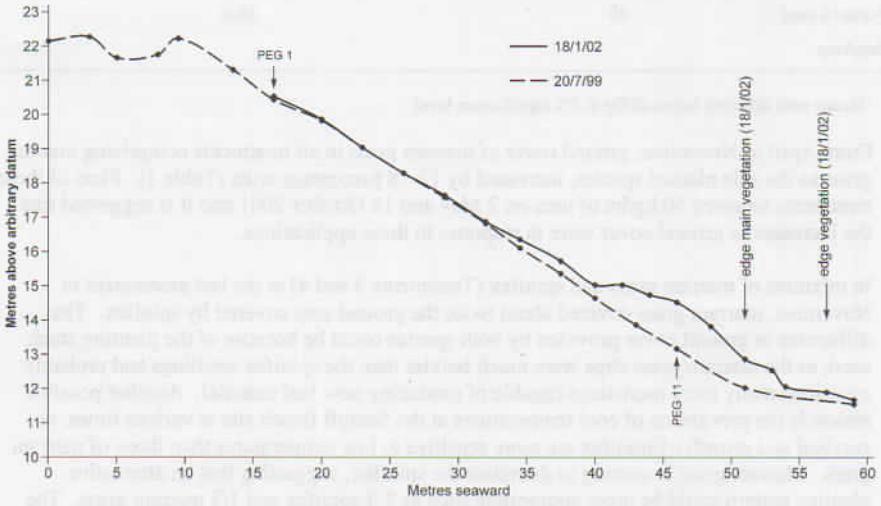


Figure 2 illustrates a transect across the middle of plots 14 and 7 (southern plots). Less sediment has been deposited across the whole profile and sand deposition has predominantly occurred on the seaward lower slope. The main area of vegetation has grown seawards by 4 metres with a few plants extending out another 5 metres. Two hummocky mounds constructed in spinifex were left intact on the base of the seaward slope when the trial was first initiated. These are now higher and some wind scour is occurring around them with the result that two incipient (and minimal so far) blowout areas are developing. The results reflect the vegetative barrier to sand movement with progression up the slope, with implications for foredune stability, and indicate the importance of establishing an effective and persistent cover on the seaward lower one third of the foredune slope.

Figure 2: Relative sand surface height (m) at two times along a transect in Plots 7 and 14



Plant establishment and growth

There was up to a two-fold difference between the treatments in ground cover of marram grass in April 2001, 22 months after trial commencement, although no differences were declared significant. By November, the treatment that provided the greatest amount of ground cover in the plots was Treatment 5 in which marram grass was fertilised with MagAmp at planting and with urea on five occasions since planting. Marram grass in these plots provided 79% cover (Table 1), compared with only 27% and 30% cover ($P < 0.05$) in the treatments comprising marram grass and spinifex fertilised with urea (Treatment 3), and marram grass and spinifex fertilised with MagAmp at planting (Treatment 4), respectively. In the three other treatments, where marram grass was planted alone, ground cover of over 50% was attained. Spinifex failed to establish from seed (Treatment 6) in the field but it covered up to 21% of the ground when introduced as potted seedlings (Table 1).

Table 1: Ground cover (%) of fertilised marram grass and spinifex in April and November 2001.

Treatment	April		November	
	Marram grass (M)	Spinifex (S)	[1]Marram grass	Spinifex
M+urea	53		65ab	
M+MagAmp	52		54b	
M/S+urea	25	18	27c	15
M/S+MagAmp	28	21	30c	14
M+urea+MagAmp	61		79a	
M+urea+S seed +MagAmp	40		56ab	

[1]Means with different letters differ at 5% significance level

From April to November, ground cover of marram grass in all treatments comprising marram grass as the sole planted species, increased by 12-18 percentage units (Table 1). Plots of these treatments received 50 kg/ha of urea on 2 May and 18 October 2001 and it is suggested that the increases in ground cover were in response to these applications.

In mixtures of marram grass and spinifex (Treatments 3 and 4) at the last assessment in November, marram grass covered about twice the ground area covered by spinifex. The difference in ground cover provided by both species could be because of the planting stock used, as the marram grass slips were much bulkier than the spinifex seedlings and probably contained many more meristems capable of producing new leaf material. Another possible reason is the prevalence of cool temperatures at the Santoft Beach site at various times, as survival and growth of spinifex are more sensitive to low temperatures than those of marram grass. Marram grass is starting to dominate the spinifex, suggesting that an alternative planting pattern could be more appropriate such as 2/3 spinifex and 1/3 marram grass. The use of larger planting stock of spinifex may be beneficial in a revised planting strategy.

Ground cover of marram grass was highest when fertilised with urea + MagAmp or with urea alone. The results indicate that on-going nitrogen application is essential for increasing ground cover of this species. In contrast, spinifex responded similarly to urea (two applications per year) and MagAmp (at planting only), which suggests that it has lower fertility requirements than marram grass, or that other factors are limiting its growth.

Plant height and vigour of marram grass and spinifex were not significantly affected by fertiliser treatment at either assessment time (Table 2). Mean height of marram grass across all treatments in April was 68 cm, increasing to 89 cm in November. Height growth of spinifex in Treatments 3 and 4 increased slightly over the same seven-month period from 45 cm to 53 cm. In April, plants of spinifex were more vigorous than those of marram grass (overall score 3.8 vs 2.8) and typically had healthy green foliage, with occasional slight die-back of shoot tips. Most plants of marram grass exhibited chlorosis and necrosis of shoot tips, possibly because of damage from sand blasting. Symptoms on all aerial plant parts were rare. By November, marram grass and spinifex had similar mean vigour scores of 3.2 and 3.4, respectively.

The average length of selected vegetative runners of spinifex in November 2001 was similar to that found in November 2000 (105 vs 112 cm), indicating negligible horizontal growth of the species during this period. This contrasts with the previous year (November 99-00) when runner length increased by an average of 22 cm.

Table 2: Plant height (cm) and vigour of fertilised marram grass and spinifex in April and November 2001.

Treatment	April				November			
	Marram grass (M)		Spinifex (S)		Marram grass		*Spinifex*	
	Height (cm)	[1]Vigour	Height (cm)	[1]Vigour	Height (cm)	[1]Vigour	Height (cm)	[1]*Vigour*
M + urea	71	3.3			92	3.3		
M+MagAmp	74	3.0			90	2.9		
M/S+urea	56	2.5	41	4.0	80	3.4	54	3.4
M/S+MagAmp	60	3.0	49	3.5	76	3.0	52	3.5
M+urea+MagAmp	73	2.5			102	3.5		
M+urea+S seed +MagAmp	61	2.0			88	3.3		

[1] Scored 1 (poor/low) to 5

CONCLUSIONS/RECOMMENDATIONS

- Both marram grass and spinifex should be planted at 50 cm spacings - not 1 metre spacings - on exposed west coast locations.
- After 29 months, between 42% and 79% ground cover is provided by marram grass, and marram grass and spinifex, with both species continuing to grow and spread across areas of bare sand.
- Spinifex can be established satisfactorily in the field from nursery-prepared seedlings, but establishment from seed was unsuccessful in this trial.
- Twice-yearly application of urea encourages the spread of marram grass. Spinifex is less responsive to fertiliser type, and time and frequency of application.
- Alternate row planting of marram grass and spinifex is an option for introducing spinifex. However, optimum planting strategies need to be developed.

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SPINIFEX ONE YEAR AFTER ESTABLISHMENT AND FUTURE DIRECTION, TE HENGA (BETHELLS BEACH), WEST AUCKLAND

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INTRODUCTION

Several trials, known as the FR 360 trial series (Ede *et al.* 2000), jointly funded by the ***Forest Research*** Sand Dune Revegetation Programme and the Coastal Dune Vegetation Network, are being established on a range of sites where the primary driver of dune instability is the physical environment. One site is Te Henga (Bethells Beach), west Auckland. This report covers the progress of a planting and seed sowing trial using spinifex on mostly bare sand areas on dunes at Te Henga established in collaboration with the local Beach Care group, Auckland Regional Council and Waitakere City Council.

SPINIFEX TRIALS

Objectives and trial design

The overall objective is to determine the performance of spinifex on the exposed dune system of the west coast of the North Island. Specific objectives included comparing performance of spinifex seedlings raised from seed and direct sowing of seedheads with and without application of slow-release NPK fertilisers applied at establishment; and to quantify performance on several sites from foredune to mid-dune with and without a cover of marram.

The planting trial was located over five different sites with details on trial design and treatments given in Sullivan *et al.* (2001). These included group planting on the front (Site 1) and back slopes of the foredune (Site 2), within marram and adjacent bare area on mid-dune site (Site 3), transects within across a large bare sand basin that traversed four sand fences (Site 4), and marram-dominated hillocks (Site 5). All sites except marram hillocks were surrounded by a rabbit-proof fence before planting. Trial sites were planted 3rd September 2000 with most planting carried out by the Te Henga Beach Care group.

Early results

A storm about 3 weeks after the trials was established caused significant movement of sand on the exposed foredune Site 1 with many plants buried and some excavation of sown seed and plants. Planting within marram appeared to give initially good protection to spinifex seedlings from both wind and to some degree, rabbits. Plants of both pingao and spinifex appeared to be thriving on the more sheltered foredune Site 2 also fenced from rabbits compared to the more exposed Site 1.

Spinifex seedheads started to germinate approximately 9 weeks after sowing coinciding with considerable wet late spring period and warm temperatures (maximum daily temperature 17°C) in the region. Best germination was from sites where there had been little sand movement such as the sheltered lowest lying areas between sand fences (Site 4). Most germination occurred in non-fertilised lines although those seedlings that have germinated from seed spots fertilised with Magamp were larger than seedlings in non-fertilised spots. Germinated plants do not seem to get rabbit browsed initially. Increases in germinated seedlings continued through November but assessment in January 2001, 6 months after sowing, indicated that few seedlings survived. Germinated plants appear to be too small to cope with sand movement on most sites. Another

factor could be that roots of germinated seedlings may be too small to cope with the high rates of evapotranspiration on exposed dunes where tops of leaves have been observed to brown-off before the plant dies about a week later.

Where spinifex has established and survived the early spring storm 3 weeks after planting, plants had grown well even where up to 50 cm of sand has slowly accumulated since planting. Best growth was for plants in more sheltered sites in troughs between sand fences. Fertilised spinifex plants were greener and appeared more vigorous than non-fertilised plants.

Performance one year after planting

Planted spinifex seedlings with fertiliser are significantly larger and more vigorous than non-fertilised plants and is the first confirmed evidence that fertiliser at planting is essential on west coast beaches. Spinifex has done best in the fenced Site 2 located landward of the exposed foredune face. Fertilised seedlings scored high for plant vigour, with most plants occupying up to a 50 cm diameter area and with runners ranging from 1-4 m long. In contrast, non-fertilised spinifex had grown significantly slower occupying less than a quarter of the sand surface, a lower plant vigour score and only occasional but shorter runners. Plots within Site 2 had accumulated from 30 cm to over 60 cm of sand in the year since planting with fertilised planted seedlings easily coping with these large sand volumes.

Within Site 4, spinifex on the windward site of sand fences had poor survival and growth. Best growth was on lee slopes and in dune slacks created between established wind fences. Only a handful of seedlings had survived from seed sowing spots across all trial sites one year after sowing.

Rabbits are continuing to be the biggest problem with growth of both spinifex and pingao planted in fenced areas looking vigorous compared to stands outside of fences. A further major problem is vandalism; for example, people using plot fencing material to build bonfires on top of seedlings. It is essential that any planted areas on beaches with high visitor numbers have interpretative signage in order to achieve co-operation from beach visitors.

Results indicate that spinifex is best established using nursery-raised plants with a slow-release fertiliser applied at planting as has become standard management practice on east coast beaches throughout the Coromandel and Bay of Plenty. Sowing of seed is not likely to be successful most years due to excessive sand movement but if used, a slow-release fertiliser placed into the planting hole may improve chances of establishment.

Site 3 where spinifex was planted within marram was destroyed by beach users and the few spinifex planted on a marram hillock (Site 5) did not survive.

FUTURE DIRECTION FOR TRIALS

Spinifex trials

Results from the Te Henga trial to date indicate that revegetation of bare sand dunes with spinifex is likely to succeed where good quality seedlings are planted with fertiliser applied at planting. Control of rabbits (and people) is also essential. The current spinifex trial will be assessed in mid-2002 to confirm these results when it is expected that sufficient information will have been obtained on performance.

Depending on resources, consideration will be given to establishing spinifex and pingao on a larger scale to determine appropriate planting pattern and density. The effect of post-plant fertilising using fast-release high nitrogen fertilisers could also be investigated. Current trials at

Oakura on reshaped exposed foredunes indicate good cover is achieve within 8 months of planting using high density planting of spinifex and pingao, application of slow-release fertiliser at planting and light broadcast dressings of urea in spring and autumn within the first year.

Semi-stable and stable dunes

Issues at Te Henga include defining which areas should be planted in native species other than the sand binders pingao and spinifex. Te Henga is a complex dune system of moving and semi-stable sand from landward of the first foredune to several hundred metres inland. Local efforts over many years has seen successful establishment of a number of hardy native tree and shrub species including cabbage tree, pohutukawa, harakeke and tauhinu (*Ozothamnus leptophyllus*).

Te Henga provides good opportunities for evaluating the establishment of a range of locally native coastal shrub and trees in trial plots covering several site types from dune slacks to exposed ridges. Current research priorities of the CDVN include defining planting patterns and techniques that favour the natural regeneration of native species known to have been present in the locality in the past on semi-stable and stable sand dunes.

Rabbit control

One of the biggest problems at Te Henga is rabbits. Rabbit proof fences are only practical on a small scale and have limitations in unstable sand areas requiring constant maintenance to ensure sand drifts do not bury fences.

CDVN will be compiling information on rabbit control measures that are being used in other regions which may be appropriate Te Henga. Of particular interest is the use of repellents for newly planted areas. Both ARC Biosecurity and Te Henga/Bethells BeachCare are keen to trial rabbit repellants in this years planting programme.

Planting within marram

Discussion at the 2001 CDVN Conference indicated that use of marram as a 'nurse' or temporary shelter while spinifex is establishing is a likely practical management tool for establishing native sand binders on exposed sites. This may be worth repeating as the mixed spinifex/marram plots were destroyed by beach users. While the local community at Te Henga do not support planting of marram, existing stands could be used to further test a range of planting patterns with and without marram at different densities. Once cover is established, practical methods for removing/reducing marram in favour of sand binders or woody species on less exposed back dunes may be required where marram cover is slow to be shaded out.

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STABILISING AND ESTABLISHING PERMANENT VEGETATION ON SAND COUNTRY ON THE AWHITU PENINSULA

David Craig
Awhitu Peninsula Land Care Group (APLG)

INTRODUCTION

Awhitu Peninsula is the southern arm of the Manakau Harbour, southwest of Auckland. The western side of the peninsula has a mixture of stable Red Hill and Horea soils formed from old weathered sand and overlain in many places by unstable Pinaki soils on unweathered sand from recent dune movement. Unstable sand dunes landward of the Awhitu cliffs can be extensive in area and spectacular. They impact on pasture growth and other vegetation, causing some farmers to lose up to 10% of their livestock carrying capacity. Currently moving dunes were formerly stable beneath shrubby vegetation but many blowouts followed the conversion to pasture in the 1800s. Farmers held them in check for much of the last century by planting marram and lupins. In recent years most of the lupin has been killed by fungal blight and dunes have re-activated. Features of these sandy soils include:

- Low natural fertility
- Inability to hold moisture
- Lack of organic matter
- Prone to erosion.

These features together with exposure to strong salt-laden winds, dry summer conditions and significant areas of steep contour, mean that special management techniques are needed to maintain pasture and other vegetation that will provide sustainable stock grazing and avert the risk of wind erosion. The sand country is naturally low in organic matter and the major plant nutrients, phosphorus, potassium and nitrogen. To add to this the free draining nature of the soil causes rapid leaching of fertiliser.

The Awhitu Peninsula Landcare Group (APLG) was established in the mid-1990s with support from the Auckland Regional Council to address issues of sand erosion along the peninsula.

STABILISING SAND

Dunes in recent years have re-activated in two situations. Where sand moving from cliff faces or coastal gullies has accumulated on existing farmland, pasture has been killed allowing wind to scour the loose sandy Pinaki soil beneath. In order to reduce or stop this erosion, the supply of sand from the coast needs to be stabilised first. Stabilising a large area of moving sand is difficult enough without additional sand burying re-vegetation efforts. APLG members have been able to stop this input of sand by creating a barrier of vegetation capable of stopping the moving sand on the windward side using a zone of marram and shrubs planted along the cliff edge.

Sand dunes have also formed well inland forming blowouts where pasture on the sandy Pinaki soil has been depleted by heavy grazing, stock trampling, tracks, rabbits, grass grub, summer drought or winter frost. Here more careful management has to be undertaken so that re-vegetation is not smothered or undermined by new blowouts. Where dunes are already on the move APLG members have fixed them by a sequence of three steps:

1. **Contouring** - Where possible, mobile sand dunes have been shaped to contours that blend with the landscape to make the areas less prone to the erosive forces of the wind. Where slopes were less than 15° this has been done with a bulldozer, tractor and blade.

2. **Temporary or permanent retirement:** Areas of mobile sand have been fenced to keep stock out. A standard two-wire electric fence can be set up for minimal cost and will suffice to keep most cattle out, so long as to is maintained and the power is kept on. Possums, rabbits, hares and deer will still get in unless there is good shooting control in adjacent paddocks.

3. **Sand binding:** On wind swept western sand country like Awhitu, only a dense cover of marram grass binds moving sand sufficiently for the other plants to establish. Spinifex or pingao after many trails by APLG are effective sand binders only on beach foredunes and perform better on eastern coastlines. Marram has been sourced from established plantings locally and from a few forest nurseries. Various degrees of success have been achieved by the use of brushwood such as pine trimmings and the laying out of car tyres.

NATIVE SHRUB AND TREE ESTABLISHMENT TRIAL

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. This was a collaborative planting trial established between APLG, Dr Douglas Hicks of Ecological Research Associates, the Auckland Regional Council and ***Forest Research***.

The aim of the trial was to test the performance of a range of hardy native tree and shrub species within small natural gaps in three vegetation cover types in fenced-off, erosion-prone farmland sites. These site types were:

1. **Rank grass site** – spots sprayed with herbicide to create 60 cm diameter circular area for the planting of a single seedling in each spot.
2. **Recently planted marram site** – seedlings planted within natural gaps between or adjacent to sparsely planted marram.
3. **Dense marram site** – existing natural gaps were utilised with minimal hand clearing where necessary to create a 60 cm diameter planting spot.

Seedlings were planted in small groups of five plants each with same species in each group. Spacing within groups was approximately 1 m with a minimum of 5 between groups. Five species were planted in 1996 – knobby club rush, flax, akeake, karo and pohutukawa. Two further species (cabbage tree and ngaio) were planted in 1998 on selected sites.

Initial 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 on 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 most knobby club rush had died out. Assessments within two years of planting indicated that a cover of marram grass or dense kikuyu grass provided shelter for planted trees and shrubs as long as planted gaps

are kept small. Intensive weed control was necessary to keep seedlings free of grass within at least the first year of planting.

Six years after planting, survival of flax, akeake, karo and pohutukawa is 80-90% and 75% for ngaio planted amongst dense marram. On the kikuyu site, flax and pohutukawa have 70-90% survival, karo 65% and akeake only 35% survival. After four years, cabbage tree and ngaio have over 80% survival within the kikuyu site. Best surviving species in the sparse marram are flax at 60% and karo at around 50% with pohutukawa at 35%. Only 10-15% of knobby club rush survived.

Best growth six years after planting has been achieved in the dense marram site with average heights in excess of 2 m for pohutukawa, karo and some akeake depending on degree of exposure. Flax is 1-2 m high as are the younger ngaio.

ESTABLISHMENT OF NATIVES

Based on the ongoing collaborative research trials and experience of local landowners, current practice by the APLG is to establish a dense cover of marram to stabilise the dune, then plant a cover of shrubby species. These species include flax, pohuehue, toetoe, taupata, karo, kohuhu, ngaio, five-finger, cabbage tree, akeake, pohutukawa, koromiko, *Baumea* (rush) and kanuka. Most of these plants have been soured as seed or plants from a couple of coastal fore dune and back dune area where native vegetation is still in existence on the Awhitu Peninsula. Interestingly, since blocks have been established with a greater cover of native vegetation, there appears to be an increase in possum and deer numbers requiring control.

Even though *Euphorbia glauca* grew well in all instances it is not sustainable in Awhitu Peninsula plantings because of rabbits, but trials of *Tetragonia tetragonioides* (New Zealand spinach) had a huge success rate and is readily available.

TRANSFER OF INFORMATION

Since 1996 APLG has spent thousands of dollars on research projects concerning coastal sand dunes on the West Coast. We have produced with the help of several research organisations a series of pamphlets to help landowners with their projects and problems. These include:

- Guideline for pasture management on sand country.
- Guideline for stabilising sand blows.
- Guideline for protecting vegetation on cliffs.
- Guide for establishing permanent tree cover on sand country.

CONCLUSIONS

Besides use of marram, exotic species have also played an important part in our plantings including radiata pine, Norfolk Island pine, coastal banksia, tree lucerne, wattles, ice plant, different lupins, gorse, lavender and kikuyu.

The indigenous trial in conjunction with ***Forest Research*** established in 1996 is continuing up to the present time with new species being added on. This has been a huge success and shows what can be achieved starting from a raw sand dune. This year large dune

stabilisation trials have begun using waste products from different industries in the Auckland region. Industries quite often pay to dispose of this product, which in some cases involve large quantities. These trials involve the mixture of these products with different grass and clover seeds to hopefully obtain a pennant cover for our dunes.

The one item still missing in all our plantings is a nitrogen-fixing plant that is sustainable in the long term such as the species formerly used in New Zealand – yellow tree lupin. APLG wishes that more research be done on lupins in the future, as this would be a benefit to the whole west coast of the North Island. There are many species available on the Californian coast of America that are suitable for this purpose but the cost is prohibitive to get new species in to New Zealand.

RESHAPED FOREDUNES AT OAKURA BEACH AND EAST BEACH, NEW PLYMOUTH: RECOMMENDATIONS FOR DUNE RESHAPING AND REVEGETATION

Paul Jamieson and Ken Schischka
New Plymouth District Council

INTRODUCTION

This report briefly summarises the performance of a partially funded Coastal Dune Vegetation Network (CDVN) planting trial at Oakura Beach, south of New Plymouth. It then gives recommendations based on early results from the Oakura trial and a subsequently established project involving dune reshaping and revegetation at East End Beach located within New Plymouth.

OAKURA BEACH RESHAPING TRIAL

ESTABLISHMENT AND OBJECTIVES

The trial was established in July 2000 where the indigenous sand binding species, spinifex and pingao, were planted on a reshaped foredune. Full detail on trial objectives and design are given in an establishment report (Bergin *et al.* 2000). Collaborators in this joint trial include:

- Oakura Beach Care Group
- New Plymouth District Council
- Taranaki Regional Council
- ***Forest Research***, Rotorua

The objectives of the trial were to undertake a mechanical reshaping of a degraded foredune and revegetate with indigenous sand binding species in consultation with the local Beach Care group and local iwi.

METHODS

A 150 m long 10 m wide strip was reshaped as indicated in Hesp & Grant (2000). Exotic grass cover was sprayed with herbicide and a tracked excavator used to remove a layer of soil and reshape the sand to form a 15° slope to high water mark. The reshaped dune was planted with nursery-raised seedlings of native sandbinders, mainly spinifex. Fences and signs placed around new dune immediately after planting.

The planting trial comprised various treatment combinations of plant spacing and slow-release fertiliser applied at planting. Three types of plants tested were spinifex seedlings raised from seed, spinifex plants raised from cuttings and pingao seedlings. Four permanent transects were surveyed before and after reshaping and pegs were placed at fixed heights throughout trial plots to monitor localised sand movement.

Ongoing maintenance has involved weed control and broadcast applications of urea fertiliser in spring and autumn following planting.

Performance to date

The trial was last assessed in December 2001, 18 months after establishment. Percentage plant cover and a plant vigour score were estimated for each treatment block.

Plant performance: Most blocks were densely covered in dense spinifex laced with long runners. Estimated plant cover for blocks planted at 50 cm spacing was 98% compared to 87.5% for blocks planted at 70 cm spacing between sand binders. All plant types were vigorous but spinifex from seed was consistently taller often up to 75 cm tall compared to lower stature spinifex raised from cuttings. Many of the lower surviving number of pingao were vigorous even amongst dense spinifex. Vigorous spinifex runners were trailing down a scarp at the toe of the dune.

Sand movement: Twelve months after planting sand accumulation was up to 15 cm along the toe of the dune. At the 18 month assessment, a scarp 50-75 cm high was evident along the base of the trial about four months after a late winter storm. Sand levels along the mid slopes increased by up to 10 cm since planting with no significant difference along the landward edge of the dune. There was no significant difference in sand levels between planting treatments.

EAST BEACH RESHAPING

With the early successful results from Oakura and interest from the local community to manage a similar degraded erosion scarp at East End Beach, a 200 m section was reshaped and planted with spinifex and pingao in mid-2001. Early results are encouraging with good survival of spinifex and pingao. The combination of pingao planted with spinifex has shown that pingao in particular has withstood exposed conditions on the dune crest compared to spinifex within the first few months of planting.

RECOMMENDATIONS FOR RESHAPING DUNES

Based on observations and experiences with the Oakura Beach dune reshaping trial and the management of the reshaped dune at East End Beach, the following notes are given to assist with planning and implementation of dune reshaping works:

Planning:

- Plan ahead a minimum of one year in advance of implementation of physical works.
- Choose a site that has a reasonable chance of success.
- Investigate options other than reshaping (restoration of existing vegetation, sand pushes).
- Conduct a site analysis that includes local offshore and onshore systems, historical rates of erosion; install permanent dune profile survey sites and carry out a site survey to determine sand volumes to be moved or harvested;
- Consult with the local community using Coast Care to facilitate liaison with local users and residents, iwi Department of Conservation and your Regional Council for education and support to promote this as an option to manage – not necessarily prevent erosion.
- Manage rear dune affects that may include redirection of storm water and changes to use/activity of the rear dune and managed retreat options.
- Apply for consents for sand harvest/placement and follow up sand pushes, that may include an Assessment of Environmental Effects.
- Determine availability of suitable local contractors and equipment and a means of their supervision.
- Determine availability of local propagation materials and a means of production of plants.
- Investigate effective and pest control requirements and options acceptable to the local community and site and ensure implementation.
- Produce a project plan with timelines (also consider how the site will be maintained in the future).
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- Provide a budget for works including maintenance of plantings such as fertiliser and weed control.

Production of plant material

- Select plant species and ratios by a survey of the local dunes to determine presence and effectiveness of local species taking note where key species are most vigorous along the dune profile.
- Source plant propagation material and collect seed. Seed collection of spinifex and pingao should be planned, monitored and harvested a year in advance of requirement. For both these species, contract nursery production of plants from seed is the most effective method. Use CDVN Bulletins for guidelines to plan seed collection.
- To ensure a balanced colony and good pollination of spinifex, it may be useful to produce 5% of plants as cuttings from male plants.
- Plants must be hardened prior to planting at a coastal site.
- Plant roots should fill their container to withstand handling so that roots and potting mix remain intact.
- Plants should be a minimum of 30 cm high.

PREPARATION OF THE SITE

- Erect site signage to inform and educate local users. Use the Coast Care group to keep local contacts informed every step of the way.
- Carry out eradication of exotic grass vegetation on the site using several applications (minimum of two) of glyphosate to control kikuyu and other weeds; spray marram with Gallant at a rate of 15ml/litre. Time applications to achieve the best kill rates without leaving the site bare for an unnecessarily extended period.
- Confirm the natural position of the toe of the dune as all works must behind this line. Do not attempt to move the dune forward of this line which must be landward of the mean high water mark.

Reshaping

- Ensure that the machinery operators are involved early on and understand the objective; continuity of contractors will also significantly ease management of future operations.
- Time reshaping work during the lowest tides.
- Reshape using machinery to remove all clay/rubble/fill (everything that is not sand); some of the less suitable material may be used to build the rear of the dune but needs to be well buried. The Oakura trial has shown that any layers of clay/soil left in the dune inhibits establishment of sandbinders, and forms scarps that do not rebuild at natural angles, once eroded.
- Restore the seaward face of the dune profile to 15-20° using only sand; steeper backslopes of 20-30 degrees° are possible.
- Height of the new dune should be no less than the existing natural dunes dominated by native vegetation where they occur.
- Minimum width of the reshaped dune should be 10 m.
- Length of the new dune should be in sections of no less than 100m – preferably 200m to avoid end effects.
- Consolidate and level out the dune with leveling bars before planting.

PLANTING PATTERN AND TECHNIQUES

- For the Taranaki coast, spinifex is likely to be the best native sand binder due to the rate of establishment, coverage and sustainable recovery.
- On reshaped dunes, pingao appears to perform best on the upper slope and crest of the foredune where young spinifex can be damaged by wind on newly established exposed sites.
- The Oakura trial showed that the quality and suitability of plant material directly influences the establishment and survival rate (range of survival across plant types 79% to 48% after 6 months).
- The Oakura trial showed that spinifex grown from seed had significantly more runners, although plants from cuttings produced longer but fewer runners. Overall, spinifex seedlings from seed gave significantly greater and faster cover than spinifex from cuttings or pingao.
- Sand carex (*Carex pumilla*) is useful to mix with spinifex, especially in areas adjacent to access ways, where this plant appears more resilient to foot traffic.
- *Euphorbia glauca* grows successfully on can be used on landward parts of the foredune dune, but not where it is likely to compromise the function of primary sand binding species

Planting and layout

- Water the dune if possible to assist with consolidation, a firm working surface and to improve plant establishment.
- Apply a light base dressing of general purpose fertiliser e.g. Nitrophoska
- The Oakura trial showed that the optimum spacing for establishment was seedlings planted at 50 cm.
- Planting should be carried out in line with CDVN Technical Bulletins. Key points to remember are that plants should be watered immediately prior to planting; planted up to 5 cm deeper than the original container level, and use of a balanced slow release fertiliser (preferably one with an early nitrogen release) in each planting hole. If planting in rows, ensure that they run along the dune, as they will provide better coverage as they start to run.
- In Taranaki, only spinifex should be used on the lower foredune as it is the most effective to repair toe erosion events. Pingao can be used on the upper slope, crest and backslope of the foredune especially where wind is likely to damage softer spinifex foliage soon after planting on exposed sites. Where the two species meet, there needs to be an random mix of the two, to avoid an unnatural transition
- If using *Carex pumila*, keep it adjacent to accessways, while *Eupurbia glauca* should be restricted to the landward slopes, until further research proves the potential of this plant.

Protect with fencing and signage

- Erect a rear dune fence no less than a standard seven wire post and batten fence.
- Add cloth windbreak to the full length of the rear fence and secure with wooden slats on the battens to prevent theft and movement of the material.
- Erect a foredune fence with posts 8-10 m apart. Two wires are adequate. Posts should be 2.5 m long and pushed in with the excavator to be approximately 1 m height above sand level.
- All fences to be with mild steel gauge 10 wire or similar with anti corrosive properties. All fences should be strained with permanent wire strainers.
- Install access points at each end of the dune using clatterboards, board and chain or similar systems that are laid over the sand and can move up or down with sand level changes.
- Install signage to mark access ways and to educate users of the site. Include recognition of the local participants.
- Resurvey dune profiles immediately after shaping and planting is completed.

Programme maintenance

- Manage invasive species, especially marram that can be controlled by careful application of Gallant to established plants. Regular hand pulling may be effective on a localised scale until canopy closure with native sand binders. If the dune is pure sand the range of herbaceous adventive species is likely be limited especially on exposed seaward face of the dune.
- Monitor plant growth to provide information on which plant establishment patterns, density and methods are most successful and incorporate improvements into ongoing dune revegetation programmes.
- Where practical, carry out maintenance of newly planted seedlings within the first few months of planting such as uncovering plants buried with sand or re planting those that may be undermined.
- Monitoring nature and frequency of pest damage to vegetation to determine ongoing control requirements.
- Apply fertiliser to optimise growth of establishing plants. Use light broadcast dressings of high nitrogen urea preferably during or when light rain is expected.
- Repair damage to fences, accessways and signage. Timely repair of vandalism and storm damage emphasises the commitment and maintains the protection of the investment.
- Monitor profiles to provide useful information such as cycles of sand build up and loss in relation to overall dune profile and type and vigour of vegetation cover.
- Consider sand replenishment of scarps after major storm damage if vegetation cover is seriously affected and not likely to recover quickly. Consents need to be in place to harvest sand to fill in the toe if the dune is seriously damaged.
- Replace plants to fill in gaps created by plant losses. Establishment of seedlings planted late in the season may be boosted with premixed crystal rain.
- Encourage active and ongoing input and support from the local community – the presence and ownership of the work by the local community will give the best long-term result for the dune.

SUMMARY OF WAIKAWA BEACH TRIAL

Aaron Madden
horizons.mw

Waikawa Beach is the southernmost beach in the Manawatu-Wanganui region, between Levin and Otaki.

At the beginning of the 2000 winter **horizons.mw** was asked to advise on a Horowhenua District Council project to establish sand-binding vegetation to the north of the Waikawa Stream mouth. The idea behind the project was to catch windblown sand from the beach before it entered the stream mouth by planting an area seaward of the existing foredune.

The District Council's proposal was to use marram grass but there was strong resistance to marram from the Waikawa Beach Ratepayers Association. The Ratepayers Association was delighted when I suggested that native plants could be used instead if the site was included in our spinifex establishment trials.

I had envisaged using only spinifex for the project but was unable to source any from commercial nurseries at such short notice. This restricted the available spinifex numbers to 1200 plants raised for us by UCOL – the local Polytechnic. As a result, 6500 pingao plants were purchased to make the numbers more respectable.

A rabbit poisoning programme was considered but not undertaken due to the difficulties and dangers posed by the high recreational usage of the general area (especially the walking of dogs).

The Horowhenua District Council employed a contractor to erect a 3-wire fence around the 1,600m^2 planting site to discourage vehicle and pedestrian traffic. Several signs were posted to inform the beach users about the trial and a walkway, angled away from the prevailing wind, was left through the middle of the site.

The planting took place in late August 2000 and involved local residents, UCOL students and **horizons.mw** staff. Plant spacing was one metre by one metre. Slow-release fertiliser (Nitrophoska Blue®) was added to the bottom of each planting hole.

All plants received the same treatment so this project could be viewed more as a 'trial run' than a trial.

horizons.mw paid for the spinifex plants and Horowhenua District Council paid for the pingao plants, the slow-release fertiliser granules, the signage and the fencing.

Very high initial losses of both species were experienced – approximately 95% of pingao plants and 85% of spinifex plants.

The factors contributing to the high casualty rate were:
1. Rabbit browsing
2. Exposure of the root systems
3. Burial of the seedlings by sand accumulation

For pingao, the major factor was rabbit browsing. Site inspections in the months following planting found very little evidence of rabbit browsing on spinifex until almost all the leaves of the pingao had been eaten (i.e. the rabbits had a clear preference for pingao).

The cause of the majority of spinifex deaths was rapid burial by sand. Sometime in early September the Works Manager for the District Council had instructed a fencer to attach windcloth to the wires on the fence.

Apparently, this was an action recommended to him in a consultant's report. He had told me about this during one of our earlier site visits and I had instructed him to ignore the recommendation, as it would likely do more harm than good. For reasons unknown, he decided to follow the consultant's advice but did not inform me.

During a site inspection in October I discovered the consequences of this action. Wind had gone underneath the cloth barrier, created a trench and deposited the excavated sand on the first four rows of plants behind the fence. The wind that had passed over the fence also dropped sand on this area until up to 75 centimetres of sand covered the plants behind the fence. Almost all of the spinifex planted was in this zone.

The windcloth was removed the very next day. The deposited ridge of sand was eventually removed by the wind but it was too late for most of the buried spinifex plants.

It was decided that something had to be done about the continuing rabbit damage. Poisoning programmes were still a last resort so in June 2001 an egg-based repellent was sprayed onto all surviving seedlings and this has been repeated several times. Rabbit browsing damage has been minimal ever since.

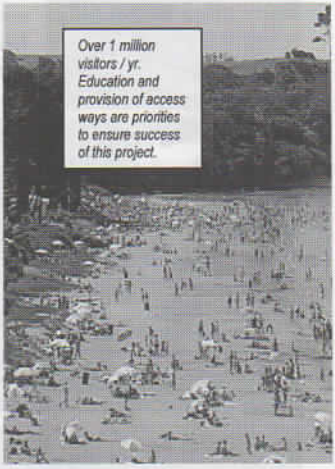
A further 800 spinifex seedlings were planted at the site during the 2001 winter at increased spacings of two metres by two metres in order to get better coverage with fewer plants. These seedlings were also sprayed with repellent prior to planting and several times since.

Beach users have been excellent and have stayed out of the trial site. Some of the initial spinifex plants now have runners over one metre long and are doing a fine job of trapping sand.

LONG BAY
URBAN BEACH DUNE RESTORATION PROJECT

Amanda Bowden, Manukau City Council
Karen Baverstock, Auckland Regional Council

Long Bay is an east coast beach situated on the North Shore approximately 20km from Auckland City centre. As well as being an ARC regional park, it adjoins the Long Bay Okura Marine Reserve administered by the Department of Conservation. The landscape of Long Bay is a highly modified one. Management has traditionally concentrated on recreational and amenity values. The dunes were clay capped and over the years introduced ice plant and Kikuyu grass have taken over from the native vegetation.



The Long Bay dune restoration project commenced in 2000 with the planting of 200 Spinifex plants by volunteers. The area that was planted at the far north end of the beach was the last remaining 'natural' dune area at Long Bay and had *one* last Spinifex plant. The area was fenced off, the Spinifex plant was fertilised with urea and further planting of Spinifex, grown from runners that were taken off Tawharanui beach earlier in the year, took place.

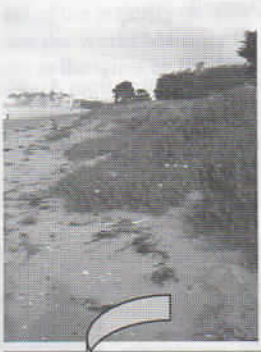
Once the area was fenced, other Spinifex plants that had been suffering from the effects of trampling and were thought to be gone started coming away. At least three more plants became apparent and responded well to urea application.

Over 18 months have passed and this area is now unrecognisable. The 200 Spinifex that were planted all took incredibly well and there is a large amount of seed being produced for the first time in years. Other sand dune species have also started to recover with Sand Convolvulus and Carex Pumila becoming increasing prevalent and re-introduced Pingao further enhancing this area. From visual observations it is apparent that sand is accumulating and being trapped by the sand binding vegetation and a foredune is slowly starting to reform. This is supported by beach profile monitoring at Long Bay which shows the base of the foredune building out and accretion of the beach up to 0.5m in the past 6 months. However continued profiles over a longer time scale need to be collected to confirm any patterns.

The success of Phase1 meant we were ready to tackle something more difficult. In mid 2001 the dune restoration project was extended approximately 100m south down the beach to cover a badly degraded dune scarp that was clay capped, dominated by ice plant and Kikuyu, and 'clumped' due to people cutting across the dunes to access the beach.

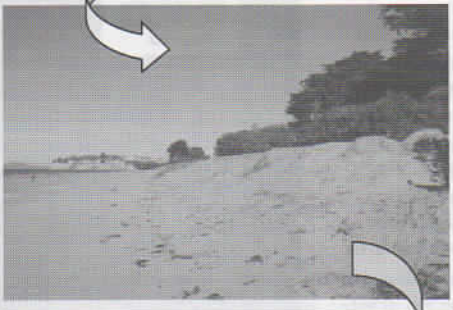
Phase 2 of the dune restoration project involved a number of stages. Firstly all of the existing vegetation was removed either by hand or spraying. Once the vegetation had died off, a digger was brought in to reform the dunes. Research and consultation indicated that a dune face somewhere between 15-18 degrees was appropriate. The digger was also used to form an accessway for the sand ladder. Once the reshaping was completed the area was fenced off and

Dune Care signs erected. A public planting day was then held in June 2001 and approximately 1500 Spinifex and Pingao were planted at 0.5m intervals with slow release fertiliser. Plant spacing was reduced to encourage success in such a high profile location.

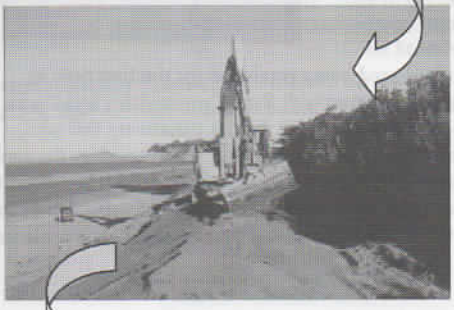


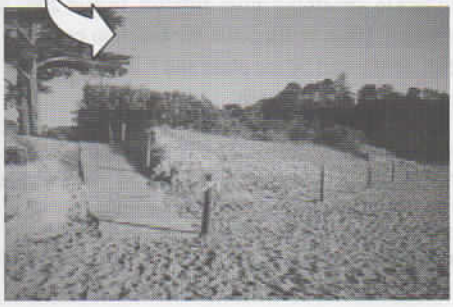
Before and even during reshaping the clay cap was an issue – its depth and thickness were unknown. Advice indicated that it would be preferable to either remove the gap or at least break it up and mix with sand. However on the day it was determined that the cap was at a sufficient depth not to create a problem and it was therefore left in place.

Over the past 6 months this site has also shown very promising results. The Spinifex and the Pingao have both taken well and the fencing and accessway prevent people from cutting across the restored dune area most of the time.



This year it is proposed to continue with the dune restoration, working southward into increasingly degraded dune systems and more heavily used areas of the beach. A focus on interpretative signage and creating close partnerships with the local community, schools and interest groups will be a key to promoting acceptance and long-term success of the Long Bay dune restoration project.





Photos show the stages of Phase 2: Scarped steep remnant dune covered in Ice Plant; Bare sand after removal of all vegetation; Regrading; Creation of accessway with fencing and replanting.

AN UPDATE ON SOME OF THE COAST CARE GROUP ACTIVITIES ON THE WEST COAST AND EAST COAST OF THE REGION INCLUDING HAURAKI GULF ISLANDS

Auckland Regional Council

Karioitahi BeachCare

The original aim of Karioitahi BeachCare was to restore, preserve and conserve the foreshore and dunes to a distance of 500m either side of the surf patrol clubhouse for the benefit and enjoyment of all beach users. Since being set-up the group has planted over 5000 native dune binding plants and has largely achieved this aim.

Karioitahi BeachCare are now hard at work addressing a problem that plagues many of our beaches – vehicles on beaches – both the damage to the natural environment including dune plants and shellfish, and real concerns about the safety of beach users. The group have formed a sub-committee to specifically concentrate on this issue. This committee includes representatives of the councils, the police, surf lifesaving, and user groups. Karioitahi BeachCare are advocating to local politicians that the district council extend bylaw control down to mean low water to enable more effective and consistent management of issues such as vehicle control, litter, dogs on beaches, etc. The group are also monitoring and educating beach users, and raising the profile of safe beach use through media releases and liaison with local user groups.

Karen Baverstock, ARC

Karekare Care

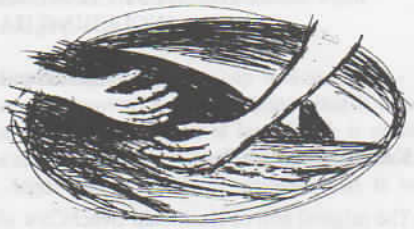
Karekare Care differs from other coastal Care Groups in Auckland in that the coastal forest and backdunes are their focus. They have divided themselves into 'Vigilante Gardeners' and "Furry Animal Killers' !!! The Vigilante Gardeners hold monthly working bees with a different weed tackled each month. Their next strategic step involves ARC drawing up a weed map that will list all the weeds at Karekare and where they are. This will help to prioritise which weeds should be attacked first and also to monitor the change in distribution of these exotics over time.

The Furry Animal Killers received funding from the ARC Environmental Initiatives Fund in 2000 and 2001 to assist with bait and traps. They are having such great success that their animal control area has been expanded. Just last week they caught 12 stoats! The benefits to the coastal forest at Karekare are already being seen.

Ngaire Sullivan, ARC

Te Henga / Bethells BeachCare

Te Henga has continued with their dune re-vegetation program. Spinifex seedheads were once again collected by the group and buried in the sand early in 2001 with great success. The key appears to be finding less exposed planting sites. More pingao and spinifex were planted in the mobile sand areas, with karo, wiiwii, tauhinu, and toetoe planted in the damper, more stable spots.



Rabbits continue to plague the beach and a rabbit control report was recently written by ARC, WCC and the BeachCare Group to counter this problem. This will see an integrated control programme, incorporating different methods and involving both professional biosecurity officers and community volunteers. The Rabbit Controllers are also enthusiastic about trialing rabbit repellents when undertaking the dune planting this year.

Te Henga/Bethells BeachCare continues to stress education of beach visitors as one of the most important means of changing beach behaviour. In 2001 a Wildlife Afternoon was held, talks were given to Waitakere Primary School, Manukau Polytech was taken on a tour around the dunes (and then got roped into a working bee!), and a "Historical Reminiscences" talk was given by older locals about what the beach used to be like in the early 1900s.

Ngaire Sullivan, ARC

Muriwai Beach Care

Muriwai is a high-energy beach on the west coast of Auckland. Land and dune management at Muriwai has little historical regard for dune processes and in the past there has been extensive efforts to construct Marram dominated artificial dunes. This has left a legacy of high unstable dunes that are now eroding. Added to this are the pressures associated with 1,000,000-plus visitors who visit the beach every year.

Muriwai BeachCare was established in 1997 to tackle some of these problems. The group's aim is to make progress towards a more stable and sustainable dune management regime between the southern car park (the beginning of the beach) and the Okiritoto Stream 2km to the north. Over the years the groups has undertaken a number of activities including dune planting, fertilising existing stands of Spinifex, beach clean-ups, installed educational signage, etc. In mid 2000 a 100m stretch of dunes was recontoured using earthmoving equipment and over 7,000 Spinifex and Pingao were planted.

The range of management solutions including dune reshaping and revegetation trials that have been implemented at Muriwai have had varying degrees of success. A long-term and co-ordinated approach to coastal management is required based on a sound understanding of coastal processes occurring at Muriwai, and uses and values of the area. A joint project funded by ARC and Rodney District Council is currently underway. This project aims to report on the nature and

scale of coastal erosion at Muriwai, causes of this erosion, hazard posed to public and private property, and values of the area. A coastal management strategy will be developed that meets community expectations and is also consistent with promoting sustainable coastal management (the statutory direction). Muriwai BeachCare is currently in a holding pattern awaiting the outcome of this strategy.

Karen Baverstock, ARC

Onetangi, Waiheke Island

The Onetangi Beach Care Group is eagerly awaiting the draft Onetangi Beach Hazard Management Strategy and aim to get as many members as possible along to their next meeting to discuss and comment on the strategy. The strategy, prepared by consultants Tonkin & Taylor in consultation with the community, identifies both short and medium term actions to sustainably manage the coastal erosion hazard at Onetangi. Implementing the strategy will be assisted by a grant from the ARC Environmental Initiatives Fund which has been granted to the Onetangi Beach Ratepayers Association to go towards the cost of dune plants, signs, and sand ladders for the beach.

Liz Ross, CoastCare Consultant

Pakiri BeachCare – Taumata B

Pakiri BeachCare – Taumata B are taking a really positive and proactive approach by protecting and enhancing a fantastic natural environment rather than waiting until they need to restore a degraded environment. Taumata B received a grant from the ARC Environmental Initiatives Fund and the WWF. With these grants iwi volunteers fenced off a significant area of dunes, erected educational signage, and constructed an accessway. The fence was continued around the back of the dunes to stop cattle getting access to the dune vegetation.

Taumata B are also working closely with Pakiri LandCare who have held pohutukawa planting days and a possum control meeting. Next on the agenda is a proposal to get involved and undertake beach monitoring at the southern end of Pakiri.

Karen Baverstock, ARC

Medlands BeachCare, Great Barrier Island

Medlands BeachCare continues to thrive! In 2001 the BeachCare Group got together with Kaitoke School for a planting day. The carpark was beautified with cabbage trees, *Coprosma acerosa* and flax, and then 12 endangered golden sand tussocks were planted on the dunes - a recent check found that most have survived and are doing well.

The Sandhills Reserve backdune planting that began in 1999 with native plants being planted directly into tufts of dead pampas is such a success that some people are wondering if the ngaio's are getting too big and shading out other plants! (luckily there are some baby nikau tucked away under there that are enjoying it).

Over the recent summer holidays, the BeachCare Group tackled dog control to try and look after the endangered NZ dotterels that are breeding on the beach. This has proved to be a tricky issue, and the group is exploring various options to ensure better success next year.

Ngaire Sullivan, ARC

Awana BeachCare, Great Barrier Island

The group has re-formed after a winter in which no 'official' activity took place, although group members continued to keep an eye on the beach for dogs, cars etc and to make comment to any offenders. As a result the message has got around locally that there is a specified area for dogs, and that the 'estuary' end of the beach is a nesting area for New Zealand Dotterel and an important gathering ground for Brown Teal. We have also encouraged cat trapping and rat trapping in the area, being carried out under the auspices of the Awana Catchment Trust.

Probably partly as a consequence of these continued activities, DoC have been more active, and constructed a tape fence-line with notices about the birds in the estuary area. This has further increased awareness and been markedly successful in keeping people (and their dogs) off the area. The presence of a DoC campsite in a major threatened species habitat still seems anomalous to me though.

The NZ Dotterels have done well this year. Last years parents and their three fledged young (I think!) returned. The parents have bred twice - two young have been fledged, and two more are currently running about when no one is watching!

Up to five pairs of Variable Oystercatchers are present. Two nesting attempts both failed, but possibly due to natural causes - no obvious predation seen. Brown Teal numbers may be up slightly too - over 50 counted.

We have had one meeting and decided to keep the planting profile as low as possible, at least until the QE2 land has been fenced and we can see exactly what it is. We hope to plant a few trees on the ACC reserve area at Easter, to provide shade and help concentrate people at the southern end.

John Ogden, Awana Beach Care

MANAGEMENT OF SAND DUNES ALONG THE CHRISTCHURCH COAST

Jason Roberts
Christchurch City Council Coast Care Unit

INTRODUCTION

The Christchurch City Council Coast Care programme was initiated in the mid-1990s with $2 million to be spent over the first 5 years. Ongoing funding has been secured for the programme for continued upgrading of amenity areas, the supply of some 60,000 native seedlings per year for planting on the coast, contact time for education groups, maintenance of plantings and the reshaping and planting of problem dune sites.

The programme is run by the Coast Care Unit of the Christchurch City Council with the involvement of several community groups and agencies including the Canterbury Regional Council, local Coast Care groups, Wai-Ora Community Trust, periodic detention groups and local schools. Overall, the programme has been successful in improving amenities for beach users as well as controlling sand movement in many of the problem areas.

INITIAL FOCUS OF PROGRAMME

The main aim over the last few years has been to control sand movement using combinations of various exotic and native plant species to provide a vegetation cover as well as the use of sand fences to slow down or prevent sand inundation of facilities landward of dunes. Reshaping of dunes by machinery has been necessary most years on a small number of sites where erosion is a major problem due to the large influx of sand and prevailing strong easterly winds.

Revegetation of dunes has revolved around the use of the exotic species, ice plant and marram grass, to revegetate bare areas as limited information was available initially on the use of indigenous sand binding species and planting stock of native plants was not available in large quantities. Emphasis has also been on the provision of formal accessways, fencing vegetated dunes in high use areas and erecting signs to highlight accessways and planted areas. A further aim has been to provide information to locals on the importance of the dune system and processes and the importance of vegetation cover. The programme has also involved enhancement of public areas along the coast for recreation and to improve scenic values.

However, there was interest during these early stages in establishing indigenous sand binding species along foredunes as an alternative to exotics. Christchurch City Council Linwood Nursery has been successfully raising thousands of pingao seedlings for dune planting for several years. There is also interest in establishing indigenous species in dense marram-dominated dunes landward of foredunes.

RESEARCH AND MONITORING

Collaborative trials between the Christchurch City Council, local community groups and Forest Research were established along the foredune at South Brighton in the mid-1990s. Nursery-raised pingao and sand tussock were planted on the steep foredune and performance monitored for several years. Pingao in particular grew well despite large influx of sand but was susceptible

to damage from beach users who did not keep to formal accessways. Some sand tussock on the upper slopes survived the moderate accumulations of sand. Many of the pingao are still actively colonising the site. No spinifex seedlings were available for planting but seed sourced from the nearest naturally colony at Cape Campbell to the north was sown in these trials. Some spinifex seed did germinate, but the small seedlings did not survive beyond late spring.

Trials were also established landward of the frontal dune in the mid-1990s to evaluate the performance of a range of locally native coastal mostly woody plant species. This involved cutting gaps within dense marram cover and planting small groups of seedling within these gaps. A small number of hardy plants were identified including harakeke, tauhinu, akeake in more sheltered sites, ngaio and cabbage tree and these species are proving successful in ongoing operational programmes.

A major success has been the reintroduction of spinifex to the Canterbury coast. Spinifex was last recorded on North Beach, Christchurch in the 1940s. A major planting trial was undertaken at Taylors Mistake, Banks Peninsula, which was considered to be more sheltered and generally warmer than the exposed beaches along New Brighton. Seedlings and cuttings were raised at the local council nursery at Linwood and planted in a trial at Taylors Mistake immediately landward of the mean high water mark in 1996. Plants in selected plots were fertilised at planting with Magamp while others were planted without fertiliser. Initial growth and vigour was better with fertilised seedlings. However, overall, there has been excellent survival and growth of the planted spinifex with a relatively good cover of the approximately 100 m long by 5 m wide zone within a year of planting. Over the last five years, the spinifex has accumulated a significant amount of sand and the zone has increased in width by active growth of runners seaward. Last winter, the Coast Care Unit has also hand pulled marram along the landward margin of the established spinifex and planted further seedlings of spinifex. Re-invasion of the spinifex zone by marram or other exotics has only been very minor. As fences have become too low with the sand accumulation over the last year, beach users this summer have caused some damage. A broadcast application of urea has been undertaken to aid good recovery and fences will be replaced to protect the planting.

Early attempts at spinifex at South Brighton were covered by large sand drifts despite good early establishment. Planting of spinifex on the main Christchurch beaches in the last two years has been more promising with good growth of surviving plants despite some frosting damage.

CURRENT COASTAL MANAGEMENT PROGRAMME

The aims of the current coastal management programme along Christchurch beaches are to build on successfully stabilised areas using combinations of sand fencing and pingao where resources permit. There is still a desire to move away from using mostly ice plant and marram for large scale revegetation projects and to use the native sand binders spinifex and pingao but it is difficult to obtain large number of plants. Spinifex seed produced at the Taylors Mistake colonies are low in viable seed. The cost of native plants compared to readily available propagation material of ice plant and marram is still high. Rabbit control is also required for pingao plantings.

There is a continuing educational emphasis involving the local community, beach users, visitors and Christchurch schools. Use of local employment schemes to assist in daily operations is still important. The coastal management programme has recently become more integrated with management of other high-use or natural areas within the city or on the outskirts including Bottle Lake Forest, Travers Swamp restoration and various riparian restoration projects.

PRIORITIES FOR FURTHER RESEARCH

Priorities for further research include establishment and monitoring of spinifex planted on the main Christchurch beaches in combination with pingao. Increasing the proportion of viable seed in the established spinifex colony at Taylors Mistake by planting male spinifex raised from cuttings amongst females could be tested.

More research on establishment of groundcover and woody species on exposed sites inland from the sandbinding zone needs investigation with and without use of sand fences. Guidelines for establishing the hardy native tree and shrub species on the dense marram-dominated sites are required. Establishment of *Euphorbia glauca* has been attempted previously but more work on suitable site selection and rabbit control is also needed. A series of trials on a recently re-shaped dune and a marram-dominated dune are planned for mid-2002 to establish a sequence of vegetation from a mixture of spinifex and pingao on the foredune, then groundcover and low stature shrubs to taller species further inland.

DUNEDIN CITY – A COASTAL OVERVIEW

Paul Pope
Reserves Officer – Dunedin City Council

Background:
The City of Dunedin covers 3350 sq. kilometres and is the largest city in NZ by area. It is also one of the most environmentally diverse, with its western boundary in the alpine slopes of the Rock & Pillar ranges, to the rich marine wildlife areas of the Otago Peninsula. Presently the Dunedin City Council manages over 300 reserves in 2700 hectares. Fourteen of these reserve sites are coastal dune areas totalling nearly 600 hectares.

The City Council took over the management of eight coastal sites in the 1989 local government reforms. In 1994 the Parks Department of City Council developed a coastal strategy that created a five-year programme of capital works for its beaches, that programme is now completed. A new plan is now being redrafted for a further eight years and this will be presented to Council for inclusion in the 2003 Annual Plan. The eight-year programme seeks to invest $1.6 million over eight years into protection works, public access, revegetation projects, and interpretation.

All of Dunedin City's 14 beaches have reserve status under the Reserves Act 1977. The provisions of the Act require these areas to have management plans written for each of them. Presently, there are four completed plans (two are out of date) and three sites are being added to a Harbour Management Plan for completion in 2002. The remaining sites will be added to a Coastal Management Plan in 2003 that will take approximately two years to complete.

The Present Situation:
The highest public profile beach areas in the Dunedin City are St Clair and St Kilda beaches, Ocean Beach Domain. Both are focal points of recreational and physical access to the coast and their popularity can be attributed to their proximity to the central city. However, in the last five to seven years significant storm and tide events have severely eroded sections of the St Clair beach and destroyed several essential beach access points. This has culminated in the exposure of nearly 200 metres of building rubble as the end wall effect from St Clair removes sand from this area in periods of high seas and tides. Construction of a Reno mattress, re-orientation of access, and removal of fill have all proved fruitless.

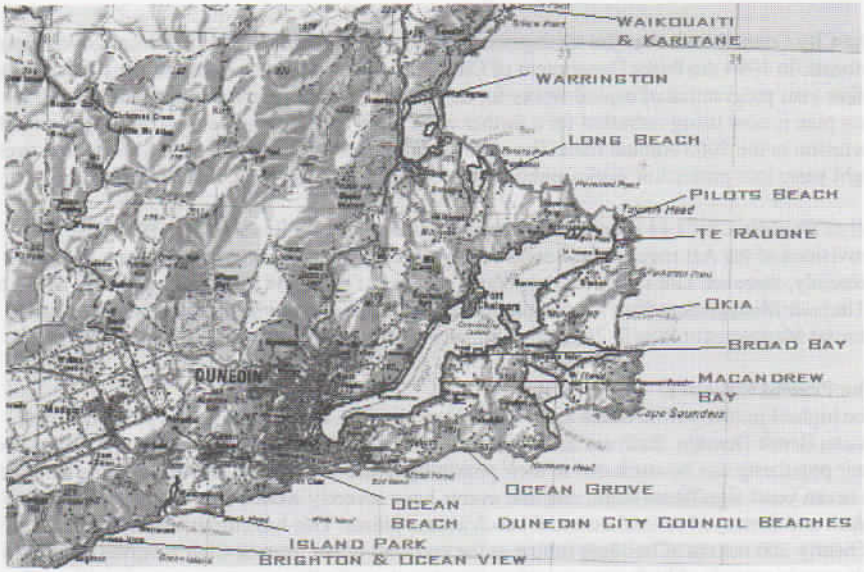
A severe low-pressure weather system coupled with unseasonal northeasterly winds, and high tides in September 2001 saw significant pressure placed on the wall and the further acceleration of the end wall effect along the beach. Engineers have advised the City Council to rebuild the wall and take urgent action on the end wall issues. There is now a significant public consultation and discussion process being undertaken over this issue.

The September 2001 storm events also severely effected other beaches in the region, though their proximity from infrastructural and housing assets lessened some of the public alarm over the retreat of sand from the beaches. Southeasterly oriented beaches such as Island Park south of the city lost 80 cubic metres of sand per metre of beach over a kilometre of its length. While the effects were severe and short-term losses of sand high, most of the beaches have recovered well. Since late December 2001 there has been some unseasonal storms along with high tides which have proved problematic.

Karitane a small township north of Dunedin was threatened by the rising water in September 2001, and had its protective sea wall destroyed along with the majority of the protective sand

dune spit at the entrance to the estuary. The small township and adjacent spit took much of the brunt of the northeasterly winds. Considerable public pressure saw the replacement of the sea wall along with dune fencing of the vulnerable spit area at a cost of $180,000.

The September events along with the proximity and scale of the St Clair example have galvanised public interest in coastal processes and management throughout the region. There is considerable political interest in the outcomes of management of beach and dune areas and this bodes well for the presentation of the Parks & Reserves units' eight-year capital plan for its beach reserves.



Community & Organisational Liaison

The City Council has a considerable leadership and consultative role to play in coastal care and management. The scale of the city and the inclusion of several coastal communities with localised reserve areas have seen the development of partnerships with these groups and the Council. The projects are predominantly replanting restoration projects of back and foredune areas along with several coastal wetland and estuary sites. Some funding is made available through existing operational budgets, community grants, and Taskforce Green & Conservation Corps assistance. The localised nature of all of these groups has not been without difficulties where the expectations of the community differ.

The City Council has been represented on the *Pikao Recovery Group since late 1995. The group was formed in 1992, coinciding with the creation by DoC staff of The Pikao Recovery Plan for the Otago Conservancy. The City Council, DoC, Otago Regional Council, Runaka, and Yellow-eyed Penguin Trust form the basis of the organisation which have been responsible for improving the profile of pikao on the Otago coast. The group has been able to develop interpretation, educational programmes, monitor existing sites, develop new plantings, and provide technical advice to a variety of organisations. A Memorandum of Understanding has

formalised the group's aims and objectives and this has been instrumental in ensuring an inter-organisational forum for the discussion of pikao restoration as well as other coastal issues.

Komiti taoka tuku iho is the cultural materials management committee for the Otago Conservancy. It is a technical advisory group looks at the allocation of cultural materials for traditional purposes. The group has representatives from the Otago Museum, DoC, Dunedin City Council, University of Otago and the various Runaka. The purpose of the group is to look at the sustainable use of materials (whale bone, feathers, pikao) for cultural use. The group provides technical advice on the sustainable management of resources, while the runaka view the cultural importance and relevance of applications for use of these type of materials. The group has developed protocols for marine mammal strandings (and the use of the bone and other material) and has been looking at the use of plant materials for food, weaving and other uses. The importance of the group is that it provides a forum for discussions on issues that effect coastal resources and develops inter agency contact and understanding with runaka.

Dunedin has a significant number of community conservation organisations that are based at a localised or regional level that liase directly through local government and government organisations. While the Pikao Recovery Group has gone some way in unifying and networking these groups there is a need to ensure this is promoted and achieved to a greater level. Further, the advent of the Annual Plan programme developed by the City Council may see more available resources within the programme for organisations wishing to be involved in the care and restoration of their beach areas.

The Future:
Politically, in the local media, and within the community, the focus has been on the serious situation that has arisen with the St Clair sea wall. Its condition and effects on the beach have been widely publicised and debated. The City Council must urgently plan its repair and restoration to avoid infrastructural damage and property loss, as well as the to prove to the public its commitment to the reserve and the St Clair area. However, with terms such as "surf reef" and "wave rotators" bandied about with abandon, and a public clearly concerned with the situation, the City Council must be very clear on its selection and methodology for this problem.

With the focus on St Clair, there has been a reawakening of concern for the condition and management of other beaches. For the City Council this means that the current development of an eight year capital programme for its other beaches is timely and more likely to better understood politically and from the community at annual plan submission time. Further, the City Council's signature on the Pikao Recovery Group's Memorandum of Understanding in October 2001 creates a formal partnership and forum with other agencies and community groups in the coastal management area. This indicates awareness by the City Council that it is a leader in the community in this area. In the community eight organisations have localised partnerships with the fourteen beach reserves managed by the City Council. There needs to be further development of their skills and integration of their organisations into a more networked coast care community.

Dunedin City is fortunate to have such an excellent coastal reserve estate available for its citizens. This paper has only focused on the sites managed by the City Council; the Department of Conservation estate in Dunedin is also very impressive and diverse. The range of areas, their vegetation, and wildlife is quite broad and the recreational opportunities are significant for the City. Dunedin is vigorously marketing itself as an ecotourism destination, and this will certainly bring greater visitor numbers to the City's beaches. Those impacts have only recently and cursorily been looked at in a handful of areas, and there is a need to investigate these impacts

further. The City Council is well placed in its role as reserve manager, economic developer, and district planner to actively play a part in that investigation.

Conclusion:

- Dunedin City has a diverse and extensive collection of beach and dune reserves managed by the City Council that are important assets to the city recreationally, financially, and ecologically.
- Like all coastal areas Dunedin is subject to the seasonal fluctuations of weather and tide and this has been most visible since September 2001.
- Significant progress has been made in improving and protecting these areas but there is still more to be done, and the Council appears to be positioning itself through it's Annual Plan in an effort to attain this.
- Public input and partnerships have increased, as coastal issues have become more prevalent.
- Inter agency partnerships have been well founded to create dialogue and a forum for coastal issues.

The Kai tahu use the word pikao to describe *Demoschoenus spiralis*, while the North Island Iwi use the word Pingao to describe this plant. The difference in dialect between Iwi of the two islands is significant and this paper has chosen to use the Kai tahu usage.

NORTHLAND REGIONAL ROUNDUP

Sarah Flavall
Northland Regional Council

Brief description of physical characteristics and pressures on Northland. Generally, there is a trend of long-term retreat of the coastline, coupled with short-term fluctuations in erosion and accretion. The retreat is now at a point where many esplanade reserves have been almost completely eroded away and private property is increasingly affected.

Northland Regional Councils involvement in coastcare and beachcare initiatives has been limited. Our organisation tends to be reactionary, providing advice when we are approached. However, coastcare has been recognised as an important area for the Council to become more proactive. The general planning of coastal margins in terms of the council's statutory responsibilities has also been brought to light, as there is a lack of planning for the coastal margin in both our Coastal and Water and Soil Plans. It is hoped that an opportunity to strategically plan for Northland's coastal margins, using both regulatory and non-regulatory approaches will present itself soon. The Whangarei District Council (WDC) is currently undertaking a coastal management strategy, which is hoped to provide a strategic, overarching framework to WDCs management approach.

Increased involvement in the establishment and maintenance of coastcare groups in Northland presents a number of opportunities for NRC. Beyond improving the form and function of beach and beach-foredune dynamics through better management practices, coastcare is seen as a major opportunity to educate the public about the nature of an environment characterised by a range of complex physical processes and dynamics, and a concentration of human use and development. The general public of Northland still maintain the classic engineering mentality, where a seawall (or other objects such as tyres) are seen as a solution to coastal erosion, even if it enhances the erosion. Coastcare is seen as a good opportunity to increase awareness of coastal processes, to provide technical advice and assistance to communities and to change the "engineering" paradigm that currently exists.

COAST CARE BOP PROGRAMME

Greg Jenks
Environment Bay of Plenty

Our local programme has been running for 6 years now, with many of the earlier projects reaching a point where we can confidently say "Yes, this concept of empowering the community to improve their coastal environment not only works, it works brilliantly and is absolutely sustainable." These successful projects create immense community pride and continuing interest and involvement, and positive media support. Our volunteer members are critical to success, and every effort is made to recognise their input wherever possible. It is pleasing to report that volunteer numbers continue to grow, with over 500 now registered on the database.

Many of the early works have been subject to at least three cyclones (remember Fergus, Drena and Gavin in the summer of '96?) and numerous other storm events. The effects of these storms on our beaches, with swell heights up to 11m, were black and white. The areas with mature plantings were able to resist major storm damage, in contrast to areas of heavy human modification where severe 'dune' recession often occurred, and could not self-repair.

A flexible approach to problem solving has proved to be worthwhile. Wherever possible, plantings utilising all four native fore dune species occur, usually predominantly Spinifex and pingao, but also Austrofestuca littoralis, and more recently the beach spurge, Euphorbia glauca. However in areas where the erosion risk is too great, other strategies have worked well, for example applying urea regularly to any remaining native species to promote their growth. It is a wonderful coincidence that fertiliser application allows the native dune plants to outgrow any exotic weeds that may be also present, so the native plants eventually dominate and return natural function to the dune. This has been particularly helpful in Ohope.

People and rabbits continue to be pests. The rabbits can be easily controlled (see Greg Corbett's contribution), but controlling people with the same techniques seems less popular generally. However, the leaf shaped rope and bollard plots at Mt. Maunganui have proven their worth, with great pedestrian control in a very high traffic area. Consequently, the pilot trial was successfully extended, and more plots are soon to be installed on the Main Beach to guide people to the beach from the new and very popular boardwalk. And all that guides people is short bollards about 5m apart, and one rope often only 400mm above the ground. This system also ensures minimal visual impact on the natural character of the beach, which is an important consideration in these days of 'built things' being nearly everywhere.

The involvement of iwi groups in the Opotiki District has led to a large increase in the demand for assistance and plants in this district. The networks operating here are extremely effective, with many communities becoming actively involved in a very short period of time. Over a 12 month period, the number of Coast Care groups in the region rose from 12 to 20, largely due to this new interest. Many of these beaches have a shingle substrate, which adds to the complexities, but results so far suggest that the all the normal fore dune plants grow quite satisfactorily under these conditions. We are looking forward to a long and rewarding relationship with these communities.

The Coast Care BOP programme continues to be unique in at least one aspect, and that is the management partnership between Environment B·O·P, the four coastal District Councils, and the Department of Conservation. This style of partnership is highly recommended wherever possible, as it ensures smooth progress can be made simply because everyone involved

understands what is happening, contributes to plans for future work, and are kept up to date with progress.

We are keen to share our experiences (and yours!!), so we can all work together to find solutions to the many problems found out there in that dynamic and challenging environment we all simply call "the beach." Keep supporting the CDVN, as this voluntary organisation is the most effective and least bureaucratic forum for us all to benefit from the large ocean of experience that exists nationwide.

WEEDS AND INDIGENOUS BIODIVERSITY OF THE MANAWATU-WANGANUI SAND COUNTRY

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Introduction

In my paper at the CDVN conference last year (Ogle 2001) I used the term 'sand country' to include all land derived from moving sand, including elevated dunes and the land of low relief between the dunes – sand plains, swamps, and lakes. Biodiversity in sand country at the ecosystem level includes grasslands, sedgelands, rushlands, herbfields, shrublands and forest. Sand country from near Patea in the north to Paekakariki in the south has been defined as Foxton Ecological District (FED) (McEwen 1987; Ravine 1992). At its inland limits, sand abuts elevated marine terraces (Manawatu Plains ED) where it often impedes drainage. Wetlands are common along this boundary.

New Zealand's sand country is home to numbers of threatened plant species, many of them found in no other habitats. Twenty-three species with a nationally threatened or uncommon status are present, or are known to have occurred in the past, in sand country between the Manawatu River and South Taranaki. For a whole range of habitats, usually unspecified, it has been widely accepted that weeds are a major cause of decline of indigenous species that have a threatened or uncommon status (Williams & Timmins 1990, 1999; Polly & West 1996; Buddenhagen et al. 1998, Reid 1998; Dopson et al. 1999). Of species classified as threatened in the Department of Conservation's priority categories A and B (Molloy & Davis 1994), it was calculated that 57% (59 species) were threatened by weed encroachment (Dopson et al. 1999). Quantitative studies of weed impacts on indigenous sand country ecosystems and species are lacking, although there are data already that might be useful in such work.

As the importance of protecting indigenous biodiversity becomes accepted, exotic plants are becoming recognised as undesirable in sand country, especially in important reserves and other natural areas. Many lists have been made of plants in various parts of FED and some of these include adventive species, i.e. plants foreign to the area that are self-establishing, which many people would call weeds. Obviously some adventive species are far more common and widespread than others. Various classifications of adventive plants have been published, such as Heenan et al. (1998) who distinguished between fully naturalised and casual weeds. Casual weeds were further divided into garden escapes and garden discards.

In this paper, I will limit my discussion geographically to that part of FED that lies north of the Manawatu River. The total area of indigenous vegetation on this sand country is small and fragmented but it still contains considerable biodiversity at both the species and ecosystem levels (Ogle 2001).

Threatened plants of Foxton Ecological District (FED)

Nationally threatened and uncommon plant species occur at a number of places in FED, although some have become extinct within the past several decades from some places (Table 1, Ogle 2001).

National ratings & Species	COMMON NAME	Present?[1]
THREATENED		
Critically endangered		
Pimelea "Turakina"	a native daphne of dune slacks	p
SEBAEA OVATA	a gentian of dune slacks	p
Endangered		
Pterostylis micromega	swamp hood orchid	
Vulnerable		
Isolepis basilaris	a minute sedge of dune slacks	p
Mazus novaezeelandiae subsp. *impolitus*	dwarf musk (of dune slacks)	p
Ranunculus recens var. *recens*	a dwarf buttercup	e
Selliera rotundifolia	a half-star	p
DECLINING		
Austrofestuca littoralis	sand fescue	e
Eleocharis neozelandica	a dune wetland sedge	p
Ileostylus micranthus	a mistletoe	(e)
Leptinella dioica subsp. monoica	a button-daisy	p
Libertia peregrinans	sand iris	p
Pimelea arenaria "southern"	sand daphne	p
Sonchus kirkii	native sowthistle	p
Urtica linearifolia	swamp nettle	p
RECOVERING		
Conservation dependent		
Desmoschoenus spiralis	pingao	p
NATURALLY UNCOMMON		
Sparse		
Crassula ruamahanga	a small semi-aquatic herb	p
Korthalsella salicornioides	dwarf mistletoe	(e)
Lepilaena bilocularis	a minute aquatic herb	p
Ranunculus macropus	an aquatic buttercup	p
Range restricted		
Crassula manaia	a minute succulent	p
Leptinella dispersa ssp. *rupestris*	a creeping button-daisy of damp sand	p
Limosella "Manutahi"	a succulent herb of damp sand	p

[1] Recent and historic records indicate the species is regionally e = extinct; (e) = probably extinct; p= present

Fig. 1. Threatened and uncommon indigenous vascular plants of Foxton Ecological District, north of the Manawatu River (adapted from Ogle et al. 2001).

The 23 species recorded in this part of FED and which have a nationally threatened or uncommon status (de Lange et al. 1999) are listed in Fig. 1[1]. This table shows that two or perhaps as many as four species have probably become extinct across the whole district. Presumed to have been extinct for some decades, sand fescue and a dwarf buttercup would have inhabited dry dunes and damp dune slacks, respectively. The two mistletoes were known until the 1990s in just one site each, the last *Ileostylus* plants showing intense possum browsing sign and dwarf mistletoe grew on kanuka that were felled to plant pines. Several others are known now from just one or two sites, having been recorded more widely in the past (Ogle 2001). The species which have probably had the most dramatic declines in known range are *Sebaea ovata, Eleocharis neozelandica* and *Libertia peregrinans.*

[1] South of the Manawatu River, FED has or had additional species with a threatened or uncommon status nationally, including *Ophioglossum petiolatum*, *Pimelea tomentosa*, and *Amphibromus fluitans*.

Adventive plants (weeds) of FED

My unpublished database of adventive plant species, including casual records (see above and Heenan et al. 1998), from a range of places in FED north of the Manawatu River contains 580 species. Many of these are very common and widely distributed. Others are known from one site only. Both the number of species and presence of individual species vary through the length of the district (Figs. 2, 3). The records come from published and unpublished plant lists and other work and from herbaria records.

Beach (north to south order)	Number of adventive species					
	Trees, shrubs, lianes	Grasses	Other monocots	Dicot herbs	Ferns, fern allies	Totals
Patea	21	18	25	118	1	183
Waipipi	3	11	6	34		54
Waitotara R (right bank)	5	24	7	58		94
Castlecliff (west of town)	12	16	20	53		101
Castlecliff (town to river)	29	24	21	80		154
Whitiau (Whangaehu R)	13	31	9	88	2	143
Koitiata (Turakina R)	17	20	8	54		99
Tangimoana	10	17	7	50	1	85

Fig. 2. Numbers of adventive species in coastal dunes in parts of Foxton Ecological District

Published accounts of the botany of parts of FED were given by Esler (1978) for the Manawatu and Duguid (1990) for Horowhenua. These both include plant lists and other comments about the status of species of the sand country. Both the Wanganui and Wellington Conservancies of the Department of Conservation have databases of the lists of plants that they hold for specific places. Many of these lists are unpublished. Where they bear the date of a survey at a particular time, such lists are a record of not only what was present but, just as importantly for some future uses, what was not seen. If a weed was not recorded earlier but is now obvious, it seems likely that it has arrived since the earlier survey. However, caution needs to be exercised in reaching this conclusion, for the plant may have been present earlier but not seen, for reasons that include incomplete coverage of the specified survey area, the species was uncommon or seasonally inconspicuous, or the recorder's unfamiliarity with the species.

Some biologists collected voucher specimens of plants for herbaria and I would encourage more people to do so. Specimens are a useful source of distribution information and the labels with the specimens often (in fact, should) give specific details of the location, date of collection, abundance of the species and the nature of the vegetation and other aspects of the plant's habitat.

Beach (north to south order)	Locations of selected adventive species						
	Acacia sophorae Sand wattle	*Anredera cordifolia* Madeira vine	*Chrysanthemoides monilifera* Boneseed	*Cyperus congestus* Purple umbrella sedge	*Juncus acutus* Sharp rush	*Lobularia maritima* Sweet alyssum	*Senecio glastifolius* Pink ragwort
Patea		x				x	
Waipipi				x			
Waitotara R (right bank)				x			
Castlecliff (west of town)	x					x	x
Castlecliff (town to river)	x	x	x			x	x
Whitiau (Whangaehu R)	x			1 on 1/00		x	x
Koitiata (Turakina R)	x		x			x	x
Tangimoana	x			1 on 3/96	x	x	x
Himatangi	x				x	x	?
Foxton Beach	x		x		x	x	?

Fig. 3. Distribution of selected adventive plants along the northern half of Foxton Ecological District.

Examples

a) Escapes from plantings

The subsequent spread of certain species planted for sand stabilisation was probably not anticipated, but it can result in costly weed control work for other agencies or individuals. In the northern half of FED, Acacia sophorae is the most obvious example and the topic of a separate session in this conference. Other species of this region that have been planted for sand stabilisation but which are now self-establishing to a greater or lesser degree include pyp grass (Ehrharta villosa), coastal tea-tree (Leptospermum laevigatum), saltbush (Atriplex halimus), coastal banksia (Banksia integrifolia) and Buddleja dysophylla.

Only four species of the African genus Ehrharta have been recorded in New Zealand and all occur in FED. Pyp grass (E. villosa) was planted as a trial on dunes at Koitiata in the 1960s and seemingly abandoned and forgotten (Edgar & Connor 2000). It was rediscovered in 1990 and, in 1991, a survey revealed that it occurred across some 700 m x 300 m, among pines, dune flats and marram-covered dunes. It appears to out-compete marram with a dense mat of shallow rhizomes, its main method of spreading, as the seeds have low viability. Although the land was partly a council recreation reserve and partly private pine forest, in the late 1990s the Department of Conservation (DoC) undertook to eradicate pyp grass from its only known site in New Zealand. The recreation reserve had contained several threatened species in the past (Ogle 2001) and still had tiny remnants of dwarf mazus and sand iris in the 1990s. In addition, pyp grass was seen as a potential threat to natural dune vegetation throughout New Zealand if people took it elsewhere. The rather unusual opportunity to eradicate an aggressive weed from the whole of New Zealand seemed feasible for pyp grass. After three years' work and as eradication seemed imminent, a second population was discovered in southern Hawkes Bay.

Coastal tea-tree was planted near the coast in Santoft Forest near the wreck of the ship"Fusilier", perhaps as a buffer for young pine plantations. With a party from the Wellington Botanical

Society in February 1987 I searched unsuccessfully for self-establishing plants. However, in March 2000 with a DoC party I discovered many seedlings and saplings of coastal tea-tree, some of them fruiting, along with mature trees. Such a lag-phase in establishment is not uncommon among weeds and shows the potential folly of assuming that any exotic species is 'safe' to plant because it is not known to spread. Also planted in Santoft, mostly along road edges, was coastal banksia. In 1992 I found small numbers of seedlings there, up to 2 m tall.

A tufted grass, Ehrharta calycina, was first recorded at Santoft in 1956 (Edgar et al. 1991) and I collected herbarium material in 1987. It may have been planted here originally because it has few New Zealand records and at least one other is also associated with planted pines, at Waitarere Beach just south of the Manawatu River. In 2000 we searched for E. calycina and found that, unlike the coastal tea-tree at the same site, it had scarcely spread at all although it was fruiting and young plants were present. Either this grass has a long lag phase or some factor is restricting its spread.

Another adventive plant in New Zealand that is confined to FED and shows no sign of extending its range is marsh woundwort. Although it was first recorded in 1878, it is known from only two locations, namely Koitiata and the Hokio estuary near Levin (p796., Webb et al. 1988).

b) Escapes from other weedy areas

The largest number of species in sand country are either pasture plants or widespread weeds in other habitats. For conservation management of natural areas, exotic pasture species, including clovers and grasses, are often seen as problem weeds. Examples follow later. Among those plants which almost all people would regard as weeds is yet another Ehrharta species, veld grass (E. erecta). At Santoft in 2000 it was found growing with E. calycina, though it was not seen there in 1987. Veld grass has one of the most spectacular increases in abundance and range of any exotic species in New Zealand since its first record in 1943 in Wellington (Ogle 1988). Based upon herbarium collections, there seems to have been a lag phase until the late 1970s. It has seldom been sown deliberately and at least some of its spread is by bird dispersal of seed. Now it is in a wide range of lowland habitats between Northland and Canterbury, including dune country and offshore islands. North of the Manawatu River it is known from just three places in coastal dunes, namely Patea, Castlecliff and Santoft, but I predict that it will spread to other dunes of the region. Dunes at Castlecliff have dense swards of veld grass that appear to smothering other species.

To complete the Ehrharta discussion, the fourth species recorded in New Zealand is annual veld grass (E. longiflora). Its only records are from Wanganui, on sand along track sides and under trees in urban areas. It also a weed Australia from where it may have come to Wanganui, perhaps on clothing. I first collected it in 1989 and soon found it to be locally abundant in an area about 1 km^2. I have been monitoring it for a decade, but it seems to be spreading very little. Sand excavated from infested areas and taken to new sites has been the source of most new occurrences. Its behaviour and life history are so similar to ripgut brome (Bromus diandrus) that it would probably grow in similar places in natural vegetation on dunes.

The accidental arrival of weeds with human activities can be seen in many terrestrial sites in dunes. In the early 1990s, a gravel track was laid into dunes at Tangimoana, in order to plant pine trees in what is now Tawhirihoe Scientific Reserve. The gravel was sourced from the Rangitikei River bed nearby where, among many weeds, meadow horsetail (Equisetum arvense) is locally abundant. This weed has been known from the lower reaches of the Rangitikei River

since at least 1978 (Brownsey et al. 1985), which was one of the earlier records outside of urban areas. In Tawhirihoe Reserve it was noted first in the gravel track, from where it is now spreading by its rhizomes. (The bed of the Rangitikei River is the source of greywacke shingle for a wide region. It is beyond the scope of this paper to examine the massive spread of horsetail around the road verges of the whole region over the past decade, from this source.) A sedge, Cyperus congestus, is becoming one of the most common road-ditch plants in the southern North Island, probably spreading by machines and by flowing water. However, it is also starting to appear in dune wetlands (Fig. 3) where early control by pulling and removing plants before they have mature seed is probably the best option for control.

To stress that wetlands are part of sand ecosystems, Fig. 4 shows a few species selected from unpublished lists of plants made at three dune lakes near Wanganui. The records are derived from a detailed botanical survey of 10 dune lakes in 1978 (Kelly 1978) and my opportunistic surveys in the 1990s. Part of the difference in recorded species is probably the result of different survey methods - my surveys were shore-based only, but included a search of shore drift for deep-growing species. However, some suggestions can be made about species now present but not recorded by Kelly (1978). At Lake Wiritoa, Kelly (1978) did not record the aggressive water plants Egeria densa, Elodea canadensis, Potamogeton crispus, or Ceratophyllum demersum, all of which are now abundant and a major impediment to recreational use of Lake Wiritoa. It is well-known that water weeds are spread by boats and boat-trailers. Lake Wiritoa has a public boat ramp and is used frequently by power boats. Neither of lakes Kaitoke or Westmere has access for power boats; any boating use is restricted to canoes or small dinghies. Some of the difference in the weeds that occur in these three lakes (Fig. 4) can be attributed directly to power boats.

c) Casual species – garden escapes and discards

Growing to the west of the beach settlement at Castlecliff, Wanganui, are a number of species that most people would recognise as garden plants. These were planted almost certainly into dunes by persons unknown, probably several decades ago. Some species have probably increased very little since they were planted (e.g. Gladiolus carneus, Babiana stricta, Ixia maculata, Amaryllis belladonna), some have produced few offspring but formed large clumps (e.g., at least three Watsonia species, Scilla peruviana, Arctotis stoechadifolia), some have dispersed a little by seed (e.g., Tritonia lineata, T. crocata, Agapanthus orientalis) and some have become so common that their eradication could scarcely be considered now (Gazania rigens, Lampranthus glaucus, Freesia refracta) (Ogle 1993 and later revisions). I led the local botanical group and others here on surveys in spring (August-October) for several years, mainly because that was a comfortable temperature for survey and most of the known species were flowering.

			Dune lakes		
			Westmere	Kaitoke	Wiritoa
Aquatic weed species	*Egeria densa*	1978		x	
		1990+		**X**	**X**
	Elodea canadensis	1978			
		1990+			X
	Ceratophyllum demersum	1978			
		1990+			**X**
	Myriophyllum aquaticum	1978		x	
		1990+		X	
	Veronica anagallis-aquatica	1978			
		1990+		**X**	
	Potamogeton crispus	1978	x	x	
		1990+	**X**	**X**	**X**
	Vallisneria sp.	1978			x
		1990+			**X**
	Ranunculus trichophyllus	1978			
		1990+			**X**
Regionally uncommon indigenous species	*Potamogeton ochreatus*	1978	x		x
		1990+	**X**	**X**	**X**
	Potamogeton pectinatus	1978		x	
		1990+			
	Myriophyllum triphyllum	1978	x		x
		1990+	**X**		
	Ruppia megacarpa	1978			x
		1990+			

Fig. 4. Distribution of selected exotic and indigenous aquatic species in 3 dune lakes of Manawatu-Wanganui region. Data from Kelly (1978) and Ogle (unpublished data from 1990 onwards).

In late November 2000 I returned to the site and found a large clump of 'fairy bells' (Dierama sp., probably D. pendulum) in flower among a patch of Watsonia spp. This points to the need for repeated surveys in different seasons in order to record the full range of plants in sand country.

Patea Beach represents a different but extreme example of garden discards in dunes. In an attempt to stabilise encroaching dunes on the true right bank of the Patea River mouth, the local council encourages residents to take garden waste to a specified site on the dune crest. Vehicle access was constructed from dumped clay which was rolled hard across the sand and the heaps of green waste are bull-dozed flat from time to time and covered with more clay. In between times, garden plants and other weeds grow and reproduce, some spreading into nearby areas of marram. Between July 1999 and March 2001 180 species were recorded growing on and around the dump site, of which 172 were attributable to garden dumping. These included national surveillance weeds such as Madeira vine (Anredera cordifolia) and palm grass (Setaria palmifolia). Many species have proved to be truly short-lived casuals, like garden pea, radish, carrot and broccoli. The legacy of past dump sites lingers on in places like Tangimoana where, a decade after the dump was closed and covered in sand, garden species such as silver beet (Beta vulgaris), mignonette (Reseda alba), Narcissus sp. and ice plant (Carpobrotus edulis) persist. Ice plant in particular has spread widely into the adjoining Tawhirihoe Scientific Reserve.

Dune swamps are the main habitat for hemp agrimony (Eupatorium cannabinum), a European daisy that probably started its move into the wild as a garden escape near Hawera. The first collection was in 1972 (CHR 234517) then 1981, followed by a 'rush' of collections from 1994 onwards, between Hawera and Maxwell, south of Waverley (Heenan et al. 1999). This colourful, rhizomatous daisy is now in most swamps in its present range, although it is unknown in the wild outside this district. The lag phase was about 20 years and there appears little to prevent its spread throughout New Zealand wetlands. As with the rapidly spreading pink ragwort (Senecio glastifolius) (Williams et al. 1999) control in specific places might be an option, but only before it becomes well-established.

Interaction between weeds and threatened plants

In the example discussed above of weeds in dune lakes, it is tempting to suggest that the apparent demise of some indigenous aquatic species present in 1978, such as *Myriophyllum triphyllum* and *Ruppia megacarpa*, is the result of competition from the exotic species. If those indigenous species have, indeed, become extinct in lakes where they were present in the past (Fig. 2), there might be other reasons. Vigorous growth of water weeds is one outcome of eutrophication. If the identified lakes have changed in their chemical or physical characteristics, these changes might not have suited some native species. Nevertheless, a comprehensive survey of the 10 lakes surveyed by Kelly (1978), using the same methodology, might provide a large enough sample to determine whether there is a significant correlation between the presence of water weeds and the loss of native aquatic plants, in both time and space.

For some terrestrial dune sites there are plant lists on dates a decade or more apart. An example is Koitiata at the Turakina River mouth. Although he did not record the adventive species here, Druce (1975) listed a range of indigenous species that can no longer be found there, despite numerous searches. These included species of short open vegetation on periodically flooded dune slacks, namely *Pimelea* "Turakina", *Corybas* sp., *Carex buchananii, Isolepis basilaris, I. cernua, Juncus caespiticius, Epilobium billardiereanum, Gunnera arenaria, Mentha cunninghamii, Myriophyllum pedunculatum, M. votschii,* and *Sebaea ovata*. Some of these are in the national threatened and uncommon plant list (Fig. 1). All these species are known still from dune slacks in other parts of FED, although not all together. I visited Koitiata with Tony Druce in 1993 and he said that the place was 'unrecognisable'. Weeds such as pampas grass, pink ragwort (*Senecio glastifolius*), silver poplar (*Populus alba*), boneseed (*Chrysanthemoides monilifera*), sand wattle and willows (*Salix* spp.) had filled much of the space. In addition, the indigenous jointed wire-rush or oi (*Apodasmia* [*Leptocarpus*] *similis*) had become more common and in dense stands. Open sites that are needed by specialist plants of dune slacks scarcely exist now. Weeds contributed to the loss of habitat for a range of species and their local extinction. However, the increase in jointed wire-rush is indicative of natural plant succession with time. In times when dune sand and river meanders occurred without human interference, new dune slacks would have been forming for the specialised inhabitants to occupy as their old sites gave way to taller species that create a total ground cover.

Faced with no prospect of new dune slacks, Jim Campbell of DoC in Wanganui is leading an attempt to reverse 'natural' succession in small parts of dune slacks in Whitiau Scientific Reserve at the mouth of the Whangaehu River. In about 1998 the immediate species of concern there was an annual herb, *Sebaea ovata*, in its last known site in New Zealand[2]. By then its extent and abundance were far less than when the species was found here in 1989 (Ogle 1989). Space for each year's seedlings seemed to be getting less, with rank grasses and mat-forming and rosette

[2] In 2000, Jim Campbell found a new population of *S. ovata* further west, in a dune slack near the moth of Waitotara River.

weeds such as strawberry clover (*Trifolium fragiferum*), hawkbit (*Leontodon taraxacoides*), jointed-leaved rush (*Juncus articulatus*), Yorkshire fog (*Holcus lanatus*) and tall fescue (*Schedonorus phoenix*) and, latterly, a small blue iris (*Sisyrinchium* sp.). As at Koitiata, native jointed wire-rush was also invading the site. Several trials of weed control were attempted, with limited success. As the total number of *Sebaea ovata* plants reduced to a few dozen, a more radical approach was tried. Close to the last site for *S. ovata*, a mechanical digger was used to scrape the vegetation and top 10-100 mm of sand from trial plots. Monitoring of these scrapes continues (J Campbell, pers. comm.). A few *S. ovata* plants have appeared and quantities of the 'vulnerable' species, *Selliera rotundifolia* and *Isolepis basilaris*. The last two species had been in the area with *S. ovata*, although *I. basilaris* seemed to be becoming scarce. Other small-statured species that were thought to be locally uncommon have appeared in the scrapes, including *Myriophyllum votschii* and *Limosella lineata*.

Discussion

It is a matter of simple observation to see that some indigenous species of sand country are more resilient than others in the face of human induced changes, including weeds. Spinifex, club sedge (Isolepis nodosa) and sand convolvulus (Calystegia soldanella) are examples. Many other indigenous species have declined, seemingly correlated with a rise in weed species diversity and weed abundance. Examples have been given from dune slacks and dune lakes. Much larger sets of data exist which might be used to strengthen these preliminary findings.

More data might be gathered also with the objective of determining the impacts of certain weeds on indigenous plant species, particular threatened species. Considering the number of authors who have accepted that weeds smother indigenous vegetation, suppress regeneration and cause a loss of indigenous species, there are remarkably few studies in New Zealand which have examined precise interactions between weeds and indigenous flora. One recent study which did quantify the impacts of a weed in indigenous vegetation was of the vine old man's beard (Clematis vitalba) in forest near Taihape (Ogle et al. 2000). There it was demonstrated that old man's beard or its control had resulted in losses of indigenous species and that the losses had been greatest among indigenous species with a nationally threatened or uncommon status. This study might be adapted for research on dune weed impacts.

A comment above about the impacts of weed control as opposed to the impacts of the weed itself needs stressing. The control of pampas grass by spraying in Whitiau Scientific Reserve resulted in the loss of the only known patch in the reserve of a regionally uncommon sedge, Carex litorosa. Natural areas in dunes have too many nationally and regionally special plants, often scattered among the weeds, for non-targeted weed control to be acceptable.

Details were given above for Castlecliff Beach, as a rather extreme example of how deliberate plantings become a source of exotic plants into sand country. Some people would see this as an acceptable practice, especially if the planted species do not spread of their own accord or, in other words, do not become weeds. However, exotic plants can be unpredictable when planted in New Zealand. The spectacular spread at Castlecliff of Lampranthus glaucus, a small shrubby ice-plant, could scarcely have been predicted. The spread of amenity plantings in places like Santoft pine forests also demonstrates the need for special care in planting in or near sand country. The ecological and financial consequences of unleashing yet more major weeds upon our sand ecosystems can be horrendous.

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PRESENTATION OF RESEARCH

"COASTAL ZONE MANAGEMENT STRATEGIES AND TECHNIQUES PRACTISED AT KEY CASE STUDIES IN U.S.A, U.K AND AUSTRALIA"

Lucy Brake
Environment BoP

In 2001 I received a Winston Churchill Memorial Scholarship to study coastal zone management strategies and techniques practised at key case studies in United States of America, United Kingdom and Australia. The objectives included:

- To compare and evaluate techniques and strategies used in coastal management at key case studies in U.S.A, U.K and Australia.
- To focus observations on 'soft-engineering' management options, such as beach renourishment, revegetation and set back of infrastructure.
- To put forward recommendations for the protection and restoration of the coastal environment in New Zealand.

New Zealand coastal areas are under increasing pressure from population growth and the resultant development along the coastline. Coastal communities, management agencies and scientists alike are beginning to understand the importance of sustainable development of these areas if we are to maintain the natural character of our coastline.

The information gathered for the report was collected from meetings and discussions with management agencies, scientists, consultants, business representatives and community members involved in coastal zone management over a period of 3 months. Observations from site visits, publications, telephone interviews and websites reviews provided additional information.

Comments are made as to recent techniques and methods being used at each location. Based on operations viewed and discussion with people involved recommendations are made for strategies and techniques which can be put in place in N.Z for the sustainable management of our coastal environment.

This research has assisted with continuing to manage the increasing pressures on the coast by understanding and gaining knowledge of the best possible techniques and strategies to be taken from a global perspective.

RABBIT CONTROL IN HIGH PUBLIC USE COASTAL ENVIRONMENTS – LESSONS LEARNT FROM THE PAPAMOA COASTAL RESERVES

Greg Corbett
Animal Pest Officer
Environment BOP

"There are no pest problems, only people problems!"

A quote one from one of my Training Officers, who was explaining the importance of good public relations to achieving successful operation results. This particularly applies when pest control operations move from the rural to the urban environment. Rabbits are no longer referred to as a 'plague' but are often thought of as cute furry animals that the children get immense pleasure out of watching on their way to school in the morning; and toxin use is no longer a necessary part of every day land management but something that threatens us, our pets, wildlife and New Zealand's 'clean, green' image! Before carrying out rabbit control operations in areas of high public use, we must have clear justification for controlling them and a clear understanding of the associated risks. Today, I intend to cover the reasons why rabbits inhabit coastal dunes, what damage they can potentially do, how to decide when it is necessary to carry out control and then managing the risks associated with pest control operations in high public use coastal environments.

Firstly, why do rabbits happily inhabit dunes?

Rabbits do best in habitats with low rainfalls (<1000 mm per annum), sunny aspects, light soils, adequate cover and with closely grazed feeding areas. While coastal areas of New Zealand generally experience a higher than desirable rainfalls, the other habitat requirements of rabbits can usually be found in coastal dune country. Once established in dune country, rabbits have the ability to gradually modify the environment by digging burrows (adding to the amount of cover available) and regularly grazing specific feed areas, thus making dunes even more suitable as habitat. This can lead to higher survival rates of young rabbits and a corresponding increase in population levels.

A few rabbits in the sand dunes – so what! What damage are rabbits capable of?

Firstly the obvious – if it is palatable, they will eat it! And as rabbits tend to graze specific feeding areas, the same plants are repeatedly browsed and are eventually killed. Even low populations of rabbits can cause noticeable damage to highly palatable plants such as pingao. Rabbits suppress any potential natural revegetation by continually browsing new seedlings. They form 'pads' (tracks) by regularly moving from resting areas to feed and play areas along the same routes. These pads may develop into bare sand tracks especially where other animals' and people begin using the same paths. Rabbits are capable of excavating large amounts of sand when burrowing and where warrens have been formed, the structural stability of the dunes may be threatened. Collectively this damage results in gradual increase in areas of bare sand and a continuing deterioration of the dune system. Rabbits may also indirectly threaten other more desirable wildlife that may inhabit the dunes, as their presence attracts predators such as cats and stoats.

This damage potential gives Land Managers good ecological justification to control rabbits in coastal dunes environments, however there are other reasons why rabbit control maybe

necessary. In regions where rabbits are declared pests, landowners maybe required by Regional Pest Management Strategy's to ensure rabbit populations are maintained below a nominated infestation level. Economically, it makes sense to control rabbits before the cost of replacing plants that have been killed or damaged exceeds the cost of controlling the rabbits. Also, to maintain the motivation of 'coast-care' volunteers, control maybe needed to protect newly planted areas.

In most situations where rabbit populations are reaching higher than desirable levels, control will considered necessary for a variety of reasons. When considering the management of rabbits set realistic goals and targets (i.e. <5% loss of plants to animal pests). Remember local eradication is extremely difficult to achieve! It is important that managers of coastal dunes decide what are maximum acceptable rabbits numbers or thresholds and that these are based on sound ecological and economic reasons as well as volunteer expectations.

Once thresholds have been set, annual monitoring should be programmed to assess whether rabbits are present, and if so, to determine whether their numbers stable or increasing. Rabbit numbers can be assessed by observing ground sign present, spotlight counts or by assessing damage levels. If rabbit numbers or damage are approaching the predetermined thresholds it will be prudent to commence planning for a control operation prior to the next rabbit breeding season (July – November).

The first step when considering a control operation is to discuss the problem with the agency or owners who administer the dunes. Determine if they have any objections or restrictions to particular control methods and what levels of funding are available for pest control. Next, accurately measure and map the extent of the rabbit problem. Determine whether there are high rabbit infestations on adjoining properties – if so contact the person responsible for that land and discuss the benefits of a combined operation. Now you can begin to consider and evaluate your options for the control operations (see "Vertebrate Pest Control Manual" published by the Department of Conservation).

The use of toxins can usually be relied upon to give excellent results if applied correctly. Currently there are three poisons registered for rabbit control in New Zealand, Pindone, 1080 and phosphorus. Of these, 1080 and phosphorus are controlled pesticides and can only be used by licensed operators. Legal requirements for the use of these toxins and public perception will normally preclude them from use. Pindone, an anticoagulant, is an effective toxin against rabbits, which if handled correctly presents few dangers to humans and wildlife. There is also little risk to pets if they are constrained when in the vicinity of laid baits. If you intend using toxins, ensure that the bait type is acceptable to the rabbits in your area, good quality bait is used, that adequate quantities of bait are used, the toxic loading is correct, and all potential rabbit feed areas are treated.

RCD is a possible option if rabbit numbers are high. While results appear to be inconsistent, it is a relatively cheap option that presents no known risks to people, pets or other wildlife. However, like 1080, public perceptions of unacceptable risk may rule out this option.

Burrow fumigation will be of limited use owing to the amount of other cover available to rabbits in most dune country, though it is a good follow-up method to poisoning as burrows that are blocked or destroyed will not be available for re-infesting rabbits to inhabit and limits their ability successfully re-establish themselves.

Shooting is generally an ineffective control method when compared with poisoning, especially if rabbit numbers are high, and presents unacceptable risks to people and property in urban areas.

While considering your control options also consider whether the control work is to be contracted out or whether local volunteers or staff can handle the work involved, as this may limit your options.

Once you have determined what suitable control options are available, prepare an operation plan taking into consideration the following:

1 Effectiveness – will the chosen method of control achieve the results required? Discuss your rabbit problem with Pest control experts *who have experience in urban rabbit control.*

2 Environmental impacts – if toxins are to be used, what will be their fate in the environment? If you dealing with a very high population of rabbits, will the smell of rotting rabbits offend neighbouring property owners?

3 Human safety – will public continue to have access to the area during the operation? If toxins are to be used, consult with the local Medical Officer of Health and Police regarding human safety. Ensure that the public will be adequately warned of any dangers. Consider temporary fencing of treated areas. Plan the timing of the operation for when it will affect the least number of people – i.e. avoid the warmer months and school holiday periods.

4 Safety of domestic pets – Again ensure that adequate warnings will be given informing people of the risks. Notify all local Vets of the intended operation and inform of what poisons you intend to use.

5 Safety of wildlife – consult with Department of Conservation and local Fish and Game to ensure the proposed methods do not pose unacceptable risks to wildlife. If the Department of Conservation administers the land, you will also have to prepare an Assessment of Environmental Effects if you intend laying toxins for rabbit control.

6 Public Consultation – allow adequate time to communicate the need for rabbit control to the local community and to address any legitimate concerns they may have. Consider attending Ratepayer Association meetings, issuing public notices in local newspapers, informing the local Iwi, visiting and talking to local schools, letter drops to all neighbouring landowners.

Of the points mentioned, by far the most important is public consultation! Large numbers of people are ignorant of the damage rabbits can do to coastal dunes and hold exaggerated views of the risks associated with their control. This lack of understanding is the greatest hurdle to overcome when planning an operation – if you handle this issue well the operation will run relatively smoothly; avoid it and you will be faced with heavy opposition.

So how to deal with this problem? First contact parties that may be affected by the planned control operation and allow adequate time to discuss the intended operation with them prior to commencing the work. Try and get people to think that the rabbits are a problem that will affect them personally. If you are meeting with the local ratepayer association – do not tell them that the rabbits are eating your plants; tell them that the rabbits are a threat to the stability of the dunes that protect beach front properties from erosion and a subsequent loss in property values.

Talk with local Iwi – tell them that the rabbits are killing the pingao, a plant used for traditional weaving. Explain the need for rabbit control to a local friendly newspaper reporter. Always give a contact number for people to ring to discuss any issues they may have and give honest information. Accept that not all people will agree with your reasons for control.

By first preparing an operation plan that covers all the points mentioned earlier you will be well prepared to answer most concerns the public may have.

If you have decided to contract out the control work, get prices from several companies who have experience in rabbit control in urban areas. Clearly identify whether you expect the contractor to complete all required public notifications or whether this will be your responsibility.

If you and local volunteers are to carry out the work ensure that all people handling bait have had proper instruction and have appropriate safety clothing and equipment. Double check that baits have been laid correctly and recover any baits that have been accidentally laid outside of the designated treatment area.

Following the commencement of the control operation ensure that warning signs are replaced when vandalised or stolen and that dead rabbits are regularly recovered from anywhere the public may have access to. Carry out thorough check for non-target kills, especially birds – people opposing the use of toxins commonly publicly state exaggerated levels of non-target kills to discredit a poisoning operation. When control has finished contact the affected parties consulted with and inform them of the results and thank them for their support.

After the control operation has been completed consider immediately replanting areas that were heavily grazed by rabbits, particularly in back dune areas, to prevent the establishment of undesirable plants.

Remember that even if your operation was very successful it is essential that you continue if annual monitoring of rabbit numbers, as they will have the potential to rapidly re-infest and ruin years of hard revegetation work. Also ensure that the agencies that administer the dunes continue to allocate funding for pest control.

In summary:

- Coastal dunes offer rabbit's good habitat. Even at low population levels, rabbits can cause significant damage to coastal dunes and revegetation programmes.
- Managers need to set thresholds for rabbit infestation.
- Control operations need to be planned prior to these thresholds being reached.
- Prepare a detailed operation plan that addresses the issues of effectiveness, environmental issues, human safety, safety of pets and wildlife.
- Consult with all affected parties and address any legitimate concerns they may have.
- Carry out the operation in accordance with this plan.
- Continue with rabbit monitoring.