COASTAL RESTORATION TRUST OF NEW ZEALAND

Tāhuna Ora

Case Study No. 3

Restoring windblown dunes using native plants

Difficult sites case study - Ngarahae Bay, west coast North Island

INTRODUCTION

The Coastal Restoration Trust is working with local communities and landowners to develop guidelines on practical methods for restoring severely degraded coastal dunes, with a focus on using native coastal plants.

Over the last two decades, significant progress has been made with restoration of degraded sand dunes using community-based approaches. However, work has tended to focus on restoration of more sheltered eastern beaches with less sand movement from Bay of Plenty to Northland, than on the west coast of the North Island.

Recent work by the Waikato Regional Council and the Coastal Restoration Trust has also investigated practical methods for achieving and sustaining backdune restoration, particularly where there are major weed issues (for more information refer to the Case Studies Article No. 1 in this Handbook - *Restoring degraded urban dunes. Case study - Eastern Coromandel*).

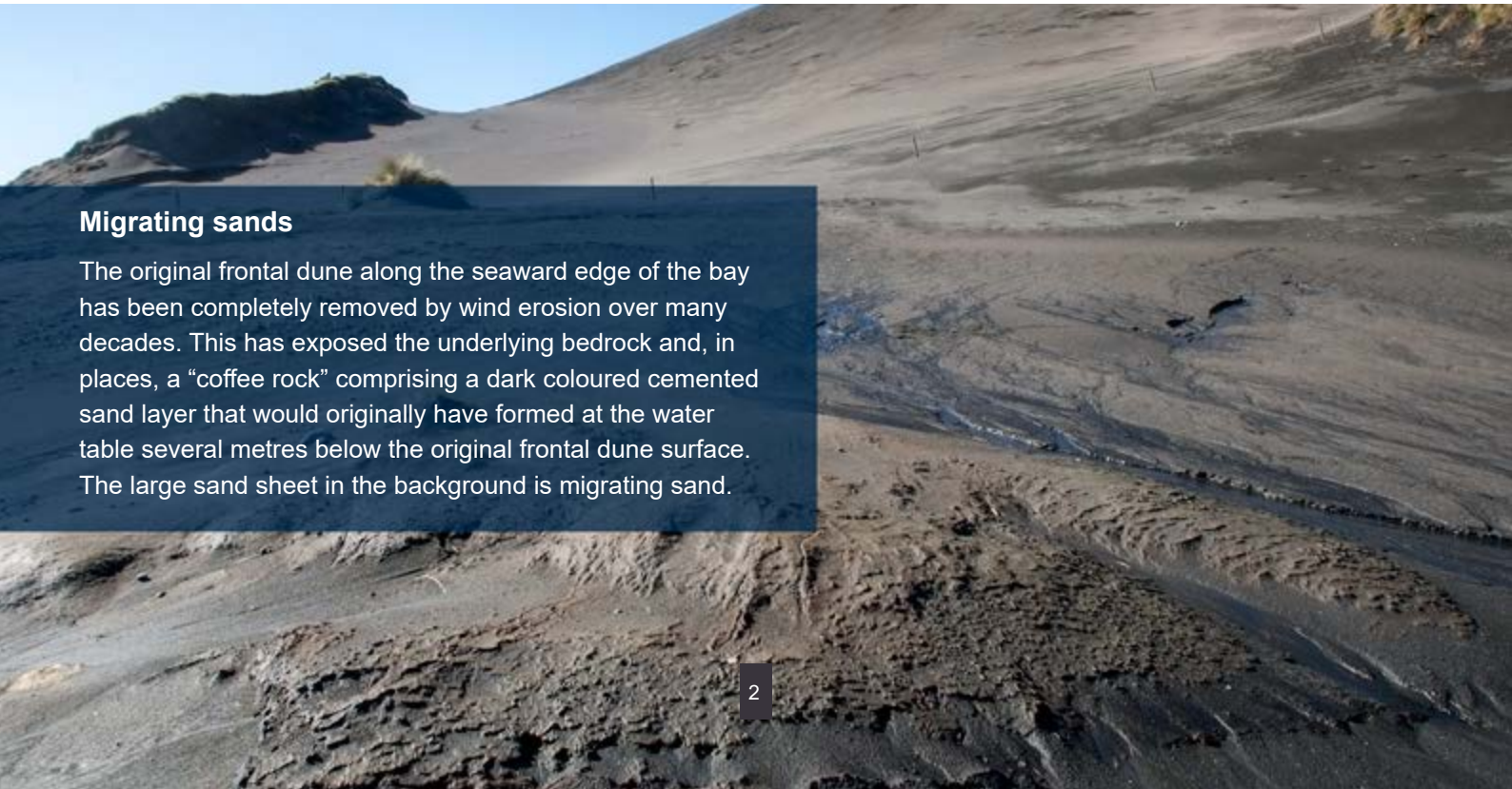
There are many examples where community groups and councils have successfully restored the frontal dune zone using spinifex (*Spinifex sericeus*) and pingao (*Ficinia spiralis*). This article describes a restoration project on severely degraded dunes on an exposed west coast beach, part of a large pastoral hill country farm. It is typical of difficult sites where high wind runs and a major sand supply create large dunes that migrate inland. Stock access has aggravated wind erosion. Historically, such sites have been stabilised and converted to forestry or pastoral land use rather than to natural ecosystems dominated by native plants. The project was funded by the Department of Conservation Community Fund and the Waikato Regional Council, in collaboration with Beach Care groups, iwi and the landowner.

STUDY SITE

Nukuhakari Station is a large sheep and cattle pastoral hill country station on the west coast between Awakino and Marokopa (Figure 1). The coastal margin of the farm has three sandy bays exposed to prevailing westerly winds, including the study site, Ngarahae Bay (Figure 1).

Over the past 150 years the dunes in these bays have experienced severe wind erosion due to disruption of stabilising vegetation by stock grazing and human disturbance. This is a common situation on the west coast of the North Island from Taranaki to Northland.

Figure 1: *Oblique aerial view of part of Nukuhakari Station, southwestern Waikato Region, showing Ngarahae Bay (aka Middle Bay) study site, with sand sheets migrating inland.*



Migrating sands

The original frontal dune along the seaward edge of the bay has been completely removed by wind erosion over many decades. This has exposed the underlying bedrock and, in places, a “coffee rock” comprising a dark coloured cemented sand layer that would originally have formed at the water table several metres below the original frontal dune surface. The large sand sheet in the background is migrating sand.

Migrating sand sheets

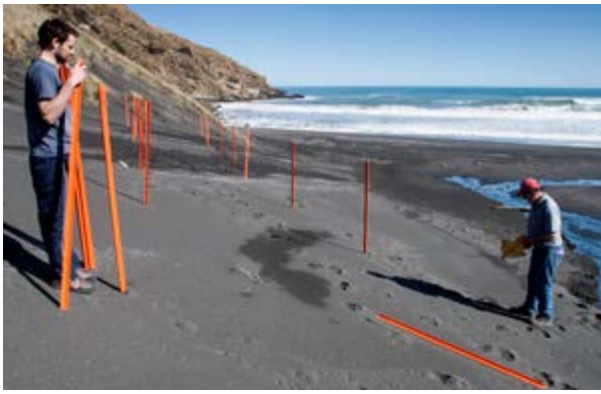
Ngarahae Bay has two large sand sheets which are migrating inland, covering a total area of approximately 8 ha with an intervening stream and narrow grassed ridge (Figure 2). The sand sheets are continuing to slowly move further inland over adjacent pasture.

Figure 2: *Views of migrating sand sheets at Ngarahae Bay burying productive pastoral farmland.*

RESTORATION PLAN

Nukuhakari Station and the Beachcare coastal restoration programme run by Waikato Regional Council have been working together to progressively restore the seaward dunes to a native dune ecosystem. The landward extension will be restored to native vegetation cover using appropriate mid and backdune species once the seaward 150-200m of dunes have been stabilised and revegetated.

Nukuhakari Station was responsible for excluding stock from the area by fencing and assisted with planting, while the council provided plants and together with the Coastal Restoration Trust, technical advice.



The Coastal Restoration Trust also became involved with the site as part of the Difficult Sites applied research programme funded by the Department of Conservation. The Trust worked with the parties to develop a simple restoration strategy to suit site and funding constraints, with monitoring over a three-year period. A range of initial trial plantings had also been conducted previously to assess site constraints such as presence of animal pests and the suitability of available native dune species.

Constraints

The ongoing restoration of this site was limited by the available budget, which imposed the following constraints:

- Only a small number of plants (typically 2000-4000) were available each year, meaning the restoration had to be undertaken slowly over a lengthy period (likely to require 2-3 decades unless resources increase).
- No significant funds were available for animal pest control or management.
- It was not practical to mitigate the effects of wind erosion (e.g., with sand trapping or wind-break fencing) to assist plant establishment.

These are common constraints for restoration of native dune ecosystems on the North Island west coast.

RESTORATION STRATEGY

As funding constraints prevented large-scale planting, the restoration strategy was initially focused on restoring an incipient frontal dune across the seaward edge of the entire embayment. The aim of this work was to cut off the sand supply from the beach to the inland-migrating dune system, with subsequent restoration then moving further landward.

It was expected that once the incipient dune was established, ongoing natural expansion of stoloniferous plants and associated sand trapping would eventually (probably over a period of at least 2-3 decades) restore a much wider frontal dune (probably >100m). The focus of restoration planting would then move to backdune areas.

The key steps in the restoration work undertaken are briefly outlined.

Management of vegetation disturbance

A key first step in the restoration of any area of severe wind erosion is to identify and address other causes of vegetation disturbance. If these are not adequately addressed, it is unlikely that any planting will be sustainable.

At this site, stock were identified as the only significant cause of vegetation disturbance. Therefore, before restoration planting began, grazing animals were excluded from the area. At many west coast sites, restriction or exclusion of public vehicle access can be an additional management requirement before restoration planting. At this remote site, however, there was no public vehicle access and the limited farm vehicle use in the area (e.g., planting activities, beach visits) avoided the planted areas.

Addressing factors such as grazing by uncontrolled stock, reducing rabbit and hare numbers, and controlling or limiting disturbance by beach users will help encourage natural recovery of dune vegetation cover on many coastal sites, as well as be essential steps before any planting programme gets underway.

Planting

Establishment of the initial incipient dune at this site was achieved by planting of spinifex and pingao (Figure 3). Along with sand sedge (*Carex pumila*), these species are the usual primary colonisers of disturbed sand dunes on this coast. Spinifex and pingao are both vigorous and effective sand-trapping plants, and the stoloniferous habit of spinifex also enables rapid spread once established. Spinifex stolons at this site commonly showed 2-4 m growth per year. Small numbers of other appropriate backdune species were also trialled in initial plantings but, as expected, were far less successful in the strong winds and mobile sands which characterise the site.

Figure 3: *Views of lower more seaward dune area (arrowed in white) at the start of the project. Planting avoided these areas because of vulnerability to stream erosion (above) and storm wave inundation, (below) beginning near the toe of the higher dune (yellow arrows).*

A minimum 15-m width of planting was adopted, with planting typically at 0.7-1m spacing. A 1-m plant spacing is usually adequate, but a higher density on exposed sites with high rates of sand movement can help with initial establishment. Planting began on the northern side of the bay and was gradually extended across the complete embayment in subsequent years. Planting each year focused first on replacing losses in existing plantings to secure the gains of the previous year, before extending further.

It is normal practice in the restoration of severely eroded dunes to start planting near the seaward edge and work inland. Otherwise, significant losses can be experienced due to burial by migrating sands. However, at this site, this approach had to be modified as the lower, more seaward dune area (Figure 3) was subject to periodic reworking - probably over several decades - from movement of the stream mouth.

There was a risk that restoration of the most seaward dune area could be lost by stream erosion before the vegetation had a chance to spread laterally into adjacent dune areas. In addition, storm debris indicated that the seaward dunes, lowered by historic wind and stream erosion, were vulnerable to periodic wave inundation. This would increase plant losses during the establishment phase. In addition, the sand in this area was often limited to a relatively thin (often <0.1m) layer of very mobile sand over rock, less suitable for establishment of spinifex and pingao.

Accordingly, planting commenced at the seaward toe of the higher dune area immediately landward (see yellow arrow in Figure 3).

Interestingly, in the period following stock exclusion, the small patches of sand sedge began to spread more widely on the lower dunes (particularly in low-lying areas close to water tables), increasing dune height (Figure 4). This common pioneer species on the west coast of the North Island has the rhizomatous growth habit frequently encountered in pioneer and early seral species, particularly where continual renewal of sand substrate occurs such as in active areas of sand dunes (Burgess 1984).

Figure 4: *A patch of sand sedge on the low dunes at the seaward edge of the site (above). This species has expanded considerably since stock exclusion (below).*

The natural expansion of sand sedge not only helped reduce the volume of sand blowing onto the new plantings further inland; it also created deeper dune sand more favourable to spinifex and pingao at a later stage of recovery. Once the incipient front dune is restored, it is expected that this spinifex and pingao-dominated dune will progressively move seaward, eventually displacing most if not all the sand sedge. As noted by Burgess (1984), sand sedge as an early coloniser is ultimately “doomed to extinction on the sites it colonises”.

Animal Pests

Initial site reconnaissance and plantings indicated moderate rabbit numbers. However, rabbits typically accounted for very few losses and evidence of grazing was only low to moderate. Losses were primarily associated with wind damage (sand blasting, exposure by erosion and burial by migrating sand) rather than browsing. Moreover, pingao, a very palatable species often targeted by rabbits, showed good survival rates. Accordingly, no pest control or plant protection has been adopted to date.

Fertilisers

All plantings involved use of a slow-release fertiliser at the time of planting based on previous work which indicated that this enhances both survival and initial growth rates (Bergin 1999; Bergin and Herbert 1998). Further trials were conducted during the planting testing fertiliser vs. no fertiliser, different fertiliser application rates and a new koi carp formulation vs. traditional fertilisers. No additional fertiliser application was undertaken after planting.

Wind protection

No sand fences or other plant protection measures were used during the plantings. Rather, emphasis was placed on locating the plantings as far seaward as appropriate and establishing a sufficient width of planting (12-15m at this site) (Figure 5) to accommodate windblown losses while maintaining a useful width of vegetated dune.

Losses tended to primarily occur along the seaward margin from sand blasting and exposure of roots. Burial by sand was limited by the location of plantings. Field inspections suggested that burial tended to stimulate and encourage plant growth once the plants were established, typically by mid-summer. However, if the plantings had been conducted further landward with higher volumes of onshore migrating sand, experience from other sites indicates that losses due to this factor would have been significant.

Losses due to wind damage varied from year to year and were usually most severe in the first year after planting. Provided these losses were replaced the next year, the desired width of incipient dune was normally well established by the end of the second year of planting, with stolon extension counteracting any losses after that. At this site, the costs of the losses (typically <$500/year) were significantly less than the cost of installing lengthy sand fences to protect the plantings, structures which would have deteriorated over time and created an eyesore and potential hazard.

Figure 5: *Views during (left) and after (right and inset) planting, showing the typical width of planting adopted at this site. Young spinifex seedlings (6 months old) subject to active burial. These plantings survived and thrived (inset).*

RESULTS

The initial project to establish an incipient frontal dune across the seaward edge of the embayment has been successful, with a well-established frontal dune now present (Figure 6).

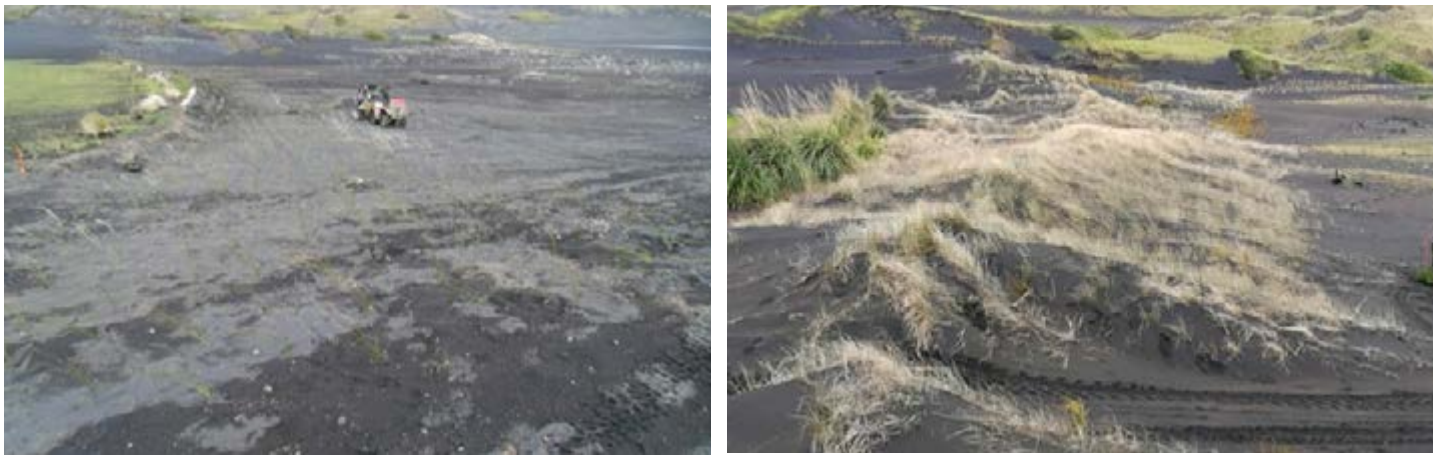


Figure 6: *View of dune - initial planting (left) and 4 years later (right).*

The stages of foredune development over time are illustrated in Figure 7. Plantings often suffered significant losses in the first year. However, once these were secured by infilling gaps, the incipient dune feature was successfully established and expanded over time.

Once established, the incipient front dunes generally showed rapid increases in height due to active sand trapping (Figure 8). In addition, spinifex stolons several metres long actively increased dune width both landward and seaward over time (Figure 9). In the oldest planted areas, these trends resulted in planted dune areas increasing in height by up to 1.5-2m and expanding in width by 10-15m in the 4 years since planting began. Provided that stock continue to be excluded from the area, this incipient dune will eventually extend seaward of the area of sand sedge (Figure 5), resulting in a foredune complex 100-150 m wide.

Figure 7: *View showing dune establishment after 1 year (above), 2.5 years (middle) and 3.5 years (below).*

Figure 8: *Close-up view of restored incipient frontal dune showing useful dune height developing. The planting in this area was 3 years old at the time.*

Figure 9: *Established incipient dune showing spinifex stolons several metres long which are progressively extending the dune both landward and seaward over time.*

The effectiveness of the incipient dune in cutting off sand supply to the migrating sand sheets further inland was demonstrated dramatically at this site. Before restoration began, pasture was restored in an area directly landward using oil drilling wastes (Figure 10 above), although this was soon inundated with migrating sand (Figure 10 middle). However, once the incipient foredune had been re-established, sand supply was dramatically reduced, with the result that the surficial sands were stripped off by onshore winds (migrating further inland) and the underlying pasture was once again exposed and able to be used (Figure 10 bottom).

Figure 10: *Views showing an area of pasture (arrowed in top photo) immediately landward of the restoration planting. This pasture was established on sands using a veneer of soil material sourced inland before the restoration (top) but was soon buried by moving sand (middle). However, once the incipient dune was established, onshore sand supply was markedly reduced and the pasture area was able to be used again (below).*

A range of native duneland species was trialled in the initial plantings but, as expected, only spinifex and pingao proved useful, given the strong winds and mobile sand which characterise the environment. Spinifex was used in preference to pingao because of the high palatability of the latter. Nonetheless, despite some rabbit damage, pingao was also established successfully at the site.

Few of the backdune species trialled in the initial plantings were successful. This was expected, as they generally require prior stabilisation of loose sand (e.g., by spinifex) to establish (refer to Section 8 in the handbook - *Native vegetation on backdunes*). The only exception was limited numbers of toetoe *(Austroderia fulvida)* which established despite the harsh conditions. However, these plants only prospered once the incipient seaward foredune had been established.

Spinifex and to a lesser extent pingao, are the best species for initial stabilisation in these environments where grazing animal pests are not a serious problem. Early successional backdune species can probably be established successfully in sheltered backdune environments, but only once an initial pioneer cover of spinifex and pingao is established.

SUMMARY

This pilot project has demonstrated that it is practicable to restore badly damaged west coast dunes suffering from severe wind erosion, even with limited funds.

The key lessons from this project for similar sites with severe wind erosion and funding constraints are:

- Before beginning restoration, it is critical to first address and reduce – or if practical eliminate – the many causes of vegetation disturbance such as fencing out grazing stock, reducing pest animals and controlling disturbance by beach users. In some cases, as at this site, this can also encourage natural recovery of dune vegetation to aid restoration.
- Failure to manage human vegetation disturbance (e.g., by stock or vehicles) will significantly increase plant losses and maintenance requirements for planting programmes. In severe cases, the restoration is not likely to be sustainable.
- Grazing animal pests were not a major issue at this site, but can be a constraint that also needs to be addressed (e.g., by pest control and/or suitable plant protection). In areas with serious grazing animal pests, use of palatable species (e.g., pingao) should be minimised.
- Restoration should first aim to create a sustainable width of incipient frontal dune along the seaward edge of the site to cut off sand supply to areas further landward. Restoration of areas further inland is best delayed until this is achieved.
- Planting should begin towards the toe of the seaward dune, while avoiding areas that could be being disturbed by storm inundation, coastal erosion or alongshore movement of steam mouths.
- The planting width required to form the initial dune will vary from site to site, but is likely to be at least 12-15m at most sites.
- Plantings should focus on spinifex until the initial foredune is established, though a small component of pingao is also useful at sites where grazing animal pests are not a problem.
- In general, sand trapping or wind-break fences can be avoided with adequate width of planting and early maintenance of plantings.
- Moderate wind damage to plantings can be expected, particularly in the first year. It is important to focus on securing initially planted areas before extending them.
- Inclusion of a single fertiliser tablet (standard practice with dune plantings) does enhance both survival and growth rates.

Figure 11: *The native sandbinders spinifex and pingao proved to be the most useful in developing a zone of foredune vegetation, where strong winds and mobile sand characterise an environment typical of the west coast of the North Island.*

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The mission of the Coastal trust is:
"To see the majority of New Zealand dunes restored and sustainably managed using indigenous species by 2050".