

# Restoration of vegetation at Smugglers Bay, Bream Head Scenic Reserve, Northland

## Technical Advisory Notes

D.O. Bergin and M.J. Bergin  
Environmental Restoration Ltd  
Rotorua

2010



*Environmental  
Restoration*  
LIMITED



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Restoring our coastal environments with native plants

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## SUMMARY

Following a field visit, technical advice is provided on restoration of native vegetation at Smugglers Bay, Bream Head Scenic Reserve, Northland.

The foredunes at Smugglers Bay are highly modified and have poor natural form and function. Rabbits have contributed to this degradation and are still having a significant influence. Loss of natural dune form and function at Smugglers has had many consequences including changes in the stability of the dunelands, loss of indigenous biodiversity, modified habitats and erosion of archaeological sites.

In order to develop a restoration plan for Smugglers Bay, a brief outline is given of the processes and importance of dune form and function, the nature and impact of human-induced factors contributing to duneland degradation, and practical options for reducing erosion and protecting middens.

Amongst a range of management issues and options discussed, priorities for restoration at Smugglers Bay are establishing native sand binders on the foredune and the control of rabbits. This along with planting appropriate ground cover natives on semi-stable dunes more landward will reduce erosion of middens. Once foredunes are restored, restoration of backdunes should initially focus on establishing a range of native shrub hardwood species in groups within sheltered areas.

**KEYWORDS:** Coastal restoration, dunes, indigenous, spinifex, pingao, foredunes backdunes, rabbits, middens, erosion, Northland

## INTRODUCTION

Smugglers Bay (sometimes referred to as Smugglers Cove) is a coastal sandy embayment within Bream Head Scenic Reserve located at Whangarei Heads, north-east of Whangarei city (Figure 1). Bream Head Scenic Reserve (Te Whara) is situated at the entrance to Whangarei Harbour. It is a reserve that is rich in biodiversity and cultural and historical values. The reserve is also popular for its recreational opportunities such as tramping, picnicking and fishing.

Smugglers Bay is very popular for recreation as it is relatively isolated from any development (Figure 2). Land access is by a 15 minute walking track that traverses the peninsula over a low saddle of grazed pasture. Headlands at both ends of the embayment are covered in dense indigenous shrubland or forest.

The Bream Head Conservation Trust was established in 2002 as a partnership between iwi, the community, Whangarei District Council, and the Department of Conservation (DOC) to restore the ecology of the reserve, to preserve its historical and archaeological features, and to enhance its recreational and educational potential in ways which are compatible with conservation values.

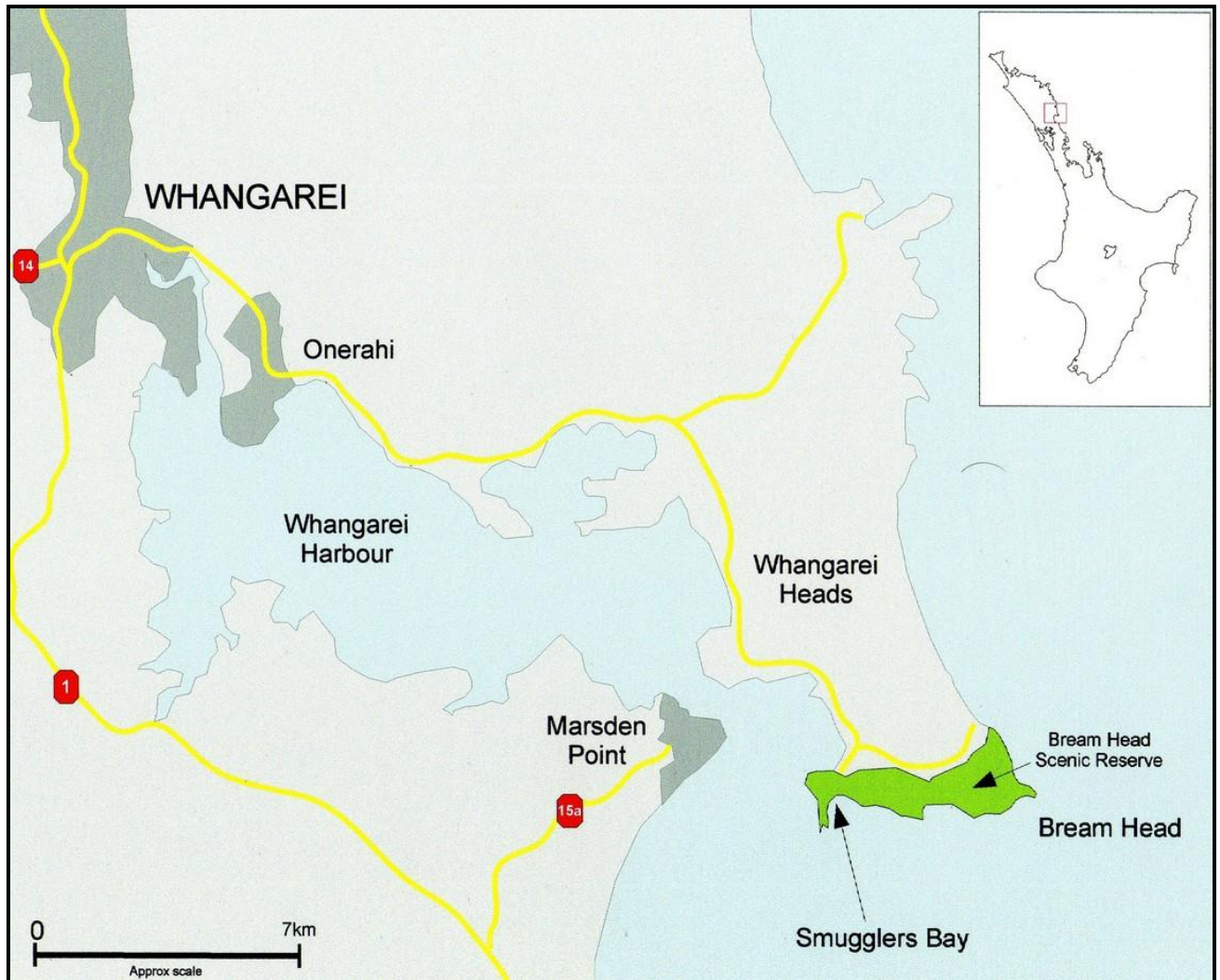


Figure 1: Location of Smugglers Bay within Bream Head Scenic Reserve located at Whangarei Heads, north-east of Whangarei, Northland.

The Bream Head Conservation Trust and Restoration Committee hold regular community events that assist with the Trust's aim to restore and maintain the ecological environment of Bream Head Scenic Reserve. Since 2003, an active revegetation programme has been underway establishing a range of local indigenous shrub hardwood and monocotyledon species on slopes around the western end of the reserve. The planting programme has involved focussing on slopes on the northern coast immediately west of Urquharts Bay with specific blocks revegetated each year (Figure 3).

Part of the focus of the revegetation programme has recently moved to include Smugglers Bay, where to date, two small blocks located on the backdune adjacent to the fence was planted with a small range of plants in mid-2009 (Nigel Miller, Department of Conservation, pers.comm.).



Figure 2: View looking southward over Smugglers Bay from near the highest point of the access track to the bay. This expansive view of the bay is the first to greet visitors as they make their way to this relatively isolated and undeveloped beach framed by rocky shores and indigenous coastal forest on headlands at both ends.

## SITE INSPECTION

The beach and backdune area at Smugglers Bay was inspected on 9<sup>th</sup> June 2010 with the Northland Regional Council, Department of Conservation staff and representatives of the Bream Head Restoration Committee and Ngatiwai Trust Board. The fringe of north facing coastal slopes along the Whangarei Harbour west of the carpark at Urquharts Bay, revegetated by the Bream Head Restoration Committee over the last few years, was also viewed and the methods of successful planting recorded.

Part of nearby Ocean Beach on the eastern side of Whangarei Heads was also inspected by the authors to view natural and degraded vegetation cover in similar zones to that present at Smugglers Bay.

## SCOPE OF THIS REPORT

The Northland Regional Council and Department of Conservation require technical advice on revegetating the beach at Smugglers Bay from the foredune landward to the fenceline indicated as the northern boundary for the 2009-2011 revegetation zone (Figure 3). The project brief is to provide a report advising on the best option for eliminating kikuyu (*Pennisetum clandestinum*) and replacing with naturally occurring natives as well as consideration of issues such as the erosion of the archaic midden sites, management of the bay for recreational use including the role of existing pohutukawa (*Metrosideros excelsa*), and habitat for a Nationally Critical land snail (*Punctidae* sp. 223) and for breeding variable oystercatchers.

It is intended that the technical advisory notes in this report would then be used by the Bream Head Restoration Committee, in consultation with agencies, to write a Restoration/Management Plan for Smugglers Bay.

Following site inspection and discussions at Smugglers Bay, it is proposed that restoration efforts will be best achieved by considering a wider brief than that originally considered. In particular, the foredunes at Smugglers Bay are highly modified and therefore have poor form and function. Rabbits have contributed to this degradation and are still having a significant influence. This loss of natural dune form and function has had many consequences including changes in the stability of the dunelands, loss of indigenous biodiversity, modified habitats and erosion of archaeological sites.



Figure 3: The western end of the Bream Head Scenic Reserve showing the staged revegetation programme using natives underway by the Bream Head Conservation Trust and Restoration Committee. This includes the current focus (2009-2011) at Smugglers Bay (Source of image: Department of Conservation).

In order to determine priorities and appropriate techniques for a restoration programme at Smugglers Bay, this report will therefore focus on the following:

- Provide a brief geomorphic and botanical description of the beach and dune system at Smugglers;
- Review some of the basic principles of dune form and function - an understanding of some of the coastal processes is considered essential in order to develop a restoration plan for Smugglers Bay;
- Describe the nature and impact of human-induced factors that are contributing to the degradation of the beach and dune system at Smugglers;
- Based on guidelines from archaeologists including those at the Department of Conservation, consideration of practical options for reducing erosion and protecting middens at Smugglers;
- Discussion of a selection of other management issues and options relevant to developing a coastal restoration plan for Smugglers Bay including:
  - Priorities and strategies for restoration;
  - Control of rabbits;
  - Plant species for the different coastal zones;
  - Recreational and aesthetic values;
  - Accessways and fencing on dunelands; and
  - Management of the Nationally Critical land snail, Punctidae sp. 223.
- And finally, provide brief notes on site-specific management options for different sections of the beach and dune system.

## SITE DESCRIPTION

### Geomorphological

Bream Head Scenic Reserve is surrounded on three sides by the sea with the coastline dominated by coastal cliffs with a small number of cobble and sandy bays. Smugglers Bay is a small sandy beach on the southern shore of the reserve.

Bream Head is classified as a geological site of regional significance. In a general description, Pierce et al. (2002) indicated that the area is a significant landscape as follows:

*The craggy peaks of Manaia and Bream Head tower over the coastal environment of Whangarei Heads. They form part of a complex scene with which many Northlanders identify strongly. Prominent headlands, sandy beaches, sheltered estuaries, rolling bush and grass-covered hills add to one of the more spectacular coastal landscapes in New Zealand. In recognition of this physical diversity, the Whangarei Heads area is defined as "Outstanding" by the Proposed Coastal District Plan.*

Goldwater and Beadel (2010) describe the landform and geology of Bream Head Scenic Reserve and surrounding area as comprising steep, bluffed coastal hills with prominent rocky pinnacles mostly of Lower Miocene andesite and eroded remnants of a Lower Miocene dacite dome and unconsolidated landslide deposits. Smugglers Bay set within this volcanic complex comprises an eroded Holocene foredune at the back of a pocket beach.

From the field visit, the beach and dunes at Smugglers is characterised by a narrow mobile foredune modified by both wave and wind erosion (Figure 4). The foredune is



poorly vegetated by spinifex. The remnant of a storm scarp runs almost the entire length of the foredune and remains largely unvegetated and vulnerable to wind erosion. The storm scarp may be a result of a '100-year' storm event in 2007 which caused very serious damage to Smugglers Bay (Maria Butcher, Department of Conservation, pers.comm.).



Figure 4: The beach and foredune system, Smugglers Bay, showing a narrow poorly vegetated and relatively mobile foredune. Note the storm erosion scarp along virtually the entire length of the foredune (arrows). With the lack of spinifex growth down the seaward face of the foredune it remains highly vulnerable to erosion by wind erosion.

Several blowouts occur within the foredune zone and also in the semi-stable backdune zone lacking vegetation cover. Fresh sand is actively being blown inland forming steep windward faces and adding sand to landward dunes. Healthy fringes of spinifex (*Spinifex sericeus*) lining the depositions zones around the largest blowout on the western side of the beach indicate active sand deposition as sand is blown inland by southerly onshore winds from the beach.

Landward, a semi-stable dune rises up, steeply in some places, to the fenceline along the back of the beach. At either end of the beach, rocky headlands occur with a small cliff at the western end and a small boulder beach grading into steep rocky slopes at the eastern end. A small rock platform that is mostly submerged at high tide occurs in one part of the beach. A small stream is associated with a ribbon of wetland vegetation adjacent to a centrally placed boardwalk erected over the foredune. Recent heavy rain and flow through the stream had exposed a bed of boulders up to a metre lower than the current sand level on the beach near high water mark (Figure 5). These boulders are similar to those on the beach at the eastern end. The extent of a boulder layer along the beach beneath the sand is not known.



Figure 5: Boulders exposed by recent heavy rain and flows through this centrally located stream at Smugglers Bay.

## Botanical

The vegetation of Bream Head Scenic Reserve comprises a large area of predominantly broadleaved coastal forest and shrubland (Goldwater and Beadel 2010). There is a complete sequence of vegetation types from the sandy and rocky seashore to high forest slopes and rocky outcrops (Clunie 1993, cited in Ritchie 2008). The significance of flora (and fauna) within Bream Head Scenic Reserve is also noted by Pierce et al. (2001) as follows:

*Te Whara or Bream Head Scenic Reserve is an area of outstanding conservation value, containing the largest remaining stand of coastal broadleaf forest in Northland. There is a full zonation of communities from the coastal sandy and rocky shores to the high forest slopes and rocky outcrops at 488 m elevation. A diverse range of species are present in the area including the threatened birds North Island brown kiwi and NZ pigeon (kukupa), threatened invertebrates, bats, and several visiting bird species from offshore islands. The plant list exceeds 300 species and includes many rare and restricted species. For these reasons the site has been placed in the highest category in the Department of Conservation's Sites of Special Biological Interest and Protected Natural Areas programmes, and is identified as a priority area for management in the Northland Conservation Management Strategy.*

While Smugglers Bay is not mentioned specifically, Pierce et al. (2001) indicated the beaches of Bream Head support a varied plant community including the foredune plants spinifex and pingao (*Facinia spiralis*), New Zealand ice plant (*Disphyma australe*), sand daphne (*Pimelia villosa* syn. *P. arenaria*), pohuehue (*Muehlenbeckia complexa*), tauhinu (*Ozothamnus leptophyllus*), pohutukawa and ngaio (*Myoporum laetum*), in addition to a wide range of exotic grass and woody species.

Goldwater and Beadel (2010), citing unpublished data of F. Brook, note the dunelands of Smugglers Bay are dominated by exotic grasses such as haretail (*Lagarus ovatus*) and

kikuyu, with frequent lupin (*Lupinus arboreus*), and occasional pohuehue, ratstail (*Sporobolus* sp.), hawkesbeard (*Crepis* sp.), knobby club rush or wiwi (*Ficinia nodosa*) and shore bindweed or nihinihi (*Calystegia soldanella*). In a survey of the coastal fringe of Bream Head, that included two sampling transects established at Smugglers Bay, Holland (1997) found 19 exotic species considered to be environmental weed species that were a threat to the reserve.

Vegetation descriptions reviewed above do not specifically record spinifex at Smugglers, which from the field inspection for this project was the main species found on the foredune. However, the spinifex cover is in poor condition and as a result the foredune is severely eroded (Figure 6). Wind funnelling by onshore winds has scoured out the foredune causing blowouts leaving exposed root systems of what was an established spinifex dune cover. Along most of the foredune, spinifex has not re-established on the seaward face of the foredune since the last major storm. Consequently the seaward face is largely unvegetated and vulnerable to ongoing erosion.



Figure 6: Part of the degraded foredune system at Smugglers Bay. Wind funnelling by onshore winds has caused a blowout (left foreground) and exposed root systems of spinifex. Remnants of the partially vegetated foredune remain highly vulnerable to further wind erosion.

Only one plant of pingao was found during this site visit in early June 2010 which was some 30 m inland at the top of a large blowout. The lone pingao comprised a single unthrifty shoot but dead typically ropy rhizomes indicated a larger plant did once occur. Other vegetation on the foredune includes scattered shore bindweed that increases in abundance with greater sand stability landward, along with an increasing presence of exotic herbaceous and grass species. Colonies of sand carex (*Carex pumila*) occur in depressed moister areas along with giant umbrella sedge (*Cyperus ustulatus*) near and within the small centrally located ephemeral stream.

Semi-stable backdune sties are dominated by an increasing density of exotic grasses, especially kikuyu that occurs through the fence into the grazed paddock behind the beach (Figure 7). Pohuehue is common amongst the rank grass. Colonies of knobby club rush, some of which are large, dominate significant areas of the dunes from near the foredune and throughout the dense grass areas on backdunes. Occasional small groups or isolated shrubs are scattered over parts of the backdune as well as ti kouka (*Cordyline australis*) and harakeke (*Phormium tenax*), some of which may have been from early plantings. Seven large pohutukawa trees occur in a curved line along the dune at the eastern end, which according to Simpson (1990), may have been planted. A dense thriving colony of New Zealand spinach (*Tetragonia tetragonioides*) dominates the ground cover at the eastern end of the line of pohutukawa trees.



Figure 7: View eastward along Smugglers Bay with knobby club rush and exotic grasses in the foreground; the track and boardwalk that gives access to the centre of the beach adjacent to a small stream draining through the degraded foredune with limited spinifex cover; further along pohutukawa trees on the foredune; and the coastal forest on the headland in the distance.

## Fauna

Detailed lists of fauna and their status is given in several references already listed above. Of particular concern at Smugglers Bay is the Nationally Critical land snail *Punctidae* sp. (Ritchie 2008). It lives amongst low herbaceous vegetation dominated by exotic grasses. It was estimated that the population occupied about 80 square metres (Brook 2002 cited in Goldwater and Beadel 2010).

With the guidance of Nigel Miller of the Department of Conservation during the field visit to Smugglers, a brief search of the exotic grass area above a midden at the eastern end of the beach did not turn up any confirmed land snails. The vegetation cover in the area is as described above – low, herbaceous, exotic grass species.

## Rabbits

Rabbit damage to vegetation and sign (droppings, scraping) was observed during the site inspection in early June. This was particularly evident along the foredune and included browsed new growth of spinifex plants and runners along parts of the foredune toe (Figure 8). Browsing damage was also evident on knobby club rush, sand carex and sea rocket (*Cakile maritima*) all of which is likely to be from rabbits.



Figure 8: Browsing damage by rabbits of spinifex at Smugglers Bay. Rabbit browsing of spinifex is common on actively growing runners and plants along the seaward face of the foredune significantly reducing sand trapping.

## Bream Head archaeological sites

Te Whara or Bream Head is a rich archaeological landscape resulting from more than 500 years of Maori occupation. Significant middens (food refuse or rubbish dumps) containing fish and shellfish remains and charcoal occur within the dunes at Smugglers Bay (source: [www.doc.govt.nz/conservation/hsitoric/northland](http://www.doc.govt.nz/conservation/hsitoric/northland)). In a geophysical survey of part of Bream Head, McCoy (2008) mapped one archaic era midden, discovered a previously unknown midden and documented areas with potential for undocumented buried deposits at Smugglers Bay.

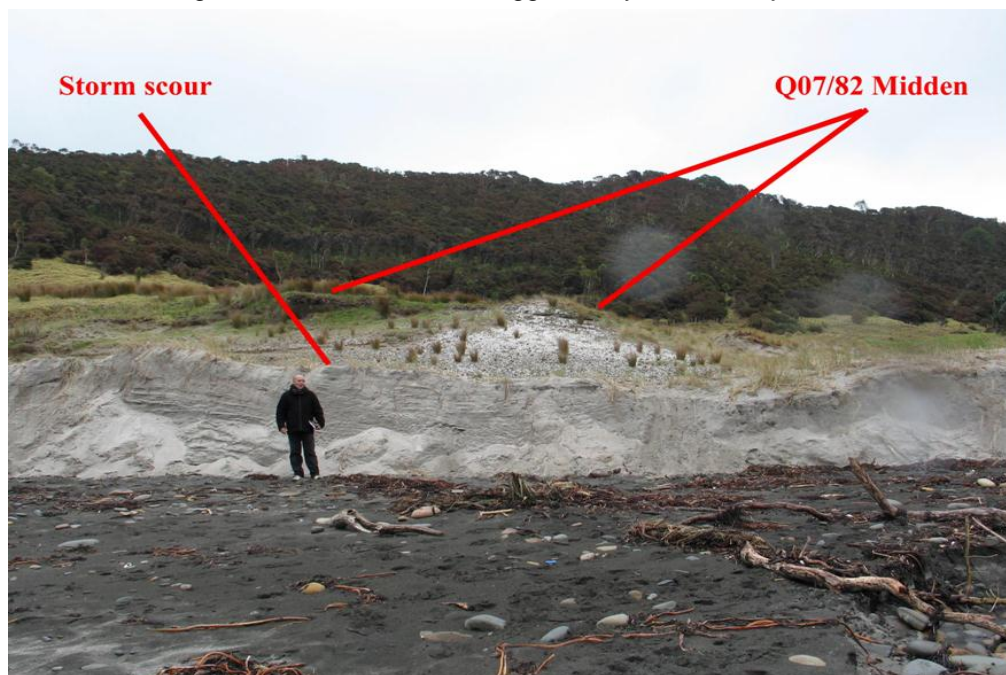
Maria Butcher, archaeologist at the Department of Conservation's Whangarei Area Office, provided the following information:

- *There are three archaeological sites recorded in Smugglers Bay (Q07/82, Q07/83 and Q07/103).*
- *Archaeological material eroding out of the Smugglers Bay dune system has been recorded since at least 1963 (M. Nicholls, NZAA site record for Q07/83).*
- *The sites are large shell midden, exposed in the eroding dune face. As well as massive quantities of shell, the midden contain bird bone, fish bone, evidence of fire and cooking, and evidence of stone working. Obsidian and chert artefacts have been reported, along with a bone fish hook and a fragment of a bone spear.*

- *The Smugglers Bay midden sites are part of the wider archaeological landscape of the Busby and Bream Head Scenic Reserves. This archaeological landscape is an Actively Managed Historic Site, where DOC has assessed its historic heritage values as being of high significance and worthy of active management to protect those values.*
- *It is thought that sites Q07/82 and Q07/83 belong to the early 'archaic' period of New Zealand pre-history. Archaic midden are poorly known in Northland, so the Smugglers midden are important for the information they may contain about the history of Te Whara/Bream Head.*
- *In 2007, a '100-year' storm event caused very serious damage to the Smugglers Bay midden (Figure 9). Site visits were undertaken by the DOC archaeologist (Jonathan Carpenter) and Clive Stone of the Ngatiwai Trust Board. With the support of Ngatiwai Trust Board, an Archaeological Authority was obtained, to carry out archaeological investigations of these midden before they suffered further damage.*
- *Preliminary results of the investigation, carried out in early-mid 2010, suggest that midden site Q07/82 extends further back into the dune than previously thought. Despite fears to the contrary, an area of midden remains intact beneath the sand dune, behind the eroding dune face. Radio-carbon dates, and results from the midden analysis are pending.*

Concern with the vulnerability of exposed middens at Smugglers Bay to further damage and loss have long been raised and was clearly visible in the latest field visit. A number of factors including wind and wave action, trampling by beach users and disturbance from rabbits are all contributing to erosion and damage to middens at Smugglers Bay. The dune has continued to suffer erosion since the storm event in 2007 (Maria Butcher, DOC, pers. comm.).

Figure 9: Site damage to midden Q07/82, Smugglers Bay, after a major storm in 2007 that caused



considerable erosion. Photograph taken in July 2007 and supplied by Maria Butcher.

The two most conspicuous middens (Q07/82 & Q07/83) are currently being exposed by wind damage associated with blowouts largely due to lack of appropriate vegetation cover (Figure 10). In addition, an irregular foredune immediately seaward of the western midden (Q07/82) is allowing wind funnelling up the steep dune face creating a windswept zone deflating the midden site and depositing fresh sand landward. A restoration programme starting with revegetating the foredunes is likely to reduce damage to this and other middens on the dunes of Smugglers Bay.



Figure 10: Exposed archaic shell midden on a poorly vegetated dune at Smugglers Bay vulnerable to further erosion from onshore winds.

## DUNE FORM AND FUNCTION

In the development of a restoration plan for a beach and dune system, it is important that some of the basic principles of natural dune form and function are considered. These principles are well documented including Hesp (2000), Dahm et al. (2005), Spence and Bergin (2009) and the Northland Regional Council website (source: [http://www.nrc.govt.nz/upload/7154/NRC\\_Northland\\_Dunes.pdf](http://www.nrc.govt.nz/upload/7154/NRC_Northland_Dunes.pdf)). Those most relevant to Smugglers Bay include:

- an understanding of the function of coastal dunes;
- beach and foredune dynamics – the ‘cut and fill’ cycle; and
- blowouts.

The basics of dune form and function, in the context of Smugglers Bay and the proposed restoration programme, is therefore discussed.

### The function of coastal dunes

The foredunes along Smugglers Bay, like any other ocean beaches provide a natural buffer that can absorb the impact of erosion, thereby protecting areas further landward. The wider and higher the dunes between inland areas and the sea, the greater the level of natural erosion protection provided. This role will become even more important with projected climate change.

***Dunes do not “stop” wave erosion. Rather, they provide a natural self-repairing buffer to absorb the erosion.*** Dune vegetation plays an important role in natural beach and dune dynamics, and for this to occur at Smugglers Bay, foredunes must be restored to their natural form and function. The natural dune repair after storms is ***critically dependent*** on the presence of appropriate sand trapping vegetation on the seaward face of the dune.

At Smugglers Bay, the key native sand binding species on the seaward dune face are spinifex and pingao. The ecology and role of these species on foredunes are provided in Bergin and Herbert (1998) and Bergin (1999), and is also readily available from the Northland Regional Council.

## Beach and foredune dynamics

Beaches and coastal foredunes are a dynamic system (Hesp 2000). High wave energy events caused by storms, including an elevation of the mean water level, are natural occurrences and may occur at any time. Coastal processes involve cycles of dune erosion and recovery and are characteristic of most New Zealand beach-dune systems. The dunes, and their cover of appropriate sand binding species, play a critical role in these beach dynamics.

As in other beach and sand dune systems, the foredunes along Smugglers Bay are an integral part of the total beach system and are subject to these natural cycles of erosion and repair. These processes, sometimes referred to as “cut and fill”, are illustrated in Figure 11 and described as follows:

- i. During periods with low to moderate wave action, sand tends to move onshore and a wide high tide dry beach develops. Dry sand blown landwards is trapped by dune vegetation, which slows wind velocities near the surface causing the sand to be deposited, building up the dune over time (Figure 11i).
- ii. During major storms, waves erode the beach and the frontal dune. Eroded sediments are deposited on offshore bar systems, which help to protect the beach by breaking waves offshore and thereby dissipating excess wave energy. Erosion continues until either the storm ceases or equilibrium is reached between beach profile shape and the storm waves. Immediately after storm erosion, the beach level is lower and the frontal dune is often characterised by a steep, near vertical eroded dune face (Figure 11ii).
- iii. After a storm gives way to calmer weather, the sand deposited on the offshore bar gradually moves onshore restoring a high tide beach by lifting the beach level. Sand drying on the beach is blown by onshore winds against the dune scarp and a ramp of sand eventually builds up against the eroded dune face (Figure 11iii). The eroded dune face also generally collapses to a more stable slope.
- iv. In extended periods without further dune erosion, the native sand binding grasses on the seaward face of the dune, particularly spinifex and pingao, gradually begin to extend down the eroded dune face – renewing the process of sand entrapment and gradually repairing the eroded dune face. The building of an incipient dune continues during this accretion phase to return the dune to a pre-storm profile



(Figure 11iv). This natural dune repair process is relatively slow and full recovery can take years after a period of severe dune erosion.

Natural dune building and repair reinstates the protective dune following severe storm erosion. The self-repairing capacity of natural dune systems covered in native sand binding plants (Figure 11iii, 11iv) is very important for the mitigation of coastal erosion.

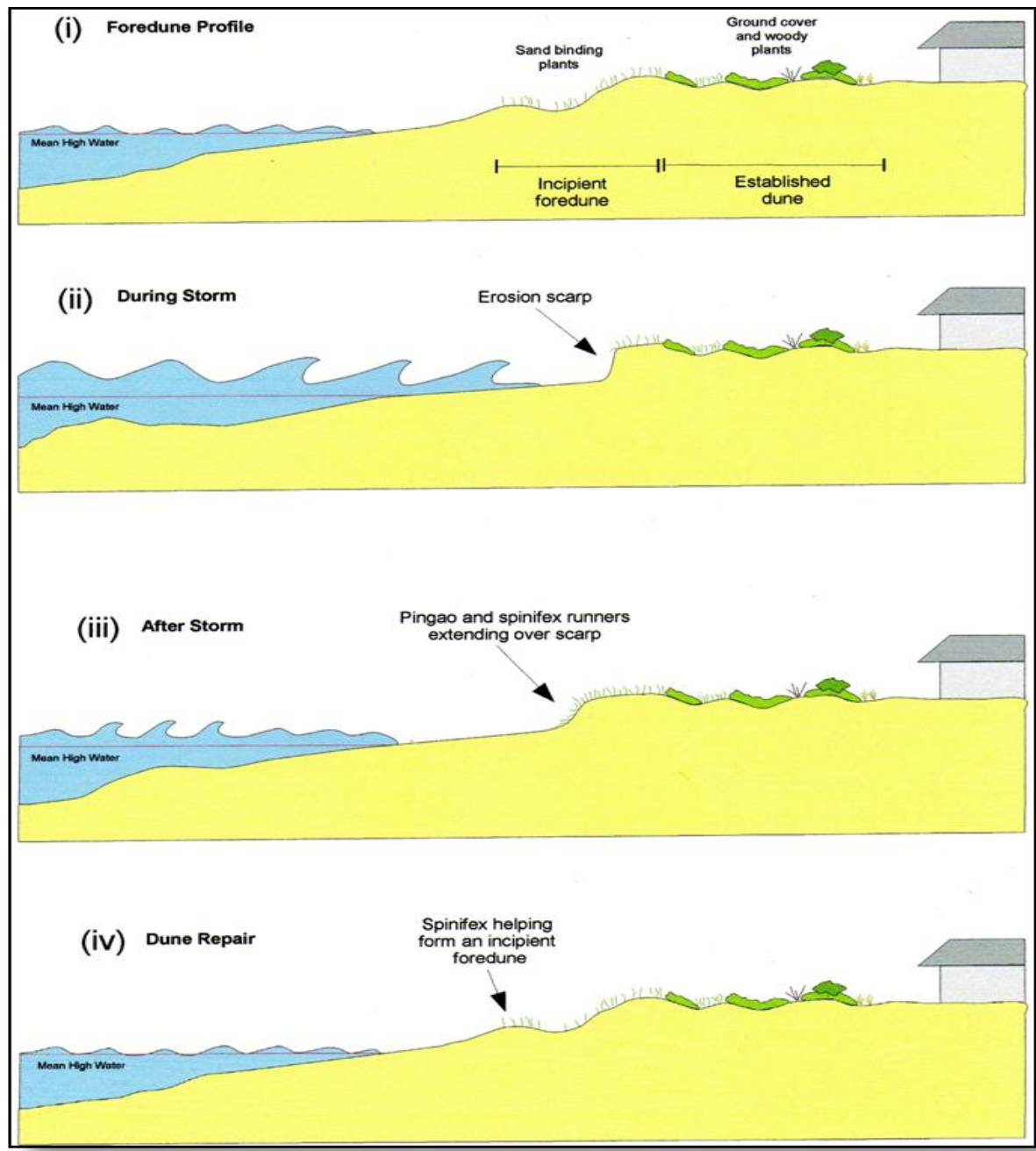


Figure 11: Natural cycles of dune erosion and recovery that occur on sandy beaches including pocket beaches like that of Smugglers Bay. The foredune profile (i) is cut back during a storm to create a steep scarp (ii). Following the storm, over the following months or longer, the native sandbinders spinifex and pingao extend over the scarp to trap sand blown off the beach (iii) and an incipient dune is eventually reformed (iv). Refer to the text for greater detail on each profile i - iv.

The 'cut and fill' cycle of dune erosion, dune re-building and stabilisation is therefore a natural dune process – and essential to this process is a cover of appropriate native sand binding vegetation, viz. spinifex and pingao. An understanding of this process that maintains the foredune as a barrier to the incursion of both sea and wind on most sandy beaches is critical before any restoration programme of a beach and dunes system is undertaken, including the pocket beach and dunelands of Smugglers Bay.

***The foredunes at Smugglers are partially degraded. Evidence of a storm cut is evident (Figure 4), but there is little evidence of recovery.*** The foredunes lack a continuous zone of native sand binding plants along the seaward face of the foredune. Without a good cover of spinifex and pingao on the seaward foredune face, natural dune repair between storms tends to be very limited. This can result in the next storm picking up where the last one left off, giving rise to more serious dune erosion than would have occurred with some dune recovery between the two events.

At Smugglers Bay, as with other beaches in New Zealand, the sand blown inland is often permanently lost from the active beach and foredune system. Sand that is building up landward dunes is clear evidence that sand is being 'lost' from the frontal dunes, and depositional zones with vigorous spinifex present are a feature at Smugglers.

## Blowouts

Wind erosion of sparsely vegetated dunes can lead to localised blowouts. There are several blowouts in the dunes of Smugglers Bay. These tend to be the saucer-shaped blowout described by Hesp (2000) as semi-circular or saucer-shaped often appearing as shallow dishes. They are characterised by a deflation (or erosional) basin, lateral erosional walls, and a downwind depositional lobe. The sand eroded by wind from the deflation basin and the adjacent walls is deposited immediately downwind to form the depositional lobes.

A large blowout west of the centrally located boardwalk and stream at Smugglers exhibits the classic geomorphological features and processes of a blowout as described by Hesp (2000). This coincides with the midden site (Q07/82) located to west of the accessway. The features illustrated in Figure 12 of the blowout over this midden at Smugglers include:

- Erosional notches and hollows in dunes where a gap in the vegetation allows locally accelerated wind speeds forming a high-speed jet. The blowout (and midden) at Smugglers is immediately landward of a partly destroyed foredune and in line with southerly winds. This beach is exposed to these onshore southerly wind flows (Wendy Holland, DOC, pers. comm.).
- Wind removes sand from the deflation basin and the lateral walls and transport it downwind. Deflation basins tend to continue to erode until a base level of more consolidated material is reached such as an old soil layer, pebble, shell or pumice layers, or as in the case at Smugglers Bay, an archaeological layer of dense shells that are part of the archaic midden (circled in Figure 12).
- Landward of the deflation basin wind flow accelerates transporting sand up the windward slope of the depositional lobe. Over the lobe crest there is a rapid decrease in windflow resulting in deposition of fresh sand at this end of the blowout. This is clearly seen in a fringe of healthy spinifex growing on the depositional lobe at the landward end of the blowout at Smugglers (arrowed in Figure 12).

Blowouts are likely to be initiated where there is a reduction in vegetation cover and subsequent wind erosion (Hesp 2000). While there are natural causes of blowouts,

human-induced factors (refer next section) can all lead to a reduction in vegetation cover and consequent erosion.



Figure 12: The features of the blowout at Smugglers Bay that is eroding midden Q07/82 toward the western end of the beach. The partially destroyed and degraded foredune (top) is allowing accelerated wind flow over the midden immediately landward (circled). This has left a typical deflation basin directly over the midden covered in a dense layer of shell and stone (lower). Further landward is the depositional zone (with healthy spinifex arrowed) of sand blown inland from the foredune and midden.

## HUMAN-INDUCED FACTORS

Human-induced factors and activities profoundly influence the characteristics of erosion and the degree of instability of our beach and dunes systems. This is largely through disturbance, destruction, or changes in species composition to vegetation cover.

The recent inspection of the beach and duneland at Smugglers Bay clearly shows that it has been significantly degraded by human-induced factors. These include:

- **Early human use** – the large number of archaic middens at Smugglers indicate the area has been occupied by early Maori and exploited for food gathering. Inevitably, these activities would have significantly altered the vegetation cover and consequently dune form and function.
- **Rabbit browsing** – particularly of the sand binders on the foredune including extension of new stolons of spinifex as well as newly establishing plants on open or sparsely vegetated sites. Pingao is highly palatable to rabbits with the only plant left at Smugglers on a depositional lobe inland of a major blowout.
- **Historical grazing** – probably to high water mark since introduction of domestic and wild animals over a century ago. As with most beaches in New Zealand, many native plants have probably been lost from Smugglers Bay or reduced significantly in extent and vigour by uncontrolled grazing and trampling of sheep and cattle.
- **Past and current recreational use** – uncontrolled access by beach users for fishing and recreation over many decades. Smugglers Bay remains a popular recreational beach for residents in the Whangarei region and for visitors.
- **Invasion of inappropriate exotic plant species** – inevitable spread of a wide range of introduced grass, herbaceous, and woody shrub and tree species. These are comprehensively documented by Holland (1997) for Smugglers with dozens of environmental weeds from inappropriate plantings, garden escapes and adjacent pastoral land use.

As with any coastal dune restoration plan, including that proposed for Smugglers Bay, many of these human-induced factors listed will need to be addressed.

## MANAGEMENT OF ARCHEOLOGICAL SITES

As the archaic middens at Smugglers Bay are under threat from erosion, some of the principles of managing archaeological sites are considered relevant.

In a guide published by the Department of Conservation caring for archaeological sites, Jones (2007) provides practical guidelines for protecting and managing archaeological sites in New Zealand. For all sites, minimising deterioration is a key management objective and the general principles within this guide will be useful when preparing management or conservation plans for archaeological sites such as at Smugglers Bay.

### Threats to middens

Archaeological sites such as middens can be visible at or above the ground surface or lie buried beneath it. Actual and potential threats to archaeological sites many of which are relevant to middens at Smugglers Bay include:

- Erosion and movement of the site including deposition of erosion deposits (Figure 13);
- Root growth of vegetation cover disturbing underground layers;
- Weed growth and inappropriate weed removal practices; and

- Where they become established, windfall of any large trees where upturned root plates disturb the substrate.

Current and potential threats to middens at Smugglers from human activities include:

- Disturbance including wear and compression from recreational activities such as walking over middens, picnicking, etc...;
- Inappropriate siting of any tracks or structures such as signs, fences or boardwalks;
- Burrowing by animals, particularly rabbits (Figure 13); and
- Insensitive restoration activities such as intensive planting on middens.



Figure 13: The effects of wind erosion of a poorly vegetated dune and rabbit burrowing on a midden site at Smugglers Bay.

**Erosion by wind** – Of most relevance to the actual and potential destruction and loss of middens at Smugglers is the erosion of the dunes by the action of wind. With regard to the effects of wind erosion, Jones (2007) states:

*Wind erosion in New Zealand often affects sites in dune areas which were occupied when the dunes were stable, but are threatened when the dunes re-mobilise. Sites can be damaged by sand removal from the surface, or by being undermined from the margins. Active dunes bury existing vegetation and then move on, leaving the site exposed and putting even apparently stable sites at risk. Midden sites which become pedestals with a cap of shell or stone protecting a small area of sand beneath them (but generally being undermined all around) are usually beyond protection. The causes of sand erosion can be remote from the site and connected with sea erosion of foredunes, vegetation loss some distance from the site, and overall changes in sediment supply to beaches.....*

**Erosion by wave action** – Coastal erosion by high seas and storms, including in some locations a landward retreat of the coastline, are common on many New Zealand beaches. These threats are also likely to increase, with the expected impacts of

increasing sea level from the effects of Climate Change (Dahm et al. 2005). Erosion by wave action poses a significant threat even at Smugglers for the more seaward located middens.

## Recommendations for protecting archaeological sites

In a review of the vegetation management of several archaeological sites in New Zealand, Jones and Simpson (1995) suggest that most archaeologists would prefer to see archaeological sites managed in a ground cover of grass or early successional species such as bracken. Three vegetation cover types are recommended for archaeological sites:

1. Grazed or mown grass swards to reduce erosion and provide views of features;
2. Early successional species such as bracken and native or exotic shrubland as a protective cover; and
3. Where there is a forest that had already regenerated, manipulation of the understorey to maintain a gallery effect to give views.

Jones and Simpson (1995) suggested that grassland covers offer a range of options. These include low-fertility native or rough grasses of low productivity typical of foredune vegetation at coastal sites. The least preferred vegetation cover for archaeological sites was the planting of large trees. The main problem with large trees is that root systems penetrate deep in subsurface horizons, and windfall with upturned root plates, can disturb archaeological layers significantly (Figure 14).

For middens on coastal sand dunes, Jones (2007) suggests that interventions such as local planting can be effective in aiding restoration, provided the fundamental initiating cause of damage or loss of midden sites is also addressed. For the highly mobile frontal dunes Jones recommends use of native sand-binding plants and cites planting and management techniques described by Bergin and Herbert (1999) for pingao and Bergin (2003) for spinifex. Jones also supports the use of fabric-covered fences (sand fences) erected across middens to transverse the prevailing wind.

For more landward semi-stable sites, the guide recommends low-growing or ground-cover shrubs as the optimum long-term cover for protection of archaeological sites as they are likely to provide protection of subsurface remains. Where necessary, removal of seedlings of potentially large trees will be required to prevent forest growth.

Practical options for management of archaeological sites in the face of coastal erosion by waves are limited. Certainly, engineered protective measures often used on eroding coastlines such as seawalls or groynes, will not be practical or desirable for sites such as Smugglers Bay for many reasons. Therefore, the favoured option is to ensure that the beach and foredunes at Smugglers are in the best state possible in terms of natural dune form and function so that the effects of coastal erosion by high seas are mitigated as much as possible.

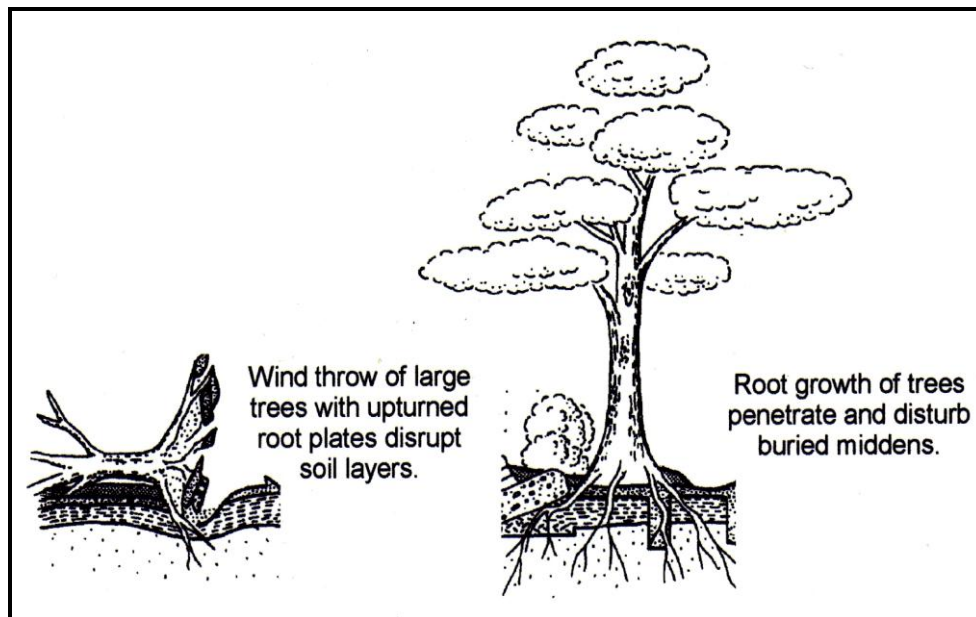


Figure 14: Effects of large trees on site stabilisation of archaeological sites such as middens (modified from Jones and Simpson 1995). Planting trees and shrubs on middens is therefore not recommended.

## Options for protecting middens at Smugglers

From the field inspection at Smugglers in early June 2010, the most conspicuous middens are those in the foredunes poorly vegetated by spinifex and more landward locations in sparsely vegetated semi-stable backdune sites. These middens in particular are being eroded by wind action although as suggested by Jones (2007), protection of middens within intrinsically unstable dune environments require a more holistic approach to dune restoration rather than a focus on the midden site itself.

Management options aimed at protecting the middens at Smugglers therefore need restoration of natural dune form and function. This involves revegetation of each zone from foredunes to backdunes using appropriate native species. Planting the dunes is consistent with the Department of Conservation's assessment of Smugglers as 'an Actively Managed Historic Site' with 'historic heritage values as being of high significance and worthy of management to protect those values' (Maria Butcher, DOC, pers. comm.).

For the middens at Smugglers, a holistic approach to restoration should include:

### ***Reinstatement of a vegetated foredune zone where necessary***

- Restoration of the foredune by infill planting of gaps in foredune vegetation cover with further spinifex to encourage dune building, reduction of wind funnelling by onshore winds and less sand blown inland;
- Implementing sustainable and effective long-term control of rabbits; and then
- Re-introduction of the highly palatable pingao.

### ***Revegetation of landward zones***

- Initially planting native sand binders to stabilise the site around the midden site to provide shelter, reduce wind speeds over midden surface and therefore slow further erosion;

- As sites become semi-stable, encouraging natural regeneration of native species around the midden by continued effective rabbit control; and
- Planting around middens sites with a range of backdune ground cover species suitable for semi-stable sites including sand carex, knobby club rush and pohuehue.

#### ***Planting on middens***

- Reinstating a vegetated foredune and revegetation of bare landward dune sites as above will hopefully obviate the need for planting directly over midden sites;
- If planting over midden sites is contemplated, a DOC archaeologist should be present during the planting;
- Planting may occur directly over the midden only if there is a layer of sand thick enough to ensure nothing is planted into the layer of cultural material (Maria Butcher, DOC, pers. comm.).

#### ***Ongoing protection of middens***

- Encouraging natural invasion of appropriate native species over and around middens by continued rabbit control and ensuring beach users keep off middens;
- While sand fences have been recommended by Jones (2007) as a possible method for reducing sand movement at midden sites, we suggest these are generally of limited value, require high maintenance and are not aesthetically appropriate especially for isolated beaches such as Smugglers;
- Encouraging the invasion of vigorous exotic grasses such as kikuyu on coastal dunes to provide protection of middens is not recommended; and
- Continuing to keep problem weeds and potentially large woody species off middens by careful removal ensuring substrate is not disturbed.

## **RESTORATION PRIORITIES AND OPTIONS**

A number of beach and dune management issues of relevance to the development of a restoration plan for Smugglers Bay are highlighted. This includes firstly, general comments setting priorities and strategies for restoration, followed by more specific management issues and options relevant to Smugglers Bay.

### **Restoration strategies**

- While the project brief indicated a focus on replacing kikuyu with native species that were likely to have occurred at Smugglers originally, it is recommended that a wider management perspective is considered.
- Restoration of degraded dune systems, including those at Smugglers Bay, usually requires addressing a range of issues to ensure resources are used effectively and to improve restoration outcomes. Determining the key factors contributing to degradation of the beach and dunes is critical to prioritising restoration efforts.
- While planting is often the focus of restoration plans, there are many other activities (e.g., rabbit control, beach usage) that are likely to be required before any planting takes place, or even if planting is required at all.
- Restoration efforts on beach and dune systems should initially focus on restoring the frontal dunes. There is no merit in restoring landward zones when onshore prevailing winds are dumping sand from poorly managed and degraded foredunes.



- Restoration activities that work with nature wherever possible are likely to be most practical and cost effective and therefore deliver sustainable gains. For instance, enhancing the factors that would encourage natural regeneration would be a preferable first step rather than launching prematurely into large-scale, resource-demanding, planting programmes.

## Planting tips for dunes

- Initially planting should focus on using the hardiest local seral species which are easily raised, most likely to perform well on a range of sites, and are therefore cost-effective for planting on a large scale.
- Planting of more sensitive species can be delayed until management issues such as control of rabbits and recreational use is well underway, and where shelter and weed control has provided suitable microsites for establishment of a wider range of species.
- Choosing relatively easy sites first for restoration is likely to increase chances of success and allows building up of local experience before moving to more difficult sites and issues. For example, where possible, plant sheltered sites before tackling more difficult exposed sites.
- Similarly, keeping restoration works at a small-scale, at least initially, enables building up of local knowledge and confidence.
- Consideration of the success and failures of previous restoration efforts at the site or on similar sites nearby provides invaluable local knowledge.
- All restoration efforts must be monitored to ensure timely weed control and to allow modification of restoration plans over time, based on what has been successful and what has failed.
- With significant changes in climatic and edaphic factors from foredunes landward, an understanding of the different zones in coastal environments is critical in matching the appropriate species to their preferred sites, for both planting and encouraging natural regeneration.

## Control of rabbits

- This is the first action to be tackled in the restoration of Smugglers Bay and is highest priority. ***Control of rabbits is essential before planting of most native plant species on dunelands and their control can often be the single best action to undertake on a degraded dune.***
- Methods for control of rabbits are reviewed by Unsworth (2005). A summary of recommendations relevant to Smugglers Bay for the control of rabbits is given in the Appendix.
- Pindone poisoning operations have proved effective for sustained control of rabbits in similar coastal dunelands as Smugglers, e.g., Te Henga Beach, west Auckland (contact Waitakere City Council and Auckland Regional Council); Bay of Plenty beaches (contact Environment BOP, Mount Maunganui).

## Restoring foredunes

- Restoration of a foredune along most of the beach of Smugglers to natural dune form and function is the next priority after rabbit control; the aim is to establish a

vigorous cover of indigenous sand binding vegetation, primarily spinifex and pingao. This should lead to the development of a foredune capable of absorbing the impact of the next storm through the natural process of storm cut erosion and recovery – simply the natural fluctuation backwards and forwards over time of the foredune (Jim Dahm, EcoNomos, pers.comm.).

- Patterns and methods for planting and managing the key indigenous sand binders to restore relevant to Smuggers Bay are given in Bergin (2003) for spinifex and in Bergin and Herbert (1999) for pingao.
- Other foredune and sand plains species such as sand carex and shore convolvulus are regenerating naturally at Smugglers, and with rabbit control, are likely to expand.
- Semi-stable dunes immediately landward of the active foredune at Smugglers will support a range of other species such as knobby club rush and pohuehue which can be increased by supplementary planting; other local plant species that have disappeared from Smugglers could be planted in this zone such as sand daphne, local carex species, sand coprosma (*Coprosma acerosa*), etc...
- Refer to Northland Regional Council publications including *Caring for Northland's Dunes - Protect the dunes and they'll protect us*. Source: [http://www.nrc.govt.nz/upload/7154/NRC\\_Northland\\_Dunes.pdf](http://www.nrc.govt.nz/upload/7154/NRC_Northland_Dunes.pdf)

## Restoring backdunes

- For revegetating backdunes, a restored dune system does not necessarily have to return the entire site to once high coastal forest that probably existed before areas were degraded by human-induced factors. There may be good reason to retain a low cover of appropriate local native species such as rushes, sedges, woody ground cover and low-growing shrubs over a proportion of the dunes. Taller shrub and tree species could be confined to lower elevated sites and in scattered groves to ensure view lines are maintained.
- Landward zones at Smugglers are dominated by rank exotic grasses are already regenerating naturally with colonies of pohuehue, dense areas of knobby club rush on flat sites and occasional single or groups of a range of shrub and tree species including harakeke, ti kouka, pohutukawa, manuka (*Leptospermum scoparium*), kanuka (*Kunzea ericoides*), etc...
- For planting native shrubs and trees into dense exotic grass sites at Smugglers, continue to use methods successfully carried out for the shoreline revegetation programmes near Urquharts Bay by the Department of Conservation and the Bream Head Restoration Committee (Nigel Miller, DOC, pers. comm.). These include:
  - Focus on small areas that can be managed intensively from site preparation and planting to post-plant care;
  - Undertake thorough grass control by spraying dense exotic grass with glyphosate several months before planting; check for regrowth and the need for respraying before planting;
  - Plant fast-growing, good quality native shrub hardwoods at high densities of up to 10,000 stems per ha (1m x 1m plant spacing) to achieve canopy coverage within 2 years of planting;
  - It is recommended pilot trial plantings of a range of native shrub and tree species are established on sheltered lower microsites on backdunes within gaps of existing vegetation at Smugglers Bay; species include manuka, kanuka, houpara (*Pseudopanax lessonii*), taupata (*Coprosma repens*), harakeke, ti kouka, karo (*Pittosporum crassifolium*), and occasional pohutukawa if desirable.

- The option of planting at a wider spacing using spot spraying will be cheaper per ha to establish but will require several years of intensive monitoring and maintenance to ensure seedlings are not lost to weed competition. Refer to Bergin and Gea (2007) for economics and pros and cons of high versus low density planting of native trees and shrubs.

## Weed control

- **Many revegetation programmes fail due to lack of post-plant weed control!** With planting programmes, do not underestimate the workload for maintenance of previous plantings. It is better to keep restoration areas small and well-maintained and hence improved chances of success, rather than spreading resources far and wide.
- On foredunes, control of potentially vigorous exotic grass species such as kikuyu into newly-planted spinifex and pingao areas is essential to ensure restoration effort is not lost.
- Invasion of problem exotic species into lightly vegetated dune areas should be monitored and timely control implemented; it will be impractical to remove all exotic herbaceous and grass species – focus only on vigorous problem species.
- For backdunes, continue spot control of any scattered woody and monocot problem weeds as they appear such as pampas, wattle (*Acacia* spp.), etc...

## Recreational and aesthetic values

- If views are desirable for visitors and users as they access Smugglers Bay, then don't plant out the backdunes completely with tall growing trees and shrubs; rather plant and maintain the backdunes in a mosaic of low shrubs, woody groundcover species, sedges and rushes; restrict planting of taller trees and shrubs to scattered groves placed carefully to maintain view.
- The large healthy pohutukawa trees that dominate the central part of the beach, which may have been planted (Simpson and Anderson 1990), are popular for shade and shelter by beach users; maintaining access and open space beneath trees is recommended.
- It is not necessary to plant further pohutukawa within the seaward sand dunes zone at Smugglers. Pohutukawa inhabit cliffs and headlands at either end of the bay and will continue to be a seed source for any natural regeneration.

## Accessways, structures and fencing on dunelands

- Keep boardwalks and any other structures at Smugglers Bay to a minimum in keeping with an isolated natural beach and coastline.
- Fixed structures, such as the seaward extension of the boardwalk and the steps giving access to the beach at Smugglers Bay, are not recommended over flexible mobile foredune systems; such structures tend to disrupt wind and wave patterns and cause localised unnatural erosion and/or accretion of sand; storm cut of the foredune can leave such structures hanging in mid-air!
- When the design life of current boardwalk is reached or when the structure is damaged by coastal processes, consider replacing the seaward section with simple guide fencing over foredunes if visitor use remains high; orientate any

access tracks over foredunes at an angle to prevailing onshore winds to reduce wind funnelling.

- If any fencing is required, keep construction and extent to a minimum – maintain the naturalness of Smugglers Bay as a relatively isolated beach. Use temporary guide fences to keep beach users off newly planted areas and sensitive areas – only where necessary.

## Education and signage

- One of the aims of the Bream Head Conservation Trust is to enhance the reserves recreational and educational potential in ways which are compatible with conservation values.
- Significant cultural and environmental values of Smugglers Bay could be highlighted for visitors in carefully designed and constructed interpretive panels erected on the main entrance track to the bay. Features that could be highlighted include the archaic midden sites, its importance as habitats for a Critically Endangered land snail and for variable oystercatcher breeding, and the importance and role of sensitive foredune vegetation.
- Erect signs to alert users to the importance of keeping to formal tracks and to avoid trampling over vegetated foredunes including newly planted areas and exposed middens.
- In keeping with the naturalness of the bay, keep signage to a minimum and discretely placed.

## Threatened land snail habitat

- Care is required in changing this area from the current cover of low exotic herbaceous/grass species as described several years ago by Brook (2002 as cited in Goldwater and Beadel 2010) as habitat for the Critically Endangered land snail (*Punctidae* sp. 223).
- It is recommended that this area is not touched until a separate investigation is undertaken involving:
  - A survey of the current status of the land snail population;
  - Further information is sought on habitat requirements; and
  - A specific plan is prepared to enhance preferred habitat for the land snail population including ongoing management.
- Only intervention on the site that could be considered is to ensure woody or herbaceous species do not become established that are likely to shade out the present cover of grass.

## SITE-SPECIFIC MANAGEMENT OPTIONS

Based on a rapid inspection of Smugglers Bay, brief notes on management options to assist in developing a restoration plan are offered. For this purpose, the beach and duneland at Smugglers has been divided into ten areas based on generalised geomorphic features, dominant vegetation cover and suggested management options (Figure 15). These broad management areas indicated on the map and accompanying notes are only to be used as a guide.

### AREA A – Rocky cliff, western end

- Rocky cliff suited to a fringe of pohutukawa; some trees and regeneration; no management required.
- Allow landward exotic grass areas to regenerate naturally in to shrubby natives over time; continue control of any sporadic appearance of problem weed species.

### AREA B – Steep face soft shore, western end

- Steep face prone to collapse from toe erosion from wave action which is a natural process.
- Limited scope to plant; allow natural spread of knobby club rush amongst dense rank grass on steep face and natural regeneration of pohutukawa along cliff edge.

### AREA C – Foredune and midden, western end (Q07/82)

- Highly degraded foredune with sparse cover of spinifex; rabbits browsing new spinifex runners and burrowing damage to midden.
- Blowout formed at western end of this foredune has allowed wind funnelling from onshore southerlies and erosion of large midden immediately inland.
- Planting spinifex and pingao and control of rabbits is the first priority in a restoration plan to restore a naturally functioning foredune; use any driftwood in low lying foredune areas to assist establishment of sandbinders; as foredune rebuilds extend planting of sand binders both seaward (to sea rocket zone) and landward (to edge of midden).
- On semi-stabilised sparsely vegetated landward sites, encourage natural regeneration of sand carex, knobby club rush, etc... as sand stabilises.
- Monitor the effect of decreased exposure (and hence erosion) of the midden as the restored foredune develops; increased protection from revegetated foredune will hopefully obviate the need to plant over the midden site.
- Consult the Department of Conservation before any planting over the midden.
- Attempt to rejuvenate the single unthrifty pingao at top end of blowout and midden by adding a small quantity of sand around plant, applying a light dressing of urea fertiliser and controlling rabbits.
- Transect 1 (Figure 16) shows where the foredune occurs (at approx. 28-36 m horizontal distance) but just west of this transect is the blowout with no foredune that has led to erosion of the midden (at approx. 5-20 m on the slope).

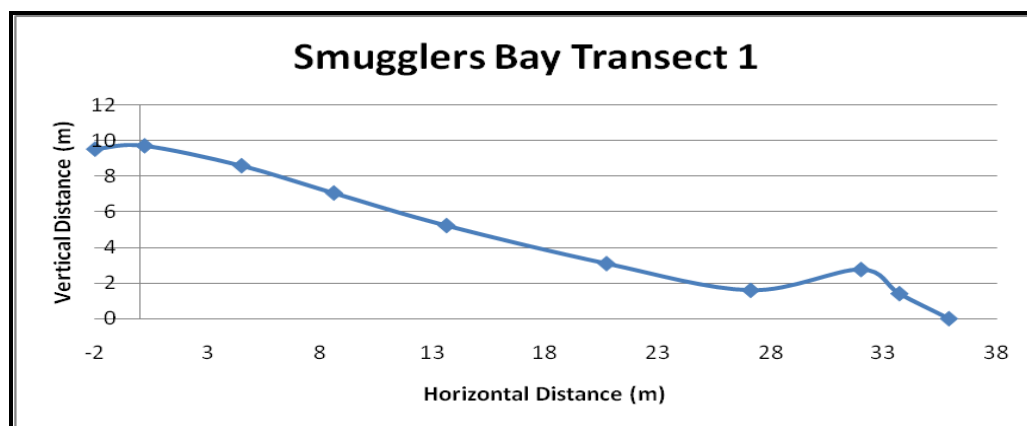


Figure 16: Transect 1 through the centre of the midden (Q07/82) at the western end of the bay. The exposed midden, which is the deflation basin of a blowout, is located at approximately 5-25 m horizontal distance. Note that the foredune (at 28-35 m) is completely destroyed immediately west of this transect resulting in erosion of the midden.

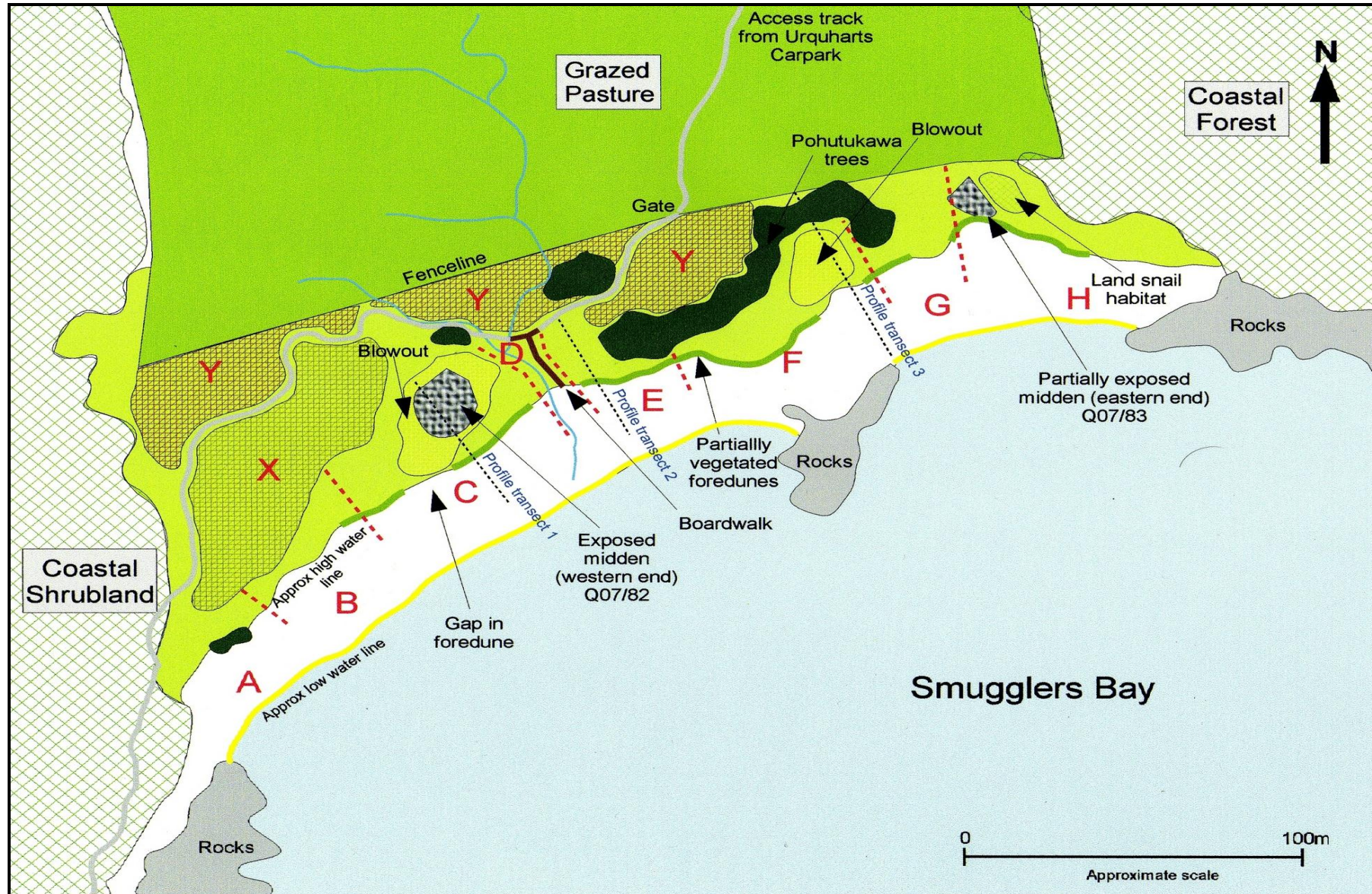


Figure 15: The ten areas identified at Smugglers Bay for which brief site-specific restoration and management notes are provided. The location of two midden sites (Q07/82 & Q07/83) that are being disturbed by mostly wind erosion is indicated. The dune profile transects (1-3) are also shown.

### AREA D – Central stream

- Dense cover of sedges in wet areas with sand carex on lower banks grading into pohuehue mixed with rank exotic grass.
- Consider use of selective herbicides to reduce grass competition and allow pohuehue to dominate; check for appropriate sprays that can be used near waterways.
- Consider enhancing stream channels with additional native plants tolerant of wet soils and occasional inundation of water. Refer to guides for restoring wetland and riparian zones provided by the Northland Regional Council. Source: <http://www.nrc.govt.nz/Resource-Library-Summary/Publications/Water/Wetland-Restoration-Guide/Restoring-a-wetland>

### AREA E – Central spinifex foredune and dune slack

- 5 m wide foredune dominated by spinifex; evidence of erosion scarp from last storm but minimal regrowth of spinifex on seaward face due to rabbits and trampling by beach users; good example of a degraded foredune with lack of natural repair after storm cut.
- High priority for restoration of foredune by controlling rabbits, planting spinifex and pingao, and erecting signs and low-key fencing to reduce damage along foredune from beach users.
- Dune swale between foredune and boardwalk in sparse cover of spinifex and sand carex rising to a steep backdune slope dominated by dense rank exotic grass; encourage natural regeneration of sand carex, shore convulvulus in dune swale; site suited to trial plantings of a range of low growing species such as sand daphne, sand tussock (*Austrofestuca littoralis*), sand coprosma.
- Extend knobby club rush to landward sites; consider small groups of harakeke in lower landward sites.
- Transect 2 from boardwalk to foredune toe (Figure 17); note steep seaward face of foredune from a previous storm cut (at approx. 25-28 m horizontal distance) which remains highly vulnerable to further erosion until a cover of native sand binders is achieved; if not restored, potential for the foredune to be destroyed as sand blown inland covering habitat landward.

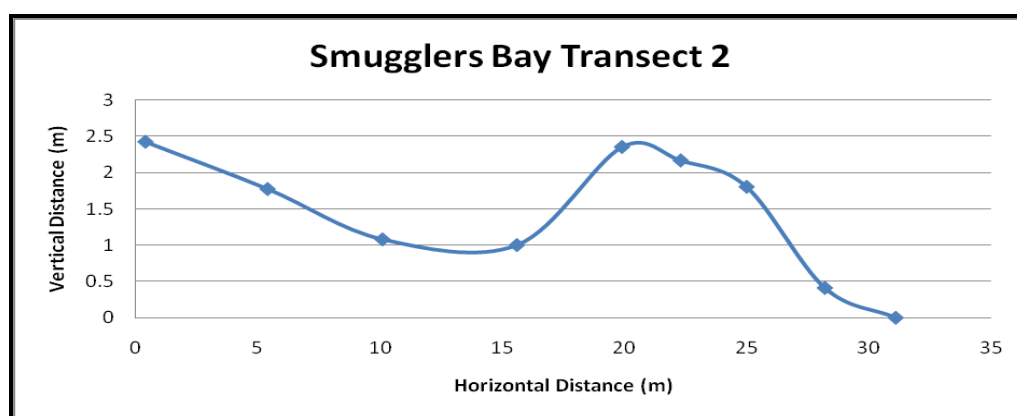


Figure 17: Transect 2 immediately east of access and central stream. The foredune with steep foredune face (approximately 25-28 m horizontal distance) is poorly vegetated in native sand binders and therefore vulnerable to further erosion. The semi-stable swale (5-10 m) is sparsely vegetated.

### AREA F – Pohutukawa zone toward eastern end

- Spinifex along most of foredune with an erosion scarp and at least 2 ephemeral water courses; scattered spinifex cover area up to 17 m wide from foredune landward with shore convolvulus and patches of exotic grasses at western end.
- Large blowout at western end semi-stabilised with scattered grasses; plant groups of spinifex and pingao along degraded foredune to fill gaps and encourage spread of vegetation over foredune faces; encourage natural regeneration of knobby club rush and pohuehue on semi-stable sites landward.
- Line of seven large pohutukawa popular shelter area for beach users with short exotic grass cover beneath; ensure any planting of natives allows continued access to shade and continued provision of cleared areas beneath; discourage beach user access to dense ground cover of native spinach further landward.
- Transect 3 from fenceline to foredune toe (Figure 18); note the remnant storm scarp in foredune (at 45-50 m); maintain flat area of low exotic grass beneath pohutukawa (at approx 30 m).

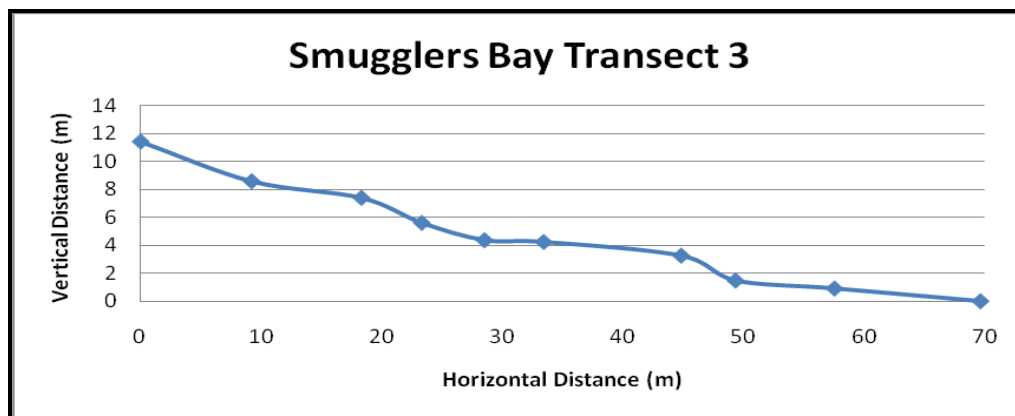


Figure 18: Transect 3 toward the eastern end from the fenceline (0 horizontal distance), pohutukawa with a dense ground cover of native spinach (0-20 m), to a part-vegetated foredune slope at near high water mark (45-50 m).

### AREA G – Exotic dominated foredune

- Short length of foredune dominated by exotic daisy species should be sprayed and planted with native sand binders.

### AREA H – Midden and land snail habitat, eastern end

- Land snail habitat of short exotic grass on terrace adjacent to midden; wind erosion of sparsely vegetated midden; refer to earlier section on suggested management options for the land snail site.
- Opportunities for planting native sand binders to reduce erosion of midden site and surrounds; extend existing scattering of knobby club rush on semi-stable sites by rabbit control to allow natural regeneration and planting if gaps in vegetation cover persist; plant low growing natives on semi-stable backdune sites such as knobby club rush, sand coprosma and pohuehue.
- Consult Department of Conservation if planting on or near midden site.
- Backdune areas covered in dense tall exotic grass with large patches of pohuehue (Figure 19); selective herbicide spraying around pohuehue could be trialled to extend this species; harakeke regenerating along with areas of knobby club rush.
- boulders along most of toe of dune at western end will reduce risk of wave erosion; planting of sand binders not required.





Figure 19: Dense mounds of vigorous pohuehue at the eastern end of the beach amongst rank grass. There is scope to trial grass-selective herbicide spraying around these mounds to reduce vigour of exotic grasses as a practical method for encouraging more rapid spread of pohuehue. This could also be trialled around established colonies of knobby club rush that also occur in this area.

#### **AREA X – Knobby club rush stands, backdunes**

- Dense cover dominated by knobby club rush, with rank exotic grass, giant umbrella grass in lower lying sites and sand carex in occasional open sandy sites, and scattered occasional problem weeds.
- No active management required other than to continue control of scattered problem weed species as these appear e.g., pampas (*Cortaderia jubata*, *C. selloana*).

#### **AREA Y – Remaining backdunes with planted sites**

- Three areas on backdunes near fenceline planted in 2009 with dense mixture of mainly manuka and kanuka using successful techniques used on sheltered harbour plantings at Urquharts Bay.
- High mortality on exposed sites; better survival in lower lying microsites and in lee of existing shrubby vegetation.
- Trial planting of small groups or stands of a range of backdune shrub hardwoods in sheltered areas to create groves that provide mutual protection; along with manuka and kanuka, species to test include taupata, houpara, harakeke and ti kouka.

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## APPENDIX

### Recommendations for the control of rabbits on coastal sand dunes (modified from Unsworth 2005)

- The need for rabbit control should be assessed before any planting programme is set up. Good communication between all groups involved is essential for success.
- Control operations should aim at a minimum kill of 90%. Effective control of rabbits and hares in the first operation will mean that follow-up treatment will be simpler.
- Long-term commitment to sustained treatment is needed to prevent recurrence of the destruction of planted material.
- Monitoring of rabbit and hare populations provides a sound basis for an effective programme. Coastal dunes are often areas of high public use, so understanding of the extent of the pest problem is important. Public perception of the risks associated with pest control methods may be exaggerated, but legitimate concerns must be addressed. A detailed operation plan must be put in place.
- Continued monitoring and evaluation will identify the success of control operations and allow effective targeting of follow-up treatment.
- Factors affecting plant susceptibility to rabbit and hare browsing are:
  - palatability, some species and specific plant parts being more attractive than others
  - density of the rabbit population
  - availability of an alternative feed source
  - size of plants
  - planting season
  - camouflage provided by surrounding vegetation
- Poisoning with Pindone-treated baits is the single most effective method for controlling rabbits. Other methods are listed which may be suitable for specific sites, and combination of two or more methods is recommended. All safety precautions must be observed.
- Night-shooting is likely to be most effective for hares.
  - Poisoning is not an effective method of control.
  - Regular shooting is the main control method.
  - Well-placed snares can be effective.
- Repellents can discourage browsing of new plantings by rabbits, but must be applied several times a year to protect new growth.