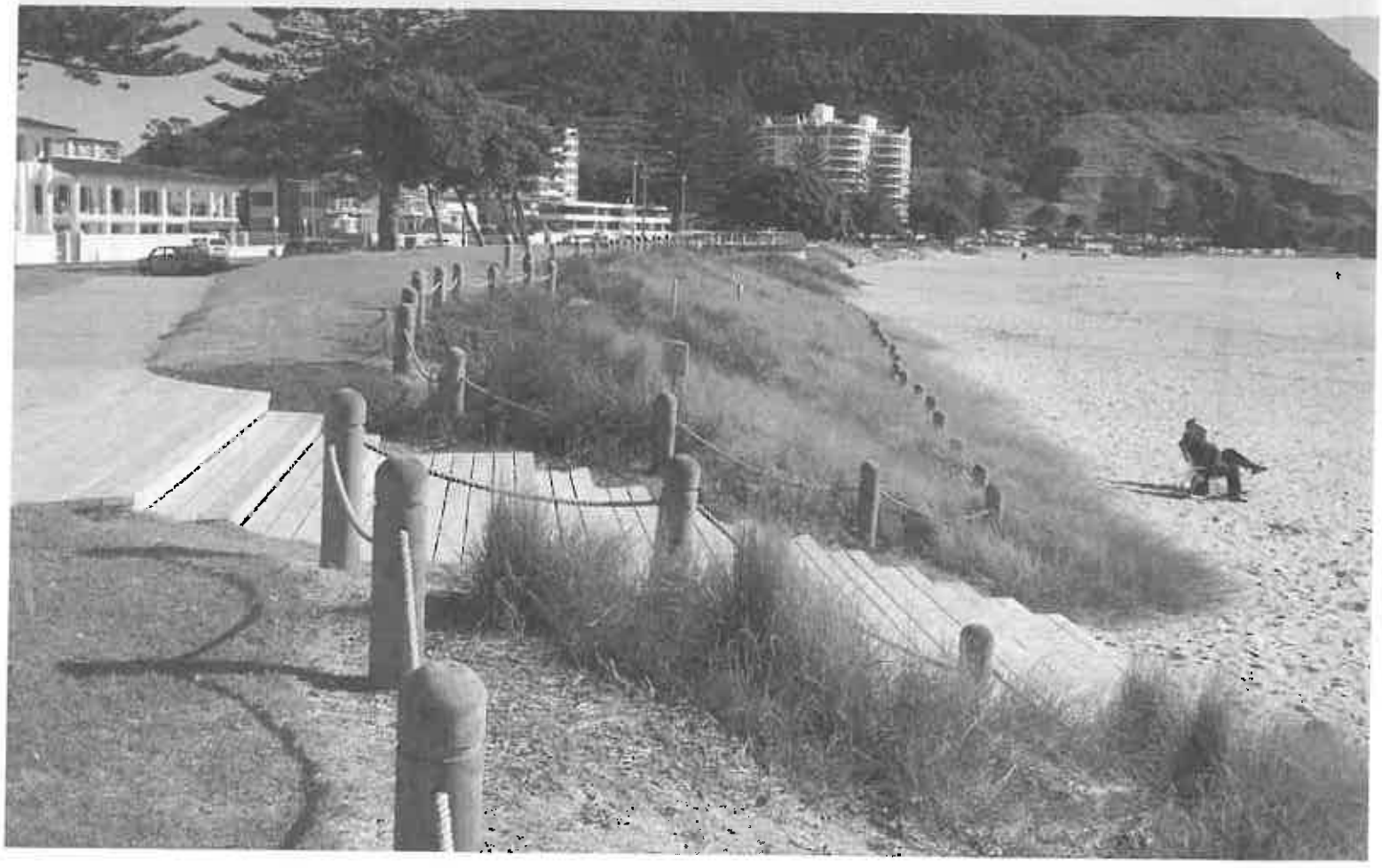
# Community-based Dune Management for the Mitigation of Coastal Hazards and Climate Change Effects:

## A Guide for Local Authorities



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Marine Parade dune in July 1995 before restoration. Pikayu grass and introduced ice plant have inferior sand binding abilities, and wind erosion regularly moves sand inland out of the beach compartment increasing the erosion potential, and occasionally blocking the important road.

**COVER PHOTOS**
(TOP) Community working bee planting native dune species to restore dune function. June 2002. (BOTTOM) The planted dune with restored natural storm resilience. Wind erosion losses are now negligible due to sand being bound securely by these flourishing native plants. July 2004.

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# 1 Introduction

Coastal dunes are a common coastal landform, occuring along approximately 1100km of the New Zealand coast (Hesp, 2000). These dunes provide natural protection from coastal hazards and climate change and play an extremely important role in the natural and human use values of the coast. However, in recent decades and centuries, coastal dunes have been significantly modified by human action and the task of dune restoration is now an increasingly important and even critical need - particularly in the face of projected climate change.

The primary purpose of this report is to bring together lessons from existing and successful dune care/restoration programmes in New Zealand to provide guidelines for councils wanting to initiate dune restoration programmes - both to mitigate coastal hazards, including climate chnage effects such as projected sea level rise, and to restore the beneficial natural and human use values associated with coastal dunes.

This report details the many benefits of utilising community-based dune restoration as both:

- An adaptive approach to help mitigate the effects of sea level rise in a changing climate, and resultant coastal hazards (including coastal erosion and inundation).
- An educative process that can be used to raise community awareness of likely coastal hazards including sea-level rise and potential impacts.

The report brings together lessons from existing and successful dune care/restoration programmes across New Zealand.

A second aim is to encourage councils to adopt community-based partnerships for successful dune restoration programmes and to provide best-practice models for easy adoption. The case studies later in the report provide examples of existing community level projects partnered and supported by councils.

The report complements earlier guidelines produced by the Ministry, particularly the report "Planning for Climate Change Effects on Coastal Margins" (MfE, 2004).

(See http://www.climatechange.govt.nz/resources/reports/index.html for relevant reports).

## 1.1 Outline of Report

This report covers the following matters:

- **Section 2:** A brief outline of the challenge posed by coastal hazards, including climate change (see further detail in MfE, 2004)
- **Section 3:** The importance of dunes in the mitigation of coastal hazards and in the protection of natural coastal processes and values
- **Section 4:** Guidelines for the development of dune management plans and outline of the key elements commonly involved with dune restoration
- **Section 5:** Use of community-based partnerships for dune management, including key issues involved in establishing and operating such partnerships
- **Section 6:** Example case studies illustrating community-based dune restoration and management programmes operated by local authorities. This section also highlights advantages of dune restoration over traditional engineering approaches.
- **Section 7:** Short summary.

This report is exclusively concerned with shore parallel dunes formed along the landward edge of a beach, where wind blown sand is trapped by vegetation. These dunes are known as *foredunes*, with the most seaward generally called the *frontal* or *active foredune* (sometimes with a small *incipient dune* further seaward) and those further landward as *relict foredunes* (Hesp, 2000) or back dunes.

# 2 Climate Change And Coastal Communities: Collision Course

In recent decades, the desire of New Zealanders to live and holiday on the coast has resulted in extensive coastal subdivision and development – often located in nearshore areas vulnerable to coastal hazards, including coastal erosion and flooding (e.g. Healy, 1993; Gibb, 1996a; Dahm and Munro, 2002).

Over the next few decades, climate change effects including sea level rise have the potential to considerably exacerbate hazard risk to these communities.

Sea level has risen by 10-15cm over the last century and projections are for this trend to continue and to accelerate for centuries, with best present estimates suggesting a relative sea level rise of 20cm by 2050, increasing to 50cm by 2100 (MfE, 2004). This sea level rise will result in severe hazard problems for many coastal communities if mitigation or adaptive plans are not progressively implemented (MfE, 2004).

With rising sea level, there will be more frequent and more serious flooding of low-lying coastal margins by extreme tides, storm surge and wave effects. Sea level rise will increase extreme sea levels and markedly increase the probability of present flooding levels (MFE, 2004). By way of example, the extreme sea level of July 1995, which seriously flooded properties and dwellings around the Firth of Thames, presently has an annual exceedance probability (AEP) estimated at about 0.2% (NIWA, 1997). However, with a rise in sea level of 50cm, the annual probability would increase to about 20% - a 100-fold increase in the frequency of such extreme water levels.

There is also potential in many coastal areas for erosion to be considerably aggravated. As outlined in earlier guidelines, sediment is "food" for beaches and long-term erosion arises when there is insufficient sediment supply to the nearshore system to keep pace with sediment transport out of the system by waves and currents (MFE, 2004). With rising sea level, open coasts that have been dynamically stable over time are likely to show a bias towards permanent shoreline erosion if sand supply and associated physical drivers do not keep pace (MFE, 2004).

For instance, the embayed beaches of the eastern Coromandel have been extensively subdivided over the last 50 years, with over 75% of these beaches now developed or partially developed (Environment Waikato, 1999). Much of this development is close to the sea and dynamic shoreline fluctuations have already threatened properties, dwellings and infrastructure at some sites, such as Cooks and Buffalo Beaches.

Recent hazard analysis indicates that erosion is likely to be severely aggravated by projected sea level rise as the beaches have little to no ongoing net sediment supply to buffer this effect (Dahm and Munro, 2002). Projected sea level rise of 50cm by 2100 has the potential to result in serious erosion damage to about 950 beachfront properties and 550 dwellings with a total (August 2004) capital valuation of $850 million (data from Environment Waikato). Similar levels of serious damage are likely at many other eastern North Island beaches (e.g. Healy, 1993; Gibb, 1996a).

In many regions throughout New Zealand, hazard vulnerability also continues to rise due to ongoing intensification of development in nearshore areas vulnerable to coastal hazards and a rapid escalation in the value of high-risk nearshore properties.

In addition to the threat to development, many existing erosion problems around New Zealand have been managed with seawalls - which in some cases has resulted in serious degradation of important beach values, including amenity values, natural character and public access along the coast (e.g. Gibb, 1996b; Dahm and Spence, 2002) – as shown in figure 1. Aggravation of erosion by sea level rise has the potential to worsen such effects and may also threaten the viability of many of these structures.

**Figure 1:**

Seawall at Waihi Beach. At higher stages of the tide, the sea is hard against this wall and there is no high tide beach.

Sea level rise is expected to aggravate the adverse effects of such structures and threaten their stability and viability.

In short, coastal communities and climate change are on a collision course (MFE, 2004) – with an escalating risk profile and the potential for serious degradation of coastal values. Effective action to mitigate hazard vulnerability, including the impact of projected climate change, is a priority if existing trends are to be reversed.

# 3 Importance of Dunes

Coastal foredunes backing sandy beaches play an important role in the mitigation of coastal hazards and in the protection of the natural and human use values of beaches. These dunes will become increasingly important with projected climate change.

## 3.1 Role Of Dunes In Natural Beach Dynamics

Frontal foredunes are an integral part of the total beach system; these dunes and their vegetation play a critical role in beach dynamics, particularly in the natural cycles of dune erosion and recovery that occur on sandy beaches (Figure 2).

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 2a).

During major storms, waves erode the beach and the frontal dune – with the eroded sediments deposited on offshore bar systems, which help to protect the beach by breaking waves offshore and thereby dissipating excess wave energy (Figure 2b). 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 is lowered and the frontal dune is often characterised by a steep, near vertical eroded dune face.

The short duration of coastal storms often limits dune erosion during individual storm events. However, during periods with a higher than average frequency of severe storms, dune erosion can cumulate over successive storms. For instance, at Waihi and Papamoa beaches dunes have been eroded by more than 5-7m during individual storm events, but total dune erosion of 20-30m can accumulate over several years with successive storms (Eco Nomos, 2003).

After a storm gives way to calmer weather, the sand deposited on the offshore bar gradually moves onshore, restoring a high tide beach (Figure 2c). The eroded dune face also generally collapses to a more stable slope.

In extended periods without further dune erosion, the native sand binding grasses on the seaward face of the dune, particularly spinifex (*Spinifex sericeus*) and pingao *Desmoschoenus spiralis*, where present) gradually begin to extend down the eroded dune face – renewing the process of sand entrapment and gradually repairing the eroded dune face (Figure 2d). This natural dune repair process is relatively slow and full recovery can take years after a period of severe dune erosion.

In addition to their importance in dynamic shoreline fluctuations, dunes also contain sand reserves that will be required to maintain beaches in the event of any trend for long term shoreline retreat – such as may occur in response to projected to sea level rise and other climate change effects.

As such, dunes dominated by these native plants are central rather than peripheral to the maintenance and enhancement of beaches and their associated values.

**Figure 2:**
Schematic illustration of the natural cycles of beach and dune erosion and recovery that characterise sandy beaches (from Environment Waikato, 2001).


**Figure 2a**


**Figure 2b**


**Figure 2c**

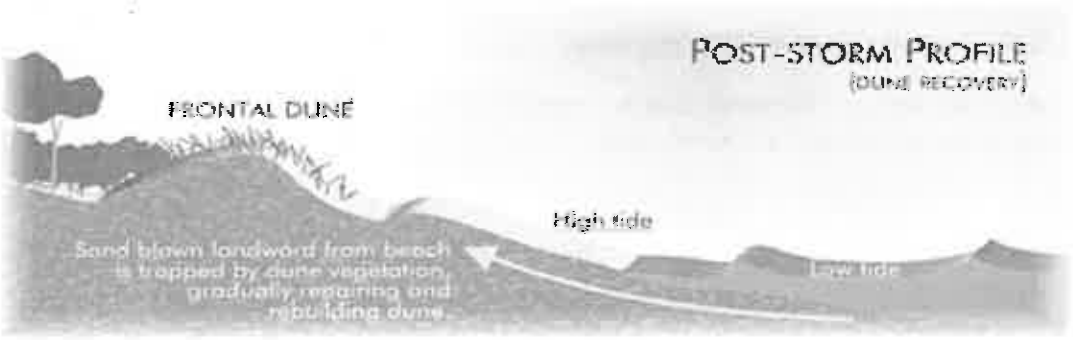


**Figure 2d**

**Figure 3a:**

Spinifex
(Spinifex sericeus)

## 3.2 Essential Role of Dune Vegetation

Dunes vegetation plays an important role in natural beach and dune dynamics and in beach and dunes values.

In particular, natural dune repair after storms is *critically dependent* on the presence of appropriate sand trapping vegetation on the seaward face of the dune. In New Zealand, the key native sand binding species on the seaward dune face are spinifex (Figure 3a) and pingao (called pikao in the South Island) (Figure 3b). Good summaries of existing knowledge on these species are provided in Bergin and Herbert (1998) and Bergin (1999). While many exotic species have been used to stabilise dunes such as marram grass (*Ammophila arenaria*), ice plant (*Carpobrotus edulis*), and kikuyu grass (*Pennisetum clandestinum*), experience has shown that these species are not as effective as spinifex and pingao in repairing storm-damaged frontal dunes.

Without a good cover of spinifex and pingao on the seaward dune 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 more natural dune recovery between the two events.

Wind erosion problems also occur if the cover of sand binding species on the seaward dune face is disrupted and can lead to severe dune damage (e.g. blowouts) and to problems with wind blown sand further inland (Figure 4a). The sand blown inland is often permanently lost from the beach system – so that a sandy beach without a vegetated dune (or with a damaged dune) is a lot like a bucket with a hole!

**Figure 3b:**

Pingao
(Desmoschoenus spiralis)

**Figure 4a:**
Serious wind erosion damage at Port Waikato in the early 1990's associated with disruption of spinifex cover by motorbikes on dunes. Large tongues of sand migrated inland from these blowouts, causing problems for houses and properties further landward.

**Figure 4b:**
In contrast, the restored dune plants at Papamoa Domain are demonstrating considerable sand trapping abilities on the seaward dune face during this severe storm, preventing loss of sand from the active beach system. The fence in this photo has been moved twice towards the sea (a total of 12m) and was originally 80cm above the sand. Since this photo was taken, the fence has been almost entirely buried by the continually expanding incipient dune, with ropes and bollards installed to provide an effective visual barrier only to pedestrians and beach users.

## 3.3 Importance of Dunes for Hazard Mitigation

Coastal dunes provide natural protection from coastal erosion and flooding and this role will become even more important with projected climate change.

For instance, dunes provide a natural buffer that can absorb the impact of erosion, thereby protecting areas further landward. The wider and higher the dunes between development and the sea, the greater the level of natural erosion protection provided. Dunes do not "stop" wave erosion; rather, an adequate dune buffer enables communities to live with natural shoreline movements – the dune erodes during erosional phases (Figure 2b) and repairs/builds during accretionary periods (Figure 2d).

The self-repairing capacity of natural dune systems (Figure 2c,d) is also very important for the mitigation of coastal erosion – as this natural dune building and repair reinstates the protective dune following severe storm erosion. Dune repair is characteristic of most New Zealand beach-dune systems, except the very rare beach systems experiencing relatively rapid rates of long-term retreat. However, the process of natural dune repair takes time (usually several years) and during periods with a higher than normal frequency of erosion events, regular erosion may prevent any significant dune recovery for several years.

Natural frontal dunes also provide significant protection from coastal flooding associated with storm surge and wave effects. For instance, the height and width of dunes significantly mitigate and often prevent wave flooding further landward. The beach erosion and the near-vertical eroded dune face that develop during storms (Figure 2b) can also provide a very effective limit to wave action.

Sand dunes and other natural buffers (e.g. mangroves) can even provide useful flooding protection in places during serious coastal flooding events, such as moderate tsunami. For instance, following the recent Indian Ocean tsunami – one observer noted:

> *"Sandunes and mangroves seem to have sheltered (their) neighbours from the force of the disaster. Only nature seemed to have been able to stand up to nature."*
>
> (Channa Bambaradeniya, Programme Co-ordinator, IUCN Sri Lanka)

These comments are reinforced in other reports of post tsunami inspection (e.g. www.dailynews.lk/2005/03/03/fea01.html). Scientists we spoke to who were involved in post-tsunami inspections also reported that dunes appear to have significantly mitigated hazard damage relative to adjacent areas (Dr Rob Bell, NIWA Hamilton, pers. comm., April 2005).

When coastal settlements with sandy beaches have inadequate dune protection, coastal erosion or flooding problems can result. Moreover, once natural dune protection is inadequate and coastal hazards directly threaten development, there are generally no cheap or easy answers – especially on ocean beaches. Resolution of the resulting hazard problems is nearly always difficult, contentious and expensive. And, as has already been noted, many management approaches used in such situations (e.g. engineered seawalls) can seriously degrade beach values.

The potential for coastal erosion and flooding to be considerably accentuated by climate change effects (MfE, 2004) further emphasizes the importance of restoring and maintaining wide natural dune buffers along the seaward margin of coastal development - with a good cover of appropriate native sand binding vegetation to ensure natural dune building and repair.

In the words of one experienced coastal scientist,

> *"The natural role of .. frontal dunes acting as a reservoir of sand for rare but severe storms ... and their enhancement needs to be adopted as a cornerstone of coastal management."*
>
> (Healy, 1993).

## 3.4 Other Values of Coastal Dunes

The protection and restoration of coastal dune systems is also required to maintain a wide range of other coastal values in the face of climate change effects.

On most sandy beaches, natural coastal dunes are central to preservation of natural character, protection and enhancement of coastal biodiversity and habitat, and the protection of landscape and other coastal amenity values (Environment Waikato, 2001). Natural dunes also have important intrinsic and scientific values (Nordstrom, 1990). In addition, coastal dunes in New Zealand have a long history of human use and frequently contain important archaeological and cultural sites (e.g. Furey, 1997; McFadgen, 2003).

## What you can do to help

- Wheels destroy dunes – follow marked tracks and keep to hard sand.
- Give plants a chance – don't walk, ride or drive on them.
- Keep stock in the paddock – fence coastal margins.
- Ride the waves, not the dunes.
- Take rubbish home.
- Don't let dogs run over the dunes or chase shorebirds. Clean up after them.
- Leave sand and pebbles for future generations.
- Get rid of weeds properly and compost garden waste instead of dumping it on the beach.

*Stick to the paths to protect the plants and dunes*

## Northland CoastCare

Northland CoastCare groups are made up of Northlanders working to protect their coastal environment.

To find out if there is a CoastCare group near you or to start a new group, contact the Northland Regional Council CoastCare Co-ordinator on 0800 002 004

For more information on Northland CoastCare go to www.nrc.govt.nz/coastcare


NORTHLAND REGIONAL COUNCIL

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# Caring for Northland's dunes

## Protect the dunes and they'll protect us

Putting Northland first

NORTHLAND REGIONAL COUNCIL

# Why protect the sand dunes?

Beaches and sand dunes are the narrow but precious bands of sand that lie between the land and sea.

In their natural state they protect land and property from storms, cyclones, and tsunamis.

In Northland there are huge variations – from the vast windswept bare dunes of Ahipara and Pārengarenga Harbour, to the small rounded dunes of popular beaches such as Matapōuri and Matauri Bay.

Northland's coast is under pressure from population growth and increasing use, and most dunes in Northland have been either modified or destroyed completely.

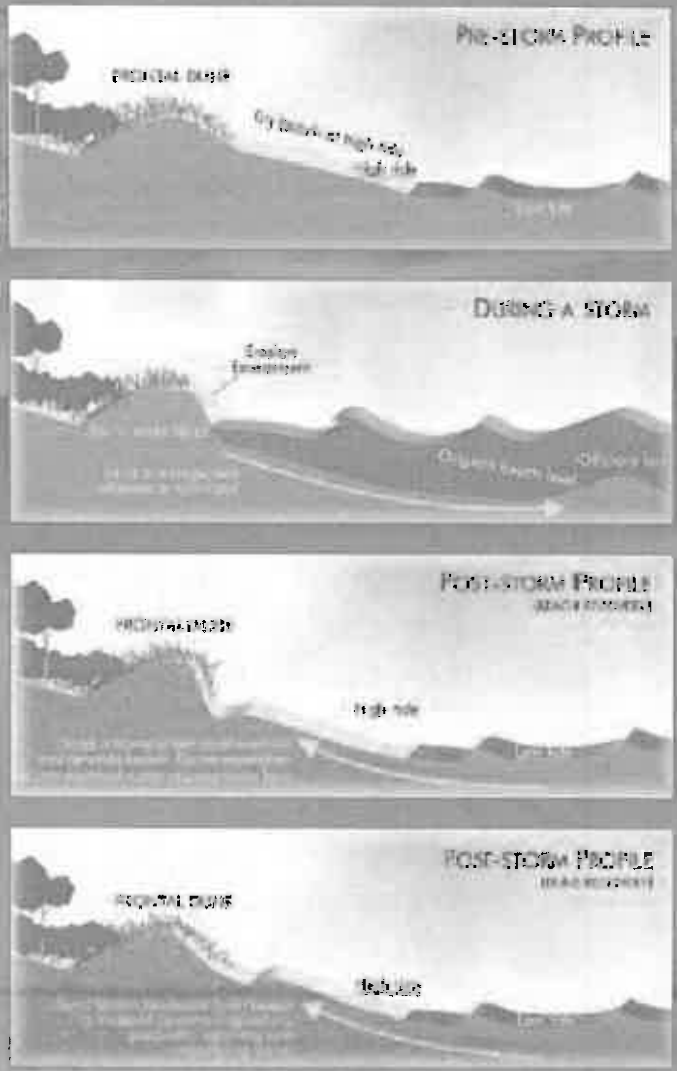
Sand dunes are the natural habitats for a number of insects, lizards, birds, and specialised native dune plants.

Coasts are always changing – either building up (accretion) or being eroded away (erosion). Changes in the beach are often cyclical, with some erosion and accretion cycles lasting 15-20 years, and others lasting between storm events.

Some areas are naturally unstable and are valued environments just as they are. Before you commit to a coastal erosion control project, take a stroll along the beach and think about the natural coastal processes that are at work.

# Dune form and function

Sand dunes and their vegetation play a critical role in beach dynamics, particularly in the natural cycles of dune erosion and recovery that occur on beaches. Natural dunes help protect coastal land and buildings from storm surges and tsunami. Modified dunes usually do not function as effectively for erosion control. Dunes can be restored to encourage natural processes, if there is sufficient space between the beach and buildings and roads.




During periods of prolonged settled weather, sand builds up on the beach and dunes.

During major storms, waves erode the beach and dune, often leaving a near vertical dune face. Eroded sand is deposited offshore in the surf zone, where it forms shallow bars that help dissipate the high storm wave energy.

Significant dune erosion can occur in a few hours, but it can take years for the dune to fully recover.

After the storm, gentler wave action moves sand back to the shore, slowly rebuilding the beach.

As the beach recovers, dry sand is blown landward and trapped by vegetation to repair the dune. Natural dune repair depends on a good cover of native sand binding plants, such as spinifex and pingao.

Significant dune erosion can occur in a few hours, but it can take years for the dune to fully recover.

*Thanks to the New Zealand Dune Restoration Trust for use of diagrams and other information in this leaflet. www.dunestrust.org.nz*

# Dune plants

Dune plants play an important role in natural dune formation, as well as beach and dune values. Depending on local conditions and natural cycles, sand dunes can be large or small, stable or mobile, bare or covered in plants.

Coastal sand dunes form one of the most extreme habitats in New Zealand. Dune vegetation is exposed to wind and salt spray, moving sand, low nutrient input and periods of severe drought.

Different plant species are adapted to grow on a particular part of the beach.

The foredunes are the harshest and most unstable part of the dune system and plants growing here need to be very resilient to withstand these conditions.

The sand secondary zone, behind the foredunes has a different range of native plants.

# Spinifex and Pingao

Spinifex and Pingao colonise the seaward slope of the foredune. They thrive on unstable sand and tolerate salt spray, prolonged drought, high temperatures, high sun intensity, strong wind and salt water.

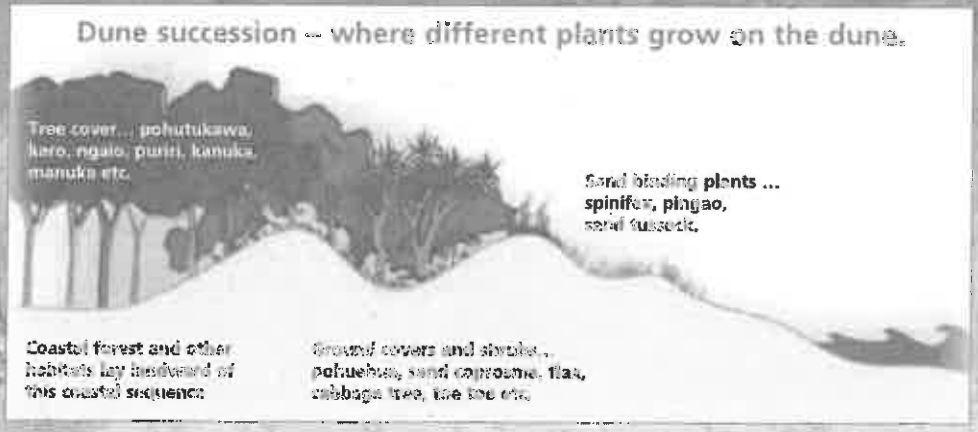
They are among the very few plants able to grow down to the toe of the dunes and they help to build the dune front. Even if buried under sand, they can usually survive by growing up through the sand into the open.

Threats such as fire, coastal settlement, off-road vehicles, weeds and browsing of dunes by stock and rabbits have decimated or wiped out Spinifex and Pingao from some Northland beaches.

Northland CoastCare groups carry out dune rehabilitation projects encouraging stronger growth in existing Spinifex and Pingao colonies and replanting with specially raised seedlings where necessary.

When planning dune revegetation projects it is important to choose sites where Spinifex and Pingao are most likely to thrive i.e. on exposed unstable foredunes. If you are planning a planting project, contact the Northland Regional Council for advice.

*Spinifex (Spinifex sericeus) is a grass native to New Zealand, Australia, India and most Pacific Islands.*




*Pingao (Desmoschoenus spiralis) is a native New Zealand sand sedge. Its tufts of coarse grass-like leaves are a rich greenish bronze colour, and grow on thick rope-like stems trailing across the sand. Pingao is traditionally used for weaving.*

# Threats to dunes

Large areas of Northland's coastal dunes have been modified for residential development and farmland. This has led to changes in dune stability, often resulting in vegetation loss and wind erosion.

As Northland's population increases dunes are coming under increasing pressure.

Wheels, feet and animals can kill dune vegetation. If even small areas of the front of the dune lose their plant cover, strong winds can destroy them.

Blowouts or eroded patches of foredune lead to dunes becoming unstable and moving inland.

Some plants – such as sand coprosma – are still reasonably common in Northland but have become critically rare in regions where there are high populations.

*Riding on the dunes destroys plants and causes erosion.*

# Dune weeds

In many coastal areas introduced plants have been planted to stabilise or beautify dunes.

Species such as agapanthus, exotic iceplant, prickly pear, daisies, acacia, boneseed, coastal banksia, freesias, kikuyu grass and agaves have become a problem in some areas.

Introduced species are not as effective at dune protection as native species, and can worsen erosion.

*Senecio elegans*

*Cortaderia selloana*

*Exotic iceplant*

Many pest plants are 'garden escapes'. Help prevent the spread of weeds.

- Compost garden waste (including grass clippings) rather than dumping it onto the dunes.
- Remove invasive introduced plants and replace with native plants.
- Contact the Northland Regional Council for removal methods and suitable replacement species.

# Native dune plants...

## ... can

- ✔ Reduce wind erosion.
- ✔ Build up sand dunes which reduce wave erosion.
- ✔ Speed recovery of dunes after storms.
- ✔ Grow in the hostile coastal environment.

## ... can't

- ✘ Prevent direct wave erosion.
- ✘ Withstand excessive physical damage from people, stock or vehicles.
- ✘ Endure mismanagement such as mowing.
- ✘ Grow well in topsoil.
- ✘ Tolerate introduction of unsuitable exotic plants.

**For more information on Northland CoastCare go to www.nrc.govt.nz/coastcare or freephone 0800 002 004**