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

A Guide for Local Authorities

PREPARED BY:

Jim Dahm
Eco Nomos Ltd

Greg Jenks
Environment Bay of Plenty

David Bergin
Forest Research

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COVER PHOTOS
Community working bee planting restored coastal dune

CONTENTS

1 Introduction

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.

The primary aim is to provide guidelines for councils wanting to initiate dune restoration programmes to help mitigate coastal hazards, including climate change effects such as projected sea level rise, and to restore the beneficial natural and human use values associated with coastal dunes.

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, 2001).

(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, 2001)
- **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, 2001). This sea level rise will result in severe hazard problems for many coastal communities if mitigation or adaptive plans are not progressively implemented (MfE, 2001).

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, 2001). 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, 2001). 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, 2001).

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 - commonly resulting 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 will severely worsen such adverse effects and will 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 will 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, 2001) – with an escalating risk profile and serious ongoing 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

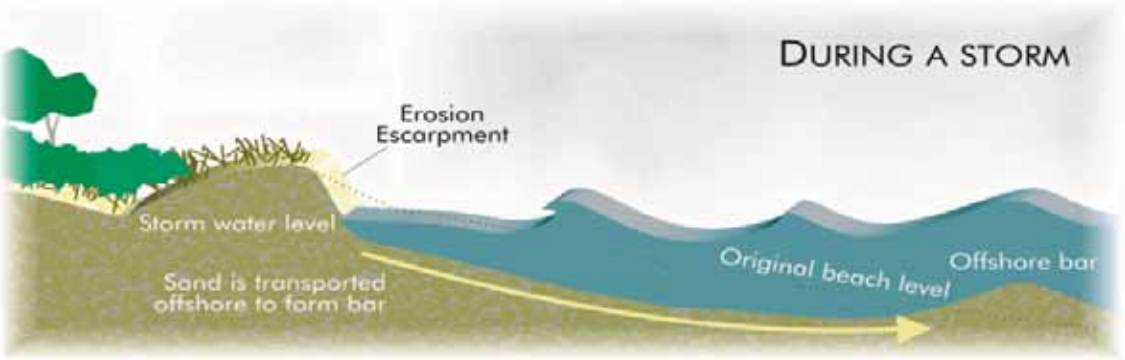

Figure 2b

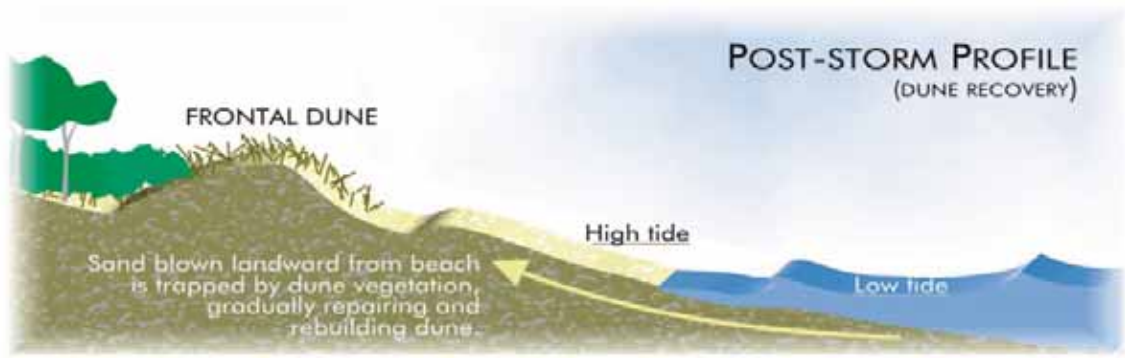

Figure 2c

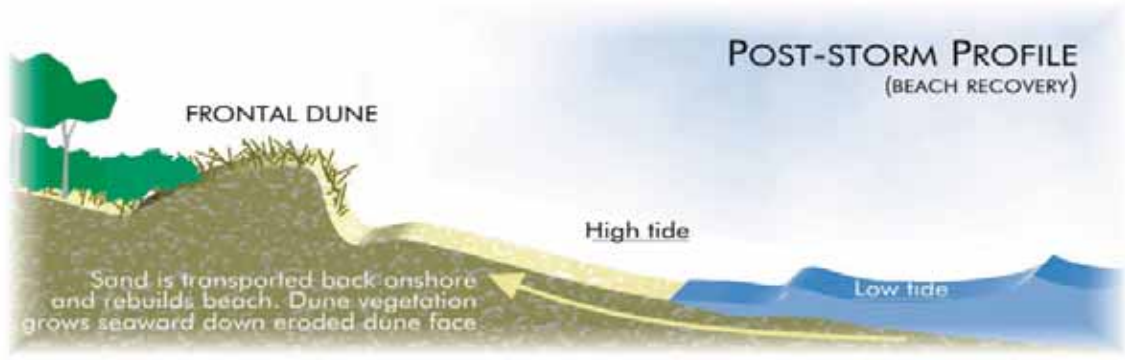

Figure 2d

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*), kikuyu grass (*Pennisetum clandestinum*), 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 have inadequate dune protection, serious coastal erosion or flooding problems almost invariably 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, 2001) 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).

4 Dune Restoration

This section briefly outlines the various human activities that have modified coastal dunes, giving rise to the need for dune management, and provides guidelines for dune management and restoration.

4.1 Human Modification of Coastal Dunes

Dune restoration is primarily required when natural dunes have been significantly modified or damaged by human activities – past and present. In the rare absence of human damage, most natural foredunes in New Zealand are self-maintaining.

Human modification of coastal dunes is common worldwide (Nordstrom, 1994). In New Zealand such impacts have been much more widespread and significant than is commonly realised – often leading to major changes in dune morphology, vegetation and natural coastal processes (e.g. Cockayne, 1909; 1911; Esler, 1978; Environment Waikato, 1999; 2001; Hilton et al., 2000; Jenks and Brake, 2001; Dahm and Spence, 2002a,b; Jenks, 2005). In fact, coastal dunelands are probably among the most modified of all New Zealand ecosystems. There are few coastal dune systems in New Zealand that have not been significantly impacted by human activities.

The following are common human impacts (listed in approximate chronological order) that should be assessed at any given site:

- **Removal of dune and lowland forests from back dune areas.** There are very few dune systems in New Zealand where the original lowland, dune or coastal forest still remains largely intact. In fact, most coastal dunelands in New Zealand are now relatively barren of native trees and shrubs, let alone backdune forests. For instance, the Catlins coast in Otago probably contains the only examples of intact native dune forest sequences on the entire east coast of New Zealand, though very rare and isolated remnants of dune forest do occur at some other sites.

- **Wind erosion damage associated with disruption of stabilising dune vegetation by a wide variety of human activities.** Serious wind erosion was particularly widespread on New Zealand dunes in the late 1800's and early 1900's (and even prior to European settlement in many places - e.g. west coast of northern North Island). The problem was so serious and widespread that it was the subject of a major report to Parliament by one of New Zealand's foremost botanists (Cockayne, 1911). The threat posed by drifting sands escalated rapidly with grazing and other pressure in the late 1800's – with the area of drifting sands in 1880 estimated at 40,000 ha, increasing to 120,000 ha by 1909 (McKelvey, 1999).

  This wind erosion significantly modified the morphology of many foredune systems around New Zealand – with the effects of this modification still evident today in many areas, even though the dunes are now largely stabilised.

  While now less extensive, wind erosion still commonly occurs where sand-binding vegetation is disrupted by human activities (e.g. stock, motorcycles, pedestrians, 4WD vehicles) – often leading to blowouts and other dune damage (e.g. Figure 4). Present problems are generally most pronounced on beaches with high vehicle usage – particularly along the exposed west coast of New Zealand where strong winds can do severe damage very quickly once dune cover is disturbed.

- **Modification of dunes associated with coastal subdivision.** Widespread subdivision of beaches for holiday settlements, particularly since WWII, typically encroached close to the shore - retaining only a narrow dune buffer between properties and the sea. Frontal dunes were also frequently bulldozed and levelled (Figure 5). In some extreme cases, the entire frontal dune was levelled, capped with fill and grassed - completely eliminating spinifex and other native sand binding species critical to natural dune building and repair.

Figure 5:

Dunes being bulldozed at Mount Maunganui in 1965

- **Damage to native sand binding vegetation:** Native sand binding species are sensitive to damage by trampling or vehicles. Problems with disruption of vegetation cover commonly arise in high use areas where pedestrian beach access is poorly managed and in areas where motorbike and other vehicle use occurs on dunes. Damage to spinifex and pingao cover on the seaward dune face seriously impairs natural dune building and repair and can also lead to severe wind erosion.

  A major impact on native dune vegetation for well over a century has been the introduction of browsing mammals, particularly rabbits, and possibly to a lesser extent hares (Unsworth 2005). Pingao in particular is highly palatable. Uncontrolled grazing by early settlers and landowners throughout New Zealand dunes, and even up to recent times in some regions has also severely reduced or eliminated many of our native dune species.

- **Displacement of native dune vegetation by exotic species:** A variety of exotic species are now widely established on dune systems (Partridge, 1992; Johnson, 1992). While many of these species are relatively harmless (e.g. hares tail), some species can significantly impact on natural dune characteristics, impair dune building and repair, and adversely impact on native ecosystems and native biodiversity.

  For instance, marram grass, a sand binding species from Europe, has been extensively used in dune stabilisation work and is now widespread – sometimes largely replacing native sand binders such as pingao (Partridge, 1995) and spinifex on the frontal foredune. This species also has a significant effect on frontal dune morphology, especially on exposed coasts with strong winds where it tends to build higher and steeper frontal dunes than spinifex or pingao (Esler, 1978; Dahm and Spence, 2002b). The use of marram should ideally be avoided on frontal foredunes. However, it can play a useful role in stabilising human-induced wind erosion damage in dune areas further landward and has been widely used as the first stage of restoration to other end points (e.g. pasture; exotic forestry) (Gadgil, 2002).

Some exotic species such as coastal wattle (Acacia longifolia subsp. sophorae), pampas grass (Cortaderia selloana, C. jubata), thorny asparagus (Asparagus officinalis) and Italian buckthorn (Rhamnus alaternus) can also create locally significant weed problems on New Zealand dunes. The dumping of garden wastes and "gardening" of dunes by adjacent property owners also introduces exotic species and weeds, many of which can spread quickly (e.g. agapanthus).

Exotic species such as buffalo grass (Stenotaphrum secundatum), kikuyu and introduced ice plant are sometimes used on seaward dune faces but are considerably less effective than spinifex and pingao in natural dune building and repair. Where practical, we would generally advise replacing any exotic species on the seaward dune face with spinifex and/or pingao.

- **Coastal structures:** Coastal development is often accompanied by the proliferation of coastal structures, which can impact on beaches and dunes (Gibb, 1996b; Environment Waikato, 1999). Examples include stormwater outlets, which can locally aggravate dune erosion during coastal storms, and seawalls, which isolate dunes from the wider beach system and can adversely impact on various beach and dune values.
- **Other:** Dunes and dune vegetation have been significantly modified by many other human activities – including sand extraction, pine forestry and pastoral use (McKelvey, 1999; Hilton et al., 2000; Hesp, 2001).

4.2 Dune Restoration Objectives

Dune restoration can have a wide range of management objectives and many of these are site specific in nature. However, as a general rule, there are two broad objectives:

- Design and implement appropriate dune restoration and management works
- Promote a dune care ethic within the wider community, through increased community awareness and participation.

In other words, the focus should not be limited to dune management works but also include an emphasis on human behaviour change. This is important for various reasons. Firstly, humans are the major cause of dune damage and sustainable dune restoration requires change in human use and behaviour. Secondly, community involvement is important to help build more resilient and sustainable coastal communities i.e. Communities that are more aware of the natural environment in which they live, are better able to adapt to change and live sustainably in that environment. These are the key reasons that we believe community-based partnerships should be used for dune restoration (see Section 5). These partnerships also bring diverse stakeholder interests together and strengthen links between councils and their communities – with many associated benefits.

"… co-operation marks a huge step forward in mutual respect, collaboration and resulting environmental improvements. All parties gain; so too, does the environment."

(McPhee, 1996).

In terms of dune restoration works (the focus of this section), dune management for the mitigation of climate change effects should aim to:

- **Restore and maintain a protective natural dune buffer between coastal development and the sea.** Ideally, the dune should be of sufficient dimensions to provide total protection from coastal erosion and flooding, including the aggravation of these hazards by sea level rise and other climate change effects. However, with existing development often located very close to the sea, this is not generally possible. Nevertheless, as wide a natural dune as possible should be maintained or restored. Coastal setbacks and associated development controls are generally required to help facilitate this at existing coastal settlements where development is very close to the sea.
- **Maintain a good cover of appropriate native sand binding vegetation – especially spinifex and/or pingao on the seaward face of the frontal dune.** This is critically important, to ensure the maintenance of natural dune building and repair processes (essential for natural repair of the dune after storm erosion) and to prevent wind erosion damage to the dune.

Despite use of the term "restoration" it is not often practical to restore dunes to their original condition. In many cases, dunes have been so completely modified that the original condition is unknown. Moreover, the environment has frequently changed – with human use pressures, introduced vegetation, introduced pests and many other factors. However, as a guiding principle, it is desirable to restore dune landforms comparable with natural dunes in appearance and function (Nordstrom, 1994).

In addition to hazard management objectives, every site will have a range of other management objectives that need to be addressed in designing appropriate dune management action. In particular, these include objectives related to:

- **Protection and enhancement of important coastal values:** - including natural character, coastal ecology and biodiversity, cultural values, recreational values, landscape amenity, public access to and along the coast, archaeological and scientific values. Most of these values are central to the purpose and principles of the Resource Management Act and the New Zealand Coastal Policy Statement and will therefore be given strong emphasis in relevant regional and district planning documents. At many sites these objectives will be as important and even more important than hazard management objectives.
- **Various site-specific stakeholder interests and values.**

Ideally, dune restoration programmes should also include activities that help develop more sustainable and resilient coastal communities – including raising community awareness of the importance of coastal dunes, natural beach dynamics and potential climate change effects and encouraging appropriate changes in human use of these dune buffers.

4.3 Common Elements of Dune Management and Restoration Plans

Basic site considerations

Dune management should generally only be considered at sites where dunes are or were a natural element of the coastal environment. Examination of historical information or similar local beach environments may be required to confirm this.

It is also important to ensure that there is sufficient space between development and the sea to form a sustainable dune (or part dune). If the space is inadequate, it will be necessary to create more space before proceeding with dune restoration.

At most developed sites, the available space may be sufficient for a sustainable dune (at least in the short-medium term) but will probably not be adequate to provide complete protection from the worst practical erosion, including climate change effects.

In this situation, dune management must be complemented with other hazard management options, particularly setbacks and development controls, to provide a complete and sustainable hazard management strategy. Ideally, and where practicable, setbacks should be designed to provide for maintenance and/or restoration of a wide range of coastal values (e.g. natural character, amenity values, biodiversity) and not just hazard protection.

Where environmentally damaging options such as rock seawalls are also necessary, ideally they should always be located as far landward as physically practicable – preferably sufficiently far landward so as to be buried and out of sight on most occasions, exposed only for short periods during very rare and severe erosion. This may well necessitate placement of the walls on private property at some sites. Failure to locate a seawall considerably landward of a beach will often result in severe damage to beach values. It will also generally mean there is insufficient space for a dune or part-dune to be re-established seaward of the structure. Moreover, environmental damage and other issues will become even more acute in the event that erosion is aggravated in the future by climate change effects such as sea level rise.

Earthworks and dune reshaping

Earthworks are not always required but can be a critical element of effective dune restoration – especially where dunes have been severely modified or damaged by human action (see case study 3 in Section 6). For instance, it is very important to remove any clay fill or soil that has been placed on the frontal dune – particularly on the seaward face. Spinifex and pingao, the key native sand binders, must be planted directly into loose clean sands. Earthworks may also be required to restore a more natural foredune shape. Removing inappropriate exotic vegetation or relocating native trees and shrubs from the foredune to more landward sites also may be necessary during reshaping projects.

Earthworks and dune reshaping are generally the best approach to repair dunes seriously damaged by wind erosion – as planting can then be undertaken almost immediately. Sand trapping fences can have a limited role but are now used less frequently.

When using earthworks, dunes should generally not be extended seaward of the existing natural dune toe. If there is room for seaward advance of the dune, this will occur naturally over time once a good cover of appropriate sand binding species has been restored on the seaward dune face. In rare cases where there is a wide high tide dry beach further seaward, pushing up sand from the beach to assist natural dune recovery can be a useful precursor to restoration work (if it is necessary). However, in most cases, any attempt to move the dune seaward in this way may simply result in erosion back to the natural duneline relatively quickly.

Earthworks can be contentious, even where well justified, especially on developed beaches. It is important to consult widely, assess other dune values that may be affected, ensure the scope of works is kept to the minimum necessary and to obtain any required landowner approvals or resource consents. If earthworks are controversial, it may be necessary to conduct a small demonstration trial.

Earthworks should be timed in accordance with favourable weather patterns and, where necessary, carried out in stages to enable planting work to commence almost immediately to minimise risk of wind erosion. This is particularly important in locations with frequent strong and persistent onshore winds – such as the west coast of the North Island and both east and west coasts of the South Island.

In repairing damaged dunes, it is always useful to draw up a proposed works plan, with some basic site surveying being a critical component.

Planting and Enhancement of Existing Vegetation

In general the most essential requirement of dune management is to ensure the maintenance of a good cover of appropriate sand binding species on the seaward dune face – particularly spinifex and pingao. While these are not the only native species that grow in this hostile area, at most sites they are the species most critical to natural dune building and repair. Theses sand binders thrive in conditions of sand movement and in fact become unthrifty once the site they occupy becomes stable. Spinifex has a southern limit of Banks Peninsula (Simpson, 1974), while the endemic pingao occurs throughout the country (Bergin and Herbert, 1998).

A good cover of spinifex and/or pingao on the seaward dune face ensures natural dune building and repair processes and prevents serious wind erosion. There is no point in revegetating an unstable backdune area when the area is being fed by sand blowing inland from the beach over a denuded frontal dune – the frontal dune needs to be attended to first. (As a general rule, wind erosion should be addressed working from seaward to landward).

While planting of nursery-raised sand binding plants is generally the major focus of restoration programmes, 1-2 light dressings of a nitrogen fertiliser such as urea can also be very effective in closing gaps in existing sand grass cover (Bergin 1999). Other measures that protect existing vegetation can also be very effective – such as accessways, signs and fencing; excluding grazing animals; etc. Obviously, any pressure that has led to vegetation damage (e.g. trampling, vehicle use, pests, etc) must be managed or any new planting will also simply be destroyed.

Comprehensive guidelines are now available for growing and planting the major native sand binders (Bergin, 1998; 1999; Bergin and Kimberley, 1999). In brief, most plantings of spinifex and pingao use high quality nursery-raised seedlings (rootrainers are recommended for these species) planted relatively densely - typically about 1 m spacing although higher densities in very exposed sites is recommended. The seedlings should be planted deeply (top of potting mix at least 5-10cm below ground surface – deepest in exposed areas with strong winds) - to reduce losses from wind erosion before the plants establish. A slow release NPK fertiliser incorporated in each planting hole significantly improves initial plant establishment and growth rates.

Native dune plants must be sourced well in advance of planting projects and commercial nurseries usually require at least 12 months notice. Spinifex and pingao usually have to be specifically ordered, as they are not common stock. Eco-sourcing (raising seedlings from seed collected from local populations) is desirable, otherwise using plants raised from seed collected from the nearest source or the same ecological district is recommended.

Once the seaward dune face has a good cover of appropriate native sand binding species, attention can be given to planting back dune areas. Due to the severity of climate along the coast (principally onshore salt-laden winds) there is a clear zonation of vegetation from the foredune through to backdunes and ultimate lowland forest. Significant differences in both plant stature and species composition occur within these backdune zones with sometimes abrupt but usually diffuse boundaries. Immediately landward of the sand binders on the foredune, low growing sedge and rushes grade into woody ground cover native species followed by an increasing diversity of shrubs that merge into trees of increasing height progressing inland. This zonation will vary from site to site depending on the severity of the climate, width of duneland, and any human-induced disturbance factors. Appropriate native ground cover species are usually planted directly landward of the pioneer sand binding species, with a wide range of hardy native coastal trees and shrubs able to be established further landward. Trees and shrubs planted too close to the beach especially on exposed coastlines are unlikely to survive or grow well due to severe wind abrasion and salt burn. Planting these species too close to the sea also risks loss to undermining during periods of coastal erosion. The appropriate native species for backdune areas vary around the country and should be assessed for each site based on local site inspections and botanical information.

Access and Vehicle Management

Well signposted and conveniently located accessways are required in high use areas - to facilitate access to and from the beach while also protecting sensitive dune vegetation, particularly the sand binding vegetation on the seaward dune face.

Many different types of access structure are used, with the most appropriate structure normally determined on the basis of site-specific requirements. However, a simple board and chain accessway (or "sand ladder") is common (Figure 6) and has many advantages – being relatively easy and cheap to construct and readily repaired after coastal erosion. They can even be rolled up prior to storms to minimise damage.

Figure 6:

Simple board and chain accessway at Whiritoa Beach. Note the vigorous plant growth in areas protected from human trampling.

Good signage is also important – simple, friendly/positive, informative and eye-catching signs being the ideal (Figure 7). The messages generally encourage people to use accessways and avoid cutting across other dune areas so that damage to dune vegetation is avoided.

Fencing is required along the margins of accessways, with bollards and rope or post and rail generally preferable to post and wire fences. Fencing off dune areas between accessways can be required in very high use areas, especially on the west coast. However, in most areas this can be avoided through the provision of well-located and frequent accessways and good signage. Maintenance of a well-vegetated dune will often in itself encourage beach users to use nearby formal accessways.

If vehicle use occurs on local beaches, management action will often be required to minimise problems as a small percentage of users (most commonly trail bikes) will generally choose to "hoon" on the dunes. This can be an extremely difficult problem to manage, especially at remote sites, and can result in serious dune damage at exposed sites with strong winds. In the Bay of Plenty work is progressing to establish a region-wide cooperative control programme using a combination of by-laws and permits to minimise this increasingly serious threat to dune stability. All statutory land managers (Regional, City and District Councils, DOC etc) are party to this control initiative to ensure consistency. Environment Waikato and other regional and district councils are also involved in discussions with a view to a coordinated approach along west coast beaches, where very serious issues are starting to develop.

Figure 7:
Simple eye-catching signage used by Coastcare Bay of Plenty

Weed and Pest Control

Control of problem plant and animal pests may be required at some sites. For instance, it is best to eliminate any potential invasive species before they become widespread. Plant pest control officers from the local regional council can usually provide valuable assistance in the design of weed control programmes.

In areas where coastal biodiversity and ecological objectives are important, local information campaigns can also be helpful to discourage "gardening" of backdune areas and the dumping of garden wastes. Encroachment of private properties onto dune reserves is also a common issue.

If the frontal dune is dominated by the introduced marram grass, kikuyu, and/or ice plant (Carpobrotus spp), consideration should be given to replacing these species with spinifex and pingao (especially on the seaward face of the dune). Care should be taken when removing large areas of exotics all at once from erosion-prone sand dunes where there could be a likelihood of blowouts particularly on exposed dynamic coastal dunes. A programme of gradual replacement of exotics with native species is likely to be a prudent option on such sites.

Animal pests such as rabbits can also cause serious problems for coastal planting programmes – with some species being particularly vulnerable (e.g. pingao, shore spurge, and coastal five finger). If using such palatable species, pest control is essential where rabbits or hares are locally significant – otherwise the plantings will largely be grazed and lost (Unsworth 2005). Animal pest control officers from the regional council can generally assist with guidance on appropriate pest control programmes.

Information and Education

This is probably the most important aspect of dune management in the longer-term as most dune damage requiring intervention usually arises from damaging human activities. Therefore, changes in beach user attitudes and behaviour are required for effective and sustainable dune restoration. The use of community-based partnerships for dune restoration is very effective in this regard and this aspect is discussed further in chapter 5. There are also many opportunities to get information into communities such as good informative signage, information materials, local community newspapers and radio stations and many other options. Ultimately, it is to be hoped that environmental education programmes will be introduced widely into the New Zealand school system so that New Zealanders gain much of the required knowledge about coastal and other environments through the education system. Coast Care programmes that involve schools are an excellent method for educating the younger generations of beach users!

Monitoring and Maintenance

Some form of simple ongoing monitoring of restored or managed areas is critical, so that any problems or damage can be identified early and addressed. At many sites, this simply consists of regular inspections of dune condition.

It is also important to ensure a regular photographic record of restored areas – including both before and after photographs. These also assist communities to celebrate success and are very helpful in illustrating the importance and success of dune management work to decision makers. Regular photographs from a fixed point can be particularly useful.

Ideally, it is also desirable to have some rigorous form of long-term monitoring of changes of dune morphology and vegetation – though this is not yet common. However, some councils operate beach profile networks that record beach and dune morphology at shore parallel transects and some of these also incorporate vegetation monitoring in the work. In the longer-term, techniques such as LIDAR and computer-controlled video monitoring offer potential to markedly improve existing monitoring.

Ongoing maintenance of dune works is generally required, as human and other factors will damage plantings and dune vegetation, signs, beach accessways, etc. However, natural storm erosion does not necessarily require intervention or maintenance. If a dune is well vegetated in native sand binders and human disruption is minimised, the vegetation will naturally repair the damage. While, this is in some ways an ideal end point, at most sites with human use pressure there will inevitably be ongoing damage that needs to be addressed to maintain natural dune functioning. In this respect, the level of maintenance required provides a useful measure of how effectively human use pressures are being managed and the level of dune care knowledge being realised among beach users.

4.4 Underpinning Dune Restoration with Science – CDVN

A feature of the Coast Care programme in New Zealand is the technical support offered by Coastal Dune Vegetation Network (CDVN) established in 1997 – which maintains close linkages between research providers and coastal managers, community groups, iwi and landowners. Collaborating research providers include the Crown Research Institutes; *Forest Research*, Landcare Research and AgResearch, as well as active linkages with staff in Geography and Earth Science Departments in a number of universities (including Massey, Waikato and Otago).

Membership of the CDVN currently exceeds 300 community groups, iwi, regional and district councils, consultants, native plant nurseries, educational institutes, and coastal landowners. Most regional councils with significant coastal dunes are financial members along with the Department of Conservation and sand dune forest owners. The success of the network has also led to it being used as model for the setting up of other multi-stakeholder networks.

The CDVN provides a forum for the free exchange of information on sustainable management of dune ecosystems with emphasis on the use of the functional native vegetation to restore natural character, form and function. With the involvement of a wide range of end user community groups, practitioners and researchers, the network also assists with the identification, prioritisation, implementation and dissemination of research results throughout New Zealand. CDVN trials are established with the active involvement of local communities, landowners and managing agencies aimed at developing practical cost-effective techniques and options for dune rehabilitation, with emphasis on native species. The aim is to ensure that wherever possible, best-practice methods based on scientific principles are adopted in restoration of dunes that improve the degree of restoration success rather than a reliance on anecdotal information and untested procedures. Involvement of end users at all stages ensures rapid transfer of research results to those involved at all levels of dune restoration and in forms that can be utilised by Coast Care and other interest groups.

The CDVN has produced a number of bulletins that bring together existing information and research on key native species and dune morphology (e.g. Bergin 1999, Hesp 2000). It also organises a very popular annual conference where information is exchanged both formally in technical sessions and informally in regional roundups and field trips. The CDVN also maintains a website and a database of technical reports, papers and books relating to sand revegetation throughout the country.

5 Community-based Approaches to Dune Management

Community-based approaches to dune management were initiated widely in New South Wales in the 1980's and expanded to other parts of Australia and to New Zealand in the 1990's. The first group in New Zealand was established at Whiritoa Beach on the eastern Coromandel in early 1993 with 3 other groups also formed in the Waikato and Bay of Plenty regions that year (Dahm, 1994). Extensive programmes now operate in both of these regions (see case studies in Section 6) as well as in other parts of New Zealand.

The groups are typically based on the philosophy of inclusive community participation supported by government or council facilitation and resourcing (Davies and Smith, 1992; Dahm and Spence, 1997; Spence et al., 1998; Jenks and Brake, 2001; Jenks 2003). The essential characteristic is that the community and other relevant stakeholders are encouraged to accept responsibility for environmental management issues (i.e. to take 'ownership'), including development and implementation of appropriate management action. The role of the statutory agencies becomes less focused on that of a decision maker and more focused on empowering or facilitating the community stakeholders as the decision maker. In New Zealand, most community-based dune management groups (often called Coastcare or Beachcare groups) are supported by either the local district and/or regional councils – usually with both facilitation and resourcing support (e.g. Dahm and Spence, 1997; Spence et al., 1998; Jenks and Brake, 2001; Jenks, 2003).

5.1 Why use a community-based approach?

Community-based approaches to dune restoration and management have significant advantages over traditional approaches in which local government has taken the prime responsibility for designing and implementing dune restoration programmes.

Most dune damage arises from human activities and changes in awareness and behaviour are generally required for sustainable dune restoration. Investigations indicate that community-based environmental management programmes are very effective in raising community awareness and changing attitudes and behaviour (e.g. Davies and Smith, 1991; McPhee, 1996; Fagan et al., 1997).

Community-based partnerships can also empower local community and relevant stakeholder groups to have a more meaningful role in the management of beaches and coasts. The level of empowerment varies between groups and over time, but existing work has found significant attributes of empowerment among successful groups (e.g. Barrett, 1995; McPhee, 1996).

Community-based partnerships also have a proven ability to achieve significant dune management outcomes (Davies and Smith, 1991; Dahm and Spence, 1997; Spence, et al., 1998; Jenks, 2003; Jenks and O'Neill, 2004). Most existing groups have also exhibited long-term commitment and maintain some form of ongoing monitoring and maintenance of dune condition.

Community-based dune management is also very cost effective relative to traditional engineering structures and has significant advantages in terms of natural and human use values (see section 6.4 below).

The success of the groups to date suggests that community-based approaches have considerable potential in promoting increased awareness of coastal hazards and climate change and assisting in the development of more resilient coastal communities.

5.2 Initiation and Operation of Community-based Partnerships

The processes involved in establishment and operation of community-based dune management groups vary considerably both within and between individual programmes, but usually involve the following activities:

- Awareness of a need for dune management action at the particular site – often from community pressure.
- Decision and commitment by relevant statutory agencies (e.g. regional council, local district council, Department of Conservation) to promote a community-based approach.
- Identification of key stakeholders and consultation with these parties to seek or test support for a community-based approach.
- Launch of the group at a widely advertised public meeting – usually at times that facilitate the involvement of both resident and non-resident stakeholders.
- Establishment of a committee to co-ordinate the development of the dune management programme and community consultation. These committees are usually loose and informal and open to anyone prepared to be involved. It is important to ensure, as far as practical, that all the various stakeholder groups are represented.
- Consultation over proposed actions and priorities – the scope of this work varying from site to site according to requirement.
- Once an agreed dune management plan has been developed, the works are usually implemented at well-advertised working bees – with required plants and other materials provided by the supporting council(s).
- Active promotion and educational work.

Once groups are established and have a plan of action, they may only meet once or twice a year to review the condition of the beach and confirm plans for the year. Most groups also hold only 1-2 working bees a year (sometimes more in the first few years), generally designed to be no longer than 2-3 hours. If well advertised, it is not uncommon to get 20-30 people at working bees and sometimes in excess of 70. Working bees can also involve schools and other educational groups (Figure 8).

Figure 8:

School group participating in dune restoration with local iwi and community members at Raglan (Whaingaroa Beachcare)

Most Beachcare/Coastcare programmes employ specialist facilitators (full or part time depending on the scale of the programme) to assist the groups with technical information, planning and implementation. These facilitators are usually Council staff or contractors with strong dune management and facilitation skills. Facilitators also advise groups on planning, consultation and consent requirements; handle most bureaucracy required (e.g. plant and equipment orders, ensuring provision for the groups in annual planning processes, annual and other reporting as required, relevant consents, etc); and undertake widespread promotional and educational activities (Dahm and Spence, 1997; Jenks, 2005)

Most existing Beachcare/Coastcare programmes generally provide ongoing support to groups through the annual planning process - to ensure security of funding for plants, materials and any other relevant costs (e.g. earthworks). Amounts allocated for each group vary, but are typically less than $5000-$7000/year. Contestable funding is not generally appropriate as it provides too much bureaucracy, uncertainty and frustration for groups to function effectively. Contestable funding is also vulnerable to capture by well-organised interest groups who often have a more limited focus. Expenses associated with group activities are usually paid directly by Council and most groups do not operate their own bank accounts to keep processes as simple as possible for the community.

> *"Durable restoration projects enjoy support by local communities, effective policies, appropriate legislation, long term financing…"*
>
> (Higgs, 2005)

5.3 Key Principles for Successful Groups

An open and inclusive approach is fundamental to group success and to ongoing community support - facilitators usually have a key role in helping develop and encourage this ethic within groups (Boyce, 1993; Dahm and Spence, 1997; Jenks, 2005; Turner, 2005).

The adoption of consensus style decision-making is important. The ability to express different opinions and concerns and to work through issues in a mutually respectful manner is critical to ongoing success of the group. The temptation to rush action before consensus is reached can be very counter-productive and seriously alienate key stakeholders and interest groups. There is invariably other action that can be readily agreed and advanced while more difficult issues are being worked through.

It is important for group development to get some early successes, "runs on the board". Start with relatively simple issues on which there is consensus. Group confidence and relationships improve and community support is strengthened as the group is seen to be achieving positive outcomes. The more difficult issues are generally addressed as the group grows in confidence and experience and as relationships are strengthened.

Celebrating success (e.g. newspaper articles; occasional newsletters; Council recognition; CDVN annual awards) is central to building group confidence and cohesion, as well as raising community awareness and support. Opportunities to socialise, such as morning tea, or a barbeque lunch after a working bee, are also very helpful in developing group cohesion.

Dunes are very dynamic environments and inevitably there are occasional problems with plantings and other activities. Occasional controversy will also often arise with group activities, despite best efforts. There is also no shortage of "armchair" critics. It is important to develop a group culture that works through such difficulties and learns the relevant lessons. Community groups need good support at such times.

It is essential to keep demands manageable to maintain widespread community involvement and support. People generally live very busy lives and if activities become too demanding, group involvement can reduce to a small band of enthusiasts. This can lead to other stakeholders feeling alienated or divorced from the group, with potential for loss of community support. Most successful groups that have been operating for several years have no more than 1-2 meetings per year and usually no more than 1-2 short working bees (though, in the first 1-2 years, it is quite common to have several meetings and working bees). This level of activity is quite adequate to achieve very significant outcomes over time.

Ideally, working bees should be well advertised and held at times convenient for a wide cross section of the community (e.g. over Christmas/New Year break when most landowners are in residence). These are the main opportunities for community involvement and, if well advertised, will usually be well supported. It takes commitment for people to come to working bees and facilitators should ensure that everyone who turns up is able to be meaningfully involved. Take time to explain the tasks and also the purpose and the desired outcomes of the activity. Maintaining a mailing list for posting of occasional newsletters will assist in keeping the wider community up to date with activities and future working bees.

6 Case Studies

6.1 Case Study 1: Bay of Plenty Coastcare

Coast Care Bay of Plenty was initiated in 1993 and the programme has now grown into a partnership involving 28 separate community groups, including many iwi-based groups, covering the full length of the regional coastline.

The programme involves all relevant management agencies along the Bay of Plenty coast – including Environment Bay of Plenty, all four coastal district/city councils and DOC (both Bay of Plenty and East Coast/Hawkes Bay Conservancies). The management agencies contribute from annual budgets for the supply of plants and materials to Coast Care groups. Each Council contributes roughly in proportion to their district population size. Representatives from each agency form a Coast Care Advisory Group, which meets every 6 weeks to discuss and review activities. This regular and open communication is pivotal to the continuing success of this cooperative relationship.

Coast Care Bay of Plenty employs two full time facilitators who liase with and support communities in their dune restoration work; including establishing new groups, developing dune management plans, providing technical advice, arranging promotional work within the community and preparing educational material.

In a typical year, volunteer members of the programme utilise around 50,000 plants to help restore the many and sometimes severely damaged dunes.

In 2005 a total of 30 species of native dune plants are being re-introduced, including many nationally threatened plants like shore spurge (*Euphorbia glauca*), sand daphne (*Pimelea arenaria*), Lepidium oleraceum (*Cook's scurvy grass*), Apium prostratum (*shore celery*), etc…

Site Specific Example: Papamoa East

Background – Threat from coastal hazards and climate change

Papamoa East is a coastal township lying between Mount Maunganui and Maketu on the Bay of Plenty coast.

In places, coastal subdivision has extended very close to the sea commonly leaving dune widths of less than 15-20m between the sea and high value properties and dwellings. However, coastal hazard assessment has indicated potential for erosion to impact up to 40-50m inland of the existing toe of dune by 2050, including the effect of projected sea level rise to that time (Gibb, 1996a) indicating potentially very serious hazard problems.

Notwithstanding the serious potential hazard issues, the frontal dune was often in a very degraded condition in the early 1990's (Figure 9), largely due to the original dune being bulldozed back into a natural stream bed immediately inland to create flat sections in 1958. Typically, there was often only a sparse cover of native sand binders and in some areas the dune had been further levelled and vegetated with exotic grasses such as kikuyu - which are almost completely ineffective for natural dune building and repair.

Figure 9:

Degraded frontal dune at Papamoa East in early 1990's. Note dune has been levelled and is vegetated with Kikuyu, with little to no native sand binding species on the seaward face.

Papamoa Coast Care

In the early 1990's, coastal storms severely eroded the degraded dune – leaving large erosion scarps within a few metres of some property boundaries. Following concern from local residents, a Coast Care programme was initiated in 1994 to improve dune management. This is still well supported by highly motivated local property owners concerned not only for existing erosion, but also for the future impacts of sea-level rise.

The work has focused on restoration of a good cover of native sand binding species on the seaward face of the dune, with plantings of several thousand spinifex and pingao and fertiliser application to existing stands of these species to assist in their recovery and spread. Dune accessways were also installed in high use areas to protect the sensitive vegetation from human trampling.

The restoration of native sand binding species on the seaward dune face has successfully restored natural dune building and repair processes, resulting in seaward dune advance of 10-15m (and sometimes more) between 1998 and 2004 (Figure 10). This dune advance provides a much wider dune with a more gentle, vegetated and resilient front slope to help buffer current and future storm erosion. (Jenks & Brake, 2001)

Figure 10:

Dunes at Papamoa East after restoration work – the seaward face now has a good cover of native sand binding species and has advanced seaward 10-15m since

As the width of the dune buffer is still less than the potential erosion estimated by Gibb (1996a), the Tauranga City Council has introduced setbacks and other development controls to complement the dune restoration work. These setbacks ensure that new houses are not built within the area at high risk from existing coastal processes, that appropriate relocatability standards are adopted for dwellings in risk areas, and that no further subdivision occurs within the hazard risk area.

However, with the Coast Care programme, the natural dune building and repair processes have been restored and the protective capacity of the limited dune buffer has been maximised.

As many of the previously damaged front dune areas in the Tauranga City/Papamoa coastal buffer are now successfully restored (about 20km length of dune), the emphasis is changing from urgent dune buffer improvement to restoration of bio-diversity values. Therefore, more time will be devoted to planting mid and back dune areas beyond 2005.

This outstanding example of successful restoration of natural and protective dune function has only been possible in this short period of time because of community empowerment and involvement in the restoration process. Communities now increasingly understand the value of natural dune buffers and the linked challenge of sea-level rise, and many actively seek to protect the dunes, both personally and by educating others in the community. As a result, there increasingly exists wide community empathy and demand for control of any threat to the integrity of the restored dunes, e.g. threats from grazing (mainly rabbit control) and vehicle damage.

6.2 Case Study 2: Beachcare Programme: Waikato Region

The Beachcare programme was initiated in January 1993 with the launch of the first community-based dune management programme in New Zealand at Whiritoa Beach. There are now community-based dune management programmes at 12 eastern Coromandel beaches and 5 beaches along the west coast of the North Island – including 3 iwi-based groups. Occasional support is also provided to other sites.

The groups are each supported by the regional council (Environment Waikato) and the relevant local district council, including ongoing provision of funding for plants and materials. Environment Waikato also contracts two part-time facilitators to support the communities in their dune restoration work.

In 2005, the programme will plant approximately 40,000 coastal plants and now uses over 30 different native coastal species, including a range of rare and endangered dune plants (e.g. sand pimelea).

Site Specific Example: Whiritoa Beachcare

Background – Threat from coastal hazards and climate change

Whiritoa is a medium-coarse sand beach located on the eastern Coromandel coast, about 1400 m long and backed by a single frontal dune, typically 5-7 metres high. The beach is no longer receiving any significant net sand supply and essentially has all the sand it is going to get (McLean, 1979; Environment Waikato, 1992) – typical of many eastern North Island beaches (e.g. Dahm and Munro, 2002).

The site was subject to very considerable controversy in the 1970's and 1980's related to ongoing sand extraction and concern with coastal erosion. Various investigations were conducted during this time, but no management recommendations were agreed or implemented.

Further investigations in the early 1990's confirmed a potential risk from erosion related to episodic coastal storms, a trend for long-term erosion and the potential impact of projected sea level rise to 2100. The width of the hazard zone was estimated at 40-60m, with a high-risk area of 30-35m (Environment Waikato, 1992). The investigations found aggravation of the erosion hazard by a wide variety of past and present human activities - including dune degradation, sand extraction and development in nearshore areas (Environment Waikato, 1992; Dahm et al., 1993).

A coastal hazard management strategy was adopted jointly by Environment Waikato and Hauraki District Council (Environment Waikato, 1992; HDC, 1992) and subsequently implemented (Dahm et al., 1993). The strategy included a variety of actions designed to protect existing sand reserves, improve dune management and control development within the hazard risk area - including closure of the sand extraction, introduction of development controls and initiation of a community-based dune restoration programme.

Whiritoa Beachcare

The Beachcare group was launched in January 1993 and attracted strong community support and participation, with over 160 individual members joining at commencement. A coordinating committee was elected at the meeting, with care to ensure all stakeholders were represented. The committee developed a broad plan for dune restoration, which was then forwarded to residents, ratepayers, local iwi and various beach user stakeholders for comment. Considerable feedback was received and after further consultation, the initial plan was finalised (HDC, 1993).

Work on implementation of the plan was able to commence before it had been finalised – focusing on those activities on which there was agreement. The first working bee attracted over 80 participants and completed installation of two board and chain access-ways and associated fencing in the high use surf club area (Figure 11).

Figure 11:

Community working bee assembling a sand ladder accessway at Whiritoa Beach

The initial plan was fully implemented within the first 4-5 years, including installation of 12 board and chain accessways and associated fencing, planting of over 20,000 sand binding species, extensive signage, clearance of invasive weed species (particularly boneseed, coastal wattle and pampas) and various promotional activities.

Large information signs were also designed and placed in popular visitor areas to help inform casual beach users. In addition, the group also worked with Forest Research and Environment Waikato scientists on a number of local vegetation trials.

The dune management action has been very successful, with a good cover of sand binding species established on most of the dune face and ongoing human damage reduced to minimal levels (Figure 12). Only limited dune lengths remain to be fully restored – with action presently restricted by other factors (e.g. close proximity of surf club building to the sea and a localised stormwater issue)

The group continues to operate, with annual working bees typically focused on maintenance of the sand binding species on the seaward face and back dune planting of trees and shrubs. The latest working bee in late 2004 attracted over 70 participants – with the planting and other work completed in less than 45 minutes.

The success of the group was recognised nationally in 2003 with “Best Community Group Award” by the Coastal Dune Vegetation Network.

The dune restoration was complemented by cessation of sand extraction and the introduction of development controls and setbacks.

Figure 12:

Successful restoration of sand grass cover on Whiritoa dunes

6.3 Coast Care: New Plymouth District Council

The NPDC Coast Care programme had its origin in the 1995 Coastal Erosion Strategy Working Party, which recommended that only significant public assets along the district's coastline qualify for possible protection, with an emphasis on designing with nature rather than against it. The programme has focused on the development of natural methods, with initial emphasis on restoration of degraded dunes.

An outstanding feature of this programme has been the significant restoration of seriously degraded dune environments. As extensive earthworks were required for effective restoration given the serious degradation of the dunes, the initial focus was a restoration trial to develop and illustrate appropriate techniques. Reshaping was carried out in 2000 at Oakura Beach, just south of New Plymouth, where the original dune had been severely degraded (levelled and capped with clay and fronted by a steeply facted seaward face with little to no native vegetation cover).

An excellent sward of mainly spinifex was successfully established on the reshaped dune at Oakura. Following the overall success of the Oakura demonstration trial, the Coast Care programme has progressively restored badly damaged dune systems in conjunction with the major inner city walkway and reserve upgrade programme using the techniques developed at the Oakura trial site. The work has been very successful (see example below) and initial restoration of the main degraded dunes around the city is nearly completed.

In view of the major earthworks required, Council maintained the primary role in the initial restoration of the severely degraded dunes due to the significant earthworks, though community consultation was a significant component of this work from commencement of the Oakura trial. Nonetheless, community-based Coast Care groups and schools have also been supported at other sites, with NPDC providing the plants and materials required as well as facilitation support.

With completion of the major earthworks and restoration of severely degraded dunes, Council is now looking to deepen the level of community involvement -similar to the programmes operating in the Waikato and Bay of Plenty regions. This will require more time for the Coast Care coordinator – presently a part time role within Council. This council is now seeking to involve other relevant management agencies in the work ahead.

Site Specific Example: East End Beach

East End Beach within New Plymouth City was backed by a severely degraded dune system in the early to mid 1990's (Figure 13), with very limited natural dune building and repair. The natural and amenity values of the site were also seriously degraded.

Figure 13:

Severely degraded dunes at East End Beach before restoration works

Restoration of these degraded sand dunes has involved:

- Earthworks to remove fill, clear inappropriate vegetation and to restore a natural dune shape and sandy substrate (Figure 14).
- Extensive planting of native sand binders.
- Installation of a range of access management measures (conveniently located accessways, fencing as required, signage, etc) to protect the sensitive vegetation.

Extensive consultation was also undertaken with the local community, iwi groups and other stakeholders.

The benefits of the dune restoration work are very dramatic (compare figures 13 and 15) and there has been strong community support and little opposition, even though the project has required major earthworks to restore natural dune conditions.

Figure 14:

East End Beach dunes after reshaping and recent planting of mainly spinifex.

Figure 15:

East End dunes after restoration works

The contrast of the restored dune with the historical emphasis on rock armouring is particularly notable. With the restored dunes lying immediately adjacent to the rock armouring, the public have been able to compare the two alternatives side by side – with significant preference for the natural approach. The dune restoration also has significant cost advantages over rock armouring (see discussion further below).

6.4 Comparison of Dune Management and Engineering Options

Historically, the management of coastal erosion has tended to emphasize "holding the line" or "stopping" coastal erosion, and a wide variety of measures have been developed to "engineer" this outcome. Rock seawalls (Figure 1) are the predominant measure that have been utilised on ocean beaches in New Zealand.

However, beach/dune erosion and recovery is central to the natural functioning of beaches and dunes (Figure 2) and so "stopping" erosion is difficult and expensive, especially on moderate or high-energy ocean beaches. Moreover, while well-designed seawalls can be successful at "holding the line" and protecting values further landward, they often result in serious adverse environmental impacts on both the beach and dune. For instance, physical effects typically include isolation of dune sand reserves from the remainder of the active beach system and narrowing or loss of high tide beach (Gibb, 1996b; Dahm and Spence, 2002a). Coastal values commonly and, often severely, impacted include natural character, amenity values, and public access along the beach at higher stages of the tide (Gibb, 1996b; Dahm and Spence, 2002a) - important values on popular recreational beaches. These difficulties and adverse effects will be seriously compounded with any future aggravation of erosion in response to climate change.

In contrast to engineering options, an adequate dune buffer enables communities to live with natural shoreline movements, avoiding the often high social, economic and environmental costs of "holding the line". Dunes also enhance rather than diminish important coastal values such as natural character, coastal landscape and amenity values, and coastal ecology and biodiversity.

Community-based dune management also has further advantages over engineering approaches in that it assists communities to better understand and live with the natural coastal environment – they come to appreciate that shorelines are not static, they move; and space has to be maintained to allow such movements. In this and other ways (see section 5), dune restoration and management programmes help promote the attitudinal and behavioural changes required to build more sustainable and resilient coastal communities. Conversely, the use of engineering

options tends to reinforce the misunderstanding that all erosion is abnormal or a problem that must be stopped – rather than natural erosion being part of a coastal process central to the natural behaviour and values of most beaches (e.g. Figure 2). Rather than part of a natural coastal process central use of engineering works also conveys the impression of protection from natural shoreline movements and can reinforce inappropriate patterns of nearshore use and development. This in turn can lock in the real or perceived need for seawalls, resulting in the many associated adverse effects becoming a permanent feature of the local beach.

Dune restoration and management also has significant cost advantages over traditional engineering approaches. Properly engineered seawalls on exposed coasts typically cost $1500-$2000 per linear metre or more. This is fairly typical of the costs for most major interventionist works (e.g. seawalls, groynes, offshore reefs, major nourishment programmes, etc) on exposed beaches and these works can sometimes cost considerably more.

Dune restoration and management is much more affordable for communities, even with very degraded dune environments. For instance, the extensive restoration of severely degraded dunes undertaken by the New Plymouth District Council Coastcare programme has averaged about $25/m2 (about $250-$500 per linear metre) inclusive of all costs (surveying, weed control, earthworks and fill removal, supply of plants, and erection of fences and accessways by contractors, with planting by Council staff). In environments where dunes are less degraded and where the works are undertaken by large community-based programmes, average costs are even less. For instance, the Bay of Plenty Coastcare programme averages about $8.50/m2 (or about $60 per linear metre) inclusive of all programme costs (i.e. staff time, travel, plants and other materials, etc). Moreover, many of these costs are associated with the extensive community education, promotion, advisory and advocacy work undertaken that are not directly associated with dune works. The Waikato Beachcare programme averages about $3.50/m2, inclusive of all associated costs (facilitators, plants, materials, etc). This programme also includes advisory and educational work not directly associated with dune works, though to a lesser extent than Bay of Plenty Coast Care as the facilitators are part-time rather than full-time.

In simpler terms, dune restoration costs range from approximately 1% to 10% of the cost of seawalls, depending on the state of dune degradation at commencement.

Therefore, even considering costs associated with education and promotion, dune management is far less costly than engineering options. As emphasized in this report, a considerable investment in community outreach and information is desirable where practical, particularly on coastlines with important recreational beaches and extensive coastal communities. Given the issues with coastal settlements in New Zealand (e.g. see section 2 of this report; also MfE, 2001), there is an urgent need to promote the development of more resilient and informed coastal communities, better equipped to make wise decisions regarding the impacts of sea-level rise.

However, in comparing dune management with engineering works it has to be recognised that there are some sites where there is presently insufficient space for dune management to be a practical option, even taking into account both public and private land. If significant assets (e.g. roads) are at immediate risk and cannot be readily relocated, engineering works may be required to prevent erosion damage until the asset can be appropriately relocated. If engineering options are required, consent should ideally be accompanied by a longer-term strategy that will, over a suitable period of time, recreate the space necessary for restoration of a natural dune system – so that the works can eventually be removed. This is particularly important where seawalls are placed directly on beaches and have a significant adverse effect on natural and amenity values. Otherwise, there is potential for the existing problems (including the adverse environmental effects) to become much worse in the future with any aggravation of erosion by climate change or other factors.

Where seawalls are required on recreational beaches, they should generally be placed as far landward as physically practical so that the wall is buried on most occasions – serving only as a backstop during rare and severe erosion, e.g. the Gold Coast seawall with restored dunes on the seaward margin. This will minimise adverse effects and may even allow a dune or part dune to be re-established further seaward. Such practice is consistent with the appropriate location and design requirements emphasized in the New Zealand Coastal Policy Statement.

7 Summary

With 90% of New Zealanders living within 50km of the coastline, beaches play a big role in the lives of New Zealanders – reflected in iconic summer holidays, a wide range of recreational and other activities, and extensive coastal subdivision and development. However, the way we have chosen to live, work and play on the coast has often bought us into conflict with natural coastal processes, giving rise both to coastal hazard (e.g. coastal erosion and flooding) problems and to environmental degradation. Climate change effects, including sea level rise, have the potential to seriously exacerbate this conflict and associated issues.

In the past, the management of coastal erosion in New Zealand has been dominated nationwide by an "engineering" paradigm, which has emphasized "holding the line" or "stopping" erosion – with particular emphasis on the use of rock and other seawalls. This approach is costly, often involves significant environmental damage and adverse impacts on human use values, and can reinforce inappropriate patterns of use and development. In the longer-term future, these shortcomings are likely to be further and quite severely exposed by accelerated sea level rise and other climate change effects.

The challenge for the future is to manage these issues in a more cost-effective and sustainable manner, while also maintaining and restoring the natural, amenity, cultural and recreational values that we as New Zealanders attach to the coastline.

This report firstly emphasizes that successful dune restoration and natural management options do exist commonly, and they have the potential to play a significant future role in meeting this challenge, for the benefit of the nation. Coastal foredunes provide natural and cost-effective protection from coastal erosion and flooding, while maintaining and enhancing the natural, cultural and amenity values of our beaches. To protect communities from coastal hazards including climate change effects, the specific requirements are to restore and maintain a protective dune of adequate dimensions to accommodate normal shoreline changes and extreme sea levels, and to manage human use pressures so that natural dune building and repair processes are maintained. The key elements involved in such work are outlined.

Secondly, the report emphasizes the advantages of adopting a community-based approach for such work. In particular, this approach helps to develop a better dune care ethic, important as the need for dune management primarily arises from human damage. It also empowers communities to take ownership of environmental problems, provides a forum where different community interests and values can be resolved and strengthens the relationships between management agencies and their communities. Involving communities in the management and restoration of natural dunes also has the potential to assist in the development of more resilient coastal communities - better able to understand and to live sustainably with natural coastal processes, and to adapt to future change.

> *"In the process of restoring ecosystems, individuals and society are re-establishing their relationships with the larger environments they live in, depend upon, learn from, and which .. must be nurtured…"*
>
> Turner, 2005.

The principles and processes involved in establishing and operating community-based programmes are outlined, drawing on experience from existing longstanding and successful programmes.

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