COASTAL DUNE VEGETATION NETWORK

# MARRAM GRASS

## FRIEND OR FOE?

A Review of the Use of *Ammophila arenaria* on New Zealand Sand Dunes

**Ruth L. Gadgil**
**Ensis Environment**

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Ruth L. Gadgil

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# INTRODUCTION

Most New Zealanders are familiar with marram grass (*Ammophila arenaria* (L.) Link) — the tough, tussocky plant that was introduced to New Zealand more than 100 years ago to stabilise drifting sand and which now seems to be a part of the beach dune scene. Few people think more deeply about it: even those who do may not be aware of its very special adaptation to the coastal sand dune environment.

The development of a remarkable ability to survive and thrive in unstable sand has given marram grass a competitive advantage over most of the other plants that are able to grow in this particular habitat. For this reason, it is often regarded as an aggressive plant, even a weed. With current emphasis of the 1991 Resource Management Act on natural character of the environment, coastal managers and planners often regard it as an alien species to be eradicated wherever possible. This view is reinforced by other legislation which requires the removal of exotic plant species from the Conservation estate whenever this is possible.

On the other hand, people aware of the problems associated with massive inland sand drifts in Northland, Waikato, and Manawatu in the early twentieth century realise that the New Zealand economy owes a great deal to marram grass. It was the only plant species that could be used to hold the sand in place long enough for productive forests to be established at Aupouri, Pouto, Woodhill, Mangawhai, Kawhia, Tangimoana, Santoft, and Waitarere. The fact that marram grass has been introduced from its natural habitat on western European coasts to alleviate major sand movement in temperate coastal dune areas throughout the world is a testament to its sand-binding capability. In South Africa, a 1974 decision to phase out use of alien species for sand dune stabilisation allowed an exception in the case of marram grass. This species is not regarded as invasive in that country and was more effective than any of the native plants as a sand-collector and sand-binder (Avis 1989; Lubke 2004). So is marram grass a friend or an enemy to the people responsible for managing New Zealand's coastal dunes? We have moved out of the twentieth century and need to review our knowledge. Because of the current upsurge of interest in the use of native species, the New Zealand Coastal Dune Vegetation Network places emphasis on the use of sand-binding plants such as spinifex (*Spinifex sericeus*), pingao (*Desmoschoenus spiralis*), sand tussock (*Austrofestuca littoralis*), and euphorbia (*Euphorbia glauca*) wherever these species are likely to be as effective as marram grass for stabilisation purposes. Outside their natural distribution range, or on exposed areas of mobile sand behind the foredune, it may be necessary to use marram grass in order to arrest encroachment or to repair blowouts. The management of areas that are already covered and partially stabilised by marram grass needs careful consideration.

The purpose of this Bulletin is to present information about the recognition, distribution, and ecology of a species that under specific circumstances may be useful to coastal managers, landowners, or coast care groups. The role of marram grass in current management of New Zealand's coastal dunes is discussed from a range of perspectives. These include advice on planting and maintenance for the achievement of sand stabilisation objectives at appropriate sites; methods for its eradication in areas where sand movement is not an issue; and suggestions about its usefulness in successional planting leading to the development of native plant communities. Finally, a multiple-choice guide is offered in order to assist decision-making about the management of marram grass on dune sites having identifiable characteristics. A list of native plant species that may have potential for use in revegetation projects is included as an Appendix.

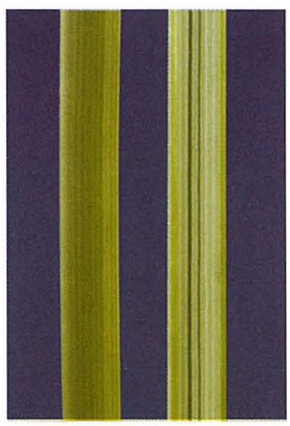
Left: *Bare sand behind the foredune;* centre: *planted marram grass;* right: *marram and native plants.*

*Healthy marram grass tussocks.*

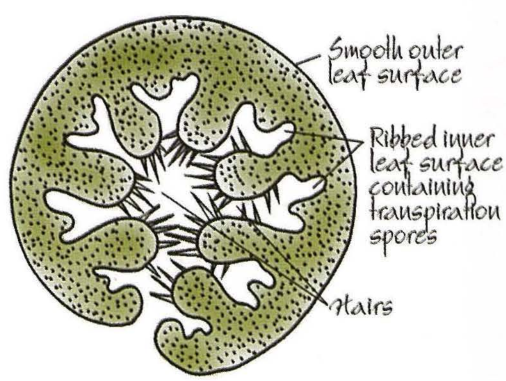
*Marram grass has a deep root and rhizome system that binds the sand grains together.*

Edgar and Connor (2000) described marram grass as an erect perennial plant which forms compact tussocks up to 170 cm tall. It spreads through loose sand by means of fleshy, later woody, underground rhizomes which give rise to roots and erect shoots (tillers). The new shoots appear above ground level at various intervals and may seem to be isolated from the parent tussock. Extensive underground connections can be revealed by excavation. The rhizomes and dense, fibrous root system descend to a depth of 1–2 m (Wardle 1991). Where there is active sand accumulation, rhizomes ascending from buried tussocks to the new sand surface may be several metres long.

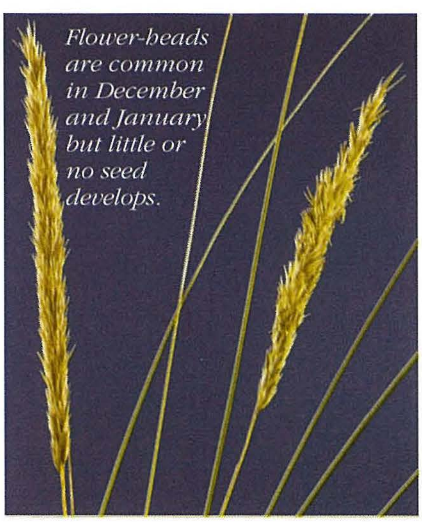
Leaves are bluish-green, with smooth, overlapping tubular bases (sheaths). The blades are up to 6 mm wide, sharply pointed, rigid, and in-rolled. They are closely ribbed and densely covered with minute hairs on the upper (inner) surface but smooth on the lower (outer) surface.



*The outer surface of the rolled leaves (left) is smooth. The inner ribbed and hairy surface (right) contains most of the transpiration pores.*




*The diagram shows a magnified cross-section of the leaf. In-rolling encloses the transpired water vapour and minimises moisture loss.*



*Flower-heads are common in December and January but little or no seed develops.*

Flower-heads develop in December and January as whitish, compact, narrow, cylindrical plumes which taper upwards. Little seed is set under New Zealand conditions but seedlings have been observed on dunes advancing across wet flats in Manawatu (Esler 1969).

Sometimes, when there are no flower-heads, marram grass can be mistaken for the native grass spinifex, which is also a sand-binding species. Spinifex is found in most coastal sand areas in the North Island but, although it has been reported as far south as Christchurch (Simpson 1974), does not grow naturally south of the Nelson and Marlborough regions. It is usually confined to the foredune zone and can be distinguished by its softly hairy leaf sheaths and fringed ligules (outgrowths at the junction of the leaf-sheath and the leaf-blade). Marram grass has brownish purple leaf-sheaths without any hairs, and the ligules are papery. The hairiness of spinifex gives the leaves a lighter green, silvery appearance. Marram grass is likely to be darker green when vigorous, or a light straw-brown colour when conditions are less favourable for growth.

***Marram grass***

***Spinifex***

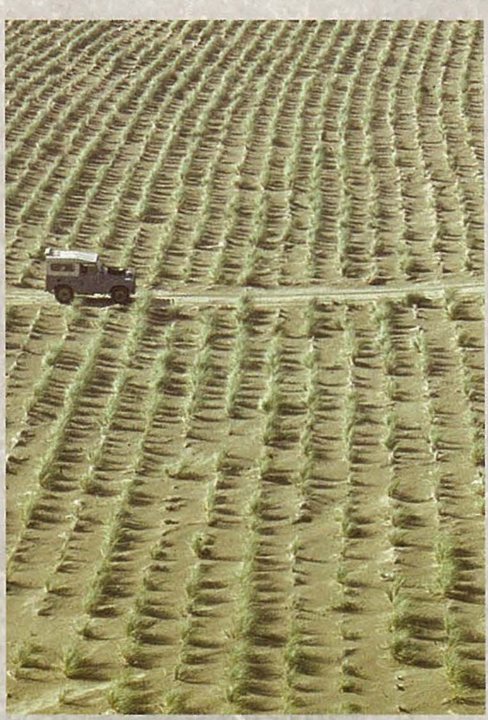
*Marram grass can be distinguished from spinifex by examining the junction between the leaf blade and the stem. The outgrowth or ligule is membranous in marram grass (left); in spinifex it forms a soft, hairy fringe.*

## Natural and Current Distribution

Marram grass is native to western Europe, where it is a major component of the coastal dune vegetation in countries bordering the North Sea, the Baltic, the Atlantic, the Mediterranean, and the Black Sea (Huiskes 1979). It has been in New Zealand for at least 125 years. The first introduction was probably in the Wellington region (Crawford 1874). At the beginning of the last century it had also been introduced into North America, North and South Africa, and Australia, and it is now naturalised in most temperate coastal regions. Its range extends between latitudes 30° and 63° in the Northern Hemisphere (Huiskes 1979), and between 32° and 55° in the Southern Hemisphere (Wiedemann and Pickart 2004). Growth and vigour seem to be restricted at latitudes lower than 34°S but the main islands of New Zealand, lying between 34°S and 47°S, are inside the optimum growth zone defined by Wiedemann and Pickart.

In this country, marram grass has been planted on a large scale and has spread vegetatively and occasionally by seeding (Edgar and Connor 2000). It is now a prominent member of plant communities growing on unstable and partially stabilised sand in most parts of the country. It has been planted on inland sand dunes near Cromwell, in Erewhon Park in the Rangitata Valley, and on drifting pumice along the Desert Road north of Waiouru (van Kraayenoord 1986a; Edgar and Connor 2000).

# History of Use in New Zealand



New Zealand's coastal sand dunes cover a total of 305 000 ha, 80% of which are in the North Island (van Kraayenoord 1986b). They extend inland for 0.1–20 km and are vulnerable to wind erosion wherever the sand is exposed and dries out. In pre-human times New Zealand vegetation was not subject to the clearing and burning that commenced with Polynesian settlement between 1100 and 1300 AD and escalated with European colonisation. Although there is evidence that mobile dunefields occurred naturally in some areas (Hesp 2000), it is almost certain that sand behind the foredune would have supported a more vigorous and diverse flora before grazing and browsing animals were introduced. There would have been less exposure and consequent movement of sand, and regrowth across breaches in the vegetation cover would have been more rapid. Human and animal activity contributed to the destruction or depletion of many indigenous dune plant communities. Large areas of sand were uncovered and exposed to wind action, and in consequence massive mobile dunes became a more common feature, especially along the west coast of the North Island (Cockayne 1911).

Economic effects of the shifting sand were all too apparent by the end of the nineteenth century. Wandering dunes inundated farmland and other valuable property in many parts of the country and road and rail communications were threatened. The New Zealand Government was eventually called upon to attend to the problem and Sand Drift Acts were passed in 1903 and 1908. Stabilisation of 115 000 ha of drifting sand was eventually accomplished by dune reshaping and revegetation, using sand fences and a method of successional planting recommended by Cockayne (1911). Revegetation involved firstly the planting of marram grass to arrest surface sand movement; secondly, the sowing of seed of tree lupin (*Lupinus arboreus*), a nitrogen-fixing shrub which completed the initial ground coverage and improved soil nutrient status; and finally the planting of trees, predominantly radiata pine (*Pinus radiata*), which provided permanent cover and the required degree of sand stability.

The resulting forests have continued to fulfil their protective role, which is not compromised by management for sustained timber production (Wendelken 1974).

# HABITAT

Marram grass will grow only in sand. It is most vigorous where surface sand is actively accumulating. On the seaward face of the foredune, growth may be inhibited by direct contact with sea water.

Mature plants tolerate sea spray aerosols and salt-laden winds but they are unable to survive concentrations of sodium chloride exceeding 1.0% in the sand (Huiskes 1979). Because of this they are more likely to colonise the upper seaward slope and crest of the foredune and sandy areas further inland.

Dense swards of marram grass may be found on the foredune if coastal erosion has washed sand away, leaving vegetation that was once behind the foredune near to the high-water mark.

*In the absence of direct contact with salt water, marram grass colonises the seaward face of the foredune.*

*Marram grass is less tolerant of salt water than spinifex. Spinifex therefore colonises the seaward face of the foredune while marram grows better on the foredune crest, lee slopes, and areas further inland.*

# How is Marram Grass Adapted for Growth in Unstable Sand?

## Underground development

Marram grass has an unparalleled capacity for rapid development and maintenance of rhizomes and roots below the sand surface. A tussock growing in loose sand consists of numbers of tillers (shoots) which develop from the tips of rhizomes at points near to the sand surface. If the plant is inundated by sand, further rhizomes form and produce tillers just below the new ground level. Initiation of new roots tends to be localised near the sand surface and is especially frequent at the base of freshly buried shoots (Willis 1965). Upward rhizome development and tiller formation are particularly vigorous when fresh sand is accumulating. Physical connection is maintained with plant parts buried at deeper levels, often several metres below the current sand surface.

*Roots and underground stems (rhizomes) extend to considerable depths and are very effective in holding and binding the sand.*

The extensive underground network of rhizomes and fine, fibrous roots holds sand grains together and can expand at a rate of at least 0.6 m/year in all directions. Below-ground dry matter accumulation of 2–4 t/ha (to a depth of 1 m) has been recorded (Gadgil 1971).

## Tolerance of sand accretion

*Marram grass tussocks trap wind-blown sand, which is deposited around the base of the plants.*

Marram grass tussocks are efficient sand collectors. The upright tillers arrest wind-blown sand grains which fall and contribute to the formation of sand mounds around the base of the tussock.

Plants have survived sand burial rates of 80–100 cm/yr (Huiskes 1979). This tolerance may be linked to an ability to survive in total darkness for longer periods than many other plants (Sykes and Wilson 1988).

Sand accretion seems to stimulate plant vigour (Marshall 1965), but increasing sand stability results in a decline of vigour. Reasons for the decline in growth rate as sand stabilises are not fully understood. Theories put forward include inability to tolerate increasing numbers of soil micro-organisms (de Rooij-van der Goes 1995), and/or physiological senescence (Wallén 1980).

## Tolerance of acidity and alkalinity

Vigorous colonies have been found growing on sands that have a high calcareous shell content and are consequently very alkaline (up to pH 9.1). They are also found on acid sands (below pH 4.5) and can therefore tolerate a very wide range of chemical conditions (Willis *et al.* 1959; Lux 1966).

## Tolerance of drought

Regular wind action causes high rates of evaporative moisture loss from sand, which has a single-grain structure and low water-storage capacity (Russell 1952). Marram grass plants are well-adapted to survive the frequent drying of sand. Transpiration pores (stomata) are concentrated on the inner ribbed and hairy surface of the leaves. This minimises exposure to air movement and reduces water loss (Purer 1942). Spongy tissue contracts when moisture levels are low, causing the leaves to become more tightly in-rolled during dry weather (Pavlik 1985). Moisture in lower sand layers is tapped by the deep and extensive fine root/rhizome system and is utilised very efficiently.

## Tolerance of high and variable temperatures

Absence of shade means that summer air temperatures on unvegetated sand dunes are high, with wide daily and hourly fluctuations. On sunny days surface temperatures may exceed those at 10 cm depth by 5–20°C. A temperature of 52°C has been recorded in surface sand at Levin in summer (Cockayne 1911). Diurnal fluctuation of 10–35°C near the surface is not uncommon. In black ironsand near Wanganui the temperature at a depth of 7.5 cm was 33°C when the air temperature was only 19°C (Cockayne 1911). Colonisation of sand by marram grass is not inhibited by these conditions, but growth is probably confined to periods when temperatures are less extreme. The plants can survive burning soon after planting, a practice once used in the Scottish Hebrides to reduce wind damage resulting in excavation of the tillers before the roots had time to develop (Hobbs *et al.* 1983). Reduction of leaf length before planting is a less drastic treatment used nowadays to serve a similar purpose.

### Tolerance of low nutrient status

Plant nutrients in recently deposited coastal sand are unlikely to be available in the proportions or amounts required for healthy growth of most species (e.g., Willis and Yemm 1961). Any soluble compounds are rapidly leached away from the rooting zone. Sea spray, rainfall, and incoming sand are the only natural external sources of plant nutrients. A negligible organic matter content means that levels of nitrogen, a major plant nutrient, are too low (<0.01%) to support the survival and growth of most species (Hawke and Maun 1988). The supply of other nutrient elements depends on the mineral composition of the sand and this varies with geographical location (e.g., Kear 1964).

Ability to colonise mobile sand requires tolerance of nutrient imbalance and efficient use of any nitrogen that becomes available. The success of marram grass on sand dunes in most temperate regions is a demonstration of this ability. Although it can grow in unstable sand of low nutrient status, shoot numbers, height, and dry weight are usually increased by the addition of NPK fertiliser. The response to nitrogen is always particularly marked (Willis and Yemm 1961).

Stands of marram grass can support populations of free-living nitrogen-fixing bacteria in the vicinity of the roots. The activity of these organisms appears to play an important part in the nitrogen nutrition of the plants (Hassouna and Wareing 1964).

Symbiotic fungi (vesicular-arbuscular mycorrhizas) have been observed in the roots of marram grass growing on unstable and semi-stable dunes. They are thought to increase the availability of less-soluble compounds (especially those containing phosphorus); to increase tolerance of drought and salt stress; and to provide protection against soil pathogens (Koske *et al.* 2004).

### Tolerance of wind action

The tough wiry leaves are anatomically adapted to withstand strong winds and associated sand movement that cause prolonged physical battering, abrasion, and desiccation (Purer 1942). Smooth outer surfaces and the narrow pointed shape of the rolled leaves offer minimum resistance to wind. Growing points of shoots and roots are located underground where they are protected from desiccation and sand abrasion.

### Resistance to browsing

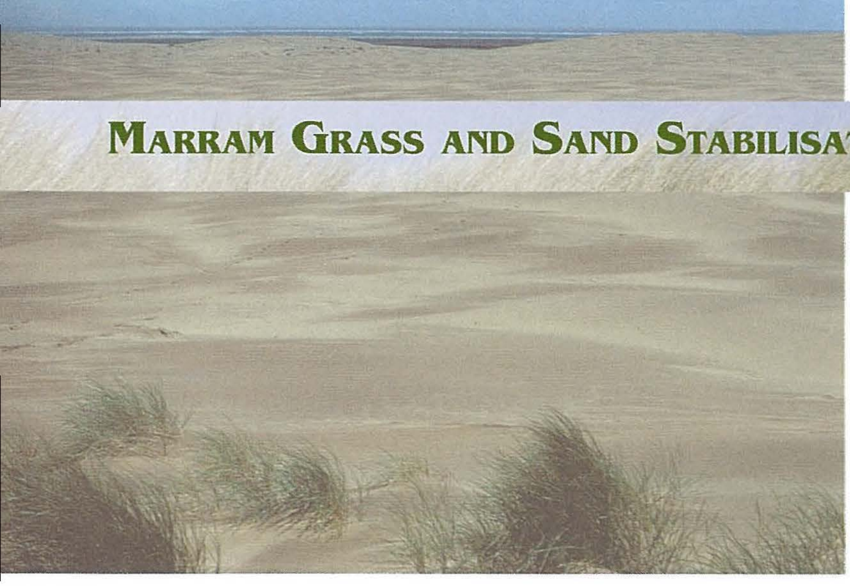
New Zealand sand dunes and their vegetation commonly support populations of rabbits, hares, and small rodents. Mature marram grass is less palatable to rabbits than many other dune species (Esler 1969). Sand dunes are sometimes accessible to feral goats, deer, and even wild horses. Farm managers often use dunelands as grazing areas for cattle, sheep, horses, and goats. Cattle, sheep, and horses will eat marram grass only when other fodder is unavailable. The plants spread mainly by vegetative reproduction, so there is little dependence on a vulnerable seedling stage. Tiller replacement from underground rhizomes usually compensates for browsing damage.

### Resistance to pests and disease organisms

In New Zealand, marram grass is free from major diseases (van Kraayenoord 1986a). Three pathogenic fungi (*Claviceps purpurea* causing ergot; *Uredo* sp. which is a rust; and *Colletotrichum graminicola* causing leaf spot) have been recorded on flower-heads or leaves but are not considered to be important. Huiskes (1979) listed a number of western European insect species known to feed on marram grass. All of these feed on other species as well and cause little permanent damage to marram grass even though 30–40% of the tillers may be killed. Organisms commonly found in soil (e.g., nematodes and fungi) may contribute to the decline in vigour which is associated with older marram grass colonies on semi-stabilised sand (van der Putten and Troelstra 1990).

*Providing that nitrogen is supplied, marram grass will grow well on a wide range of sand types including the alkaline, black, titanomagnetite-bearing sand of the Manawatu coast (left) and the more acid, lighter-coloured sands found elsewhere (right).*

# Marram Grass and Sand Stabilisation



Stabilisation of coastal sand is the conversion of mobile sand into a permanently fixed substrate. It involves a sequence of four major processes:

- Sand-trapping
- Sand-binding
- Sand-covering
- Organic matter build-up and soil formation.

Marram grass is useful only for *initial* sand stabilisation. It is an effective sand collector by virtue of the density and erect form of its tussocks (Cockayne 1911). Sand grains are arrested and built up into small mounds around the tussocks; new roots, rhizomes, and shoots grow through the sand as it accumulates; and the three-dimensional underground network holds the sand grains together. The capacity for both sand-collecting and sand-binding, combined with a rapid growth rate in most temperate latitudes, makes this species physically effective during the early stages of sand stabilisation. The fixing of extensive dune systems in Northland, Auckland, Waikato, Manawatu, Canterbury, Otago, and Southland was accomplished through initial use of marram grass. Large tracts of sand along the west coast of the North Island, in North Canterbury, and parts of Otago are still covered in marram grass originally planted to reduce sand movement. These areas can be regarded as semi-stable: the sand is still vulnerable to erosion in the event of damage to the vegetation cover.

Other plant species are required for *intermediate* and *final* sand stabilisation. Many people forget that the planting of marram grass is not the end of the sand stabilisation procedure. Marram grass populations that do not receive a regular supply of fresh sand or regular dressings of nitrogenous fertiliser may eventually lose vigour and become moribund.

Experience has shown that vegetation with strong, deep roots and a greater potential for providing permanent cover and adding organic matter to the ecosystem will be needed to hold the sand permanently. Native trees and shrubs that were once prominent members of the sand dune forest community are ideal candidates for this role. These species need a semi-stable substrate and some shelter in order to become established. As soon as the marram grass stand has developed sufficiently, they can be introduced to grow with the grass and eventually replace it.

Sustainability of the vegetation cover will increase as more decaying material (litter) containing carbon and nitrogen is added to the sand, and the long process of soil formation will begin. Before human intervention (burning, grazing, introduction of browsing animals), large areas of New Zealand's sand dunes were firmly fixed by native shrubs and trees that fulfilled this role and provided effective resistance to wind erosion (Cockayne 1911).

*If there is no sand movement, marram grass eventually loses vigour.*

*Where necessary, transition from bare sand to native forest can be assisted by use of marram grass in the early stages. The grass is eventually suppressed as the shrubs and trees develop. When mature they fix the sand permanently.*

# Studies Comparing Marram Grass with Other Species

*The three major sand-binding species in New Zealand are the native grass spinifex (left), the native sedge pingao (centre), and marram grass (right). Spinifex colonises the foredune but does not grow well further inland.*

## Tolerance of salt water

Of the three major sand-binding species in New Zealand (marram grass, the native grass spinifex, and the native sedge pingao), marram grass is least tolerant of the effects of seawater (Esler 1978).

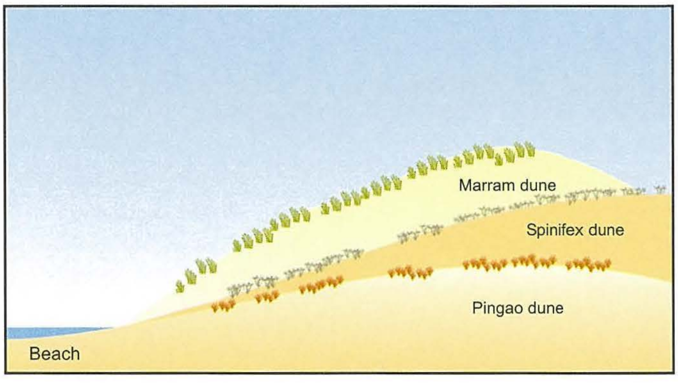
Marram grass is therefore often less successful as a coloniser of the seaward face of the foredune than either spinifex or pingao, even though it grows more vigorously than these species behind the foredune crest.

*Marram grass cannot tolerate direct contact with salt water.*

## Influence on dune shape and size

Esler's (1978) observations in Manawatu showed that foredunes formed under marram grass were steeper (24–28°) and higher (≥ 8 m) than those associated with the native sand-binding grasses spinifex (14–16°; 6 m) and the less-abundant pingao (8–14°; < 3 m). This was attributed to the fact that above-ground shoot systems of spinifex and pingao are more extensive and diffuse than those of marram grass. According to Esler, a dune formed by spinifex or pingao will be lower but will cover a greater area to leeward than that formed by marram grass.

Colonisation by marram grass can have a pronounced effect on sand migration and dune shape. This can be turned to advantage if careful planting and long-term maintenance are assured (Restall 1964) but is likely to have negative or destructive consequences if there is no vegetation management (Hilton *et al.* 2005).




*Dunes formed under marram grass are higher and steeper than those developing under spinifex or pingao (after Esler 1978).*

## Wind effects and sand trapping

Esler (1978) drew attention to the tendency for wind to be funnelled between marram tussocks. This leads to erosion, channelling, and blowouts if roots and rhizomes are not continuously well-developed beneath the sand surface. "Turret" formation ensues if plant vigour and density are not maintained.

*Sand erosion and "turret" formation are likely if marram plants are spaced too widely, if dead plants are not replaced, or if there is no regular treatment with nitrogen fertiliser.*

Pingao is subject to turret formation, but to a lesser degree. Spinifex, with its long, faster-growing surface runners, disperses wind and sand more evenly.

In a study of the aerodynamic effects of sand dune vegetation, Holland (1981) found that individually the dense erect tussocks of marram grass had a greater sand-trapping effect than the more diffuse tufts of pingao. The decrease in windspeed to leeward of a marram grass tussock was more pronounced, while lateral windspeeds were greater, and this resulted in strong eddy formation. Lower leeward and lateral windspeeds associated with pingao plants resulted in weaker eddying and deposition of smaller amounts of sand in mounds with a smoother topography. In spite of marked differences at the individual plant level, Holland could find no clear differences between the species in terms of interaction with sand movement when groups of plants were compared.

Although pingao is an efficient sand collector, it is a less-effective sand-binder than either marram grass or spinifex because it grows more slowly (Holland 1981) and is more sensitive to erosion of sand around roots and buried rhizomes (Esler 1970). It is less tolerant of exposed sites than marram grass, and its rhizomes tend to develop more rapidly downslope than in an upslope direction. In habitats that are equally suitable for marram grass, spinifex, and pingao (i.e., the upper seaward face and crest of the foredune), spinifex is therefore the more effective native sand stabiliser. Where spinifex grows less vigorously (i.e., on most dune sites landward of the crest of the foredune), marram grass is more effective than either spinifex or pingao by virtue of its faster growth and multidirectional above-ground development.

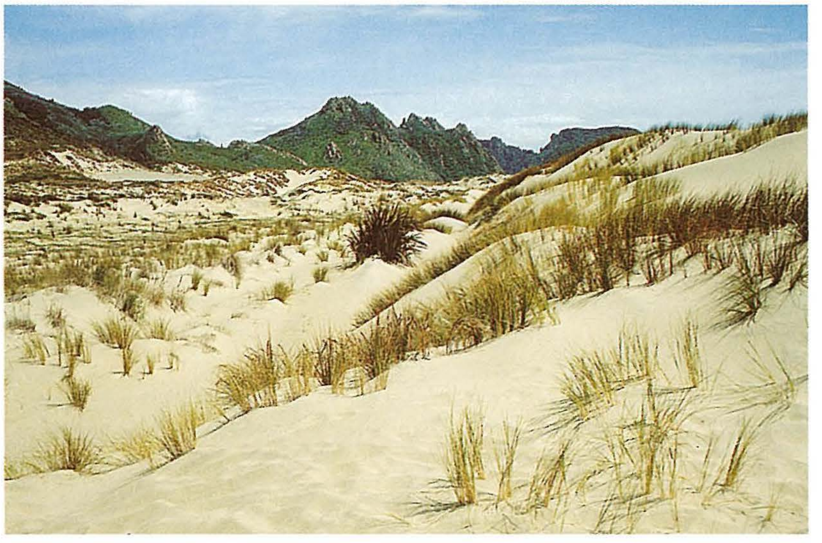
## Competition effects

According to Esler (1978), marram grass does not compete well with spinifex on the foredune.

Although Hilton *et al.* (2005) have shown that pingao cannot co-exist with marram grass in active dune sites, Partridge (1995) has described circumstances under which marram grass does not constitute a threat to pingao. These include any situation in which marram growth is restricted by lower salt tolerance or an inadequate supply of fresh sand. Where moisture is not a growth-limiting factor, the two species can co-exist as a mixture even though marram grass may assume dominance. In a glasshouse pot trial, Dixon *et al.* (2004) showed that marram grass was more tolerant than pingao of water deprivation.

Research on inter-species relationships in radiata pine forests on sand dunes has shown that, although marram grass retained its vigour in 5-year-old tree stands planted at 2224 stems/ha, plants did not survive tree canopy closure (Gadgil 1983). Marram grass is a light-demanding species that cannot tolerate shading.

*Marram grass cannot tolerate shade. It will die as soon as light is restricted by taller vegetation.*



*The Department of Conservation is controlling the spread of marram grass in southern New Zealand to prevent loss of natural populations of native dune species such as sand tussock and pingao.*

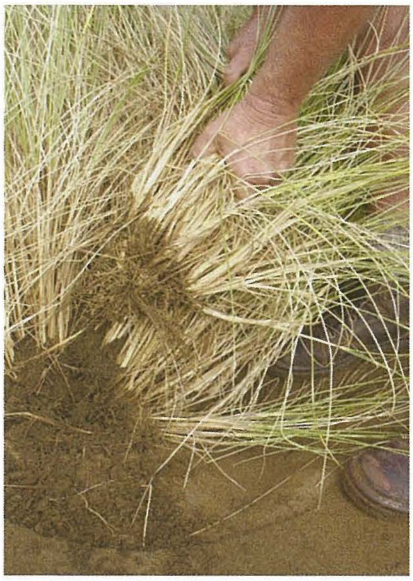
Current interest in the restoration of native vegetation has stimulated planning for the replacement of exotic species with native plants. Providing that the consequences are clearly understood, it may be necessary or desirable for marram grass populations to be contained, reduced in size, or eradicated. Choice of method will depend on the extent and density of the stands and the nature of resources available for undertaking the work. Restriction or removal of marram grass may compromise sand stability and this possibility must be considered carefully before any control or eradication measures are put into practice. On exposed sites where sand mobility is regarded as a threat, maintenance of a vegetation cover should be the priority even if conversion from an exotic to a native plant community is likely to be a lengthy process.

Removal of marram grass can be achieved by hand-pulling if it is done frequently over a long period (Partridge 1995). Rhizome material left in the ground is likely to grow more vigorously, probably because sand is disturbed and older material is removed. Hand pulling is not considered to be practical, especially on a large scale.

Other methods found to be effective, especially when used in combination, are excavation or deep burial using earth-moving equipment; repeated burning; and repeated application of herbicide (Wiedemann and Pickart 2004). Herbicides have been used by the Department of Conservation in parts of South Westland, Southland, and Stewart Island where marram grass is considered to impede the natural development of the dune flora, fauna, and overall morphology (M.J.Hilton, University of Otago Department of Geography, unpubl. reports). The possible consequences of marram grass removal are assessed at the start of their management programmes. If undesirable sand movement is at all likely, spot-spraying techniques are used to allow development of pingao and other native plants and to minimise damage to the vegetation cover.

For total eradication of marram grass, blanket aerial and ground spraying with the grass-specific systemic herbicide haloxyfop (Gallant and Gallant NF plus the additive Uptake) achieved a 70–95% kill after each application, but at least two operations in successive years were required for complete eradication. Results with the herbicide glyphosate (Roundup plus the additive Maximiser) which kills a broad range of species, were much more variable (10–90% kill rate). Gallant does not affect pingao, which is a sedge, but native grasses should be protected from contact with the spray.

The planting of shrubs and trees is an effective but longer-term method of removing marram grass wherever an appropriate woody vegetation cover can be established. Development of a dense overtopping canopy will completely suppress growth of this light-demanding species. In the absence of any buried seed source no regeneration can occur, even if canopy gaps develop at a later stage.



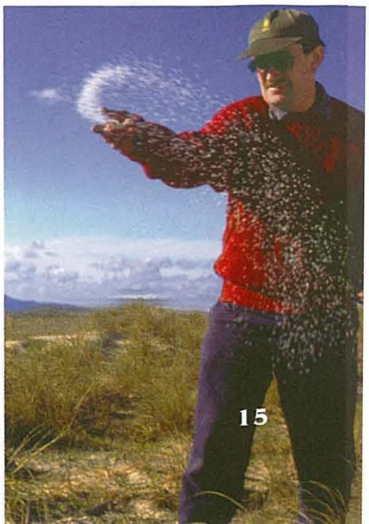
*Planting material is taken from healthy marram tussocks (left). Bunches of tillers with roots and rhizome buds are trimmed (centre) and planted deep into the sand (right).*

Although use of native plants is to be encouraged wherever possible, there are dune sites where sand mobility is an urgent concern and practical alternatives to the planting of marram grass are not available. For example, good quality native planting stock may be in short supply; or, where spinifex cannot be used (most areas behind the foredune; dunes in the south of the South Island), there may be insufficient confidence in the effectiveness of alternative native sand-binders. The planting of marram grass may be justified in such situations. The possibility of replacement with native species at a later stage can be borne in mind wherever this will lead to an increase, rather than a reduction, in the density and extent of the vegetation cover.

Methods used for marram grass establishment in successful sand stabilisation projects in New Zealand have been described in detail by Restall (1964), Wendelken (1974), van Kraayenoord (1986b), and McKelvey (1999). Material for planting is ideally derived from a "nursery" area of 2-year-old marram grass growing in a flat, sheltered, but not wet location. The grass stand should have received nitrogenous fertiliser in the first spring and autumn (10 kg N/ha/application) and a heavier application (50 kg N/ha) in the second spring. During the following winter, tussocks are dug out. Tillers with roots and rhizome buds attached are bundled in groups of approximately 500, top-trimmed to a length of 60 cm (to reduce transpiration and wind resistance), and immediately stored so that roots are covered with damp sand. Grass in the dug-over area will regenerate during the following season.

Handfuls of about 12 tillers are planted to a depth of about 40 cm at a spacing of 0.5–1.4 m. Orientation of planting rows at right angles to the prevailing wind, the staggering of plant positions in adjacent rows, and closer plant spacing all reduce the likelihood of wind funnelling and sand excavation. All planting prescriptions involve the use of nitrogenous fertiliser (10 kg N/ha/application, broadcast) at time of planting and further applications in spring and autumn are recommended (Restall 1964; Wendelken 1974).

Prompt replacement of buried or blown-out plants is essential. The development of roots and rhizomes is expected to bind the sand sufficiently for other species to be introduced one or two years after planting. Annual or (preferably) six-monthly nitrogen fertiliser application will maintain plant vigour until organic matter cycling within the ecosystem becomes self-sustaining. Interplanting with nitrogen-fixing plant species is an efficient alternative to repeated fertiliser treatment but raises difficulties because no native nitrogen fixer has been found to be suitable for this purpose. Exotic plants identified as alternatives to tree lupin, once used to supply biologically-fixed nitrogen to planted marram grass (Douglas *et al.* 2004), are unlikely to be acceptable.



*Regular treatment with nitrogen fertiliser will be needed to maintain healthy growth and ensure rapid underground development.*

## Marram Grass as a Nurse for Native Dune Plant Species

Many specialised dune plants such as tauhinu, karo, ngaio, and flax are secondary colonisers, unable to tolerate the degree of sand movement that actually increases the vigour of marram grass, spinifex, and pingao. They are well-adapted to dune conditions that would exclude many other species, but will not establish on mobile dunes or blowouts unless a sand-binding plant has colonised the site first. They cannot grow on the foredune, where spinifex (within its natural distribution range) and other native sand-binding species are able to trap and hold the wind-blown sand particles. Unfortunately, none of the native sand-binders, including spinifex, grows as vigorously as marram grass on exposed mobile sand behind the foredune. In this particular habitat, marram grass is the only species that can be relied on to hold the sand particles long enough for secondary successional species to become established.

If populations of the native open-dune flora are to be re-established behind the foredune, or if native forest is to be re-established further inland, it would be wise to arrest any mobile sand first, even if this occurs in relatively small pockets. On sites that are too exposed for direct introduction of native species, planting of marram grass can modify conditions and provide an environment that is more suitable for the establishment and growth of secondary dune colonisers. Pegman and Rapson (2005) acknowledged that the establishment of native species in rear dune communities may be facilitated by the relatively stable environment provided by marram grass.

*Native plants such as tauhinu and pohutukawa will survive only if the sand is partially-stabilised and shelter is provided.*

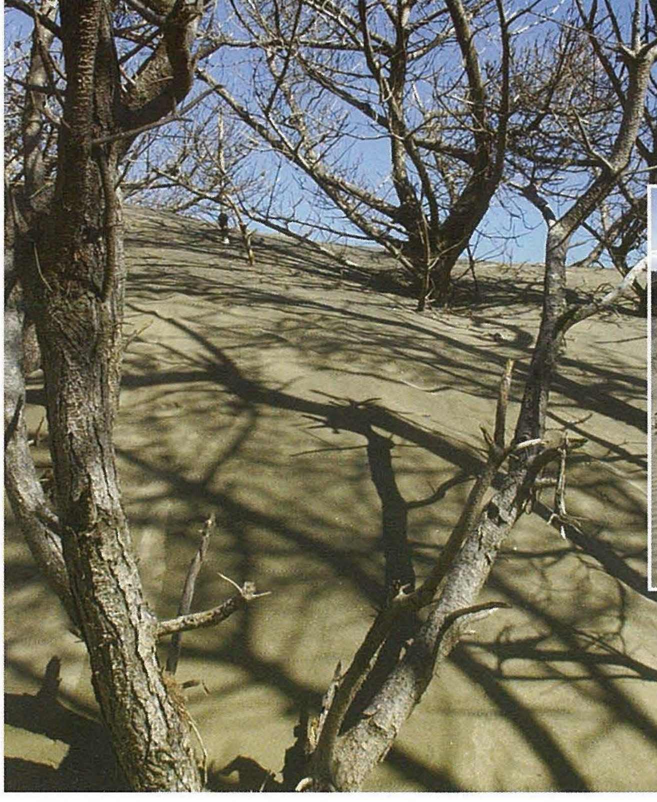
## Management of Marram-dominated Dunes

*Neglect of planted marram grass can lead to wind-funnelling, severe gully erosion and an irregularly-shaped foredune.*

Foredunes dominated by marram grass can be up to 11 m high.

The seaward faces of these dunes are often steep, with irregular contours. Marram grass is often present as isolated clumps, although from the crest of the foredune landward the stands are more continuous. On exposed coastlines with prevailing on-shore winds and a plentiful supply of mobile sand, any fragmentation of the vegetation cover will promote wind funnelling between tussocks and lead to erosion and the formation of blow-outs. Unless these are repaired, there is a very real danger that large volumes of sand transported inland will overwhelm backdune vegetation and inundate beachside amenities such as carparks, roads or housing.

For many years the then Department of Lands and the New Zealand Forest Service followed the advice of Cockayne (1911) who pointed out that windblown sand could be arrested on the foredune, providing that an even height was established and maintained. Sand fences were built across gullies at right angles to the prevailing wind and new fences were erected as soon as the old ones were buried under trapped sand. When gaps were filled, marram grass was planted and managed carefully to prevent further wind-funnelling and erosion (Restall 1964; Wendelken 1974). The development of a continuous and carefully monitored foredune made it possible for stabilising vegetation



*Once started, mass movement of sand is very difficult to arrest. Mobile dunes will inundate anything in their path including wetlands (top right), forests (left and centre), and roadways (below).*

(ultimately protection/production forest) to be established to leeward.

Nowadays the use of modern earth-moving equipment can speed up the dune-reshaping process. The Christchurch City Council has a regular programme for bulldozing large areas of sand and replanting the evenly contoured foredunes with sand-binding plants. Similar programmes are in place on the Kapiti Coast, the Manawatu Coast, New Plymouth, Coromandel, Auckland, and Northland. The success of all these projects will depend on continued surveillance and management (e.g., replacement of dead plants; fertiliser treatment) of the revegetated sites.

Although the aim of any dune management programme should be the restoration of a sustainable ecosystem that includes as many native dune species as possible, there are many exposed coastal areas, particularly behind the foredune on the west coast of the North Island and the south-east of the South Island, where sand stability could be threatened if native species are introduced too early in the reconstructed plant succession. The planting of marram grass and its maintenance may be the only practical method by which colonisation of bare sand can be initiated. Appropriate species should be introduced as soon as the marram grass can provide the degree of sand stability and protection required for their successful establishment. Unless other species are introduced, careful and expensive management of the marram grass stand may be required in order to retain vegetation cover and prevent sand movement. The possibility that planted marram grass could spread into areas where sand stability is not an issue must always be kept in mind.

*This reshaped foredune at New Plymouth has been planted with spinifex.*

# Who Regards Marram Grass as a Friend?

## Landowners and managers dealing with sand drifts and blowouts

Most coastal landowners and managers, when faced with sand drift problems, acknowledge the need for arresting, binding, and permanently covering areas of mobile sand as soon as possible. This can be achieved with coverings of artificial materials such as concrete, roading metal, and plastic products, but the direct use of self-sustaining and sometimes productive vegetation is usually a more attractive alternative, especially when large areas are to be considered.

The planting procedure in such situations will involve firstly the establishment of sand-binding species. In New Zealand, spinifex, within its natural range, is the plant best adapted to conditions on the seaward face of the foredune (Bergin 1999). As a member of the indigenous flora, this species enhances the natural character of the dunes and thus fulfils a dual purpose. However its landward limit is only about 100 m from the sea (Esler 1970). Other native sand-binders such as pingao (Bergin and Herbert 1998), sand tussock (Bergin 2000) and euphorbia are often less vigorous when planted behind the foredune, and an alternative sand-binding species is needed for drifts and blowouts in exposed areas. No native plant is as effective as marram grass for initiating sand stabilisation, and in areas other than the foredune this species is currently the first choice for use as a sand collector and sand binder if inundation or erosion is a problem.

Managers, especially those responsible for long stretches of sandy coastline exposed to strong winds, regard marram grass as an essential tool for starting the stabilisation process and for providing sufficient shelter for other plants to become established in areas behind the foredune.

## Owners of property adjacent to sand dunes

Unmanaged sand dunes present a potential threat to neighbouring properties. Breaks in the vegetation cover and exposure of dry sand can easily lead to the formation of blowouts and sand drifts that may inundate pasture, alter water courses, close roads, and even bury houses.

*This blowout in the area behind the foredune is unlikely to be recolonised by plants unless marram grass is used as a primary sand stabiliser and provider of shelter for other species.*

The fixing of large areas of coastal sand in the extensive rear dune systems of Northland, Auckland, Waikato and Manawatu was largely dependent on the use of marram grass during the early part of the revegetation process.

Around Your Region

Evening Standard

THURSDAY, SEPTEMBER 14, 1995

HIMATANGI

Sand dune threatens to swallow up house

# Who Regards Marram Grass as an Enemy?

### Guardians of the native flora and fauna

The introduction or encouragement of a highly successful exotic coloniser is seen as a threat to indigenous species by many people who work to protect and restore natural ecosystems on the coast. Concern has been expressed in many countries that marram grass introduced for sand stabilisation purposes has been so successful that it has displaced native species and altered the character of local plant communities (Martínez *et al.* 2004). Evidence from California suggests that colonisation of sand dunes by marram grass disrupts the structure of arthropod communities and reduces species diversity (Slobodchikoff and Doyen 1977). Marram grass is often regarded as a weed and its eradication is expected to enhance the natural development of native dune species.

In New Zealand, several plant ecologists have described the invasiveness of marram grass and its current dominance at the expense of native species, especially pingao (e.g., Wardle 1991; Partridge 1992, 1995; Walls 1998).

### Some geomorphologists

Scientists who study the origins and development of land forms have a particular interest in natural processes of rock erosion, deflation, accretion, and consequent changes in topography. They regard wind erosion and sand movement as natural processes, and may consider any attempt at stabilisation to represent interference with the natural character of sand dunes (see, for example, Wiedemann and Pickart 2004). There is no doubt that destruction of the indigenous vegetation cover resulting from human activity and the introduction of browsing animals modified the shape and inland extent of our coastal dune system (Cockayne 1911). Conversion of extensive sand drifts into forest and pasture during the last century restored the vegetation cover, relying mainly on exotic species. This caused further modification of dune morphology, as will any future human interference in the form of vegetation removal or sand stabilisation measures.

One disadvantage of the tussock habit of marram grass in sand stabilisation work is that wind-funnelling between plants may cause erosion of sand which has not yet been penetrated by roots and rhizomes. If air speeds are sufficient to excavate and dislodge adjacent plants, remaining tussocks and the sand held by their roots may then contribute to the "turret" topography typical of neglected plantings on exposed sites.

*At Mason Bay, Stewart Island, marram grass is being eradicated in an attempt to restore the natural character of the dunes.*

## I am concerned about dune care. I have economic, environmental, and social responsibilities. Do I use marram grass or should I destroy it?

There is no single answer to the above question — every combination of circumstances will present a different set of priorities. The nature of the sand dune environment varies from coast to coast, changes with latitude, and is also affected by sand source, topography, aspect, and past history of burning, grazing, or planting.

### In some situations the use of marram grass is clearly undesirable

There is no doubt that surviving remnants of the natural flora and fauna on New Zealand sand dunes must be preserved wherever possible, and that all practicable steps should be taken to protect them. There is considerable potential for native plants which are low in stature to be suppressed by marram grass if there is no management intervention. Providing that sand stability is not an issue, marram grass should not be planted in their vicinity and any encroaching tillers should be removed.

A policy of eradicating marram grass is taking effect in National Parks in Fiordland and Stewart Island where a considerable amount of research on control methods and results has been undertaken by the Department of Conservation in collaboration with the University of Otago (Mike Hilton and colleagues, Department of Geography, unpubl. reports). In other parts of the country, areas designated for conservation of existing native flora and fauna may be amenable to marram grass control, but this will require long-term vigilance on the part of those responsible for coast care.

### In some situations, the use of marram grass is the only practical option

Even on the foredune, if mobile sand is causing problems and the use of spinifex or pingao is not a practicable option, marram grass is still the only alternative as a stabilising plant. This is likely to be so in coastal areas outside the natural range of spinifex, or where the supply of native sand-binding plants is limited. The introduction of marram grass to areas in which it is not already a member of the local flora should be regarded as an extreme "last resort" solution.

In the area of duneland behind the narrow strip of the foredune, marram grass is the only species known to be able to hold drifting sand long enough for other species to become established. Mobile sand in wandering dunes and blowouts can be arrested and the revegetation process initiated by the planting of marram grass. Other species can then be introduced and/or protected from suppression through careful management. The New Zealand Forest Service demonstrated beyond any doubt that the planting of marram grass was a fundamental step in the conversion of bare sand to high forest. During the last century, the creation of sustainable exotic forests at Aupouri, Pouto, Mangawhai, Woodhill, Waiuku, Kawhia, Santoft, and Waitarere was a remarkable example of a planned increase in the density and diversity of plants, animals, and microbes from virtually zero to uncountable numbers per cubic metre over an area exceeding 110,000 hectares. What was possible for exotic forests is no less possible for native forest and shrubland, again comprising countless species in a planned and self-adjusting community. Marram grass can be used to provide the initial sand stabilising step that will allow the establishment of native plant species and eventually the self-sustaining development of native plant, animal, and microbial communities. There is great potential for the careful replacement of existing marram grass stands with appropriate shrub and tree species. The planting and subsequent replacement of marram grass can open up opportunities for completion of the process of succession from bare sand to a stable native duneland plant community.

*Once established, native plants can survive to maturity and grow well in coastal sand.*

# A Multiple-choice Guide for Managers

This section is a practical guide for people involved in coast care. It will help them to identify their own particular problems in the sand dune landscape and to decide whether marram grass is likely to be an essential, useful, neutral, or undesirable part of the solution. The key is based on information presented above and also on the following considerations:

- Marram grass has not been classified as an Unwanted Organism in this country. Providing that the consequences of its use are understood and managed properly, it can be a very helpful tool.
- The use of fire and the introduction of browsing animals have had a massive destabilising effect on sand dunes through destruction of the natural vegetation cover. Most of New Zealand's coastal dunes have been modified in this way.
- Unstable sand can be a real or potential threat to human productivity.
- Initial stabilisation of mobile sand by pioneer sand-binding plants is necessary before secondary colonisers can be introduced.
- Native sand-binders do not grow well in unstable and semi-stable sand in the area behind the foredune. Marram grass thrives in this environment.
- Many specialised rear dune species are not sand-binders and need some sand stability and shelter during the establishment phase.
- Once marram grass has initiated the process of sand stabilisation behind the foredune, interplanting with other species becomes a possibility. Providing that continuous vegetation cover is achieved and maintained, there is no need for marram grass to dominate the plant community.
- Marram grass does not tolerate shade.

**START HERE and follow the numbers until guided to one of the Scenario Advice Sections A to J.**

| | | |
|---|---|---|
| **1** | (a) There are no areas of unvegetated mobile sand on the dunes and little or no sand accretion | → Go to 2 |
| | (b) There are areas of mobile sand on the dunes | → Go to 6 |
| **2** | (a) The vegetation cover contains very little marram grass | → Consider eradication of marram grass See Section A |
| | (b) The vegetation cover consists almost entirely of marram grass | → Go to 3 |
| **3** | (a) The marram grass cover is satisfying all my requirements | → Do nothing |
| | (b) I would like to introduce native dune plants to replace marram grass wherever possible | → Go to 4 |
| **4** | (a) The marram grass is on the foredune | → Go to 5 |
| | (b) The area of marram grass lies behind the foredune | → Interplant with native dune species. See Section B |
| **5** | (a) Earth-moving equipment is available | → Interplant marram grass with spinifex or pingao. See Section D |
| | (b) Dune re-shaping is not a practical option | → Consider dune re-shaping and planting of native sand-binders. See Section C |
| **6** | (a) The mobile sand is not causing any problems. It is an integral part of the natural character of the dune landscape | → Consider eradication of marram grass. See Section E |
| | (b) The area of mobile sand is increasing. It is associated with unacceptable erosion or inundation of vegetation cover, nearby structures or properties | → Go to 7 |
| **7** | (a) The area of concern is the foredune, i.e., the line of dunes nearest to the sea | → Go to 8 |
| | (b) The area of concern lies behind the line of dunes nearest to the sea | → Go to 9 |
| **8** | (a) The area of concern (the foredune) lies in a region where marram grass does not exist or is being eradicated under a carefully considered programme (e.g., Fiordland and Rakiura National Parks) | → Do not introduce marram grass. See Section F |
| | (b) The area of concern(the foredune) lies in a region where marram grass is an acceptable current constituent of the local flora | → Go to 10 |
| **9** | (a) The area of concern (behind the foredune) lies in a region where marram grass does not exist or is being eradicated under a carefully considered programme (e.g., Fiordland and Rakiura National Parks) | → Do not introduce marram grass. Try pingao, sand tussock or euphorbia. See Section G |
| | (b) The area of concern (behind the foredune) lies in a region where marram grass is an acceptable current constituent of the local flora | → Plant marram grass first, native dune plants later. See Section H |
| **10** | (a) The area of concern ( the foredune) lies within the natural distribution range of native sand-binding plants. Use of native sand-binders is a practical option | → Plant spinifex and/or pingao. See Section I |
| | (b) Use of native plants is not a practical option | → Plant marram grass as a last resort. See Section J |

## A

### Continuous vegetation cover; very little marram grass.

Eradicate marram grass by continued hand-pulling or repeated application of haloxyfop (e.g., Gallant at label rate) using a weed wiper.

## B

### Continuous marram grass cover behind foredune.

Exclude grazing and browsing animals. Plant native dune species between the marram grass tussocks (establishment from seed is not likely to be successful). Spot-spraying with grass-specific herbicide (haloxyfop) may be necessary to allow space for plants to develop. Mix slow-release nitrogenous fertiliser (e.g., 30 g Magamp or Agroblen) with sand in each planting hole. Stands of marram grass aged 1–2 years are most suitable for the introduction of secondary colonisers. A list of plant species that may have potential for use in stabilisation procedures is given in the Appendix.

## C

### Marram grass-dominated foredune with no mobile sand and little sand accretion - earth-moving an acceptable option.

Use earth-moving machinery to reshape the dune and remove marram grass. Exclude grazing and browsing animals. Plant spinifex and/or pingao at close spacings, mixing slow-release nitrogenous fertiliser (e.g., 30 g Magamp or Agroblen) with sand in each planting hole. Monitor carefully and replace dead plants immediately. Broadcast fast-release nitrogenous fertiliser (e.g., 40 kg urea/ha) every spring and summer until continuous cover has been established.

## D

### Marram grass-dominated foredune with no mobile sand. Dune reshaping impractical.

Exclude grazing and browsing animals. Commence replacement of marram grass by interplanting with spinifex and/or pingao. Spot-spraying with grass-specific herbicide (haloxyfop) may be necessary to allow space for pingao plants to develop. Herbicide will kill spinifex. Mix slow-release nitrogenous fertiliser (e.g., 30 g Magamp or Agroblen) with sand in each planting hole. Broadcast fast-release nitrogenous fertiliser (e.g., 40 kg urea/ha) every spring and autumn.

## E Mobile sand present and tolerated.

Blanket spray with haloxyfop (e.g., Gallant at label rate) to eradicate marram grass. Repeat as necessary.

## F Foredune with mobile sand - marram grass absent or being eradicated.

Do not plant marram grass. Exclude grazing and browsing animals. Arrest drifting sand in gullies by erecting physical barriers near the source of sand supply. When an even contour has been achieved, plant spinifex or pingao, mixing slow-release nitrogenous fertiliser (e.g., 30 g Magamp or Agroblen) with sand in each planting hole.

## G Mobile sand behind foredune - marram grass absent or being eradicated.

Erect physical barriers near the source of sand supply. Exclude grazing and browsing animals. Plant pingao, sand tussock, or euphorbia, mixing slow-release nitrogenous fertiliser (e.g., 30 g Magamp or Agroblen) with sand in each planting hole. Replace any dead or excavated plants as soon as possible.

## H Mobile sand behind foredune - marram grass a component of the local flora

Arrest drifting sand by erecting physical barriers near the source of sand supply. When an even contour has been achieved, plant marram grass and broadcast fast-release nitrogenous fertiliser (e.g., 40 kg urea/ha) every spring and autumn. Replace any dead or excavated plants as soon as possible. Exclude grazing and browsing animals and plant native dune species between marram grass tussocks after 1–2 years, mixing slow-release nitrogenous fertiliser (e.g., 30 g Magamp or Agroblen) with sand in each planting hole. A list of plant species that may have potential for use in stabilisation procedures is given in the Appendix.

I

## Foredune with mobile sand - native sand-binding plants available.

Do not plant marram grass. Exclude grazing and browsing animals. Arrest drifting sand in gullies by erecting physical barriers near the source of sand supply. When an even contour has been achieved, plant spinifex and/or pingao, mixing slow-release nitrogenous fertiliser (e.g., 30 g Magamp or Agroblen) with sand in each planting hole. Broadcast fast-release nitrogenous fertiliser (e.g. 40 kg urea/ha) every spring and autumn until continuous cover has been established. Monitor and repair any damage to the vegetation cover.

J

## Foredune with mobile sand — native sand-binding plants not a practical option.

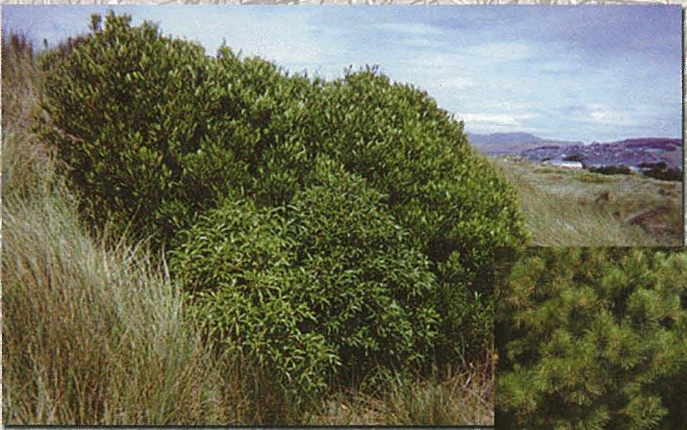
Use marram grass as a last resort. Arrest drifting sand by erecting physical barriers near the source of sand supply. When an even contour has been achieved, plant marram grass and broadcast fast-release nitrogenous fertiliser (e.g., 40 kg urea/ha) every spring and autumn. Replace any dead or excavated plants as soon as possible. Monitor and repair any damage to the vegetation cover.

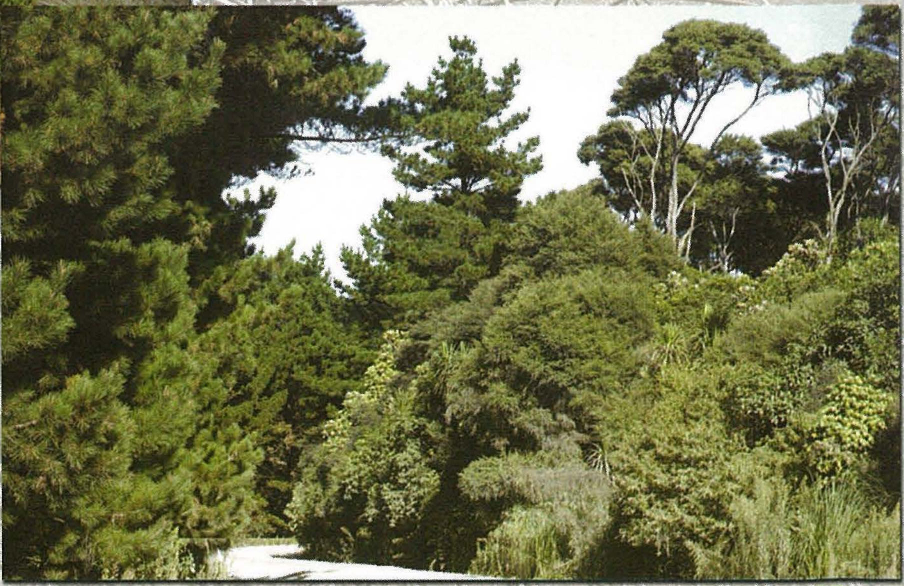
## Summary

Coastal dune managers need to be aware of the following facts:

- New Zealand's sand dunes were once covered to a greater extent by native vegetation, often high forest. Much of this natural cover was destroyed by human activity.
- Destruction of the vegetation cover exposed dry sand to wind erosion, creating more than 110 000 ha of active dunes.
- Stabilisation of 110 000 ha of mobile sand was achieved by successional planting based on use of marram grass as the initial sand-binder.
- Marram grass has been and remains an important and useful initial component of the vegetation succession on many of our sand dune areas, particularly on the west coast of the North Island and the south-east coast of the South Island.
- On the foredune, spinifex is the most appropriate native sand-binder for use within its natural distribution range (currently the North Island, Nelson/Marlborough, and North Canterbury regions). Where spinifex will not grow, pingao is likely to be the most suitable species.
- Behind the foredune, no native sand-binding plant grows vigorously enough to arrest mass movement of wind-blown sand in the short term.
- Where sand stabilisation is not a priority, marram grass can be eradicated so that existing or planted native plant communities can develop according to their natural potential.
- Where the stability of sand lying **behind the foredune** is a major concern, marram grass will be the most effective plant to use at the start of the planting succession.
- Marram grass can be used as a protective **nurse species**. Providing that browsing animals are excluded, native plants that would die of exposure on bare sand can establish and grow when sheltered by marram grass tussocks.
- Appropriate shrubs and trees established in a marram grass stand will eventually shade, suppress and replace the grass.
- Marram grass can be a useful **intermediate** tool for managers who wish to increase the natural biodiversity of New Zealand's sand dune ecosystems.

*Native shrubs and trees growing vigorously in sand stabilised by marram grass.*





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# Appendix

## 100 Native Plant Species that may have Potential for Use in Revegetation Projects on Coastal Sand Dunes

Published information about species and techniques required for large-scale re-establishment of plant communities behind the foredune is scarce, although some comparative trials with shrub and tree species have been established (D. Bergin, pers. comm.). Local vegetation remnants and historical records can be used to suggest species that would be appropriate for specific sites. More research work is required in order to develop recommendations for establishment and management; in the meantime, Department of Conservation and Regional Council staff can advise on the preservation and use of many of these species.

| Scientific name | Common name | Dune zone | Special features |
|---|---|---|---|
| *Apodasmia similis* | Oioi; Jointed wire rush | Moist sand flats | Rhizomatous. Traps sediment. |
| *Aristotelia serrata* | Wineberry | Coastal forest | Found in sheltered hollows or later successions. Light-demanding. |
| *Astelia banksii* | Kowharawhara | Backdune forest | Drought tolerant understorey plant. A northern species. |
| *Austrofestuca littoralis* | Hinarepe; Sand tussock | Foredune; sand plains | Sand-binder; sand collector. |
| *Calystegia soldanella* | Nihinihi; Shore bindweed | Foredune and other unstable sand | Salt and drought tolerant; sand-binder. |
| *Carex pumila* | Dune sedge | Unstable sand hollows | Sand-binder. |
| *Carex testacea* | Speckled sedge | Semi-stable sand | Very hardy. |
| *Carmichaelia australis* | Makaka; NZ broom | Semi-stable sand | Small bush with lavender flowers |
| *Coprosma acerosa* | Tataraheke; Tarakupenga; Sand coprosma | Unstable sand. | Effective sand-trapper. More common in the south. Susceptible to browsing. |

| Scientific name | Common name | Dune zone | Special features |
|---|---|---|---|
| *Coprosma foetidissima* | Hupiro; Stinkwood | Coastal forest | |
| *Coprosma lucida* | Karamu | Coastal forest | |
| *Coprosma propinqua* | Mikimiki | Coastal forest and shrubland | |
| *Coprosma repens* | Taupata | Dune scrub. | Shrub or small tree. Very hardy. |
| *Coprosma rhamnoides* | Twiggy coprosma | Coastal forest | Shrub. |
| *Coprosma robusta* | Karamu | Coastal forest | Shrub. |
| *Cordyline australis* | Ti kouka; Cabbage tree | | Tree. |
| *Coriaria* spp. | Tutu | Semi-stable and stable sand | Nitrogen-fixers. Light-demanding. |
| *Cortaderia fulvida* | Toetoe | Stable sand | Large tufted grass. North Island only. |
| *Cortaderia richardii* | Toetoe | Semi-stable or stable sand | Large tufted grass. South Island only. |
| *Cortaderia splendens* | Toetoe | Lee slopes of unstable dunes | Stout rhizomes extend several metres through sand. Northern North Is. only. |
| *Cortaderia toetoe* | Toetoe | Sand plains | Central and southern North Is. |
| *Corynocarpus laevigatus* | Karaka | Coastal forest | Salt tolerant |
| *Cyperus ustulatus* | Giant umbrella sedge | Damp sand hollows | Tufted perennial. |
| *Dacrydium cupressinum* | Rimu; Red pine | Coastal forest | Requires shelter. |
| *Desmoschoenus spiralis* | Pingao; Golden sand sedge | Unstable and semi-stable sand | Sand-binder with long, rope-like rhizomes. |
| *Dicksonia squarrosa* | Wheki | Coastal forest | Tree fern. Intolerant of salt winds. |
| *Disphyma australe* | Horokaka; New Zealand ice plant | Semi-stable sand near the sea | Salt and drought-tolerant; an effective sand-catcher. |
| *Dodonaea viscosa* | Akeake | Coastal scrub and forest | Small tree. Hardy. Wind-tolerant. |
| *Dysoxylum spectabile* | Kohekohe | Coastal forest | |
| *Einadia triandra* | Poipapa; Berry saltbush | Semi-stable and stable sand | Prostrate shrubby perennial. |
| *Entelea arborescens* | Whau; Corkwood | Backdune forest | Becoming rare. Shrub or canopy tree. |
| *Epilobium billardiereanum* | Re-stemmed willow herb | Moist sand hollows | Erect herb |
| *Euphorbia glauca* | Waiuatua; Waiu-o-kahukura; New Zealand shore spurge | Unstable and semi-stable sand | Sand-binder. Soft shrubby perennial. |
| *Fuchsia excorticata* | Kotukutuku | Coastal forest | Small tree. |
| *Geniostoma ligustrifolium* | Hangehange | Coastal forest | Shade tolerant shrub. |
| *Geranium sessiflorum* var. *arenarium* | | Semi-stable sand | Herbaceous perennial. South Otago and Fiordland. |
| *Griselinia littoralis* | Papauma; Broadleaf | Coastal scrub and forest | Hardy. |
| *Gunnera arenaria* | Sand gunnera | Moist sand hollows | Nitrogen-fixer. Stout, creeping stolons. Becoming rare. |
| *Gunnera hamiltonii* | | Damp sand hollows | Creeping herb. Stewart Is. Very rare. |
| *Haloragis erecta* | Toatoa; Shrubby haloragis | Semi-stable sand | |
| *Hebe elliptica* | Coastal koromiko | Partially-stabilised sand | Tolerates salt winds and poor soil. |
| *Hebe stricta* | Koromiko | Coastal forest | Shrub. |
| *Hierochloe fusca* | | Semi-stable sand; margin between open dune and shrubland | |
| *Hydrocotyle novae-zeelandiae* | | Damp, semi-stable sand | Prostrate herb. |
| *Ipomoea pes-caprae* ssp. *brasiliensis* | | Dunes | Prostrate vine. Northern species. |
| *Isolepis nodosa* | Wiwi; Knobby clubrush | Moist sand flats | Tolerates dry, blown sand. |
| *Juncus krausii* var. *australiensis* | Wiwi; Sea rush | Salty sand flats | Forms dense clumps with large root masses. |
| *Kunzea ericoides* | Kanuka | Fixed dunes; sand hollows | Shrub or small tree; withstands exposure |

| Scientific name | Common name | Dune zone | Special features |
|---|---|---|---|
| *Lachnagrostis billardierei* | Perehia; Sand wind grass | Sandy flats and hollows | Stiff, tufted perennial grass. |
| *Leptinella dioica* | Salt-meadow cotula | Dune hollows | Small, creeping herb |
| *Leptospermum scoparium* | Manuka; Tea-tree | Fixed dunes; sand hollows | Hardy shrub. |
| *Leucopogon fasciculatus* | Mingimingi | Coastal shrubland | Shrub. |
| *Libertia peregrinans* | New Zealand iris | Sand hollows | Rhizomatous, tufted perennial. |
| *Linum monogynum* | Rauhuia | Semi-stable sand | Low perennial herb or shrub. |
| *Lobelia anceps* | | Sand hollows | Small, erect herb. |
| *Macropiper excelsum* | Kawakawa; Pepper tree | Coastal forest | Shrub or small tree. |
| *Mazus arenarius* | | Moist sand hollows | Rare. |
| *Melicope ternata* | Wharangi | Coastal forest | Small tree. |
| *Melicytus crassifolius* | Thick-leaved mahoe | Coastal shrubland | Shrub. |
| *Melicytus novae-zelandiae* | Coastal mahoe | Semi-stable sand | Shrub. |
| *Melicytus ramiflorus* | Mahoe; Whiteywood | Coastal forest | Spreading tree. |
| *Metrosideros excelsa* | Pohutukawa | Fixed and semi-stable dunes | Spreading tree, salt wind-tolerant. |
| *Metrosideros umbellata* | Southern rata | Coastal forest | Forest tree. South Island. |
| *Muehlenbeckia astonii* | Pohuehue; Wire vine | Semi-stable sand | Drought-resistant tangled shrub. |
| *Muehlenbeckia australis* | Pohuehue; Wire vine | Semi-stable sand | Drought-resistant tangled shrub. |
| *Muehlenbeckia complexa* | Pohuehue; Wire vine | Backdunes | Drought-resistant tangled shrub. |
| *Muehlenbeckia ephedroides* | Pohuehue; Wire vine | Semi-stable sand | Drought-resistant tangled shrub. |
| *Myoporum laetum* | Ngaio | Coastal scrub and forest | Hardy shrub. |
| *Myosotis pygmaea* | | Semi-stable sand | Tolerant of salt winds. |
| *Myrsine australis* | Mapau; red matipo | Coastal forest | Shrub. |
| *Olearia solandri* | Coastal tree daisy | Stable shrubland | Shrub or small tree. |
| *Ozothamnus leptophyllus* | Tauhinu; Cottonwood | Semi-stable sand near sea | Salt-tolerant shrub. |
| *Parietaria debilis* | New Zealand pellitory | Backdunes | Slender annual herb. |
| *Phormium cookianum* | Wharariki; "Mountain" flax | Sand hollows | Withstands salt winds. |
| *Phormium tenax* | Harakeke; New Zealand flax | Backdunes; swamps | Tolerates wet and dry conditions. |
| *Pimelea arenaria* | Autetaranga; Sand daphne | Dune ridges and hollows | Becoming rare. |
| *Pimelea lyallii* | | Unstable sand | Otago, Stewart and close islands. |
| *Pimelea prostrata* | Pinatoro; Native daphne | Semi-stable sand; dune hollows | |
| *Pittosporum crassifolium* | Karo | Semi-stable and stable sand | Shrub. |
| *Pittosporum eugenioides* | Tarata; Lemonwood | Coastal forest | Small tree. |
| *Poa cita* | Silver tussock | Fixed dunes | Otago and Foveaux Strait. |
| *Podocarpus hallii* | Hall's totara | Coastal forest | Forest tree. |
| *Podocarpus totara* | Totara | Coastal forest | Forest tree. |
| *Prumnopitys ferruginea* | Miro | Coastal forest | Tall tree. |
| *Pseudognaphalium luteo-album* | Pukatea; White cudweed | Sand hollows and shrub dune | Small, erect, annual or perennial herb. |
| *Pseudopanax arboreus* | Fivefinger | Coastal forest | Shrub or small tree. |
| *Pseudopanax colensoi* | Threefinger | Coastal forest | Shrub or small tree. |
| *Pseudopanax crassifolius* | Horoeka; Lancewood | Coastal forest | Small tree |
| *Pseudopanax lessonii* | Houpara; Coastal five finger | Coastal forest and scrub | Shrub. Withstands wind. |
| *Ripogonum scandens* | Kareao; Supplejack | Coastal forest | Liane. |
| *Schefflera digitata* | Pate | Coastal forest | Shrub or small tree. |
| *Scleranthus biflorus* | Kohukohu | Sand hollows | Forms low cushions. |
| *Selliera radicans* | Remuremu; Selliera | Dune hollows | Creeping herb. |
| *Senecio lautus* | Shore groundsel | Semi-stable sand | Small herb. |
| *Spinifex sericeus* | Kowhangatara; Silvery sand grass | Foredune | Effective sand-binder with long runners (stolons). Northern species. |
| *Tetragonia implexicoma* | Kokihi; NZ or beach spinach | Semi-stable sand | Salt and drought tolerant. |
| *Tetragonia tetragonioides* | Kokihi; NZ or beach spinach | Semi-stable sand | Salt and drought tolerant. |
| *Vitex lucens* | Puriri | Coastal forest | Spreading tree. |
| *Wahlenbergia congesta* | Harebell | Semi-stable sand | Rhizomatous perennial herb. |
| *Zoysia* spp. | | Semi-stable sand | Small perennial rhizomatous grasses. |

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## THE COASTAL DUNE VEGETATION NETWORK

The Coastal Dune Vegetation Network (CDVN) was formed in 1997. It provides linkages between a wide range of agencies, interest groups, iwi, nurseries, and consultants having a mutual concern for the rehabilitation of degraded sand dunes, particularly revegetation techniques incorporating indigenous coastal species. Financial members include Regional and District Councils, forest companies owning sand dune forests, and the Department of Conservation.

The aims of the CDVN include:

- fostering effective communication between participants on dune rehabilitation issues at all levels,
- prioritising research requirements,
- providing partial funding for research, and
- disseminating and promoting free exchange of information between research providers, coastal managing agencies, Beach Care/Coast Care groups, iwi, and other coastal user and interest groups and individuals.

For more information, contact the CDVN Secretary, Private Bag 3020, Rotorua. Phone (07) 343 5899; Fax (07) 343 5332.

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