Management of Marram Grass in the Restoration of Indigenous Coastal Dune Vegetation in Australia and New Zealand

D. O. Bergin[1], P. FitzSimons[2], C. Freeman[3], J. W. Herbert[1] and N. A. Kesby[4]
[1] New Zealand Forest Research Institute, Rotorua
[2] Department of Natural Resources and Environment, Melbourne, Victoria
[3] Christchurch City Council, Christchurch
[4] Department of Land and Water Conservation, Wollongong, NSW

SUMMARY Problems with degradation and management of sand dunes occur in both Australia and New Zealand. Many parts of sandy coastlines have been modified, particularly since European settlement. Marram grass (*Ammophila arenaria*), introduced last century to both countries to assist in stabilising dunes, has become a successful coloniser of dunes in higher latitudes where the climate is temperate. Management of marram grass-dominated sites is becoming a major issue in situations where coastal management agencies and community Coast Care groups wish to restore sites to indigenous vegetation communities while maintaining sand stability. Use of marram grass in New Zealand and the south-eastern states of Australia is reviewed. Examples of research and operational projects designed to replace marram grass with indigenous species are described. Continuing collaboration between research providers and dune managers on both sides of the Tasman is likely to result in enhancement of the natural character of the dunes without compromising the stabilising role of the vegetation cover.

1. INTRODUCTION

Marram grass is a sand binding tussock-forming perennial grass that is native to the coasts of Europe. It has been introduced to many other countries including Australia and New Zealand where it has proved to be a successful primary coloniser of coastal sand dunes (FitzSimons 1995).

Marram grass is readily established from culms (vertical stems with one or more nodes) which are dug from established tussocks, top-trimmed to reduce transpiration and wind resistance, and then planted in sand dunes (Hill, FitzSimons and Thomas 1988; Restall 1964). In sand stabilisation programmes it usually has high survival and good early growth providing a rapid, cost-effective technique for stabilisation of mobile sand. Marram grass has excellent sand-trapping ability due to its vertical tillering and its ability to stabilise loose sand with an extensive underground network of rhizomes and fine roots. It is a very hardy plant with high tolerance to extreme temperature range, strong winds, sand inundation, sand blasting and salt spray. Planted marram grass can provide a more favourable micro-environment for the establishment of other plant species in the harsh dune environment. When combined with a follow up indigenous vegetation planting programme involving taller plants, marram grass can be shaded out or displaced (Kesby & Druett 1992).

Marram grass is dependent on a temperate climate with an annual rainfall in excess of 450 mm. On favourable sites it often forms pure stands. In a study of the sand dune vegetation on the west coast of the North Island, New Zealand, Esler (1970) found that foredunes where marram grass was dominant were higher and steeper than foredunes dominated by two key indigenous sand binding grasses, hairy spinifex (*Spinifex sericeus*) and pingao (*Desmoschoenus spiralis*). Due to vertical tillering and tussock formation, marram grass on foredunes is associated with steep seaward faces. If marram grass cover is not dense and even, wind-funnelling between the tussocks can lead to sand erosion and dune blow-outs. Unlike Cockayne (1911), Esler (1970) doubted the value of marram grass on the seaward face of the foredune. In New Zealand, spinifex, which does not form dense tussocks, is regarded as the most appropriate species for this particularly exposed habitat.

In warmer climates, marram grass plantations lack vigour and if unmanaged will eventually die out (Kesby 1986). In the absence of follow-up planting, these sites will eventually be left unprotected and a second phase of erosion is likely to cause further degradation.

2. INTRODUCTION AND DISTRIBUTION OF MARRAM GRASS

2.1 Australia

In the late 1800s the Victorian coastline was subject to extensive wind erosion of its coastal dune systems. The predominant cause was the destruction of the indigenous vegetation cover by domestic sheep and cattle, combined with the fact that regional development was concentrated along the coastal strip (Molineux 1902; Bird *et al.* 1975). Marram grass was introduced to Australia in the Port Fairy District, Victoria, in 1883 by the Government Botanist, Baron von Mueller, for stabilising coastal sand drifts (Maiden 1895). It was recorded as being naturalised in Victoria late last century (von Mueller 1893). Since that time it has been extensively used in dune stabilisation programmes in Victoria, Tasmania, NSW and South Australia. It has proved to be the most successful primary sand binder in southern latitudes of Australia.

In contrast the vigour of marram grass decreases progressively from the southern to the northern coasts of New South Wales. In this State it is used as an effective temporary sand stabiliser and cover crop during the establishment of indigenous vegetation. In Victoria, revegetation techniques using indigenous dune species are now encouraged as an alternative to marram grass (FitzSimons 1995; Irving 1996). Areas free of marram in Victoria are now rare and considered worthy of conservation. The Department of Natural Resources and Environment classifies marram as an environmental weed rated as a 'very serious threat to one or more vegetation formations in Victoria' (Carr, Yugovic & Robinson 1992).

In Tasmania, marram grass dominates most of the coast displacing the native sand binders spinifex and sand fescue (*Austrofestuca littoralis*) (Kirkpatrick & Harris 1995). Opposition to use of marram for sand stabilisation work in Tasmania is increasing.

2.2 New Zealand

New Zealand has over 100,000 ha of sand dune country bordering its coastlines (Courtney 1984). The dunes extend between latitudes 34° and 46°, corresponding to the Australian coastline between Sydney in the north and the southern point of Tasmania in the south. From the early 1870s, there was concern over dune instability (e.g., Crawford 1872; Whitcombe 1873). Cockayne (1911) attributed the sand drift problem to destruction of the plant covering by grazing animals and by fire.

After the beginning of this century the then Ministry of Lands adopted a technique based on Cockayne's (1911) recommendations for dune revegetation, physically maintaining a continuous even foredune and using exotic species to stabilise the sand behind its seaward face (Restall 1964). Up to the late 1980s the method involved planting of marram grass followed one year later by yellow tree lupin (*Lupinus arboreus*). The latter supplied biologically fixed nitrogen to the ecosystem (Gadgil 1971) and thus avoided the need for continued expensive fertiliser treatment. The final stage, once the vegetation was continuous, was the planting of trees. Large areas of coastal sand throughout the country were successfully stabilised and considerable areas of duneland were reclaimed for economic development (Wendelken 1974).

Marram grass has become widely established on New Zealand sand dunes. Inventories of the vegetation of beach systems in the North Island (Partridge 1992) and in the South Island (Johnson 1992) indicate that marram grass is present on 79% of all North Island beaches and 45% of all South Island beaches. It occurs most commonly on the west coast of the North Island (71%) and the east coast of the South Island (70%).

3. RESTORATION OF DUNES IN NEW SOUTH WALES

3.1 Introduction and use of marram grass

Coastal dune rehabilitation was first attempted on the NSW coast in the late 1940s when sand trapping fences and surface brush matting were used. In the 1960s, successful trials with marram grass as a sand binder, paved the way for new dune stabilisation programmes. Severe storms in 1974 increased the need for this approach. Marram grass material was obtained from Victoria.

In New South Wales, marram grass has been used successfully as a cover crop during the establishment of indigenous vegetation (Hawley & Kesby 1989). In the south at Bega near the Victorian border, planted marram grass can live 10-15 years. Along the Sydney coastline its lifespan is 5-7 years and in the north near Kempsey only 3 years. Marram grass is, therefore, a useful temporary nurse plant in these warmer latitudes.

In order to achieve a continuous cover of local indigenous species in degraded areas, rehabilitation techniques in NSW involve firstly, the reshaping of dunes to form a low even profile and planting with marram grass. Subsequent stages involve the establishment of a range of indigenous plants including grasses and creepers on the foredune; mostly shrub species behind the foredune; and tree species on the backdune area. The dune system is also protected by fences and accessways provided for pedestrian and authorised vehicles. All programmes are designed and planned to include long-term maintenance (Soil Conservation Service of NSW 1990). Complete rehabilitation can take up to 10 years and requires long-term commitment from funding bodies, government authorities and coastal managers (Kesby & Davies 1989).

3.2 Case studies

3.2.1 South Coast of New South Wales

At Tathra (south NSW coast), where public use is heavy, marram grass is used to provide quick cover on eroded foredune sites. Indigenous species including spinifex and coastal wattle (*Acacia sophorae*) are then planted or sown.

Further north at Wairo Beach where major sand movement occasionally closed the Princes Highway and threatened an adjacent lake, heavy machinery was used in the late 1980s to reshape the mobile dune. Spinifex stands on the foredune were treated with 200 kg/ha of a high-nitrogen, fast-release fertiliser twice a year and formed a dense sward. The exposed faces of the dunes were planted with marram grass followed by spinifex, coastal wattle, coastal banksia (*Banksia integrifolia*), coastal tea tree (*Leptospermum laevigatum*), coastal pigface (*Carpobrotus glaucescens*) and other creepers. This area has provided a well-documented example of the successful restoration of a mobile dune system (Kesby 1986).

Near Nowra, south of Sydney, spinifex seed is sown in recently planted marram grass stands by placing 2-4 seedheads in 150 mm deep holes spaced at 1.2m x 1.2m (Soil Conservation Service of NSW 1990).

3.2.2 North Coast of New South Wales

Large-scale restoration of Blacksmiths Beach near Newcastle, where roads and housing were threatened, was undertaken in the early 1990s (Chapman & Watt 1994). Erosion was caused by uncontrolled use of the beach which disturbed the vegetation cover. As on many other New South Wales beaches, the

problem was exacerbated by a major infestation of bitou bush (*Chrysanthemoides monilifera* ssp. *rotundata*), an introduced species which suppressed indigenous vegetation and formed unstable hummocks. Restoration involved burying bitou bush hummocks and their seed banks in the backdune; reshaping of dune profiles; treatment of spinifex remaining on the foredune with high-nitrogen fertiliser; and revegetation. Marram grass was used successfully on the reshaped dunes to give early stability and as a temporary nurse for establishment of local native species including coastal wattle and coastal banksia.

Further north at Harrington, North Haven and Lighthouse Beaches, marram grass has been used to stabilise drifting sand and provide shelter for subsequent sowing and planting of spinifex and a range of backdune species. After about 3 years most areas are dominated by spinifex and coastal wattle.

4. STABILISATION OF DUNES USING MARRAM GRASS IN VICTORIA

4.1 Dune characteristics and management

The Victorian coast ranges across a relatively narrow latitudinal range. About one-third (500 km) of the coast is bordered by sand dunes (Zann 1996) dominated by marram grass. Indigenous species are mainly confined to scattered patches along the foredune but can become prominent on the backdunes. Most large sand drifts in this region have been stabilised with marram grass. In some areas this is so vigorous that, without intervention, later successional species including shrubs and trees may take at least 20 years to assume dominance.

4.2 Case studies

4.2.1 Phillip Island

In the mid-1970s a major stabilisation and revegetation programme commenced at the Cape Woolamai Faunal Reserve, a site with a long history of erosion caused by clearing, grazing and burning of the original vegetation (Hill & FitzSimons 1982). Rehabilitation of the 45 ha back dunes area has largely been completed. Stage one involved large-scale planting of marram grass at 45 cm spacing followed by hand broadcasting of high-nitrogen fertiliser at 250 kg/ha. Repeated topdressing was required to maintain the vigour of marram grass. Long-term maintenance of marram grass was rejected because of high cost, uncertain effects such as possible weed development and a desire to restore indigenous vegetation as soon as possible.

The second stage involved artificial establishment of secondary and tertiary species. Groups of 10 or more trees and shrubs of one species were planted at spacings ranging from 0.5-5 m apart within groups depending on species (most shrubs and small trees at 2-3 m spacing). More than ten indigenous tree and shrub species were planted using nursery-raised seedlings propagated in 15 cm tubes or small pots from local seed collected from remnants. Highly palatable species were protected with wire netting tree guards to reduce losses from rabbit browsing. Survival has been over 50% but growth has been extremely variable. Twenty year old trees in very exposed situations are still centimetres high but in more sheltered situations they are several metres tall.

4.2.2 Rye Ocean Beach Backdune trial

In a trial established in Mornington Peninsula National Park, nine local tree and shrub species were planted on the backdunes in 1981. The aim was to investigate establishment of secondary and tertiary species after primary stabilisation using marram grass. Species tested included coastal wattle, common correa (*Correa reflexa*), white correa (*C. alba*), daisy bush (*Olearia glutinosa*), coast daisy bush (*O. axillaris*), coastal everlasting daisy (*Helichrysum paralium*), sea-box (*Alyxia buxifolia*), common boobialla (*Myoporum insulare*) and coastal tea-tree. The nursery-raised seedlings were planted amongst marram grass which had been planted two years previously on completely bare sand.

Some mortality occurred during the first six months after planting but most species had good survival. Canopy cover was achieved after 15 years where natural regeneration had occupied gaps between planted trees and shrubs. In contrast, an adjacent unplanted control area has had little natural recruitment of secondary and tertiary species where the site has remained in scattered marram.

4.2.3 Beaches west of Melbourne

Since the mid-1980s, the Victorian Institute of Marine Sciences at Queenscliff has co-ordinated a major coastal revegetation programme involving a large number of schools, several local councils, the Department of Natural Resources and Environment, and local communities. The foredune is exposed to very strong onshore winds and has a steep seaward face, probably due to the earlier use of marram grass during stabilisation.

Brush matting is laid to stabilise the sand surface (Irving 1996). This discourages people from trampling the site, may be a source of seed, and protects any plantings. The matting consists of selected trimmings from parks and roadsides, care being taken to avoid potential weed species. Subsequently, nursery-raised seedlings and cuttings of a range of local indigenous foredune and backdune species are planted. Labour is provided by schools participating in environmental education programmes, and to a smaller extent by local communities. Species commonly used are hairy spinifex, karkalla (*Carpobrotus rossii*), bower spinach (*Tetragonia implexicoma*) and knobby club rush (*Isolepis nodosa*) which is also native to New Zealand. Hairy spinifex cuttings 50-80 cm in length are transplanted directly into trenches surrounded by brush matting. Clumps of knobby club rush are transplanted successfully on a large scale. Although there are no accurate records of the success of the plantings, the apparent density of vegetation cover on these sites indicate that these techniques are having some effect in reducing erosion.

5. MANAGEMENT OF DUNES IN CHRISTCHURCH, NEW ZEALAND

5.1 Dune characteristics and management strategies

Christchurch beaches are characterised by a relatively high, partially vegetated foredune and an undulating 50-120 m wide backdune strip dominated by dense marram grass. Roading and

residential development lie behind the backdune. In places, carparks and Surf Club buildings intrude onto the foredune.

The 8 m high foredune has a steep seaward slope often devoid of vegetation except at the crests. It is directly exposed to the prevailing easterly winds. Blowouts originating on the seaward-face are the source of large volumes of sand which are blown inland at intervals and reach the road and other developed areas. The stable backdune has a continuous cover of tall marram grass with widely scattered exotic shrubs and trees.

For many years, marram grass and introduced ice plant (*Carpobrotus edulis*) have been used in an effort to reduce erosion of the foredune. Both species are available locally at low cost, are easy to establish on a large scale, and grow vigorously on exposed sites. The Christchurch City Council has lowered and re-contoured unstable sections of the foredunes using bulldozers to shift excess sand seaward. Revegetation with marram grass and ice plant is seen as the most cost-effective means of controlling erosion, although restoration of natural vegetation sequences across the whole dune system would be preferred.

A Coast Care programme is currently being promoted (Christchurch City Council 1995). The goal is the development and enhancement of 12 beach parks from the Waimakariri River south to Gollans Bay in Lyttleton Harbour. Specific objectives of the programme are improvement of the scenic values; enhancement of the ecological and recreational values of the dune ecosystem; and sustainable long-term stability of the dunes. There is a strong emphasis on revegetation with indigenous coastal species to enhance recreational values of the beach environment for the large and increasing numbers of beach users. There is also a desire to develop techniques for rehabilitation of degraded dunes to emulate a sequence of natural plant communities from foredune to backdune.

Under the Coast Care programme, several thousand trees and shrubs are being planted annually and maintained. Large numbers of pingao have already been planted with some degree of success. Coastal woody and herbaceous species have established successfully in a small trial at North Brighton (Colin Meurk pers. comm.).

5.2 Planting trials

In 1995, the Christchurch City Council and the New Zealand Forest Research Institute (FRI) initiated a series of large-scale planting trials on foredunes at several sites along the Christchurch beaches. The trials tested indigenous species recommended by McCombs (1992) as practically and ecologically appropriate for the area.

In a trial on the backdune, small clearings (1.5 m in diameter) were cut in the dense marram grass using motorised scrub bars. Most of the underground stems and roots was removed with spades. Small groups of nursery-raised seedlings of 16 coastal woody shrub and tree species were planted in the clearings. Small clearings were considered most appropriate on these difficult sites in providing some shelter for planted seedlin and would also be less vulnerable to sand erosion compar with larger clearings. A randomised complete block design wi 4 replicates was used so that effects of site, fertiliser treatme at time of planting, and bark mulch placed around the base planted seedlings could be assessed separately.

To date, performance of 13 species has been poor due unseasonal frosts, browsing by rabbits and vigorous regrowth marram grass and weeds. Three species, tauhinu (*Cassin leptophylla*), *Euphorbia glauca* and flax (*Phormium tenax* have performed satisfactorily.

Further research on revegetation techniques is required, wit particular attention to site preparation and selection, specie selection, planting pattern, rabbit control, fertiliser treatmen and maintenance. Recently, site preparation trials have bee established on backdunes where accidental burning of marra grass has created bare sand areas. A comparison of sit preparation and weed control techniques using herbicides an hand pulling methods is being made in burnt areas wher marram is readily sprouting and in adjacent dense matur marram grass stands.

5.3 Monitoring of Dune Profiles and Vegetation Cover

Several New Zealand Regional Councils have established series of transects to monitor changes in sand movemer (erosion and accretion) on coastal dunes over time. Most c these are monitored on a regular basis. Little or no informatio has been collected on vegetation cover.

In collaboration with the Canterbury Regional Council, a pilo vegetation monitoring system has been developed by FRI fo application to the 45 transects located along the Christchurc coast. Major species composition and percentage ground cove will be assessed at a series of fixed Geographic Informatio System (GIS) co-ordinates along transects. The system wil allow collection of data on long-term changes in vegetatio composition in relation to sand movement on these dun systems. The role that marram grass has in sand movement o the Christchurch dunes is of particular interest.

6. MANAGEMENT OF DRIFTING SAND AT AWHITU PENINSULA, NEW ZEALAND

6.1 Dune characteristics and management strategies

The coastline of the Awhitu Peninsula (south head of th Manukau Harbour, west of Auckland) is composed of high san cliffs. Land at the cliff-tops is, for the most part, managed i pasture. Instability and wind erosion of the cliff face results i extensive sand drifting over farm properties (Lambrechtsen & Hicks 1995). With support from the Auckland Regiona Council, local landowners formed the Awhitu Peninsula Lan Group and have developed a sustainable management plan t reduce erosion. One area of concern was the lack of informatio on indigenous species appropriate for use on erosion-prone site retired permanently from grazing and where marram grass ha been established.

6.2 Indigenous species planting trial

Planting trials using indigenous tree and shrub species were established in mid-1996 by the Awhitu Peninsula Land Group in collaboration with FRI. The specific objective was the determination of practical and cost-effective techniques for establishing an indigenous vegetation cover. Five species were planted in a randomised complete block design on 3 site types - ungrazed kikuyu grass (*Pennisetum clandestinum*); recently planted marram; and dense marram stands. Five seedling-groups were planted in small natural gaps on the marram sites. On the grass site, planting spots were sprayed with herbicide before planting. All seedlings received the slow-release fertiliser Magamp at time of planting. Intensive weed control has been necessary to keep seedlings free of grass within the first year of planting.

Over 90% of karo (*Pittosporum crassifolium*), pohutukawa (*Metrosideros excelsus*), and flax plants survived and made good height growth in the dense marram site and in the kikuyu grass site. All species performed poorly on the more exposed, recently planted marram grass site where significant sand movement had continued to occur. Akeake (*Dodonea viscosa*) performed poorly on all sites especially where seedlings were exposed to on-shore winds. Virtually all knobby club rush, transplanted as clumps from nearby plants, had died out. Early results indicate that a cover of marram grass or dense kikuyu grass is providing shelter for planted trees and shrubs as long as planted gaps are kept small. However, the small gaps require constant maintenance to ensure planted seedlings within dense covers are not suppressed. If growth continues with ongoing maintenance, the indigenous species may eventually suppress the grass cover.

7. DISCUSSION

Experience with dune rehabilitation programmes indicate that without marram grass or some other primary sand coloniser, it can be difficult to establish indigenous shrubs and trees on exposed, degraded dunes, particularly on a large scale. Without marram grass, dune erosion in Australia (particularly along the Victorian coastline) and in New Zealand (North Island west coast and South Island east coast), would have resulted in even more devastation due to inundation of production and conservation land (Molineux 1902; Wendelken 1974). Marram grass was used because it was cost-effective. Current dominance of marram grass over extensive areas in higher latitudes of both countries is largely a result of the failure of local indigenous plant communities to tolerate pressures on dune systems over the last century including fire, grazing, recreational use and coastal development. Experimental and operational-scale planting of indigenous shrub and tree species in Australia has demonstrated that marram grass will eventually be suppressed in the long-term. On the Victorian coast, good examples of this outcome exist at Rye Ocean Beach and Phillip Island.

In the lower latitudes of NSW, where marram grass dies out naturally within several years of planting, it is considered to be an essential tool for providing stability to exposed dunes while indigenous species are becoming established. Case studies discussed illustrate the widescale use and success of this technique along the coastline of New South Wales. In the long-term, lack of persistence automatically reduces the dominance of marram grass and consequently it does not pose an ecological threat to sandy coastlines in this State.

Although not yet quantified, there is circumstantial evidence that the vigour and longevity of marram grass in New Zealand is similar to that in the same range of latitudes in Australia. Observation suggests that in New Zealand vigour is lower on the sheltered northeast coasts than on the more exposed western beaches of the North Island and eastern and southern coasts of the South Island. The greater vigour of marram grass on exposed sites is also supported by Willis (1965) who showed an improvement of marram grass vigour in the presence of mobile sand. The backdune trials at both Christchurch and Awhitu Peninsula indicate revegetation of these marram grass-dominated sites with indigenous species is not easily achieved. In New Zealand at least, further trials are required to determine appropriate techniques for establishing indigenous woody species on the marram grass-dominated backdunes. Site selection, species selection, site preparation, planting pattern and maintenance require evaluation and testing.

As in Australia, it is probable that successful techniques will be those that accommodate the vigour and longevity of marram grass in the interests of dune stability. More fundamental research is required on interactions between marram grass and indigenous species in this unstable environment in situations where marram grass is providing stability but the desired end result is a sustainable indigenous species-dominated plant community. Community groups and coastal managers along the west coast of the North Island and Pegasus Bay in the South Island are particularly interested in management options which will remove the need for exotic species.

8. CONCLUSIONS

In both Australia and New Zealand, experimental and management-scale dune revegetation programmes have used marram grass as an initial coloniser and dune stabiliser. However, there is increasing concern over the dominance of dune vegetation by marram grass in both Victoria and Tasmania as well as in parts of New Zealand. Australian experience with follow-up plantings of indigenous species have been successful in terms of maintaining dune stability while suppressing the marram grass. Although the comparative benefits of Australian and New Zealand indigenous species for replacing marram grass on dunes are not known, Australian experience is providing some insights for management of marram grass-dominated stands in New Zealand. Continued interaction between New Zealand and Australian researchers and managers will result in mutual benefits to coastal communities in both countries.

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