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SECTION 6: Plant Materials for Sand Dune Stabilisation

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According to the New Zealand Land Resource Inventory the total area of coastal sand dunes is 305,000 ha. Of this some 240,000 ha are in the North Island, the largest areas being along the west coast in Northland, Waikato, Rangitikei and Manawatu and vary in width from 3 to 20 km.

Sand dunes have a fragile ecosystem which can be easily disturbed by man and animal.

6.1 Introduction

In pre-European times most dune areas were stable and covered by vegetation, except for isolated areas where wandering dunes had developed due to increased sand deposits near the mouths of the main rivers. Tracking and burning of the bracken fern country by the Maoris also caused some sand drifts. However, the extensive indiscriminate grazing of the sand country after European settlement caused accelerated deterioration. Overgrazing, stock trampling and burning to facilitate stock access and mustering destroyed the vegetative cover. In particular the palatable spinifex cover was eliminated from the frontal dunes which began to drift inland—covering farmland and threatening houses and communications.

The Department of Lands and Survey recognised the problem was out of control in 1911 when it published a 'Report on the Dune areas of New Zealand', prepared by Dr L. Cockayne, but it was not until the depression years of the thirties that large-scale stabilisation projects commenced. Interrupted during the war, sand dune reclamation was recommenced in 1951 by the NZ Forest Service which had by 1985 stabilised and developed into forestry all the major sand dune areas on crown land (115,000 ha).

Most of the remaining unconsolidated sand drifts now occur on privately owned land. In general these areas are not large but are difficult to treat in isolation. Catchment authorities are, through sand stabilisation schemes, assisting with the control of sand drift on farms.

Establishing and maintaining a permanent vegetative cover is the most effective way of stabilising sand dunes.

Sand dune reclamation is carried out in three stages:

(a) the establishment and protection of a stable foredune parallel to the coast, followed by

(b) the fixation of the unstable sand area behind the foredune and further inland with sand binding plants in preparation for

(c) the establishment of a permanent vegetative cover using trees for afforestation or grasses or legumes for pasture development.

For each stage plant materials best adapted to the conditions are selected. These primary, secondary, and tertiary (or permanent) stabilisers are listed in an appendix to this section.

6.2. The Foredune

Sand originating from erosion debris in the hill and high country is transported by the rivers to the sea, and carried by ocean currents and wave action along the coast

where it is deposited on the beach. From there the sand is blown inland by the prevailing wind, and when trapped in driftwood or vegetation, a dune is slowly formed. This frontal dune or foredune gradually becomes stabilised with vegetation, mainly *Spinifex sericeus* (silvery sand grass) and *Desmoschoenus spiralis* (pingao). The foredune forms the main barrier against the sea and prevents sand movement inland. A continuous foredune of uniform height, properly maintained, is essential in any sand dune stabilisation scheme.

6.2.1 Foredune building

Where no foredune exists, the development of a dune is encouraged by constructing sand-catching brush or palisade board fences parallel to the coast some distance above high tide mark. Usually two fences are built some 3 m apart and 1.5 m high. As the sand builds up between the fences and forms a small dune, additional fences can be erected on top of those buried until the dune reaches a height of some 6 to 8 m. The aim is to develop a foredune which is continuous, is of consistent height, and has a gradual slope on the seaward side and a rather steeper slope on the inland side.

As sand-catching material, scrub or tree branches have been used. These are inserted into the sand to a depth of about 0.2 m and held in place between wires. When branches are in short supply, sand-catching fences are constructed from 10 to 12 cm wide mill slabs fixed to a 2-wire fence with posts 3 m apart. To prevent the fences from being blown over and to enable the sand to settle there should be a 5 cm gap between the slabs in these board fences. Other materials in use are plastic mesh or woven polyethylene fabric.

6.2.2 Vegetation establishment

When sufficient sand has built up, the bare sand has to be stabilised by planting marram grass (*Ammophila arenaria*) on the new dune at 60 × 60 cm spacing. *Spinifex*, which is better adapted to salt spray conditions, can be planted or sown on the coastal face of the dune where, together with naturally established seedlings, it will gradually take over from the planted marram (see Volume 2 (Technical Note H2) of this Handbook). Pingao, a primary stabiliser, establishes naturally on the foredune but it is never planted because it tends to form irregular hillocks.

6.2.3 Maintenance

Blowouts in the foredune should be repaired without delay, otherwise they will extend and the beach sand will be blown further inland. Blowouts can be repaired by bulldozing sand into the gap and/or by erecting a sand-catching fence.

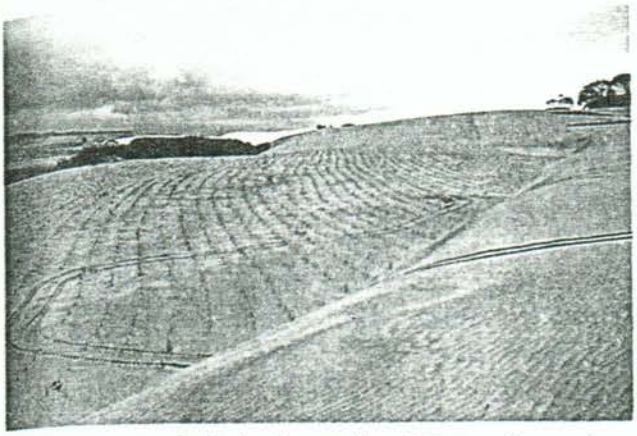
Regular topdressing with a nitrogenous fertiliser will maintain a healthy vegetative cover on the foredune.

In densely populated areas, the foredune may have to be fenced off and special pathways constructed to give access to the beach in order to prevent damage to the plantings. Under no circumstance should the construction of buildings or roads be permitted on the foredune. Stock should be permanently excluded from the foredune area, as should dune buggies and trailbikes.

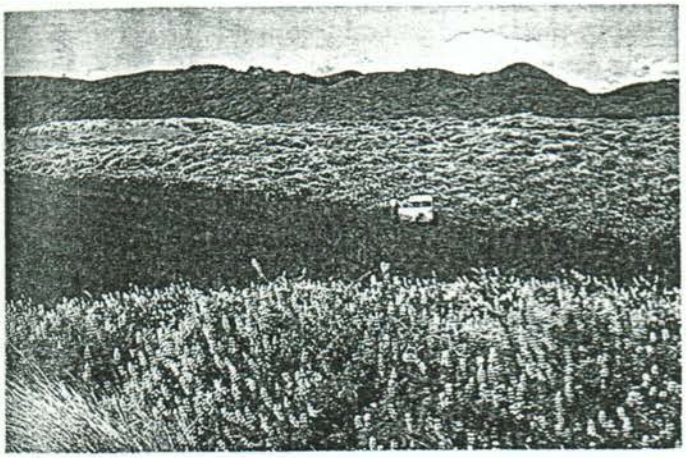
6.3 Dune Stabilisation Further Inland

Unconsolidated areas immediately behind the foredune or further inland are planted in marram grass and tree lupin (Plates 6A, B and C).

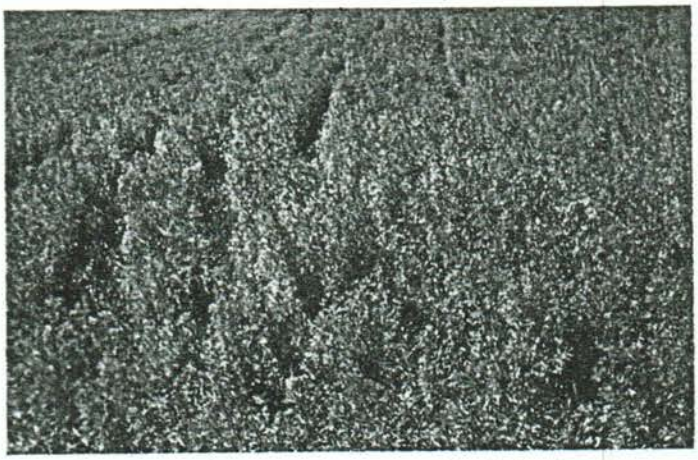
Marram grass grown in special 'nursery areas' is planted in July/August as small bunches (or sets) of unrooted culms, either by hand or by a special planting machine



A, B Marram planting is the first step in stabilisation (above and right).



C Tree lupin (yellow flowers) and annual blue lupin (seed stage in centre) are used as secondary stabilisers.



D The second generation blue lupin crop provides shelter for generating pasture sward.

E Sand dune erosion control plantation, west coast near Wanganui.

at a spacing of 50 × 50 cm to 100 × 100 cm. The application of a nitrogenous fertiliser is essential for successful establishment and rapid growth of marram grass. In November/December a top dressing of nitrolime (calcium ammonium nitrate) at a rate of 45 kg/ha is applied and repeated the following autumn. For further details, see Volume 2 (Technical Note H2) of this Handbook.

Tree lupin (*Lupinus arboreus*) is either sown at the same time as the marram is planted or, on more exposed sites, during the following autumn by which time the marram should be well established and providing better shelter.

Tree lupin can be broadcast at 15–20 kg per ha but is better shallow drilled because this gives a more even strike and uses less seed—a rate of 5–8 kg/ha is sufficient. Sometimes blue lupin (*Lupinus angustifolius*) is sown with the tree lupin to give quick temporary protection on difficult areas (refer also to Volume 2 (Technical Notes H1 and S6) of this Handbook and Plate 6D).

In some years the lupin is attacked by the caterpillar of the Kowhai moth (*Uresiphyta polygonalis maorialis*) which when epidemic can completely defoliate and even kill individual plants. However, there is usually sufficient seed in the soil to recover the site. When an area has been stabilised by marram grass and tree lupin, a cover of annual grasses and weeds will gradually develop.

For immediate protection of critical areas after marram planting or lupin sowing, mulches can be used. Old straw or hay spread over the surface and partially disced-in gives good temporary protection. Other materials such as bitumen, oil, latex or PVA have been effective on less exposed sites. However, their effect is not long lasting and they are expensive to apply.

6.4 Tertiary Stabilisation

6.4.1 Development into forestry

Some 3 to 5 years after the establishment of marram grass and tree lupin the sand is sufficiently stabilised for tree planting to commence.

Immediately behind the foredune a protection zone of some 100 to 150 m width is established by planting hardy shrubs and trees to form a windbreak for the main forestry planting further inland. Species which can withstand the very exposed conditions and salt-laden winds are *Acacia sophorae, Acacia saligna, Tamarix chinensis, Olearia traversii* and *Cupressus macrocarpa*. The latter, being the tallest growing, is usually planted in a belt in front of the forestry plantations. Except for the *Tamarix*, which is planted as one-year-old rooted cuttings, the other species are planted as container-grown material. Native species such as *Coprosma acerosa, Coprosma repens, Olearia solandri, Cassinia leptophylla, Pimelea arenaria* and *Muehlenbeckia complexa* usually establish naturally in this zone and thereby provide additional stabilisation and protection.

Behind this protection zone, *Pinus radiata* can be established successfully as a commercial crop. Prior to planting, lines have to be cut by hand or crushed by tractor in the dense tree lupin cover. When the pine trees have established, further release clearing is required. This can be done by hand cutting, but where the area concerned is large a solution of 0.15 ℓ of 2,4,5-T high ester plus 1 ℓ of 'Versatil' in 100 ℓ of water is sprayed over the crop. This will weaken the tree lupin but not affect the young pines.

The pines are initially planted at an approximate spacing of 3.5 × 2 m (1500 per ha), subsequently thinned at age 5 to 800 per ha and pruned to 2.5 m, and finally thinned at age 8 to 400 per ha and pruned to a height of 5 m (Plate 6E).

6.4.2 Development into pasture

(a) Following tree lupin planting

When the inland dunes have been stabilised by marram and tree lupin, the easier contoured areas can be developed into pasture and the higher dune ridges planted in pines. The tree lupin, which has built up nitrogen and organic matter in the soil, should only be partly cleared by crushing or rotary slashing to leave narrow strips at right angles to the prevailing wind. In autumn, the pasture mixture either can be sown using a disc drill or be broadcast on the surface and the seed trampled in by sheep.

(b) Following blue lupin planting

Annual bitter blue lupin (*Lupinus angustifolius*) has been successfully used as a temporary primary stabiliser of bare sand on inland dunes which are of easy contour and reasonably sheltered. Blue lupin has the advantage that seed is readily available, can be easily drilled, and will stabilise and consolidate the sand in a relatively short time. It provides shade and shelter for other plants which will benefit from the nitrogen build-up in the soil. Its reseeding habit enables it to keep the sand covered in succeeding years, until such time as the pasture species become established.

Prior to sowing, steep dune slopes and hillocks with remnants of vegetation should be smoothed off or bulldozed out. It is also essential that the complete dune area is treated in one operation starting from the windward side because sand blowing from untreated areas can smother the lupins. Bitter blue lupin is drilled in late autumn at a rate of 90–100 kg per ha, across the direction of the prevailing wind to prevent wind funnels along the rows. Difficult areas can be double drilled. Sometimes barley or ryecorn is used in combination with the blue lupin. Inoculation and topdressing of blue lupin at seeding time is recommended. The crop ripens in early summer and is allowed to seed. It is possible to harvest seed by direct heading. Fallen seed will remain among the stubble and will germinate with autumn rains. A light discing will assist germination. A dense second crop of blue lupin results and this can be eaten off by sheep later in the autumn following which a pasture mixture should be overdrilled through the lupin cover (Plate 6D).

If the blue lupin is not harvested or eaten off, the resulting blue lupin cover may be too dense and will have to be partially crushed to admit sufficient light for the germinated pasture seeds to establish satisfactorily.

(c) Seed mixtures for sand country

When semi-consolidated sand is developed into pasture, grasses and legumes should be selected which are suited to the free draining, droughty, poor fertility soils and can withstand the often extreme soil temperatures.

Perennial ryegrass is generally only used on the inter-dunal sand flats which have a better moisture status and a higher organic matter content. It can be incorporated in the mixture to provide a short-lived nurse crop on the drier soils. 'Grasslands Nui' is the most suitable perennial ryegrass cultivar for these flats. Cocksfoot, prairie grass and phalaris are important components in the mixture; they establish well in sand country and tolerate droughty conditions. 'Grasslands Apanui' cocksfoot has been generally used in sand country but the recently released cultivar 'Grasslands Wana' is now preferred because it has a more prostrate growth habit and is more densely tillered. 'Grasslands Matua' prairie grass and 'Grasslands Maru' phalaris are cultivars able to withstand the dry conditions and produce well in winter. Another useful grass is Yorkshire fog. In Northland Kikuyu grass is successfully planted by sprigging to

provide the main permanent grass species following initial stabilisation by blue lupin or tree lupin.

The main legumes used for sand country are white clover for the moister sites and red and subterranean clover for the drier soils. 'Grasslands Pitau' white clover, 'Grassland Hamua' broad red clover and 'Tallarook' and 'Mount Barker' subterranean clovers are late summer-early winter producing legumes. Summer growing legumes such as lucerne or birdsfoot trefoil are included in the mixture although lucerne is higher producing when sown on its own because it prefers to have no competition.

All pasture legumes require inoculation with the appropriate rhizobium before sowing. Seeding rates are relatively heavy, using 35–45 kg of pasture seed mix. Autumn sowing is preferable because the conditions are better then for seed germination.

At sowing time the area should be topdressed with 150 kg/ha NPK fertiliser (12:10:10). Approximately 6 months later 200 kg/ha of 30% potassic superphosphate is applied to the young pasture.

The following grasses and legumes can be included in sand country mixtures:

Lolium perenne— 'Grasslands Nui' perennial ryegrass	15–20 kg/ha
Dactylis glomerata—'Grasslands Wana' cocksfoot	6–10 kg/ha
Bromus wildenowii—'Grasslands Matua' prairie grass	6–10 kg/ha
Phalaris aquatica—'Grasslands Maru' phalaris	8–10 kg/ha
Holcus lanatus—'Massey Basyn' Yorkshire fog	4–6 kg/ha
Trifolium repens—'Grasslands Pitau' white clover	2–3 kg/ha
Trifolium pratense—'Grasslands Hamua' broad red clover	3–5 kg/ha
Trifolium pratense—'Grasslands Turoa' Montgomery red clover	3–5 kg/ha
Trifolium subterraneum—'Mt Barker' subterranean clover	1–2 kg/ha
Trifolium subterraneum—'Tallarook' subterranean clover	1–2 kg/ha
Medicago sativa—Marlborough lucerne	4–8 kg/ha
Lotus corniculatus—'Granger' birdsfoot trefoil	2–3 kg/ha
Lotus tenuis—narrow-leaved trefoil	1–2 kg/ha

Seed mixtures which have been successfully used in sand dune development include:

for dry sandridges	**kg**	**for moister sandflats**	**kg**
'Matua' prairiegrass	8	'Nui' ryegrass	15
'Apanui' cocksfoot	6	'Apanui' cocksfoot	5
Marlborough lucerne*	4	'Pitau' white clover	3
Broad red clover	2	'Mt Barker' subclover	4
Montgomery red clover	2	'Pawera' red clover	5
'Mt Barker' subclover	1.5	'Hamua' red clover	5
'Tallarook' subclover	1.5		
Lotus corniculatus	3		
	28 kg/ha		**37 kg/ha**

*Marlborough variety not now recommended because it is subject to aphid damage.

(d) Pasture maintenance

Stabilised sand dunes developed into pasture must be very carefully managed and maintained. Maintenance topdressing of 200 kg of 30% potassium superphosphate should be applied every two years. Although excellent wintering country, stock

grazing should be strictly controlled, particularly during the summer. Fencing out the dry ridges from the moist sand plains is often necessary because the pasture on the dry ridges is easily damaged by stock trampling and overgrazing, exposing bare soil. Any blowouts should be immediately repaired before they become a major problem. Stock should be excluded by a temporary fence and the area sown in blue lupin and a pasture mix, and covered with old hay.

Table 6.1 Sand Dune Stabilising Plants

1. Primary Stabilisers

Pioneer sandbinding plants which are able to survive and colonise drifting sand.

Ammophila arenaria (Marram grass) (European beach grass)	The most important and effective sand stilling grass. Requires moving sand for continuous vigorous growth. (Refer: Vol. 2, Technical Note H2)
Ammophila breviligulata (American beach grass)	Although equally vigorous as marram, planting trials were discontinued because it was found too palatable to rabbits and stock.
Spinifex sericeus (Silvery sandgrass)	An endemic strong growing sand binder, colonising the seaward side of the foredune. (Refer: Vol. 2, Technical Note H2)
Desmoschoenus spiralis (Pingao)	A sand binding native sedge confined to the foredune area. Does not hold sand well. Difficult to establish and not used in sand dune work.

2. Secondary stabilisers

Species which can grow well on bare sand which has been partially consolidated by marram grass.

Lupinus arboreus (Perennial tree lupin)	A Californian leguminous shrub extensively used as a nurse crop after marram planting. (Refer: Vol. 2, Technical Note S6)
Lupinus angustifolius (Annual blue lupin)	An excellent cover and nurse crop. Can be used on inland sand dunes as a primary stabiliser prior to pasture oversowing. (Refer: Vol. 2, Technical Note H1)
Secale cereale (Ryecorn) *Hordeum vulgare* (Barley)	Two cereals sometimes sown as a quick cover prior to pasture oversowing.

Mesembryanthemum spp. (Iceplant)	A prostrate mat-forming succulent. Suitable for covering sandy areas near dwellings and on road cuttings. Established from cuttings.
Acacia longifolia var. *sophorae* (Eastern coastal wattle) *Acacia cyclops* (Western coastal wattle) *Acacia cyanophylla* (Cyprus wattle)	Three nitrogen fixing shrub wattles useful for planting in the protection zone behind the foredune. (Refer: Vol. 2, Technical Note T1)
Olearia traversii (Chatham Island akeake)	A native shrub able to withstand salt spray and used in the protection zone or in windbreaks. (Refer: Vol. 3)
Chrysanthemoides moniliferum (Bone seed or Bitou bush)	A 1 m tall South African shrub naturalised as a garden escape. Sometimes planted in the protection zone. Has a weed potential because the fleshy seeds are spread by birds. Not recommended.
Tamarix chinensis (Tamarisk)	A small Mediterranean tree suitable for planting in the protection zone behind the foredune. Tolerates saline soils. (Refer: Vol. 2, Technical Note S10)

3. Tertiary Stabilisers

Species which provide permanent stability and preferably have a productive capacity, e.g., forestry or pasture.

(a) Pasture Species

Drought, salt laden wind and low fertility limit species selection but the grasses and legumes referred to in this section all tolerate sandy soil conditions.

Other adapatable grasses and legumes are:

Stenotaphrum secundatum (Buffalo grass) *Cynodon dactylon* (Indian doab)	Two subtropical perennial grasses for warmer districts.
Melilotus indica (King Island melilot) *Ornithopus pinnatus* (Yellow serradella)	Two winter annuals for warmer districts.
Trifolium fragiferum (Strawberry clover)	A low growing perennial clover for moist interdunal or saline flats.

(b) **Trees**

Pinus radiata (Radiata pine)	The principal tree species for commercial forestry on sand dunes. (Refer: Vol. 2, Technical Note T9)
Cupressus macrocarpa (Macrocarpa)	A hardy tree able to stand coastal exposure. Planted behind the foredune to protect *P. radiata* plantations. (Refer: Vol. 2, Technical Note T5)
Araucaria heterophylla (Norfolk Island pine)	A tall tree able to grow on stabilised sand and used as windbreak. Can withstand salt spray.
Populus alba (Silver poplar)	A suckering tree forming dense thickets in exposed positions. (Refer: Vol. 2, Technical Note T12)
Pittosporum crassifolium (Karo)	A hardy native shrub suitable for windbreaks. (Refer: Vol. 3)
Banksia integrifolia (Coast banksia)	A medium sized Australian tree suitable for windbreak planting. Withstands salt spray.
Lagunaria patersonii (Norfolk Island hibiscus)	A small tree used for windbreaks in warmer districts.

6.5 Further Reading

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