

SAND DUNE RECLAMATION IN NEW ZEALAND

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SYNOPSIS

Estimates of the extent of sand in New Zealand have varied because authorities have adopted different standards of stability and maturity of soils derived from sand. Cockayne refers to 24,000 acres in the South Island and 290,000 acres in the North Island. A thousand years of Maori occupation had modified the vegetation of the sand country and caused some acceleration of wind erosion, but the last century of European settlement has initiated a cycle of more active sand movement, mainly through cattle grazing and burning. Some concern at the increase in sand drifts was expressed by individuals before the end of the nineteenth century but Government recognition of the problem appears first in the Sand Drift Act 1908. However, this remained a dead letter. Cockayne reported on the sand problem in 1911 and the Government initiated a pilot stabilization scheme at Tangimoana in 1915. This work was begun by the Lands Department but was taken over by the Forest Service on its formation in 1929. However, the Forests Act 1921-22 was not considered to provide authority for sand reclamation and in 1931 further schemes were undertaken by the Public Works Department, partly for relief of unemployment. Sand reclamation was greatly reduced during the last war, while the need to increase farm production led to a shift of emphasis to farm development. In 1951, the development of sand country was transferred to the Lands Department with the proviso that all reclamation would be the responsibility of the Forest Service. Further schemes were initiated under this new policy.

*Pastoral occupation has caused considerable changes in vegetation. Some plants have disappeared, new plants have become established but the native sand-binders, *Spinifex hirsutus*, and *Desmoschoenus spiralis* remain. Introduced marram grass has become the most important primary stabilizer. None of the indigenous shrubs are sufficiently aggressive to be a satisfactory secondary stabilizer, a role filled primarily by *Lupinus arboreus*. The final or tertiary stabilizer is the forest for protection or production. The mainstay of the coastal forests is *Pinus radiata*.*

The principles of sand reclamation have not changed but methods have altered in the direction of mechanization, improved transport and economy in manpower.

EXTENT OF SAND

Sand dunes are an extremely frequent characteristic of the sea coast in New Zealand and to a limited extent they occur inland, as on the volcanic plateau, in Central Otago, and near Lake Tekapo. The total area is open to question. Cockayne (1911) speaks of 24,000 acres in the South and 290,000 acres in the North Island, of which 184,000 are in the Auckland Province. Lucy B. Moore (1963) in her

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recent publication on coastal plants, states that four out of every 1,000 acres in the country are sand, giving a total of 262,000 acres for the two main islands. Cowie and Fitzgerald (in press) write that an extensive complex of dunes, sand plains and peaty swamps bordering the west coast of the southern half of the North Island covers 270,000 acres. It is evident that different authorities have adopted different standards of stability and maturity of soils in estimating the extent of sand country.

ORIGIN

Dune sands originate from erosion of the uplands and from the action of the sea on the coasts. When carried to sea by the rivers, a great deal is caught by the shore currents and added to that caused by marine erosion. Drying on the beaches, this sand is carried inland by the prevailing wind and formed into dunes. The composition of these wind blown sands depends on that of the parent rock (e.g., magnetite, hornblende and augite in the ironsands of the Taranaki coast deriving from Mt. Egmont) and on the time during which they have been subjected to weathering and leaching.

The inland extent of dunes is evidence that they have accumulated over a long period. Cowie (1963) mentions the Koputaroa phase in the Manawatu as 15,000 years old, though other more extensive phases are appreciably younger. Weathering and consolidation would in the absence of human disturbance be accompanied by plant colonization and succession until a high degree of stabilization was achieved under a vegetation including much forest.

HUMAN INTERFERENCE

The moa-hunter and later Maori lived and travelled widely among the dunes for about a thousand years. No doubt they set fires and caused considerable renewal of sand movement. Sand drifts were noted by travellers who came here early in the nineteenth century. In the neighbourhood of Wanganui, Lieutenants C. H. Smith and C. Hutchison wrote of the sand blowing in their faces and of numerous sandhills "being drifted by heavy gales". Samuel Marsden in his missionary journeying stayed in the vicinity of Woodhill in 1820 and in his diary (Elder, 1932) wrote, "The sandhills are very high and command a wide prospect on the sea and in the interior. There is no vegetation upon them and the sand shifts with the contending winds. They are several miles broad."

Captain Cook's rediscovery of New Zealand opened the way for the white settler with his cattle and sheep. The hinterland was largely impenetrable and unexplored, but well grassed stable dunes were found handy on the coasts. Mustering could be made easier if the cover of bracken (*Pteridium esculentum*), tutu (*Coraria ruscifolia*) and scrub was burnt. With increased stocking, food became scarce and the cattle wandered from the flats to the hills and ridges, breaking the surface and eating sand-binding plants. The results of the burning and over-stocking were soon evident. Hills were turned into wandering dunes, fertile flats were buried, and gradually desert conditions prevailed. Such deterioration caused little concern except to the few it affected. No sand drift problem was recognized by Government until the early part of the twentieth century. However several individuals had taken some interest in the

problem and early papers are to be found in the *Transactions of the New Zealand Institute* and in the *New Zealand Country Journal*. J. C. Crawford, who probably introduced marram grass (*Ammophila arenaria*), published a short paper giving directions for raising it in nurseries.

EARLY CONTROL MEASURES

Eventually the increasing deterioration of the dune areas became evident to Government and the Sand Drift Act was finally passed in 1908. Under this Act any local authority, or two or more persons interested, could petition the Crown to set aside a specified locality as a Proclaimed Area. Once the petition had been approved and proclaimed, the Minister of Lands would then apportion the cost of the scheme among the owners of land within the Proclaimed Area. No sand reclamation scheme appears to have been proclaimed under this Act. There was also a bonus system whereby lessees on sand areas would be repaid for planting specified plants, but according to Cockayne (1911) this proposal was unlikely to lead to any useful results.

The Minister of Lands, recognizing that little was known of the dune areas, decided that a study should be made to gain further knowledge of their extent and condition, with a view to their future development. Cockayne was engaged to carry out this survey and his *Report on the Dune Areas of New Zealand* was published in 1911. Four years later, the Forestry Branch of the Department of Lands and Survey began a demonstration of reclamation at Tangimoana. The work was undertaken on a small scale, some foredune fencing was attempted and marram planted. The total cost of these operations from 1915 to March 31, 1917, was £370 6s 6d. The scheme lapsed during the remainder of the war, but the newly established Forest Service revived it in 1921. By March 31 1930, 671 acres of forest had been established, with 508 acres of *Pinus radiata*, 118 acres of *P. pinaster* and 45 acres of *P. muricata*. Trials included: *P. nigra*, *P. ponderosa*, *P. thunbergii*, *P. strobus*, *P. banksiana*, *P. echinata*, *P. canariensis*, *P. torreyana*, *P. densiflora*, *Pseudotsuga taxifolia*, *Chamaecyparis lawsoniana*, *Alnus glutinosa*, *Cupressus macrocarpa*. Except for a remnant of *P. densiflora* and scattered clumps of *A. glutinosa* and *C. macrocarpa*, all but a few individuals of these species failed.

Reclamation and the establishment of plantations were also carried out by the Railways Department at Foxton and by local bodies at New Brighton and Dunedin. Attempts were also made by individual settlers to stem the soil encroachments by marram planting in places along the Foxton-Himatangi-Turakina coastal belt. At the Flock House Farm of Instruction near Bulls, then administered by a board of trustees, 700 acres of forest was planted between 1924 and 1936 with radiata pine, some macrocarpa and *P. muricata*, along the eastern margin of the advancing dune complex. The mature radiata pine in this forest is now being logged.

GOVERNMENT POLICY

On completion of stabilization and tree planting at Tangimoana, the scheme reverted to the Lands Department and little reclamation or maintenance has been done there since.

Because of a rather rigid interpretation of the Forests Act 1921-22, the large-scale sand reclamation undertaken from 1931 onwards was assigned to the Public Works Department. The need to provide relief work during the depression set in motion a number of reclamation projects. In the Wellington Province the Hokio-Manawatu scheme commenced with marram planting in 1935 and tree planting began in the following year; reclamation has not yet been completed. This is now known as Waitarere Forest.

Work started in 1932 at Waiuku, Woodhill and Te Kopuru. The Woodhill scheme was extended to include Rimmer's and South Kaipara Head a year or so later under the title of Woodhill-Helensville Sand Reclamation Scheme. Further projects commenced at Pakiri-Te Arai, and at Kaitaia and Ruakaka.

The object of all these schemes was, first, to find relief for unemployment, secondly, to fix the sands and prevent further encroachment on to adjacent farmlands and, thirdly, to plant productive forests. Contact with the Forest Service was maintained. The late Chief Inspector of Forests visited the major reclamation projects on occasions and inspected the work undertaken. None of the stands at Woodhill or Waiuku had reached the tending stage before the war broke out in 1939. During the war both reclamation and tree planting reverted to a maintenance basis. When stands did reach an age to warrant tending, the only silviculture undertaken appears to have been complete low pruning.

LAND DEVELOPMENT

At this time the demand for primary produce to be sent overseas was unlimited. In attempting to meet the demand, production had to be increased. Land development for farming became a major activity of the Lands Department and, after the war, land was acquired for closer settlement under the Land Act 1948.

The coastal sand reclamation projects came under consideration during this expansion of land development, and in 1951 the Government transferred all sand projects from the Ministry of Works (as the Public Works Department had become) to the Lands Department, with the proviso that all reclamation work would be the responsibility of the Forest Service. The three major schemes transferred to the Forest Service were Waitarere, Waiuku and Woodhill. The Department of Agriculture, which had taken over Flock House before the war, also surrendered to the Lands Department 6,000 acres of coastal land, of which some 1,300 acres were coastal sands and 700 acres forest. Since the change of policy two other reclamation projects have commenced—Santoft in 1952 on the coastal sector between Rangitikei and Turakina rivers in the Wellington Conservancy, and more recently Aupori, northward from Ahipara in the Auckland Conservancy.

VEGETATION OF THE SAND DUNES

Of the pre-European vegetation found on the dunes by the early settlers there is little information. In the Horowhenua, Rod McDonald is recorded (O'Donnell, 1929) as saying that there was a heavy cover of scrub, tutu and bracken along the coast from the Hokio Stream northwards. To enable stock to be mustered, this was burnt, resulting in wind erosion and sand drift, and finally in a decline in the number of stock carried.

Occupation of the dune areas of New Zealand by European settlers has no doubt caused a considerable change in their vegetation. Plants have been introduced, a few plants have completely vanished, but the native sand-binders remain. On the foredune is found the silvery sand grass (*Spinifex hirsutus*), a true sand-binder which is an excellent foredune plant. The pingao (*Desmoschoenus spiralis*) is an endemic sand-binder found growing above high-water mark where it will, when conditions are favourable, build up a rather irregular foredune. It also colonizes damp flats, forming a series of hillocks. The third sand-binding grass, the introduced marram, *Ammophila arenaria*, is essential for reclamation. The indigenous sand-binders are not easily established from rootstocks or seed but the marram reproduces freely from stool shoots and is therefore used as the primary stabilizer.

Among the dunes are found sand flats or plains, some dry, some moist. In addition there are often lakes, but the largest and more permanent of these are usually found along the eastern margins of the advancing sand drifts. All these situations have more or less specialized flora, but the moist flats may become drier and both moist and dry site species are sometimes found growing together as conditions change. The plants on drier sites are *Carex pumila*, *Cotula* sp., *Leptocarpus simplex*, *Libertia peregrinans*, and *Pimelea arenaria*. *Mariscus ustulatus* appears adaptable to either moist or dry sites. On the moister are found *Juncus maritimus*, *Scirpus americanus*, and *Plantago coronopus*. Grasses and white clover, meilot and *Lotus* occur. The shrubs of the fixed or partly fixed dunes are *Cassinia leptophylla* mainly in the Wellington coastal belt, and *C. retorta* in the Auckland Province, *Olearia solandri* in the Rangitikei with bracken, manuka (*Leptospermum scoparium*), *Coprosma acerosa* and *Muehlenbeckia complexa*. Toetoe (*Cortaderia conspicua*) is commonly associated with flax (*Phormium tenax*) and cabbage tree (*Cordyline australis*) adjacent to lakes; but it is also found growing on sand plains in compact areas covering acres. Mention must be made of the tree lupin (*Lupinus arboreus*). This is used in conjunction with marram to complete the stabilization. The vegetation of most sand dunes now includes this most useful ground cover plant, though it is interesting to record that Cockayne did not favour it. This is no doubt the reason for its omission from the early work at Tangimoana.

Among the plants mentioned as forming indigenous (vegetative) cover among the dune complex, none has been used extensively for sand reclamation.

Neither *Spinifex* nor pingao grow freely from seed or rooted cuttings and so both are difficult to establish. The natural role of pingao is as the pioneer plant which will build up a foredune. The seed lodges in logs and driftwood above high water mark, there germinates and, if conditions remain reasonably favourable, it survives and begins to accumulate sand mounds. When driftwood abounds, pingao will often form a reasonably even foredune. The seedheads of *Spinifex* will lodge among the pingao stems and gradually supersede the latter until, as the foredune becomes completely covered with *Spinifex*, the pingao gradually dies away.

Marram is used where an artificial foredune is to be built. After catching fences are made, it is planted at close spacing and, although it needs a good deal of replanting, it will complete a foredune satisfactorily. The American beach grass, *Ammophila breviligulata*,

has not been successfully established at either Waitarere or Santoft. It has proved highly palatable to rabbits and hares, and has been of no practical stabilizing value.

These primary stabilizers do not achieve the complete fixing of the dune sands without further aid. Surface sand will move inland from the foredune and secondary cover is required to complete the reclamation. Shrubs such as manuka, *Olearia*, *Cassinia* and *Pimelea* may follow naturally but their growth is usually slow and sparse, and other quicker growing species capable of withstanding the arduous conditions are required for reclamation work.

The tree lupin has in this country proved most successful in arresting surface drift, giving shade to the ground surface and countering the nitrogen deficiency of sand soils. Another secondary stabilizer, *Acacia sophorae*, has also proved reasonably successful for cover on the foredune. It is of slower growth than the tree lupin, but will reproduce from seed and by layering. *Acacia cyanophylla* as foredune cover has not been successful, but has grown satisfactorily about a mile inland from the beach at Santoft. Trial plantings and direct seeding with *Acacia cyclopis* were unsuccessful.

The final or tertiary stabilizer is the forest for protection and production. Salt-laden winds and infertility limit the species which will succeed on sand country. The mainstay of coastal production forest is radiata pine, because of the rapidity of growth, high yield and market acceptance. *Macrocarpa* does well on sand, excelling radiata pine in the foredune area as a protective belt. It is rather difficult to establish and has not been a success as open-rooted stock, while balled or tubed stock are costly for extensive use. There is a need for further work on species suitable for protective belts. The ideal would be a tree that will do well on the free-draining sand soils, will withstand salt-laden winds, and preferably be fire resistant. Among shrubby hardwoods planted in trials, *Olearia traversii*, *Leptospermum laevigatum*, *Osteospermum monoliferum* and *Acacia sophorae* have been established in the lee and on the crest of the foredune. Of poplar plantings the most successful have been the common Lombardy (*Populus nigra* var. *italica*), Boll's poplar (*P. alba* var. *pyramidalis*) and *P. candicans*. More time will be required to evaluate the result of plantings of *Eucalyptus botryoides*, *E. camaldulensis*, *Acacia melanoxylon* and *Pinus serotina*.

Preparation for planting follows the usual pattern of line cutting, crushing, aerial spraying or ploughing. The last method is used on sand plains where there is a heavy cover of rushes; the lines only are ploughed. It has been found that aerial spraying for preparation will to a great extent obviate the necessity to release cut after planting. Further experience with spraying may allow even more effective control of lupin. Silvicultural procedures for radiata pine on the sand country of the Wellington Conservancy are similar to those for the species on other forests, but the need to maintain a high diameter/height ratio by regular thinnings is of greater importance where high winds occur frequently and stem breakage rather than wind-throw is a major hazard. As far as practicable, the protective zone immediately behind the foredune is being established before the main planting further inland. In the older forests where this procedure was often reversed there remains a big problem in utilizing a series of wind-swept edges and gradually replacing them with trees of more normal growth.

CHANGING TECHNIQUES

The principles of sand reclamation have not changed significantly since the work began in 1915 at Tangimoana. What has altered is the methods used to put these principles into operation, particularly in the fields of transport and mechanization. The foredune must still be built or maintained, the marram planted, lupin cover established, and finally trees planted. In the thirties, the need to apply as much of the available finance as possible to relief work did not at first allow for any means of transport. Men walked from the camp to the job, the marram was carried on home-made stretchers, all marram was planted by hand. Contracts were let for the supply and planting of marram at 4 × 4 ft spacing at a price of 32s. 6d. per acre. The equipment and the camps would now be classed as primitive. Later, approval was obtained to use pack horses, sledges and even bullock teams to transport marram and camping materials. However, everybody still walked.

After the war there were changes. Labour was in short supply and suitable transport was available to go over sand, roads or no roads. Tractors replaced horses, and planting machines were designed to work with the tractors.

PROTECTION

There are the usual hazards encountered at any forest: fire, climate, animals and insects. The risk of the lack of continuing finance to complete any project started is one of the major hazards in sand reclamation. Once an area is planted with marram it must be maintained in the following season. This involves blanking and replanting of blown out areas. If this is not done, the treated area usually reverts to a mass of hills and hollows which are costly and difficult to stabilize in after years. There are plenty of examples in New Zealand of this type of reclamation which has been started and abandoned.

Fire hazard is present, as in all exotic forests. The growing resident population of the seaside villages adjacent to some of the coastal forests, and the thousands of visitors to beaches during the summer months, make the chances of fire occurring rather higher than on most exotic forests. This danger from fire can usually be reduced to reasonable proportions by good public relations and the co-operation of the local inhabitants; also by the provision of plenty of water points and trained fire-fighting personnel.

Rabbits and hares must be kept in check on newly planted marram areas. When present in moderate numbers, the damage is usually limited to a few well-defined flats. As on other forests when tree planting begins, all steps must be taken to obtain more complete control. Opossums do not frequent dune areas to any extent, until forest has been established. At Waitarere Forest their favoured diet to date has been the young shoots of *P. pinaster*. Fallow deer inhabit the Woodhill-South Kaipara Head coastal belt; Sambur deer the sector from Hokio to Turakina. They cause considerable damage by stripping the bark from young radiata pine.

The caterpillar of the native moth (*Mycena maoralis*) defoliates tree lupin and, when present in epidemic numbers under drought conditions, has caused heavy mortality among mature lupin.

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