

SAND COUNTRY OF THE WELLINGTON
WEST COAST

G. H. HOCKING

Reprinted from *New Zealand Journal of Forestry*, 9 (2): 128-38
(1964).

SAND COUNTRY OF THE WELLINGTON WEST COAST

G. H. HOCKING*

SYNOPSIS

Sand soils occupy 270,000 acres of the Wellington West Coast between Paekakariki and Patea. Four age phases are recognized, the older three being referred to collectively as the Older Dune Complex and the most recent, the Waitare Phase, as the Younger Dune Complex. This last derives from wind erosion caused mainly by a century of European farming occupation. The climate is characterized by strong winds and summer drought. The natural vegetation has been modified to a limited extent by 1,000 years of Maori occupation and more completely by recent pastoral use. The stability and use of the soils of this sand country are largely dependent on their moisture status, which forms the main basis of their classification. The earliest official recognition of the sand drift followed by a pilot reclamation scheme undertaken by the Lands Department and the Forest Service at Tangimoana between 1915 and 1931. Sand reclamation was then extended under the Public Works Department until 1951, when it reverted to the Lands Department and the Forest Service. Government policy in sand reclamation has aimed primarily at bringing more coastal land into farm production, forest production being a secondary consideration. At present, State forests at Waitare, Tangimoana and Santofi contain 18,700 acres of which 12,000 acres are regarded as potentially productive and 5,200 acres have been planted. The timber requirements of the Manawatu-Wanganui district and adjacent districts are substantial and a land-use study has shown that, on the freer draining sand soils, forestry is significantly more profitable than sheep/beef farming and is of comparable profitability to dairying on the limited areas suitable for this type of farming. Dairying combined with farm forestry is more profitable than either enterprise on its own.

INTRODUCTION

Soils formed from wind-blown sand cover 270,000 acres on the Wellington West Coast extending from Paekakariki in a semi-circle for 110 miles to Patea with a few minor occurrences westward along the coast of south Taranaki. They form an appreciable part of the lowlands of the Horowhenua, Manawatu and Rangitikei counties where they vary in depth from 2 to 12 miles. The general level of production from these soils is low, but recent studies of the soils and land-use economics have shown that production could be raised considerably with forestry playing a major role.

The sands forming these soils are derived from greywacke of the main ranges, mudstones and sandstones flanking these ranges, and volcanic materials from the Taupo and Taranaki districts. Quartz

and feldspar are the dominant minerals with magnetite, hypersthene, augite and hornblende as minor constituents which become more abundant northward along the coast. The ease with which most of the minor minerals weather ensures a good supply of most nutrients to the soil, though potash is low. Shell fragments mixed with the sand on the beaches provide initially a rich source of calcium. Even the older soils here show no sign of podzolization. Addition of sand from the rivers to the beaches is a continuing process so that the sand country soils generally increase in age with increasing distance from the beach. Adkin (1948) estimates that the Waitare beach has built out at an average rate of 2 ft per annum for the last 600 to 800 years, and at Santofi, north of the Rangitikei River, there has been an average advance of about 3 ft per annum in the 80 years since the *Fusilier* was wrecked there. Accretion and stabilization of sand has not been a regular process and Cowie (1963) distinguishes four dune-building phases — see Fig. 1. In decreasing age these are:

- (a) *Koputaroa Phase*. This is of limited extent and much older than the other phases; the sandy loam soil has a well developed profile. It is thought to be 10,000 to 15,000 years old.
- (b) *Foxton Phase*, occurring in a belt 2 to 4 miles wide and abutting on older sedimentary beds or river deposits, is older than the Taupo eruption, probably 2,000 to 4,000 years old.
- (c) *Motuhi Phase*. Carbon-dated totara stumps and buried Maori occupation material indicate that this phase was formed 500 to 1,000 years ago; it may be attributed to destruction by the Maori of vegetation on previously stable dunes. Dunes of this phase contain a large proportion of pumice in many places but, as they are considerably younger than the Taupo eruption, they cannot have been directly caused by it.
- (d) *Waitare Phase* occurs as a coastal belt up to 2 miles wide throughout the sand country and as small patches where the previously stable sand plains and dunes of the Motuhi phase have been wind-eroded. The advance of the Waitare dunes is attributed partly to over-grazing and burning of the original vegetation on previously stabilized dunes, and partly to accelerated erosion inland causing increased accumulation of sand along the beaches. This phase is generally a development of the century of European occupation.

The Waitare phase is conveniently referred to as the Younger Dune Complex and the Motuhi and Foxton phases collectively as the Older Dune Complex, but small areas of unconsolidated dunes occur within the Older Dune Complex where there has been rejuvenation of previously consolidated dunes and flats. The forester, in his dual role of stabilizing drifting sand and developing production forests, is concerned mainly with the Younger Dune Complex and the freer draining soils of the Older Dune Complex.

The overall relief of the sand country is flatish with a gentle slope from the beach to the inland margin, usually about 100 ft but rising to 350 ft near Bulls. North of the Rangitikei River the surface of the sand still rises gently from the coast but is sometimes interrupted where wind-blown sand thinly covers old marine or river terraces. West of the Wanganui River the sand country is separated from the beach by cliffs of sedimentary beds which increase in height westward.

* Assistant Conservator, N.Z. Forest Service, Palmerston North.

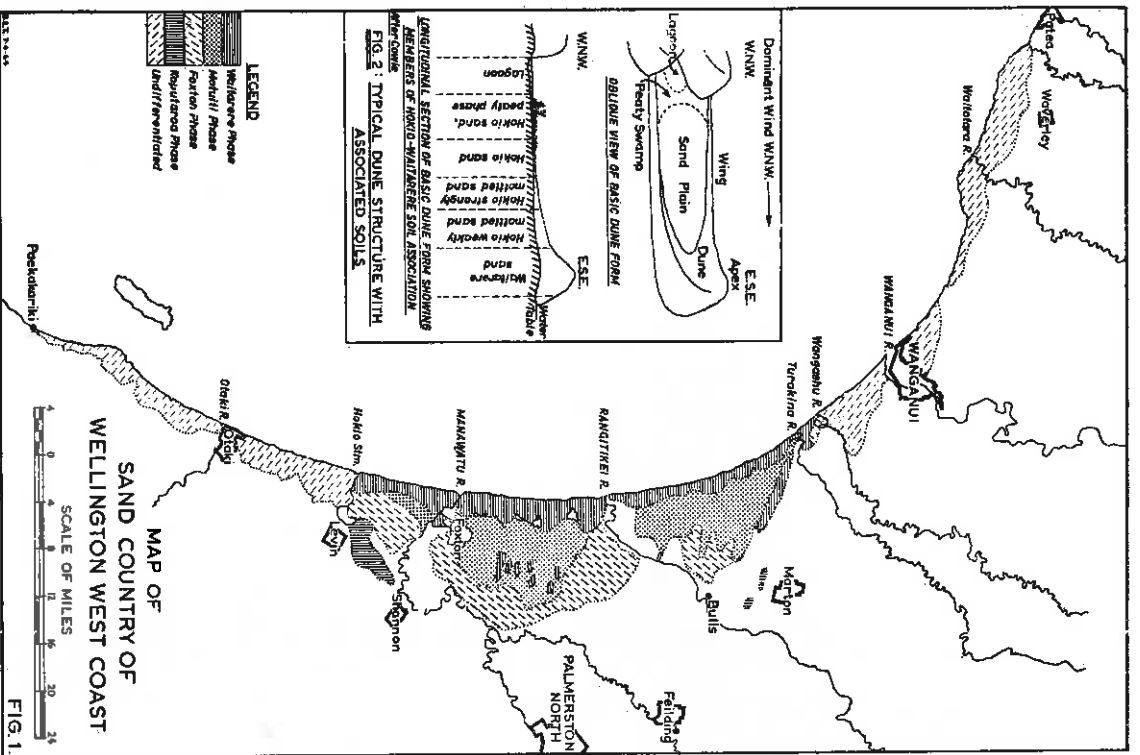


FIG. 1

This low relief is obscured by the alternation of dunes and sand plains; these affect the drainage and lead to the differentiation of soils. The basic dune form consists of two parallel east-south-east trending wings, up to 2 miles long, united at their eastern end to form an apex which is generally the highest part of the dune — see Fig. 2. The land enclosed by the dune is a flatish sand plain which slopes up eastwards towards the apex where the water-table is well below the surface. As the level of the enclosed plain declines westward the water-table approaches the surface and, at the foot of the next dune, is usually only a few inches down. Where the flow of the surface water away from the sand plain is restricted by encircling dunes, peaty swamps, ponds and lakes are formed. There is a string of such lakes in the Manawatu district where sands of the recent Waitarere phase about on those of the older Motuiti phase. Although examples of the basic dune form are common, the pattern is usually more complex, particularly where breaks in vegetation have led to renewed movement.

The direction of dune movement has remained consistently east-south-east in sands of all ages, indicating that the prevailing wind direction has not changed over a long period. In the Horowhenua and Manawatu districts, sand movement is almost at right-angles to the beach, but the westward sweep of the coast results in an oblique movement in the Rangitikei district and one almost parallel to the beach north of Wanganui.

CLIMATE

The coastal lands considered here lie within the Western Wellington Climatic District which is characterized by warm summers and mild winters, a reliable rainfall evenly distributed throughout the year, and prevalent west to north-west winds with relatively frequent gales (Robertson, 1959). However, conditions on the sand are distinctly harsher than on the more inland parts of the district; rainfall is lower and drought conditions are common on the more freely draining soils during summer.

Most of the rain is brought by westerly winds and the rainfall pattern is largely controlled by the position of the higher country to the east which causes precipitation of moisture brought by these winds. The average rainfall between Waitarere and Santofi is 33 to 35 in. on 120 to 140 rain-days. There is only a slight increase north of Santofi, but a more rapid one to about 40 in. on the narrowing coastal plain south of Waitarere. The dominant west and north-west winds are most frequent in the spring and early summer and carry much salt inland, damaging vegetation.

Observations at Flock House Farm of Instruction show that the air temperature is greatest in February when the mean monthly temperature is 63.1°F and mean daily maximum and minimum temperatures are 71°F and 55°F, respectively. They are lowest in July when the mean monthly temperature is 46.4°F. The mean number of days with ground frosts is 50.7 per annum and severe frosting can occur on low-lying sand plains right to the coast.

NATURAL VEGETATION

There are no detailed descriptions of the vegetation found by the early European settlers—a vegetation already modified by

the Maori. Early reports of the area mention open country with grassy flats and ridges interspersed among areas of manuka (*Leptospermum scoparium*), bracken (*Pteridium esculentum*), tutu (*Cortaria ruscifolia*), rushes, toeioe (*Cortaderia conspiciua*) and flax (*Phormium tenax*). These accounts also mention that the western edge of the forest ran from the northern end of Lake Horowhenua to Poroutawhao Pa, and from Rangioitu to the junction of the Makowai Stream with the Rangitikei River. On the wetter flats this was typical semi-swamp forest composed chiefly of pukatea (*Laurelia novae-zelandiae*), kahikatea (*Podocarpus dactyloides*) and tawa (*Beilschmiedia tawa*), while on the drier sand plains and dunes the forest consisted chiefly of totara (*Podocarpus totara*), tawa and titoi (*Alectryon excelsum*). Buried stumps and logs, particularly of totara, point to there having been much more forest on the drier soils than the first European settlers found.

Cockayne's classic report (1911), which gives the first comprehensive account of the vegetation of this and other sand areas in New Zealand, was made after this district had been subjected to 50 to 60 years of European occupation during which the vegetation had been profoundly changed by grazing, burning and the introduction of exotic plants. Space does not allow of any description of the natural associations and succession of vegetation on sand under various conditions of consolidation and soil moisture. These have been described by Cockayne (1911), Moore (1963) and Carrahan (1957).

SOILS

The soils of the Wellington West Coast sand country have been described by Cowie (1957), Cowie and Smith (1958), and Cowie and Fitzgerald (in press). Because they are coarse-textured and occur in a district with a fairly low summer rainfall, their stability and use are largely dependent on their moisture status. Consequently soil characteristics such as drainage, content of organic matter, texture, structure and consistency—features which determine the moisture status and erodibility of the soil—are used as the main criteria in distinguishing soil types and phases. Differences in these characteristics can be related to the topographic position of the soils (dunes, sand plains and peaty swamps), their age, and the native vegetation under which they have developed.

The Soil Bureau, D.S.I.R., has surveyed the coastal country from the Hokio Stream below Waitarere to the mouth of the Waingahau River, and discussed the soils, their utilization and management (Cowie and Fitzgerald, in press). In this survey soils have been mapped, not by individual types and phases, but by associations. These are groups of types and phases which are geographically associated in a regular pattern; thus the soils of dunes are grouped with their accompanying sand plain and peaty swamp soils, differences between soils being due to drainage, relief or aspect. The principal members (types and phases of an association) are those which individually occupy from 10% to 70% of the area; minor members are those occupying less than 10% of the area. In naming associations the dominant member comes first. Thus in the Younger Dune Complex two associations are distinguished, the Waitarere-Hokio and Hokio-Waitarere. The first has a predominance of excessively draining dune soils (Waitarere sand) and a minor amount of the less freely draining Hokio soils of the sand plains; in the second

the proportions are reversed. In the Older Dune Complex soil associations are differentiated first into dune soils dominant or sand plain soils dominant; the latter are further divided on the dominance of either wet or dry sand plain soils.

Soil associations provide a convenient basis for broad land-use planning and for determining the best type of farming for a particular holding. The forester and the farmer will need to recognize the individual soil types or phases within an association in order to make the best use of a particular compartment or paddock. Cowie and Smith (1958) have mapped and described in detail the individual soils over 40,000 acres towards the middle of the area under discussion. This survey has already proved a valuable guide in determining the limits to which radiata pine can be planted on moist to wet flats without suffering root rot or wind-throw. In this connection it may be noted that afforestation of the more freely draining soils will often result in a lowering of the water-table in adjoining peaty soils, making them suitable for tree growth.

PAST LAND USE AND THE SAND DRIFT PROBLEM

Nearly a thousand years of Maori occupation undoubtedly had a considerable effect on the sand country, particularly in the Motuiti phase. In the early days of European settlement the beach formed the main line of communication up the west coast of the North Island, as it had done in Maori times. The first use of the land by the early settlers was for extensive cattle grazing. McDonald (O'Donnell, 1929) recalled that, in the seventies, six settlers leased all the country from Otaki to the Manawatu; similar conditions obtained further north. The cattle would have reduced much of the protective cover, including the palatable *Spinifex* on the foredune. But burning to open up the country for mustering was probably the most damaging aspect of this use of the Younger Dune Complex.

For long the sand country was considered to have no better use than extensive cattle grazing, and wind erosion became increasingly severe. Dairying developed on the moister soils, mainly between the Manawatu and Rangitikei rivers, but there was little attempt to develop the younger soils for mixed sheep and cattle farming until after the last war. Tree planting was primarily for shelter or control of wind erosion. Before the end of the last century, sand drift was becoming an obvious and increasing problem, and the Railways Department found it necessary to plant radiata pine to keep sand off the Foxton line. There were individual efforts at stabilization and the Sand Drift Act of 1908 reflected some public concern, but remained a dead letter.

It was Cockayne's report of 1911 which provided the first comprehensive scientific analysis of the sand drift problem and emphasized that it was of national importance. As a result of his recommendation, the Forestry Branch of the Department of Lands and Survey began sand stabilization in 1915 preparatory to afforestation on a demonstration area at Tangimoana. Ironically, the pilot scheme was on a resumed Crown lease which had been devastated by grazing—a part of a belt of such leases which extended almost uninterrupted from Himatanui Beach to Wanganui. The Tangimoana scheme languished during the war years but was revived by the newly established Forest Service in 1921.

Though Cockayne had pointed out the dual objectives in sand stabilization — protection of farm lands and productive forestry — there was still little appreciation of forestry as a land use in its own right. Thus it is found that, when the Forest Service had completed the pilot scheme at Tangimoana, the land and its plantations reverted to Lands Department control in 1931. In the same year the need to find useful relief for the unemployed opened the way for increased sand stabilization by the Government. Because the Forests Act 1921-22 was considered not to provide legal or financial authority to engage in large-scale reclamation, the work was undertaken by the Public Works Department. The only project on the Wellington West Coast under this arrangement was at Waitare where stabilization began in 1935 and tree planting in 1936 on a belt kept as narrow as practicable.

In 1951, still with the primary object of bringing more coastal land into farm production, the Government transferred control of sand reclamation to the Lands Department with the understanding that the Forest Service would carry out the work of fixation and tree planting as required; but planting was to be kept to a minimum. The Land Act 1948 gave the Lands Department power to buy land for settlement or for any Government purpose and to develop Crown land for settlement. Incidentally the Forest Act 1949 also gave the Forest Service the authority to "acquire, use or develop land . . . for stabilization of soil, including sand fixation". It was agreed that compact and readily definable areas which had no immediate agricultural potential were to be proclaimed State forests, but in all other cases the land was to remain Crown land.

It was soon realized this procedure would allow little productive forest to be developed and that consequently, in times of financial stringency, the protective work might be neglected and lead to subsequent revival of the sand menace to farm lands. Such deterioration had indeed occurred at Tangimoana through neglect of maintenance after the Forest Service withdrew in 1951, and at Parewanui. Consequently, in 1955, inter-departmental procedure was modified. Reclamation of land for farming remained the primary objective but, where possible and approved, the need to have a sufficient area of productive forest to allow the Forest Service activities in any sector ultimately to be self-supporting was to be taken into account. This remains Government policy, so that areas to be devoted to productive forestry are still determined and the issues obscured by considerations other than a weighing of farming and forestry as alternative land uses.

Under the present arrangement, the Forest Service took over control of the Waitare scheme in 1951 and began stabilization at Santoft in 1952. Here the inland limits of the part devoted to forestry coincide with the inner limits of the Younger Dune Complex but minor areas within the Santoft Farm Settlement are assigned to forestry because of their actual or potential instability, and to provide access.

RECLAMATION AND AFFORESTATION

The present position of sand stabilization and forestry undertaken by the Forest Service is briefly as follows:

- (1) At Tangimoana there are approximately 500 acres of plantation,

predominantly radiata pine, established by the Forest Service 35 to 40 years ago. Less than 100 acres of this is on State forest land, the remainder being on the Tangimoana Farm Settlement where felling is now in progress. Some of the forested land in the settlement may revert to the Forest Service after logging. A frontal strip, mainly unplanted, and an interior area of unstable sand aggregating 1,490 acres have been made State forest, and the extension of stabilization and afforestation southwards to Himatangi Beach is intended. The scheme is estimated to comprise ultimately about 1,600 acres of State forest, about 800 acres of which will be productive.

- (2) Santoft, with a gross area of 12,850 acres, includes 780 acres of predominantly radiata pine aged 30 to 40 years established by the Flock House Farm of Instruction; logging and re-establishment are proceeding in this block. On the remainder of Santoft, the emphasis has until recently been on stabilization, which is continuing at a reduced tempo. Tree planting since 1955 has now built up to 1,470 acres and is proceeding currently at the rate of 400 acres per annum. The estimated ultimate area of productive forest is 8,000 acres.

- (3) Waitare has a gross area of 4,370 acres of which 2,790 have been planted, mainly in radiata pine. The ultimate productive area is expected to be about 3,200 acres.

- (4) At Himatangi the Forest Service administers two small blocks aggregating 27 acres, immature third-rotation remnants of the former Railways plantations.

In total, the Forest Service administers approximately 18,700 acres of sand country of which 5,200 acres have been planted and 12,000 acres are regarded as potentially productive. At present the allowable cut for the group of forests is 400,000 cu ft per annum. It is probable that the Forest Service will at some time be required to take over more unstable country in the Manawatu and possibly in the northern Horowhenua district, but it now seems unlikely that it will need to take over any land north of the Turakina River for protection. It is probable that the Justice Department (Borstal) will undertake stabilization and tree planting in the Wangaeih-Wanganui sector. Elsewhere it seems unlikely that State intervention will be necessary. Stabilization should be achieved under private ownership with assistance under soil conservation subsidy and with better farming practice. Private and company forestry is likely to assist by removing some of the less stable sand soils from pastoral use, while there is an increasing interest in farm forestry.

Private planting for shelter and sand stabilization has been widespread but rarely within a mile of the beach. Three sawmilling companies have their own forests of about 1,200 acres and all other planting with any productive potential might be expected to aggregate about another 4,000 acres. Most of these commercial plantings are on the Older Dune Complex but the largest company plantation is on an inland intrusion of the Waitare-Hokio association, 3 to 4 miles from the coast.

In the past, management of the frontal zone bordering the beach has been concerned almost entirely with stabilizing moving sand

and silting the productive farm and forest land behind. Now the beaches are becoming increasingly important for recreation and the frontal dunes for seaside housing. Established resorts are expanding rapidly, new ones are developing, additional areas of Crown land are being set aside for future settlement, and access to the coast is being improved. These developments are increasing fire and trespass hazards and will necessitate the creation of less inflammable cover near the beach and better public relations.

REGIONAL TIMBER REQUIREMENTS

Granger (1960) has shown that, to achieve self-sufficiency in the Manawatu-Wanganui planning district in the year 2025, an additional 25,000 acres of exotic forest will be required. This estimate may be conservative, as no allowance was made for the predominance of long-rotation species in Kariri Forest. Apart from the sand country, the planning district contains little land suitable for large-scale forestry, except for sandstone formations inland from Wanganui, and much of these would be more costly to develop than sand country. Furthermore, the Manawatu-Wanganui planning district adjoins two other deficient districts: Wellington, requiring 90,000 acres of forest, and Taranaki, requiring 20,000 acres. Any production beyond local requirements in the southern half of the Wellington West Coast sand country would have an advantage over much of Wellington's alternative source of supply in Waitarapa. Similarly, any surplus in the western part of the district is likely to be a more economical source of supply, at least for southern Taranaki, than an extension of forestry in the difficult hinterland of that province. The generally favourable situation of the sand country is further illustrated by the fact that, at present, there is a population of 136,000 within a radius of 30 miles of the mouth of the Rangitikei River in the centre of the potential forest land, and 500,000 within 100 miles.

An added advantage of this country for forestry is that it has a fairly well developed system of roads at least in the Older Dune Complex, provides good logging conditions all the year round, and is close to established sawmills. These facts are already reflected in the stumpage level, which is appreciably higher than for neighbouring districts. Consequently there is likely to be a favourable market for sawlogs for any foreseeable extension of State, company or private forestry. At present there is an unsatisfied market for roundwood as posts and poles but, unless new industries develop, the supply will soon overtake the demand and disposal of thinings will be difficult. The overwhelming reliance on one species, radiata pine, may also be a weakness.

ECONOMICS OF FARMING AND FORESTRY

With this favourable economic environment for forestry, a policy of relegating it to the subordinate roles of erosion control and shelter can hardly be sustained. Returns from untended stands, often planted primarily for these protective purposes, compare very favourably with the returns from farming similar land. There is a real need for economic analysis of the alternative land uses for soils of the Younger Dune Complex and the drier associations of the Older Dune Complex.

Fortunately such a study has recently been undertaken (Chisholm, 1963) under the auspices of Massey University. It determined the comparative profitability of sheep/beef farming, dairying, and forestry on the basis of land expectation value; also whether developed or partially developed land in any of these uses could be more profitably converted to an alternative land use. It was made on the agriculturally lower-producing sand country where expanding farming and forestry are most likely to be in competition — *i.e.*, on the Younger Dune Complex and a drier group of associations of the Older Dune Complex (Himatangi-Foxton, Foxton-Himatangi, Foxton-Omanuka and Awahou-Foxton). The establishment of protective cover adjacent to the beach was regarded as a benefit shared equally by all land uses. Other variables included were the planting period in forestry, the stages of development in the two types of farming, and four interest rates ranging from 4½% to 6½%. The general trend of results showed that:

- (a) Large-scale forestry was significantly more profitable than sheep/beef farming.
- (b) The profitability of large-scale forestry and dairy farming was of the same order on similar soils.
- (c) Dairy farming combined with farm forestry was more profitable than either enterprise on its own.

Only 20% of the area of the associations studied have sufficient moist soils to support dairying, and the expectation values for this use are restricted to this part. Land for winter run-off for dairy stock, mainly on the drier associations of the Older Dune Complex, commands prices of from £45 to £90 per acre or equivalent rentals — prices far above the value of the land as part of a complete farm unit. This special value, associated with highly productive land elsewhere, could be a hindrance to the consolidation of areas of drier sand country for large forest blocks.

The study suggests that, in an area of 74,000 acres in the associations studied between the Hoki Stream and the Turakina River, 6,500 acres would be absorbed in the protective coastal strip; 39,000 acres should be used for large-scale forestry; 13,500 acres for dairy farms (preferably with some farm forestry); and 15,000 acres for run-off. It is considered inadvisable to use any the area for sheep/beef farming.

This study serves to emphasize the unsatisfactory basis for decisions which in recent years have assigned land composed of the drier members of the Waitare-Hoki soil association to sheep/beef farming and have even removed forest from these soils to extend such farming.

Considering the sand country of the Wellington West Coast as a whole, it is apparent that extensive patterns of land use make very inadequate use of its productive potential and lead to serious wind erosion. Fullest production and stability can be achieved only by a clear recognition of the soils and their characteristics based on drainage status and their assignment to their best use under a more intensive pattern of land use.

ACKNOWLEDGEMENT

Grateful acknowledgement is made to J. D. Cowie of the Soil Bureau, D.S.I.R., Palmerston North, for making available his un-

published as well as published work on these sand soils, and for discussing this paper; also to A. H. Chisholm, now of the University of New England, New South Wales, for permission to use material from his thesis presented for the degree of Master of Agricultural Science in Massey University of the Manawatu.

R E F E R E N C E S

- Adkin, G. L., 1948. *Horowhenua: Its Maori Place Names and their Topographical and Historical Background*. Department of Internal Affairs, Wellington, 477 pp.
- Carrahan, J. A., 1957. Botany of the Manawatu Sand Country. *Proc. N.Z. Ecol. Soc.*, 5: 17-8.
- Chisholm, A. H., 1963. *The Relative Profitability of Forestry and Agriculture on the Manawatu-Rangitikei Sand Country*. A thesis presented in partial fulfilment of the requirements for the degree of Master of Agricultural Science in the Massey University of Manawatu.
- Cockayne, L., 1911. *Report on the Dune Areas of New Zealand*. Department of Lands and Survey. Parliamentary Paper C.13.
- Cowie, J. D., 1957. The Soils of the Manawatu Sand Country. *Proc. N.Z. Ecol. Soc.*, 5: 15-6.
- Cowie, J. D., 1963. Dune-building phases in the Manawatu District. *N.Z. J. Geol. Geophys.*, 6: 268-80.
- Cowie, J. D.; Fitzgerald, P. (in press). Soils of the Manawatu-Rangitikei Sand Country. *N.Z. Soil Bureau Bull.*
- Cowie, J. D.; Smith, B. A. J., 1958. Soils and agriculture of the Oroua Downs, Glen Oroua and Taikorea Districts, Manawatu County. *N.Z. Soil Bureau Bull.* 16, 56 pp.
- Granger, M. B., 1960. *Future Forest Requirements in Wellington Conservancy*. N.Z. Forest Service, unpublished report.
- Moore, I. B.; Adams, N. M., 1963. *Plants of the New Zealand Coast*. Paul's Book Arcade, Auckland and Hamilton, 113 pp.
- O'Donnell, E., 1929. *Te Hekenga*. G. H. Bennett & Co. Ltd. Palmerston North.
- Robertson, N. G., 1959. The Climate of New Zealand. *A Descriptive Atlas of New Zealand*. Government Printer, Wellington, pp. 19-22.