

The dune area varies from a foredune, or merely a few low mounds of sand, to a width of several miles, the maximum being about seven miles between the rivers Wangaeahu and Rangitikei, in western Wellington. It is easy to overrate dune distances, for traversing them on foot is very laborious.

Large tracts of land such as the above are not at all worthless by any means. There are low-lying wettish flats clothed with nutritious grasses, streams, shallow lakes, and extensive swamps. The hills themselves are not generally bare, but possess a plant-covering varying from a few tufts of sand-binding grass or sedge to a close turf overlying a deposit of loam, and affording fairly good pasture. It frequently is at the extreme inland boundary where the wandering dunes, huge masses of bare sand, slowly moving, are encountered (see Photo. No. 19).

Generally speaking, the view from an eminence is that of a sea of sand, the ridges stationary billows, as indeed they are, the scanty vegetation showing only as small yellowish or dark patches on the general white or greyish groundwork.

The dunes differ much in height in different parts of New Zealand. The foredune may be from 8 ft. to 20 ft., but the inland dunes are very variable, attaining to the great height of 300 ft. or more at Mason Bay, Stewart Island, and to about the same between Cape Maria and Ahipara. Generally speaking, 20 ft. to 50 ft. is a common height, but hills of 100 ft. or more are not infrequent, especially on the fixed and most inland dunes, whose instability was so little suspected in the early days of settlement that they received names (Mount Amon, Mount Jacob, &c.), and were made the site of trig. stations.

(F.) MOVEMENTS OF DUNES AND DUNE SAND.

(a.) GENERAL.

It is easy to see that, built of so unstable a material as sand, a dune area is in a constant state of change. Just as the ridges of ripples and the hollows alternate, so do dune ridges and sand plains. The dune having reached maturity, it is at once attacked by the wind, gashes are made in its surface, slight depressions are changed into deep gullies, plants are uprooted or buried, and high hills are finally blown away. Also, as Shaler has shown, the rubbing together of the sand-grains leads to the formation of dust, which will, with much very fine sand, be blown away from the dune area altogether (46). But with the destruction dune-building goes hand-in-hand, new dunes arise, and fresh chains of hills are formed, these in turn to be destroyed. All this round of destruction and regeneration is the work of the wind, modified by the plant life.

(b.) WIND AS A DESTRUCTIVE AGENT.

So long as the wind brings a sufficient sand-supply, and the sand-binding plants form a close enough and even enough covering, will the dunes remain intact. But with increasing stability of the surface so does the sand-supply decrease, while in any case the tendency of the plants is to raise prominences and hillocks, nor do they usually in a state of nature grow closely, there being many isolated tufts or tussocks.

The wind performs a dual function; it transports material, and it erodes. When there is less than a certain amount of material brought the erosion will predominate. So, too, will this be the case with winds of abnormal intensity. Where a high wind blows over a well-fixed area it transports little, but attacks every bare spot.

A certain velocity of wind does not act everywhere with uniform power; on the contrary, it is a variable factor, depending on circumstances. First of all, the nature of the ground-surface is a matter of great importance, all irregularities tending to break the force of the wind, as the observations of King and Olsson-Seffer have shown, the experiments of this latter author demonstrating that *the velocity of wind over a smooth surface is at least 34·7 per cent. greater than on uneven ground* (35, p. 560). Grassy ground, then, can be seen to have a powerful influence in restraining the wind, while the effect of rows of sticks, &c., fixed in the soil, small as it might be thought, is very great indeed, and on such depend some of the methods of sand reclamation to be discussed in a continuation of this report. When the wind strikes on a solid object, such as a dune, its power is greater at the sides than in front, while in the lee an eddy is formed varying according to the force of the wind. Each obstacle, then—every sand-mound, tussock, or shrub—favours erosion. Still more is the velocity of the wind increased by the proximity of two objects, as two adjacent mounds, making a channel (see Photos. Nos. 1, 14, and 15). Through such the compressed air blows with increased erosive power, making ever-deepening cuts into the sand, until finally what were at first but bare sand patches become gullies, these latter varying from merely saddles to miniature gorges. In such wind-channels there is nothing but bare sand; the sand-binding plants are uprooted in the first place, and it is impossible for them to gain a foothold again without shelter (see Photo. No. 1). Nor is it simply a direct wind-current which operates; there is always the lee eddy playing a powerful part, and there is a vertical as well as a horizontal stream of air; in fact, an air-current is a most complex matter (see Langley, 29). Moreover, as shown before, air vortices are caused by impact upon certain obstacles. The erosive power of the wind is therefore frequently much intensified, and a dune unprotected, or partially protected, by vegetation is by degrees cut into deeply, and finally may be quite blown away, the only trace of its former presence being dead rope-like rhizomes of the pingao (*Scirpus frondosus*). Dunes in all stages of destruction may be seen in any area from a tiny bare sand-hollow between two tussocks to a sand-plain without a trace remaining of the former dune chain which occupied the ground.

From the above it may easily be seen that the natural fixing of sandhills by tussock-forming plants or by shrubs may lead finally to the destruction of what one would expect to be stable dunes, any irregularity of surface favouring the erosive power of the wind. Irregular planting of