(*f.*) Stratification of Dunes.

The size of the sand-grains moved varies according to the force of the wind, which, as seen in the case of sand-ripples, has a distinct winnowing action, an exceptionally strong gale moving even pebbles and small stones. So, too, is there an ever-variable transporting power passing up the inclined plane of the windward surface, so that layers of sand differing in coarseness* are deposited and overlie one another. This leads to an irregular stratification, plainly to be seen when a dune is so laid bare by the wind that a horizontal section is exposed. Old soils, &c., also form layers beneath the sand, and in some cases are important food material for any trees, &c., which may be planted.

(*g.*) Effect of Climate.

Sand, as already noted, can only move when dry,† the cohesion of the particles when wet being too powerful for the wind to disturb. Quite a gentle shower will fix the sand; in fact, owing to its great power of absorption, the heaviness of the downpour is of little moment, whereas the duration is everything. It is not the rainfall of a district, but the number of hours yearly during which rain falls that, besides the perennial supply of sand, governs the magnitude of a dune area, the wind factor being considered constant. The dunes of Enderby Island, in the Auckland Group, are virtually stable, notwithstanding the absence of sand-binding plants, owing to the almost daily rain and constantly cloudy skies (see Cockayne, 85, p. 237). The sand on the summit of the dunes dries more rapidly than that below, and so is the first to be moved after rain. Irregular drying of a flattish sand-surface leads to irregular low deposits of sand extending in the direction of the wind. Wind, especially that from the south-west, is often at first accompanied by a downpour, and its subsequent effect is correspondingly lessened. A wet season will lead to a general flattening and lowering of the dunes, and a dry one to their raising. Indirectly, also, dry weather leads to extension of dune areas, since the owners burn more of the plant-covering.

Sunshine plays its part in sand-drying, summer being more favourable for dune-building than winter, while cloudy skies are adverse.

Frost is not of much moment in New Zealand generally, but on certain South Island dunes it retards drifting.

(D.) THE FOREDUNE.

The dry sand of the foreshore is blown inland by every sea-breeze, but either through its own weight or on account of meeting with an obstacle, such as the drift wood or a strand plant, it is piled up in a continuous ridge which follows in every case the contour of the shore-line, no matter whether the prevalent wind be at right angles or oblique. This ridge is early on captured by *Scirpus frondosus* in the southern floristic province of New Zealand, or by this sedge or the silvery sand grass (*Spinifex hirsutus*) in the northern and central.

Where the supply of sand is fairly uniform a very even ridge may be formed with a gently sloping flattish top, well covered with the grass or sedge or with both. The lee side is generally more or less bare sand.

In some parts of the coast this front line of dunes, here called the foredune, forms such an even, unbroken, and well-established wall, as near Waikanae, for instance, that one might easily believe it to be an artificial structure (see Photo. No. 13).

A well-shaped and plant-fixed foredune is a land-form of the greatest importance, since it not only cuts off in part the sand-supply of the shore from the land, but it forms a natural protection against the inroads of the sea, thus safeguarding the coast. Owens and Case (38, p. 143) call attention to the value of the foredune for coast protection, and point out it has not received the recognition in England that it deserves, and "that unfortunately it is therefore necessary to look abroad if we wish to make a careful study of the matter, and benefit by the knowledge which practical experience alone can give."

The natural foredune is not always so even as that just described, but may be cut into by the wind or washed away by the sea, when at once destruction begins in the dune complex and in time a general flattening takes place. Where a well-made natural foredune does not exist, in the best European procedure an artificial one is constructed. This has been done in a few places in New Zealand, either by design or accident. There is one at Waikouaiti Bay, but which is not altogether satisfactory (see Photo. No. 3). At New Brighton, Canterbury, is a much better example, which has quite checked the former very troublesome drift from the shore, and its further extension is a matter urgently needed by the borough.

(E.) GENERAL TOPOGRAPHY OF A DUNE AREA IN NEW ZEALAND.

Where the supply of sand is small there may be only a foredune, and this of the smallest dimensions, but usually behind the foredune are numerous chains of sandhills of quite irregular form, which are generally divided in places by basin-like hollows of greater or less extent. Usually the ridges are at right angles to the prevailing wind, but in New Zealand there are nearly always one or two other more or less common winds, which operate to no small degree in regulating the position of the hills (*c*) in altering their form, in determining windward and leeward slopes, and in modifying the slope-angles. There are also many openings through the chains, hills at all stages of decay or growth, basins in process of being hollowed out or filled up, and comparatively flat masses of sand where the dune-chains have been destroyed. In short, there is usually a bewildering maze, especially where winds blow from several quarters, the actual origin of which could be traced only with the greatest difficulty and uncertainty. Such a collection of dunes is called by Cowles the "dune complex" (10, p. 194), a term well suiting the case.

* Consequently of different water-holding power.

† Small masses of sand whose wet grains cohere will be blown along if loosened by some means, as by the hoof of an animal. Particles of this kind are frequently blown along a wet shore.