(γ.) *Flexible open Obstacles.*

A typical and frequently observed obstacle of this class is a bunch of the pingao (*Scirpus frondosus*) or of marram-grass (*Ammophila arenaria*). Here the sand is blown into the calm interior of the bunch, which it fills, but as further sand strikes from the windward it creeps over the interior sand and on the leeward side of the obstacle forms a tongue-like mass. On the stony plains between the mouths of the Wangaehu and Waitotara Rivers the long tongues of sand collected on the leeward side of the small wind-swept shrubs of *Coprosma acerosa* are very noticeable (see Photo No. 41).

(δ.) *Inflexible open Obstacles.*

In this third case the wind-current is checked to some extent in passing through the obstacle; there is no eddy, consequently the sand is piled up on both sides. Obstacles such as these are formed naturally by certain stiff shrubs, which consequently fill with sand. They are also used artificially for sand-catching or drift-arresting.

It can easily be seen that obstacles of various kinds assist materially in dune-building, and that when plants grow upon dunes their height may be considerably increased, while their stability is maintained so long as the obstacles remain unburied. In the case of dead obstacles this must eventually happen, also in living ones which cannot grow upwards at a rate to correspond with their burial, as in the case of all true sand-binding plants. Even these, when the supply of sand becomes too great, are frequently overwhelmed and killed, the dune then becoming the sport of the wind (see Photo No. 32).

(vi.) 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 the layers of sand differing in coarseness, and consequently in water-holding power, 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. The sand-planter, then, should carefully examine his dunes as they are laid bare or cut into by the wind.

(vii.) 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 days yearly during which rain falls, and their distribution throughout the year, 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, 86, 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 in certain parts of New Zealand 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.

Wind, the most potent factor with regard to dune-development, is fully dealt with under other heads.

(*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 driftwood or a strand-plant, it is eventually 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 captured by *Scirpus frondosus* in the southern botanical 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 (47, 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."