

and the pasturing of stock on the sand area, led to a state of affairs endangering a most important harbour, and "the problem of controlling the drifting sands has concerned the municipal, State, and national authorities for two hundred years" (Westgate, 56, p. 10).\*

The wandering dunes of the Kurische Nehrung, too, were forest-clad, and the felling of this forest for timber has cost Germany vast sums of money, and a considerable annual outlay is still expended in refixing the dunes so well fixed by Nature.

### III. BOTANY.

#### (A.) GENERAL REMARKS.

The study of the dune vegetation is of the greatest moment with regard to the economic treatment of sandhills. Not only does it show what plant forms and structures are most fitted for growing on the moving substratum,† but the investigation of the evolution of a fixed dune—i.e., an inquiry into the dynamics of the plant-covering—shows exactly how Nature acts regarding dune fixation, and the methods she has applied with more or less success.

The dune flora proper consists partly of plants specially attuned to sandhill conditions, and partly of those found, and sometimes abundantly, in other formations, but whose "adaptations" fit in with such conditions—i.e., tolerate the peculiarities of the environment. This toleration is exhibited by different species to a much varying degree, and so, as the dune conditions relax, does a greater number of plants enter in. This fact must not be lost sight of, since otherwise quite a wrong conception may be gathered as to the capabilities of dunes as a whole for reclamation, for false and dangerous generalisations may easily be made from a study of some particular sand area. Near Paekakariki, for example, the tree-lupin grows well right up to the foreshore, whereas in many places in the same position it would be overwhelmed, and a moving dune be the result (see Photo. No. 26).

The dune flora is remarkably uniform throughout New Zealand, its physiognomy being much the same from the north of Auckland to Stewart Island and the Chathams, notwithstanding considerable differences in climate between the extreme points. In other words, the climatic factor is of less moment than the soil factor. At the same time, some species occur only in certain localities, and, although there is a common groundwork, additions or the contrary take place in passing from one extreme to the other. The dunes of the Auckland Islands have a special flora of their own, and that of the ancient dunes of Stewart Island is also quite distinct from that of a typical fixed dune (see Cockayne, 90).

#### (B.) CONDITIONS FOR PLANT LIFE.

##### (a.) GENERAL.

The conditions governing the plant life of a dune area are extremely severe, and bring about a state of affairs very similar to that of a desert. But between this latter and the dune is the important economic difference that the one can be made fertile only by irrigation, whereas the other has a sufficient rainfall, and *the sand-drifting propensity has alone to be dealt with*. Also, it must be remembered that the dune region offers very dissimilar plant stations, with its wandering dunes, naturally fixed dunes, and sand-plains.‡

##### (b.) CLIMATIC FACTORS.

###### (a.) Wind.

Wind is by far the most important of the climatic factors. According to the position of the sea-shore with regard to the prevailing wind, so is the average intensity very different.

The effect of a sea-wind is frequently counterbalanced in part by a land-wind, as in the case of the north-west, south-west, and east winds of the Canterbury coast, or the south-west and north-west of western Wellington, a matter, if not directly connected with plant life, affecting the distribution of the species and the associations. An occasional excessive velocity will cause a sudden drift, but such is generally of less moment than is a much lighter but continuous sea-wind, while a very high wind may remove the dry upper layer, exposing the moist sand beneath, when all movement will cease.

The wind factor acts as follows:—

1. It moves the sand, laying bare the roots of plants, and causing damage or destruction.
2. It causes sand-drifts or a dune to advance, thus overwhelming whole plant associations.
3. It makes the surface so unstable that none or only a few species specially endowed can gain a footing.
4. Sand carried by wind strikes on the plants, cutting, bruising, or otherwise damaging their tender parts.
5. Plants not actually broken are bent in a direction contrary to the wind, and their foliage is "wind-shorn," but this is no more marked than on non-sandy coasts or in exposed alpine localities.
6. The soil is cooled (this frequently beneficial), and rapid evaporation takes place from the ground.

\* Recently the United States Government sent one of its botanists over to Europe to study foreign methods of dune-culture for the benefit of the above district and elsewhere (see Hitchcock, 21).

† It is surprising what absurd plants have been suggested in certain cases owing to want of knowledge of the life-forms of true dune plants and of their physiological requirements.

‡ This fact has generally been quite overlooked by New Zealand writers on dune reclamation.