

even small stones are swept along the ground or borne in the air, while the fine sand is carried for miles, darkening the sky, and finally deposited here and there on the distant hills. Thus it may be seen that unless there is a constant supply of sand the drifts will finally cease to be. This is the case with the earliest sand-sweep at Tarras; its site is well marked, but its activity and power for destruction is gone. And this seems to be happening at the other localities. In many places, where the ground is not swept bare, coarse sand and gravel alone are present. The ground itself is cut into deep furrows, while at Tarras both the present and extinct sand-sweeps are marked by their area having almost entirely reverted to river-bed (see Photo No. 30), the vegetation first, and then the surface soil, being altogether swept away. It is most interesting, geologically, to see how in so short a time the face of the landscape can be changed by a cause—a flood in a river far below, which might well be thought to have no possible relationship with the ancient flood-plain high above that it had laid down and abandoned many thousands of years before. The three areas—Alexandra, Cromwell, and Tarras—show three stages in the progress of the work: Alexandra, with its barchans and dune-masses, being the youngest; Tarras, the oldest, with its dunes almost gone, except in the sheltered lee of certain terraces, and its active sand and gravel sweep; and the one now extinct, its surface rejuvenated river-bed.

## II. BOTANY.

### (A.) ECOLOGICAL 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 generalizations 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.

The flora of the unstable and semi-stable dunes 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, 86).

#### (b.) CONDITIONS FOR PLANT-LIFE.

##### (i.) 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 there 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, a fact hitherto altogether overlooked by New Zealand writers on dune-reclamation.

##### (ii.) 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. For instance, the oblique south-west wind at Ocean Beach, Dunedin, is much less to be dreaded than the direct but less intense east wind of New Brighton, Canterbury.

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-form, 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.

\* 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.