(9.) *Lakes.*

Dune-lakes originate in exactly the same manner as swamps, being really an earlier stage of the latter's development. Both lakes and swamps assist in checking the sand advance for a time, but finally the surface becomes dry, the sand drifts over the site of the swamp, and no trace of it remains visible.

(H.) THE VIRGIN DUNES.

Before the advent of man there can be little doubt that the dunes were much more stable than they are at present. The opinion, however, expressed by many that their present instability and wandering is entirely the work of man, due to using the dunes as grazing land, is certainly incorrect. Even before the white man arrived, the Maoris lived much among the dunes, as remains of dwellings, heaps of shells, stones, and ancient burial-places testify. Their presence would conduce to considerable dune-movement.

But, apart altogether from man, the dunes could never have reached their present breadth had not their wandering been of long duration. The presence also of the endemic sand-binding plant *Scirpus frondosus* is significant, since its well-being depends upon the coming of drifting sand and its endemism proves that such a drift has been taking place for a long period.

Notwithstanding what is stated above, there can be no doubt the virgin dunes were, as a whole, much more stable than at the present time. Even now the dune complex near the sea does not move to any great extent, and certain hills are completely shrub-clad and actually stable, and will remain so until such time as the advancing sand shall bury the plants.

The distance a dune area can penetrate inland depends upon the general topography of the coast-line, the extent of the sand-supply, and the counteracting effect of land winds. At any rate, a point is finally reached where the velocity and erosive power of the wind so much decrease that non-dune plants can get a foothold, increase in number, and finally absolutely fix the dune, giving it by their decay, in course of time, a coating of loam. Thus the virgin dune areas were well fixed and beyond the power of the wind to disturb, while the general plant-covering of the dunes as a whole would keep back any moving sand of moment. Doubtless, too, in certain cases, there has been a rising coast-line, and certain of the inland dunes are very ancient. In Stewart Island, for example, dunes extend virtually across the island from the head of Paterson Inlet to Mason Bay, marking the presence of a former strait.* A line of ancient dunes also forms the "backbone" of the great sandspit between Mongonui and the North Cape.† Ancient dunes covered with loam should be much less liable to drift when disturbed than would the youngest but furthest inland dunes of an area in progress of formation.

I. EFFECT OF MAN, ETC., ON THE DUNES.

Apart altogether from the natural struggle between sand, wind, and plants, which resulted not only in a steady movement of sand inland, but also in its ultimate fixation, man, by the aid of animals, fires, and cultivation, on the one hand, has brought about most powerful dune-movements; but, on the other hand, he has to some extent counteracted these by the planting of various sand-fixing plants.

The early settlers, tempted by the numerous extensive well-grassed sand-plains, made use of them as grazing-grounds. Also, in order to make room for better growths, they burned the "rushes"‡ and shrubs which appeared to be occupying good ground. Moreover, the cattle and sheep did not confine their attention to the flats, but, as food got scarce, wandered over the dunes, breaking the surface, and pulling up some of the sand-binding plants. The result was soon manifest. The unstable hills were turned into wandering dunes, the fertile flats were buried with sand, and desert conditions grew apace. Introduced plants also made their appearance, but economically were generally of a worthless kind.

With the stable dunes it was worse. These were clad with various native grasses, shrubs, and bracken fern, and beneath a layer of loamy sand. Burning the shrubs, &c., here did no harm, but rather good at first, preparing the way for various useful grasses. Later on overstocking played its part, and, notwithstanding their quite stable character, the fixed dunes gradually began to revert to the active conditions (see Photo. No. 23).

It is quite astonishing how little will set even the most stable dune in motion. A sheep rubbing its back, irritated with ticks, against the surface, soon lays bare a patch of sand, which, attacked by the wind, may rapidly develop into intense activity. Such a hole as that shown in the photograph (Photo. No. 24) would, if not checked, set in time the whole hillside in motion. Rabbits also work considerable harm. It is worst of all when the damage commences in a gully, where, as shown before, the wind has special power. Such gully wounds are most difficult to heal (see Photo. No. 1), and on that account are neglected after one or two failures, and so the contiguous slopes are undermined, and in no very long time a revivified wandering dune, itself originally good ground capable of growing rape or oats, as the photograph shows (Photo. No. 25), is invading and burying land of much greater value. At the present time *the neglect of wounds in the turf by the farmer is perhaps the greatest source of danger to the adjacent fertile lands.* These wounds seem so trivial, but they are capable of the most profound mischief, and their neglect must already have cost the Dominion thousands of pounds.

New Zealand is not alone in having once more set in motion the dunes fixed and made not only harmless but valuable by Nature. The moving dunes of Cape Cod, in North America, had originally three-fourths of their area covered with trees, the destruction of which, through fire

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* See Cockayne, 79. † Cheeseman, 70; Mackay, 98. ‡ *Leptocarpus simplex* and *Scirpus nodosus.*