(γ.) *Light.*

No data are available as to the intensity of the illumination. On the frequent cloudless days of the north especially, and of eastern Canterbury, insolation must be powerful. The glare of the sand as one walks for hours over the bare dunes is an experience hardly to be forgotten. The yellow colour of certain dune-plants belonging to different unrelated families is doubtless correlated with excess of light, and seems to me a possible example of heredity of an acquired character. Shade conditions are virtually absent, so far as the open vegetation of the unstable and semi-stable dunes are concerned. Just as with heat, so with light, there is generally a considerable decrease in the far south of the region; and in the south and west of the South Island, as also in Stewart Island and the Chatham and Sub-antarctic Islands, cloudy skies and correspondingly dull light are frequent.

(δ.) *Moisture.*

The rainfall and number of rainy days of all the New Zealand dunes is amply sufficient to support a rich forest-vegetation, but except under certain exceptional circumstances such is absent.

Considerable differences in rainfall do not affect the dune-flora in the least. Martin's Bay, on the west coast of the South Island, with a rainfall of considerably more than 100 in. yearly, has a dune-vegetation no richer than the sandhills of eastern Canterbury, with their rainfall of some 25 in. or less. An extreme number of rainy days combined with cloudy skies, however, does bring a change, as seen in the low mixed forest on the lee side of the high dunes at Mason Bay, Stewart Island, and the dunes of Enderby Island, in the Auckland Group, where there are no true sand-binding plants; and, notwithstanding, the sand does not drift to any extent.

Quite apart from the rainfall, at a distance of only a few inches below the surface, even on the summits of dunes some hundreds of feet high, and in the driest climate, the sand is moist. This state of affairs has usually been explained as being due to capillary attraction, but that as a full explanation has experimentally been shown to be impossible. Jentzsch has shown (18, p. 103) that in all probability there is an internal formation of dew within the dune. The matter is thus explained: The air between the grains of sand at the base of the dune, in close proximity to the water-table, is saturated with moisture, and its absolute humidity corresponds with the yearly mean temperature of the layer of soil. At a depth of 60 m. (196 ft.) this temperature is only 2° C. (3·6° Fahr.) higher than the mean temperature of the air at the surface. Through diffusion of gases the air of the upper and colder sand-layers becomes saturated with water-vapour, but, since these layers are colder, their saturation-point is lower, and dew will be deposited. The slight difference between the two temperatures is hardly sufficient to account for much deposition of dew, but the diurnal and nocturnal variations of temperature are considerable, and sufficient to cause periodical condensation of water in the sand.

It seems to me possible to account for the perpetual moisture within the dune on the supposition that a sandhill from its very beginning is always wet within, that the rain from time to time sinks into the sand, wetting the upper layers as they are formed, and that drying to any considerable depths is alway hindered by the upper layer of dry sand. But this explanation, though it may suit the moist climate of New Zealand, will not explain the moisture in a desert dune.

Rain-water falling upon the sand descends to a depth proportional to its amount; none runs off the surface, and so all is absorbed. But evaporation, as soon as the rain is over, dries the surface with great rapidity, but only for a trifling depth, since the loose surface sand acts as a dry mulch, and checks evaporation from below to a most marked degree. After a period of drought a dune will be much wetter than the adjacent clay land, notwithstanding the water-capacity of the one is 90 per cent. and the other 30 per cent., or even much less. It must, however, be borne in mind by the dune-planter that by no means is *all* the water present available, and that sand at best can offer only a scanty although a perennial water-supply. The water-content of sand plains and hollows is quite different to that of the hills, since the water-table is in close proximity to the surface, so close indeed in some instances as to be antagonistic to ordinary land plants.

(iii.) The Soil Factor.

This has already been partly dealt with under some of the preceding heads. Equally with the wind is the sand a most important factor, and to the two combined do the special dune-plants owe their distinctive characters, and the associations their distribution and physiognomy.

The rate and ease of movement of the sand by the wind depends upon its coarseness, and so also does its water-content, coarse sand being drier than fine, the rate of percolation increasing with the coarseness. In any case, sand will hold less water than any other soil except gravel or scoria; consequently it cannot support, under ordinary circumstances, a continuous covering of meadow-grasses or typical herbaceous plants. Flattening the dunes, if it does not increase the water-supply, decreases surface evaporation by reducing the wind's drying-power, the sand remaining moist for a longer period. Humus is frequently altogether absent, except on the surface of the ancient fixed dunes, or in certain hollows and sand-plains. But in some places old humus soils have been buried, and such may be found at variable depths, as evidenced by layers of dark-coloured sand. Further, where the sand covering is shallow, roots may penetrate to a richer or moister soil beneath.

The chemical composition, theoretically of much moment, is actually of little account so far as regulating the occurrence of species is concerned, though a pure quartz-sand, according to Warming (63, p. 59), is sterile, one containing feldspar, mica, or lime being more nutritious. Where broken shells are present there is more plant-food, and the celebrated ironsand of Taranaki should affect the plant covering, but in point of fact it does nothing of the kind; while, so far as I have observed, the same general uniformity of vegetation occurs on all the New Zealand unstable dunes, those of the Auckland Islands and the Kermadecs excepted.