

7. Transpiration is much accelerated, thus leading to desiccation, and strong xerophytic structure is thereby demanded, or plants may be wholly or in part killed.*

(β.) *Heat (taken in conjunction with the Soil).*

Sand has a low specific heat. The upper dry layer becomes excessively hot under a cloudless sky. At Levin, on the surface of the foredune, on the 4th February, at 11.30 a.m., an ordinary mercury thermometer registered 120° Fahr. to 127° Fahr.; and on the black ironsand of the Nukumarū dune-complex, on the 16th December, at 11 a.m., the heat at a depth of 3 in. was 92° Fahr., while the air-temperature was 66° Fahr. The wet sand absorbs heat much more slowly, and, as at a depth of a few inches below the surface the sand is always moist, the plant-roots descend into cool soil very quickly. This is a most important matter, since it renders possible the cultivation in pure sand of quite short-rooted plants.

The heat is rendered still more powerful by the strong reflection from the sand, so vegetative parts high above its surface are, during sunshine, exposed to a much greater heat and also more powerful illumination than are denizens of a meadow with the same air-temperature. This has an effect on increasing transpiration, and also on ripening fruits and accelerating flowering.

The general dryness, in conjunction with heat and intense light, leads to rapid oxidation of all dead organic matter, and prevents the formation of humus. The common belief that dune plants are "making soil" is to some extent unwarranted. Generally speaking, there is but little frost on the dune areas. Those of eastern Canterbury are the coldest, owing to the cold air from the Southern Alps sinking to a low level; but they rarely, if ever, experience more than 15° of frost, and that for but a few hours.

(γ.) *Rain.*

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 more than 100 in. yearly, has a dune vegetation no richer than the sandhills of eastern Canterbury, with their rainfall of some 25 in. An extreme number of rainy days combined with cloudy skies, however, does bring a change, as seen in the low mixed forest on the leeside 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, 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 (15, p. 103) that in all probability there is an internal formation of dew, and this theory seems quite feasible. The dry layer of surface-sand assists strongly in checking evaporation, playing the part of what gardeners call a "dry mulch." At the base of the dunes is abundant water, and this can be utilised by deep-rooting plants. The powerful surface-dew must also play an important part.

(b.) 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 wet, 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, the sand remaining moist for a longer period. Humus is frequently altogether absent, except on the surface of the ancient fixed dunes. 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.‡

The chemical composition, theoretically of much moment, is actually of little account, though a pure quartz sand, according to Warming (55, 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 uniformity of vegetation occurs on all the New Zealand dunes, those of the Auckland Islands excepted.

In the immediate neighbourhood of the sea there will doubtless at times be a little salt on the surface,§ but it is now considered that the salt-content of dunes has been altogether overestimated, and that the soil has no excess of salt (see Kearney, 24). An analysis of New Zealand sands is wanted to settle the point, so far as our dunes are concerned. At any rate, many meadow plants, which could not tolerate excess of salt—e.g., the daisy (*Bellis perennis*), white clover (*Trifolium*

* The "salt-gales" of the coast of part of Wellington and Taranaki, which occur every few years, make their effect felt even at twelve miles inland, damaging deciduous trees, eucalypti, and some conifers, while certain species—e.g., Norfolk Island pine and African boxthorn—are undamaged.

† Forests of the Chatham Island akeake (*Olearia Traversii*) were formerly common on the dunes of Chatham Island, but many have been buried since the introduction of sheep and cattle.

‡ That of the New Brighton dunes makes an excellent soil for experiments in pure cultures of plants, as it contains no seeds of any kind.

§ I have noted an incrustation of salt on the leaves of *Scirpus frondosus* at Houghton Bay, Cook Strait. Salt is also carried for some miles inland by the Taranaki "salt-gales."