(*g.*) LAND-FORMS OF THE DUNE-AREA.

(i.) DUNES.

(*α.*) *Dune-ridges.*

The foredune is a typical example of a dune-ridge, and has already been described. Partly sheltered by the foredune, lie the interior dune-ridges. These are most irregular in form, and much cut into and denuded by the wind. They are the *Kupsten* of the German writers, a word derived from the Lithuanian "kùpstas," meaning a small hill. These chains of hills resemble miniature mountain-ranges with their prominent or rugged peaks, rounded tops, saddles, deep or shallow gullies, and at times quite precipitous faces. Frequently the parallel chains have lateral connections. Near the coast they are generally but semi-stable, the plant covering usually only occupying half their surface, and in many places they are so bare as to be a transition to the wandering dunes. Ridges absolutely fixed by nature are to be found at the inland termination of a dune-area, where they are frequently a considerable distance from the shore, or crowning old consolidated dunes, though in this case it is the rock beneath rather than the sand above which forms the ridge or chain of hills. They are generally much more rounded and offer less play for the wind than the ridges just described. Possibly in many instances they are of considerable age, dating back to a time when the land was lower, the sea coming farther inland.

(*β.*) *Isolated Hills.*

Sandhills not forming chains may be either portions of such separated by wind-action, or they may have originated directly on a sand-plain, or elsewhere, after the primary hills were destroyed or had wandered on. Sand-binding plants are chiefly responsible for the origin of these secondary hills. Sometimes they are formed upon a decaying dune itself, which in this manner may be rejuvenated. The curious isolated hills called "barchans" are noted further on.

(*γ.*) *Mounds* (see Photo No. 69).

The pouring of sand into a sand-plain by means of a rapid drift sometimes leads to a remarkable hummocky surface, made up of numerous low mounds built through the rapid growth of silvery sand-grass (*Spinifex hirsutus*). Isolated mounds, generally formed by *Scirpus frondosus*, are common on sand-plains and also on a wide sea-shore (see Photo No. 21), where in both positions they may eventually build isolated hills or dune-chains. Mounds of a more temporary character are formed by the aid of the sand-coprosma (*Coprosma acerosa*) and other shrubs (see Photo No. 22).

(*δ.*) *Wandering Dunes.*

The wandering dunes are the greatest feature of the dune landscape, and the land-form to be most dreaded. It is they which in populous lands have devastated the adjacent country, burying villages, and even churches, as in Norfolk, Cornwall, Aberdeenshire, Gascony, and elsewhere.

Wandering dunes are broad, high masses of sand extending over many acres, so gently sloping on the windward side as to be apparently flat in places, where they are quite firm to the tread. On the leeward they are very abrupt; so much so, where absolutely sheltered from the wind, as to merit the title of "sandfall," the extremely loose sand moving with the slightest touch, or, when wind moves the surface of the dune, forming long trickles which fall to and accumulate as talus on the ground. The quite smooth surface, destitute of all plant-life, stretching for hundreds of yards, and more or less of a glistening whiteness, forms a striking spectacle. The surface is here and there traversed by wind-troughs, or secondary dunes may be built upon the surface, but over wide areas there may be a quite even surface, broken only by long lines of sand-ripples. At the angle formed by the ascending slope and descending sandfall is often a sharp ridge, the result of the eddy (see Photo No. 14). In other cases the angle may be rounded, a sign of contrary winds.

Wandering dunes have a twofold origin. On the primeval dune-area they arose from the coalescence of a number of dune-ridges (see Photo No. 8). It can be seen that this is an easy matter; the unequal rate of advance of contiguous dune-ridges will bring it about, for one thing, the lowest portions moving the fastest and leading to a crescent-like form, the horns advancing in the same direction as the wind. Then, too, winds from different directions causing irregularity of the direction of the movement play their part. A rapid undermining of plants on the windward side of a dune also (Photo No. 23) causes an accumulation of loose sand, thus giving material for burial of plants and filling up of hollows. According to Jentzsch (18, p. 81), it takes 100 dune-chains, each 6 metres high, to build a wandering dune 60 metres in height. With the general flattening and increase of sand-surface there is less shelter than in the area of sand-ridges and isolated dunes: the wind catches the surface fairly, increasing in intensity as it ascends, and the natural establishment of even sand-binding plants becomes impossible, while those present are rapidly exterminated. *It is therefore useless to attempt artificial planting on many wandering dunes without shelter of the proper kind.*

Between the true wandering dune and the dune-complex are all kinds of transitions, many of the dunes of the latter, although quite small, being altogether unstable, and both wandering and drifting. A dry season, burning the vegetation, the presence of cattle—these, singly or combined, may easily convert an unstable dune-complex into a wandering dune. So, too, does a breach in the foredune by the sea lead to destruction of the dune-complex, whose members become undermined by the wind, and the increased sand-supply helps to bring about a flatter condition, hollows being filled, and extensive sand-drifts resulting.

Frequently the wandering dune is quite unconnected with the dune-complex and with the perennial sand-supply of the shore; in which case, as no fresh sand is arriving, and as waste is ever present, either