

As for the spread of the plants on the dune-area itself, this is chiefly the work of the wind. Especially are the ball-like infrutescences of *Spinifex hirsutus* suitable for wind carriage. Caught by the breeze, these hop over the sand on their long spines as if endowed with life, until eventually, falling to pieces, they come to rest, and the seeds are buried ready for germination. In this manner originate the embryonic dunes of the upper foreshore.

The "seeds" of *Festuca littoralis*, *Carex pumila*, *Calystegia Soldanella*, *Coprosma acerosa*, and *Pimelea arenaria* are cast in great numbers near the bases of the plants, and can there germinate, or are more frequently driven when dry along with the surface sand. Generally speaking, however, there are very few seedlings on the sandhills themselves. It is in the hollows that seeds, even those of the sand-binding grasses, germinate, the seedlings of these, on receiving a sand-supply, building dunes. On the hills seedlings are extremely scarce, the increase there being almost altogether by vegetative means, which amply suffices, under favourable conditions, to cover the ground.

(e.) THE PLANT ASSOCIATIONS OF THE NEW ZEALAND SAND-DUNES.

(i.) GENERAL.

The words "New Zealand" are here used in the plant-geographical and not the political sense, and include, besides the two main islands and Stewart Island, the Kermadec, Chatham, and Subantarctic groups, but the tropical appanages of the Dominion (Cook Islands, &c.) are excluded. The term "plant-association" is restricted to the usage proposed by Warming (63, p. 145), the associations as a whole being parts respectively of the sand-dune formations of the entire earth. This conception of plant-formation and plant-association seems to me scientifically sound, although, in more complicated arrangements of vegetation than that of dunes, difficult, if not impossible, to act up to in the present state of knowledge.

The comparative simplicity in the progress of dune-development, its rapidity, and the ease with which it can be observed, as stated already when dealing with the geology of dunes, makes a genetic study of the vegetation of a dune-area much more easy than that of a series of land forms whose evolution is extremely slow. Beginning with the foredune and ending with the fixed dune, a gradual change may be noted in harmony with the increasing stability of the sand, a condition which is in large part the work of the plants themselves. Also certain stages enter in where a new class of associations branch off, which may be either transitory and doomed to obliteration, or become permanent, their persistence depending upon the stability of the dune-area as a whole. *The above is important from the economic standpoint, since where nature has brought stability and inserted shrubby associations in the midst of dunes originally unstable, so too can afforestation be artificially carried on, but with greater ease, or the better land be used without danger for certain agricultural purposes.*

The various plant associations may receive either a physiographic or a botanical name, the two exactly coinciding, each association forming a definite step in the progress of events whose final goal is stability. The treatment also does not go into minutiae which are of little importance, an attempt only being made to give a clear general idea of the associations, which necessarily will not be absolutely true for every part of the district.

The associations, taking on account of its practical significance a physiographic classification rather than a botanical, may be divided into those of the *dunes* and the *dune-hollows*, including amongst the latter the most extensive sand-plains, lakes, and swamps. Between the associations as described below there are all kinds of gradations, even those of dunes and dune-hollows having at times the closest relationship. Where the dunes abut on river mouths and estuaries there are salt meadows and marshes, but these are here excluded.

Many portions of the dune-area are not typical—i.e., there is no sand-supply from the shore, nor a general procession of events such as here described, which is only to be observed on the broader dune-areas. This arises from their being situated on cliffs, while their movement is due to destruction of their plant covering. Other areas again form but a narrow belt along the shore, and there are few evolutionary stages to be observed. In what follows, fuller details are given of typical dune-areas than of these more ancient rejuvenated dunes, which, if undisturbed, would generally represent the fixed dune—i.e., the climax association of dune-development. Nor do the smaller areas receive more than a very brief treatment at best, while many are not dealt with at all, since their economic importance is trivial.

(ii.) DUNE ASSOCIATIONS PROPER.

(a.) *Sand-grass Dunes* (see Photo No. 61).

These are distinguished by their instability and by the presence of some sand-binding grass or sedge. They occur along the sandy beach, where, if continuous, they build a long low ridge (the fore-dune), and extend inland for a variable distance, depending on the position of the shore with regard to the prevailing winds. At first they are clothed with the pingao (*Scirpus frondosus*) and the silvery sand-grass (*Spinifex hirsutus*), one or both, the latter occurring only on the dunes of the northern and central botanical provinces. The sand-grass dunes may remain at this stage, and frequently do so near the shore; but by degrees there come in, first, the minor sand-binders, then the sand-catchers, many of them shrubs, until finally a shrub dune is established.

Generally the sand-grass dunes are by no means closely covered by tufts of the *Spinifex* or *Scirpus*, there being as many or more bare patches than vegetation. At the junction of foredune and shore in the northern and central botanical provinces the long bamboo-like stems of the *Spinifex* may extend over the loose sand of the foreshore, as may also the rhizomes of the *Scirpus*. Also, both plants not uncommonly build small dunes on the foreshore itself, pioneers of a new line of foredunes. Frequently one or other of the above species is dominant, *Spinifex* giving a silvery and *Scirpus frondosus* a yellow colour to the ridges. Sometimes the two plants grow side by side, but they are usually not intermixed. *Spinifex hirsutus* rarely extends inland for any considerable distance, its presence being a sign that