

differences occur. 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. Where the dunes abut on river mouths and estuaries are salt meadows and marshes, but these are here excluded.

(b.) DUNE ASSOCIATIONS PROPER.

(a.) "Sand-grass" Dunes.*

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 foredune), and extend inland for a variable distance, depending on the position of the shore with regard to the westerly winds. At first they are clothed with the pingao (*Scirpus frondosus*) and the silvery sand-grass (*Spinifex hirsutus*), one or both; but by degrees shrubs enter in, which finally becoming dominant, the next stage of dune development, the shrub-dune, is installed.

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 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. Generally one or other of the above species are 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 generally not intermixed. *Spinifex hirsutus* rarely extends inland for any considerable distance, its presence being a sign that the shore is near; but *Scirpus frondosus* is to be found wherever there is moving sand, even on the retrogressing fixed dunes at the landward boundary of the area.

Calystegia Soldanella, *Euphorbia glauca*, *Festuca littoralis*, and *Calamagrostis Billardieri* are also in part plants of the moving dunes, but they do not confer such stability as the dominant sand-binding plants. The *Calystegia*, with its shining green leaves and in their season showy lilac flowers, forms a refreshing contrast to the grasses or sedge. It forms dense masses on the sand, sometimes quite covering small dunes, but, the mats being only a couple of inches deep, a heavy drift will soon overwhelm them. All the same, it is remarkable how long such closely covered dune-summits persist in an area where the *S. frondosus* dunes are blown flat, the absolutely covered sand defying the wind, the dune itself creating an eddy, and a channel being formed in front of the advancing sand. *Euphorbia glauca* is by no means a common plant of western Wellington, but when it is present it forms colonies of considerable size, the pale-green colour of the leaves and erect habit rendering it conspicuous.

Juvenile sand-grass dunes are met with on the foreshore, on sand-plains, on dunes themselves, and indeed anywhere if there is a supply of moving sand and a sand-binding plant to arrest its progress. During a period of calm weather, or in some spot where there is no movement, such as a moist sand-plain, the seed of *Spinifex hirsutus* or *Scirpus frondosus* germinates, a young plant arises, and if it can attain a few inches in height may hold its own. Vast numbers of seedlings must perish, but an occasional one here and there will serve for dune-building. The young plant catches the sand, which then forms a tongue on its lee side; into this the growing rhizome extends, and, with increase of size of plant, through much branching of rhizome and development of leaf-branches, more and more sand is held, this stimulating the growth of the plant. Thus grass and sandhill increase in size at the same time, the former looking like many independent plants, and the latter acting now as the obstacle, catching the windward drift, which is finally arrested by the leaf-branches, each building a tongue of sand on its lee side as did the original young plant. Thus in a few years a dune several feet in height will arise from one young plant of the *Spinifex* or *Scirpus*, which, through its extensive branching, might well be thought to consist of a colony of separate plants.

Natural planting, such as the above, leads to the formation of mounds and ridges, and ultimately on that account to destruction of the dunes, as already explained in Section II. But in an artificial plantation extending over a flat area, where the plants are regularly arranged, the building of mounds is more or less suppressed, and a stable plant association will result; but where this is subject to a windward supply of sand it is frequently destroyed (see Photo. No. 9).†

The number of species present on a sand-grass dune depends entirely on the wind factor. Where strong sea winds are frequent only *Spinifex hirsutus* and *Scirpus frondosus* are present, but where the wind is weaker sand-shrubs will appear, and where weaker still, ordinary wind-tolerating shrubs and even certain introduced plants; in short, *the plant-covering is an exact index of the wind-force.*‡

(β.) Shrub Dunes.

(1.) Sand-shrub Dunes (see Photo. No. 30).§

Sand-shrub dunes are the second stage of progressive dune evolution. They are occupied only by those shrubs which tolerate drifting sand (e.g., *Coprosma acerosa*, *Cassinia leptophylla*,

* The shifting or white sand-dunes of Warming (55, pp. 263-264).

† Artificial plantings in many positions are much benefited by the use of suitable expedients to prevent the sand-drift. An account of these, including the various kinds of sand-fences successfully used abroad, will be given in the sequel to this report.

‡ Thus a knowledge of the vegetation of the area to be reclaimed is an important preliminary.

§ The stationary or grey sand-dune of Warming (55, pp. 265-268).