

the shore is near; but *Scirpus frondosus* is to be found wherever there is moving sand, even on the retrogressive fixed dunes at the landward boundary of the area.

Calystegia Soldanella, *Euphorbia glauca*, *Festuca littoralis* (this actually building primary dunes on the shore in certain parts of Southland), *Scirpus nodosus*, 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* (Photo No. 36), 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 for 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 everywhere, but when it is present it forms colonies of considerable size, the pale-green colour of the leaves and erect habit rendering it conspicuous.

The sand-coprosma (*Coprosma acerosa*) is a very early comer, and belongs to this association. Where the wind is not excessive the great tussocks of the toetoe (*Arundo conspicua*) especially on the Auckland dunes, are a conspicuous feature; in fact, Carse considers it the leading dune-plant in the Mangonui County (81). The fleshy-leaved sowthistle (*Sonchus littoralis*), generally a rock plant, occurs on the sand-grass dunes of Stewart Island; and here, too, as also in Southland, are bushes of *Pimelea Lyallii* flattened to the sand, together with rosettes of the small *Geranium sessiliflorum*, which thrives, thanks to its very stout, deeply descending, woody root. In Southland also several species of piri piri (*Acaena novae-zealandiae*, *A. microphylla*, *A. species* with sessile flower-heads), *Hydrocotyle novae-zealandiae*, and *Myosotis antarctica* var. *Traillii* are fairly common in some places.

The unstable dunes of Central Otago are occupied in many places by tussocks of *Poa caespitosa*, which becomes under these conditions a minor sand-binder. So efficacious is it in this regard that it is planted at Cromwell to stop sand-drift.

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 "grass" 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, catch the windward drift, which is finally arrested by the leaf-branches, each tuft of leaves 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 more or less destruction of the dunes, as already explained in the geological portion. 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 sometimes destroyed (see Photo No. 32).

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, minor sand-binders, and sand-holders 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.) *Pes caprae* Dunes.

These only occur on Sunday Island, in the Kermadec Group. They are covered with *Ipomaea pes caprae*, a creeping herb with prostrate stems some feet in length which root here and there. The leaves are large, 2-lobed, dark yellowish-green, and firm in texture (R. B. Oliver, 127, p. 133). Growing amongst the *Ipomaea* are the grasses *Imperata Cheesemanii* and *Eleusine indica*, the stiff club-rush (*Scirpus nodosus*) and the wild celery (*Apium prostratum*). These dunes are of no moment except from the scientific standpoint.

(γ.) Dunes of the Auckland Islands.

Dunes occur only on Enderby Island. The most important feature, as I have explained elsewhere (Cockayne, 86), is a negative one—the absence of special sand-binding plants. All the same, the dunes were originally quite stable, owing to their surface being kept constantly wet by the almost daily rain. The plant covering is, however, by no means close. It consists of *Pratia arenaria*, *Lagenophora pumila*, *Epilobium confertifolium*, *Crassula moschata*, *Ranunculus acaulis*—all low creeping herbs—and a moss of dense habit. On some parts, especially where cattle have caused drift, there is the shore-dock (*Rumex neglectus*), a low-growing herb with stout and far-creeping underground stems. This plant is here to some extent a sand-binder, though elsewhere it is not a dune-plant.

(δ.) Shrub Dunes.

(a.) *Sand-shrub Dunes* (Photo No. 38).—Sand-shrub dunes are the second state of progressive dune-evolution. They are occupied only by those shrubs which tolerate drifting sand. Leaving out of consideration the Kermadec and Subantarctic botanical provinces, the actual shrubs vary more or less in different parts of the botanical region. *Coprosma acerosa* occurs throughout. So too with *Pimelea arenaria*, Stewart Island and perhaps Southland excepted, where there is *P. Lyallii* instead. *Cassinia retorta* is confined to the Auckland dunes, *C. leptophylla* to those of the central botanical province, while *C. fulvida*, though chiefly on the dunes of Canterbury, is more or less common in parts of the central province also.