

those in the vicinity of Westport. From the above it will be seen that I have inspected nearly all the important dune-areas of the Dominion, and am consequently in a much better position to make definite statements *re* dune-reclamation than was the case when my former report was written.

Although certain owners of dune-areas are fully aware of the sand-drift evil, and are making brave efforts to overcome it, these are in no few instances misdirected (see Photo No. 16). Others, again, are doing nothing; they recognize the need for action, but have no idea as to the methods to be pursued. Some even hold the most strange or dangerous views, such as that the sand did not originally come from the sea-shore, or that a belt of shrubs will stop a wandering dune. Even where the best successes have been won there has been only a planting of marram-grass (*Ammophila arenaria*) or tree-lupin (*Lupinus arboreus*), which is at most but a makeshift, except under special circumstances. *The final treatment of dunes should assuredly be afforestation*, and yet by many this is thought to be impossible, and, except in a few specially favourable localities, nothing of the kind has been attempted.

The dunes of New Zealand are of special scientific importance. Those of the Old World have been materially changed by the many centuries of man's occupation. Their reclamation was for the new and unnatural conditions. But in New Zealand there is an opportunity of observing what nature, quite unhindered, has done for their fixation. The native dune-plants are also of much interest, since some are endemic and also of quite remarkable form, while their value as "sand-fixers" is by no means generally appreciated.

During the progress of my work I have received valued assistance and encouragement from so many that only quite a few can be specially mentioned. To all those whose names do not appear I here tender my sincere thanks. I am also indebted to the following gentlemen who have assisted me in various ways, and but for whose aid, generously given, interesting material and observations of moment would have been neglected, and I thank them most heartily: Drs. Truby King and L. Talbot; Messrs. A. W. Amon, D. L. Blyth, K. W. Dalrymple, J. Handley, J. H. Herrold, R. Hoe, and W. Waide. I must also specially thank Mr. H. Carse, who put his intimate knowledge of the far north of Auckland at my disposal; Mr. W. H. Field, M.P., for some most excellent photographs of the dunes near Waikanae, and for assistance and advice; Mr. R. Speight, M.Sc., F.G.S., who has contributed the section on the origin and material of dune-sand; my son, A. H. Cockayne, Government Biologist, who has given me much assistance in dealing with the subject of grassing the dunes; and Mr. T. F. Cheeseman, F.L.S., who gave me important information regarding the dune-flora of Auckland, and discussed with me various critical matters. For help from outside New Zealand I here tender my grateful thanks to Professor J. W. Harshberger (University of Pennsylvania), Professor L. Diels (University of Marburg), Mr. A. S. Hitchcock, Agrostologist (United States Department of Agriculture), and Dr. B. T. Galloway, Chief of Bureau of Plant Industry (United States Department of Agriculture). Finally, I must express my great indebtedness to Mr. W. C. Kensington, I.S.O., the Under-Secretary of Lands, who has assisted me most materially and offered various important suggestions which are embodied in this report.

#### (b.) OBJECTS OF DUNE-CULTURE.

It seems needful to state briefly the objects of dune culture or reclamation, since usually in New Zealand the only point considered is the fixing of such sands as threaten fertile land.

In Europe the culture of dunes has been in progress for more than one hundred years. There the first object is not reclamation at all, but the *protection of the coast-line*. This is a matter which as yet has received little attention in New Zealand, nor has my examination up to the present revealed any pressing need for action in this direction. At the same time, the sea does make encroachments, as at the Ocean Beach, Dunedin; at various points on the coast of western Wellington (see Photo No. 1); near New Brighton, Canterbury; and elsewhere. When really close settlement fills the Dominion the coast-line will need attention. So urgent is this matter in the Motherland that a Royal Commission has recently dealt with the question, and issued a voluminous report.

Closely bound up with coast protection is the obstruction of waterways. This is exemplified by the bars of rivers and estuaries, which, although mostly of marine and fluvial origin, are strengthened by sand from the dunes. Sandspits crowned by dunes also bear an important relation to harbours (see Photo No. 2).

As for the dunes themselves, the damage they do is twofold. On the one hand, at their extreme landward boundary they bury good ground quite free from sand, adding it to the dune-area, and, on the other, they overwhelm a great deal of fairly good low-lying land within the dune-areas themselves (see Photo No. 3). Besides fertile soil, valuable flax swamps are filled and destroyed (see Photo No. 4). Also, watercourses are choked or diverted, and the drainage of the neighbouring country is much impaired (see Photo No. 64).

Finally—and to my mind this is the most important of all, nor has it been approached to any degree as yet—the dune-areas themselves, now simply deserts and always a menace to the neighbouring valuable land (see Photo No. 3), even when supposed to be checked by shelter-strips, should be reclaimed and made productive by afforestation. The methods to be pursued and the trees to be made use of, on account of economic value of one kind or another, are given in Part II of this report. Here a few words will not be out of place as to afforestation of dune-areas in Europe, since there is a belief amongst many that sea-spray is altogether antagonistic, and that afforestation, near the shore at any rate, is impossible. Such forget, or do not know, that natural coastal forests, and even dune forests, exist in New Zealand, and that various trees and shrubs (pohutakawa, *Metrosideros tomentosa*; Chatham Island akeake, *Olearia Traversii*, &c.) grow even on cliffs subject to constant wetting with sea-spray.

The best-known and always-quoted example of afforestation is that of the dunes of Gascony, in France. Here the justly celebrated Brémontier, during the closing years of the eighteenth