III.—BOTANY.

Art. XXVIII.—*A Short Account of the Plant-covering of Chatham Island.*

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[*Read before the Philosophical Institute of Canterbury, 6th November, 1901.*]

Plates XVI–XIX.

The group of islands and rocks known collectively as the "Chatham Islands" lies isolated in the South Pacific Ocean, at a distance of about four hundred and fifty miles east-south-east from the nearest point in New Zealand. It lies between the parallels 43° 30′ and 44° 30′ south latitude, and the meridians 175° 40′ and 177° 15′ west longitude. The largest member of the group—Chatham Island—is about thirty miles in length, and contains 222,490 acres. Pitt Island is next in size, with a length of barely eight miles and a half, and an area of about 15,000 acres. The only other islands sufficiently large to contain flowering-plants to any extent are Mangere and South-east Island, each of which is about a mile and a half in length. Pitt Island lies to the south of Chatham Island, from which it is separated by a narrow passage of water, about fourteen miles in width, called Pitt Strait. Mangere lies to the west and South-east Island to the south-east of Pitt Island, from which the former is distant a mile and a half and the latter a mile and a quarter.

The botanical history of the Chathams dates from the year 1840, when Dr. Dieffenbach visited the islands on behalf of the New Zealand Company, and made at the same time a small collection of the plants. These are recorded in the "Flora Novæ-Zelandiæ," and comprise only some twelve species of phanerogams and vascular cryptogams. For a space of eighteen years after Dr. Dieffenbach's visit nothing more was done botanically, when, a direct trade being established between Melbourne and the islands, a few plants were from time to time brought to Baron F. von Mueller, including the remarkable *Myosotidium nobile* (45, p. 2); but it was not until the year 1863 that the first real botanical exploration of the

islands was undertaken, when Mr. W. T. L. Travers, who previously had done so much to advance the knowledge of New Zealand botany, sent his son, Mr. H. H. Travers, to Chatham and Pitt Islands to make as complete a collection of the indigenous plants as possible. The expedition resulted in a very interesting collection of plants, from which Baron F. von Mueller compiled his well-known work "The Vegetation of the Chatham Islands." This was published in 1864, and contains descriptions or notes of 129 species of phanerogams and twenty-five species of ferns and lycopods, of which seven were species new to science. Had the distinguished author of the work not been a most staunch believer in the fixity of species (45, pp. 7 and 8), the number of species recorded would have been considerably larger, in proof of which statement it is only necessary to note his treatment of *Veronica*, *Calystegia*, *Epilobium*, and certain other genera.

In 1867 a paper appeared (24), written by Mr. Halse, which gives a most excellent idea of the general aspect of certain parts of the main island. Much more important, however, is the account of his journey in 1863 by Mr. H. H. Travers, published in the first volume of the "Transactions of the New Zealand Institute" in 1869 (51). In 1871 Mr. Travers paid a second visit to the islands, and his new collection added very considerably to the known number of their plants. Baron F. von Mueller contributed a short note on this collection to the "Transactions of the New Zealand Institute" (46), giving a list of certain genera* not collected during Mr. Travers's former visit.

In 1874 Mr. John Buchanan published a revised list of the flowering-plants and ferns of the Chatham Islands, based on the two collections of Travers (3), bringing the genera up to 129 and the species to 205, describing three new species and recording the occurrence of that very interesting restiaceous plant *Sporadanthus traversii*, now referred to the genus *Lepyrodia* (32, p. 969). Mr. Buchanan's list seemed at the time it was published to quite exhaust the possibilities of the Chathams as a field for new species, and so for many years Chatham Island botany appeared to be at a standstill. But during part of that time a most enthusiastic naturalist, Mr. F. A. D. Cox, who resides in Chatham Island, was collecting and studying its plants during his few intervals of leisure, so when the late Mr. T. Kirk sought aid with regard to Chatham Island plants, during the compilation of the "Students' Flora of New Zealand," Mr. Cox was very able and very willing to supply him with material, and, better still, with information

* In this list *Myosotis* is noted, so I was mistaken in writing of it as an unrecorded genus for the Chathams (11).

gathered at first hand from the plants themselves. In consequence of this valuable assistance Mr. Kirk treated the flora of the Chathams in a more searching and thorough manner than had been the case previously.

From the foregoing short history of the botany of the Chathams, it may readily be seen that botanists and collectors have been mainly concerned with the classification and finding of plants, and that very little indeed has been published regarding the plant-covering itself, the plant-formations, the conditions under which the members of the formations are living, the plant-forms which these conditions have evoked or preserved, the changes which civilised man has brought about in the vegetation, or many other matters of high œcological interest. It was with the intention of observing and studying such matters, and, above all, in the hope of being able to put on record a fairly accurate picture of a most remarkable vegetation, doomed in its primeval condition to extinction, that I paid a visit to Chatham Island at the beginning of this present year 1901. I stayed on the island during part of January and February, six weeks in all, but did not visit any of the other islands, so the details in this paper refer only to the vegetation of the principal member of the group, as notified in the title. I had not time to visit every part of the island. Details on this head are noted in the part of this paper dealing with the physiography; here it need only be mentioned that I camped for eleven days on the southern tableland, and was thus enabled to examine with some degree of care the vegetation of a portion of the island not previously visited by any botanist. And this was the more important since there alone may be seen tracts of country clothed with unaltered primeval vegetation, but which unique and interesting spots are every day becoming fewer in number and more limited in extent, so that without doubt in a year or two there will be no longer any virgin plant-formations on the island, except those of inaccessible rocks or of the larger pieces of water. As I write, Mr. W. Jacobs sends me word that the previously inaccessible forest lying under the precipitous cliffs of the south coast has been opened up to stock, and in consequence the last remnant of the Chatham Island forest will soon be a thing of the past so far as its primitive physiognomy is concerned.

Although Chatham Island is only small, its very irregular shape, the great lagoon which occupies its centre, and the difficult travelling through a vegetation sometimes extremely dense would require a much longer time than I was able to devote in order to make anything like an exhaustive examination of the plant-covering. This paper must be looked upon, then, as an introductory and most general one, and intended

merely to pave the way for much more thorough œcological investigations. I have purposely usually only treated with any detail those plants which are endemic, and in this case the sins of omission are many, while a too rapid examination of most of the formations has probably in some cases led to error.

Before concluding this introduction I must express my most hearty thanks to all those residing on Chatham Island with whom I came in contact. All sought to render me every assistance possible, and whatever success may have attended my visit is due principally to their great hospitality and extreme kindness. Also, I must specially express my great obligation to the following: Mr. F. A. D. Cox, Mr. A. Shand, Mr. E. R. Chudleigh, Mr. W. Jacobs, Captain F. W. Hutton, F.R.S., Mr. T. F. Cheeseman, F.L.S., Mr. D. Petrie, M.A., F.L.S., and Mr. H. Carse.

Physiography.

For the sake of convenience Chatham Island may be divided into three portions—a northern, a central, and a southern. The northern portion consists of two peninsulas, the western and the eastern, which are separated from one another by the northern and widest portion of Te Whanga Lagoon, and are connected only by the very narrow strip of land which in the north separates the lagoon from the ocean.

The western peninsula — Whareka on the map (49)—is about 16½ miles in length from Te Raki Point to Waipapa on the lagoon, and some seven miles broad at its base from the north of Waitangi Beach to the shore near Wharekauri. In the north two triangular pieces of land jut out northwards, culminating in Capes Young and Pattisson respectively. The eastern peninsula is a narrow triangular piece of land nearly nine miles and a half in length and five miles in width at the base, its widest portion. The northern portion of the great lagoon is eight miles and three-quarters in width, and is separated from the ocean by a narrow strip of land varying from a mile and a quarter in its widest to one-eighth of a mile in its narrowest part. The central portion of the island is occupied for a great part of its area by the southern part of Te Whanga Lagoon. This is separated from Hanson Bay on the east by a very narrow strip of land, varying from a mile and a half to a quarter of a mile in width; but on the west the land bounded by Petre Bay is of greater size and importance, having a width in the south of from two and a half to three miles and in the centre a mile and a half, while in the north a broad triangular piece of land stretches into the lagoon, measuring seven miles and a quarter from Karewa to the Waitangi Beach.

The south portion of the island forms a compact four-sided block of an almost uniform length of nine miles and a half from Petre Bay to Pitt Strait, and with a breadth of, from east to west, 13¼ miles. The south-east corner beyond Ouenga juts out slightly towards the east.

The greatest length of the island as a whole is thirty miles, measuring from Cape Young to Te Rahui, and its greatest breadth, measuring in the north from Te Whakaru Island to Te Raki, is thirty-five miles. From the above it may be seen that, owing to the peculiar shape of the island, no place in the interior is at any great distance from the sea or the great lagoon: in the north two miles and a half is the extreme limit, in the centre only one and a third miles, and in the more compact south four miles and three-quarters. Hence, no part of the island is beyond the reach and influence of a strong sea-breeze.

Speaking generally, the surface of the land is low, though in most places more or less undulating. The southern portion of Chatham Island is by far the highest above sea-level, and in comparison with the rest of the island looks quite hilly. Its highest portion, however, the Trig. station near Te Awatapu, is only 286 m., and Pipitarawai, the highest point of the main ridge and watershed of that part of the island, is about 2 m. lower. From this ridge to the sea stretches a kind of tableland, culminating in some abrupt cliffs, which vary in height from 182 m. to 213 m., and are cut in places into deep gorges by the small streams which drain the tableland. From the other sides of the Pipitarawai Ridge the land slopes gradually downwards to the coast. The flat but usually undulating surface of the northern and central portions of the island is relieved here and there by conical hills, which reach at times a height of 152 m. or 182 m., and of which the most important are the forest-clad Korako, Wharekauri, and Maunganui. The extensive coast-line varies in character from flat ground bordered with sandhills or low rocks to the high cliffs of the south coast. Small streams are abundant all over the island, but only two, the Waitangi and the Awainanga, rise to the dignity of rivers. Most of the streams flow slowly, and the water is always dark-brown, from the large amount of peat which it holds in suspension. The great lagoon, Te Whanga, is nearly fifteen miles in length, and its area is estimated at 46,000 acres (18). In certain places the lagoon is so shallow that it can be forded on horseback; indeed, under certain conditions of the wind the northern ford may be quite dry. Besides Te Whanga there are many other lagoons and lakes; indeed, it is stated that fully one-third of the surface of the island is occupied by water (18). Bogs of considerable size are very frequent, and occur both on the high and low ground.

Thus both the very low north-west of the island and the highest parts of the tableland of the south consist of quaking bog. Even when the ground is not boggy its water-content is usually very considerable; and, speaking generally for the whole island, excepting in places long cultivated, wet ground is much more common than dry.

The soil in most parts of Chatham Island consists of peat, which must in many places be of a very great depth, Mr. Travers stating that it is often 50 ft. deep (51). If the peat through any reason should become dry it will burn with great readiness, and should it be set on fire it may slowly burn for many years. Such burning—and it is perhaps from this that he gave his estimate of the depth of peat—is thus described by Mr. Travers (51, p. 177): "In several parts of the island this peat has been on fire for years, burning at a considerable depth below the surface, which, when sufficiently undermined, caves in and is consumed. I have seen the loose ashes arising from these fires upwards of 30 ft. deep." On the peaty plain on the north-west peninsula I saw a hollow caused by the peat having been burned, which even then was smouldering in places. This hollow was about 3 m. in depth—*i.e.*, only one-third of the depth stated by Mr. Travers —and its area about 2 acres. The burning must have taken place many years ago, for the bottom of the hole was a dense mass of vegetation, thus affording a very interesting example of what species of indigenous plants will, under present climatic conditions, people a piece of virgin ground. Very often these burnt-out hollows become filled with water and remain as permanent lakes; indeed, Mr. A. Shand is of opinion that probably all the lakes of the island, including even those of the tableland, have originated recently in this manner. Besides peat, a much richer soil, called locally "red clay" and formed of disintegrated volcanic rock, occurs in some few places—much of the country from the south of Lake Huro to the Whanga Lagoon and for some distance further south-east is of this character; other patches occur from the Ngaio to Waitangi along the coast, and others again in the neighbourhood of some of the old volcanic conical hills.

As pointed out in the introduction, I did not visit quite a number of important localities. Of these the chief were the extremity of the north-western peninsula, from Maunganui to Te Raki Point; the south coast of the north-western peninsula; the narrow slip of land along the north coast from Wharekauri to Matarakau; the east coast of the island from the ford over Te Whanga to Ouenga; and the greater part of the coast-line on the east from Waitangi to the Horns.

GEOLOGY.

Not very much is known about the geology of Chatham Island. Mr. Travers collected rock specimens and a few fossils. From these specimens and from notes supplied by Mr. Travers Sir Julius von Haast published the only paper (a very short one, occupying a page and a half) which, so far as I am aware, has appeared on the geology of the island.* Captain F. W. Hutton, F.R.S., has also examined Mr. Travers's specimens, and he tells me that he agrees with the main conclusions in Haast's paper—namely, that the Chatham Islands first emerged from the ocean during some portion of the Tertiary period.

The following is abstracted from Haast's paper (23): "The principal island is of volcanic origin, and consists chiefly of basaltic and doleritic rocks and tufas." "Several cones with a crater-like character show in the different centres of eruption, whilst around them and extending from one to the other marine sands have formed barriers enclosing tracts of low land favourable for the formation of peat swamps." I may here point out that, as probably the islands have extended over a much wider area than is now the case, these sand barriers must be of comparatively recent origin, while also these tracts of low land are in the north and not in the south of the island, which also contains most extensive deposits of peat. "The oldest rocks visible occur near Kaingaroa, and consist of micaceous clay slates, silky and of a pale-grey colour." These rocks, Captain Hutton tells me, must be a portion of an ancient rocky platform from which the new volcanic islands arose. "Some beds of limestone fringe the south-western shores of that lagoon"—Te Whanga. Haast concludes, "Thus clear evidence is offered to us that in an early part of the Tertiary period volcanic action took place in this part of the Pacific Ocean, and, although we meet on the main island some signs of the existence of old sedimentary rocks, there is no doubt that these volcanic eruptions gave birth to this archipelago." Haast also mentions the occurrence of lignite beds overlaid by limestone on Pitt Island, and Mr. Florence (18) calls attention to the occurrence of lignite in the north of Chatham Island.

CLIMATE.

Meteorological observations have been taken for a number of years by Messrs. Shand and Cox in the neighbourhood of Waitangi, the thermometers being kept in a screen standing on the grassy slope facing south-east in front of Mr. Cox's

* See Trans. N.Z. Inst., vol. II., art. xliii.: "Notes on the Geology of the Outlying Islands of New Zealand" (including Chatham Islands), p. 183, by J. Hector.—[ED.]

residence. This locality is about 30 m. above sea-level. In an area so small as Chatham Island, where every part is within a few miles of the sea, and where the highest land only attains a height of 286 m., it seems unlikely that there should be any marked differences in temperature or rainfall; but Mr. W. Jacobs, who is intimately acquainted with the high southern portion of the island, assures me that there the rainfall is greater and the cold more severe than in the neighbourhood of Waitangi. With regard to differences in temperature, I think he is mistaken; but, as for the rainfall, my own very limited experience goes to confirm his statement. Mr. Cox also writes to me of the greater rainfall in the neighbourhood of Pipitarawai as if it were a well-known fact.

The average rainfall at the meteorological station is 30·4 in. (18). This is by no means high when compared with many places in New Zealand, but the number of rainy days is considerable. *For example*, 28·32 *in. of rain fell on* 192 *days in* 1890; 34·46 *in.* fell on 187 days in 1899; 24·29 in. on 185 days in 1897; 32·17 in. on 194 days in 1896; 34·48 in. on 194 days in 1895; and 35·01 in. on 190 days in 1894. Thus light showers, very often of short duration, are frequent, while heavy rain is exceptional, although there is usually at least one fall during the year of from 1 in. to 2 in. or even more during the twenty-four hours. The rain usually comes from the north, consequently it is a warm rain; but, as is so often the case in many parts of New Zealand, this is immediately followed by much colder rain from the south-west, which has a direct effect on restraining vegetable growth. The driest month is December, with an average rainfall of 1·67 in., while the wettest is July, with an average of 3·92. Taking the seasons of the year, summer is the driest and winter the wettest, the figures being: Spring (September, October, November), 6·11 in.; summer (December, January, February), 5·97 *in.*; autumn (March, April, May), 7·76 in.; and winter (June, July, August), 8·83 in. The character of the vegetation of any region depending more upon the number of rainy days than upon the total rainfall, the average number of rainy days for each month of the year is of special interest; these are: January, 11·7; February, 11; March, 12·1; April, 13·7; May, 17·8; June, 19; July, 23·2; August, 18·2; September, 16·8; October, 17·7; November, 14·7; December, 10 9.

Turning now to the temperature, the mean yearly temperature is 51·4° Fahr., and the mean daily range 10·4° Fahr. The extreme maximum and minimum temperatures for each month are respectively: January, 73° Fahr., 35° Fahr.; February, 70° Fahr., 35° Fahr.; March, 69° Fahr., 40° Fahr.; April, 67° Fahr., 37° Fahr.; May, 64° Fahr., 34° Fahr.; June,

58° Fahr., 32° Fahr.; July, 59° Fahr., 31° Fahr.; August, 58° Fahr., 30° Fahr.; September, 59° Fahr., 31° Fahr.; October, 60° Fahr., 34° Fahr.; November, 67° Fahr., 36° Fahr.; December, 74° Fahr., 38° Fahr. The mean daily maximum temperature for a series of years ranged between 67° Fahr. and 60° Fahr. for January, the hottest month, and between 51·6° Fahr. and 48·8° Fahr. for July, the coldest month; similarly, the mean daily minimum ranged between 56·3° Fahr. and 48·6° Fahr. for January and 42·6° Fahr. and 38·2° Fahr. for July. Such figures as the above are of very little value in estimating the degree of heat to which the plants are subjected, since the readings were taken in the shade. On this point Mr. T. H. Kearney writes, in a recent work on the vegetation of a certain island near the coast of the United States (34, p. 262): "Readings were taken in the shade, consequently they do not represent the temperature to which most of the vegetation is actually exposed, being subject to insolation during the hours of sunshine; they are chiefly valuable for purposes of comparison with other climates." Although the thermometer very frequently falls below 40° Fahr. in Chatham Island, owing chiefly to the frequency of the cold south-west wind, it rarely reaches the freezing-point. The frost never exceeds 1° or 2°, or perhaps double this amount on the ground; while not unfrequently there is no frost at all during the year. Some years are quite without snow, in others snow has fallen on one or two days; but it usually melts as it falls, and never lies on the ground for more than a few hours. Associated with the frequent showers is a cloudy sky, and mists are not uncommon, especially in the early hours of the morning. The average number of calm days during the year is only seven. This fact speaks volumes as to the importance of the wind factor on the plant-life of Chatham Island. The most important winds are the rain-bringing north-west and south-west winds; if to the former are added those marked "N." in the statistics and to the latter those marked "S.," the average number of days on which it blows from north-west to north are 116·3, and on which it blows from south-west to south are 139. Taking the east, south-east, and north-east winds together, these blow on an average on 71·1 days, while the west wind blows on 28 3 days.

Speaking generally regarding the climate of Chatham Island, as shown by the above figures and others in the statistics not quoted here, also from information given to me both by Messrs. Cox and Shand, the climate is exceedingly mild and equable—the summers are never very hot, while in winter there is occasionally a very slight frost. Light showers, lasting only a very short time, are frequent. The

sky is often cloudy, and mist accompanies the northerly winds, especially in spring. The winter is the wettest season of the year, and in consequence of the wet nature of the ground, even in dry weather, much water lies about in flat places and hollows during that season. The wind is always blowing from some quarter or another, and often with considerable violence. The air, in part owing to the wet nature of the ground, must contain a great deal of moisture. Thunder-storms occur occasionally, after which there is nearly always a week or more of unsettled weather.

A good deal can be learnt about the climate of any district by observing the plants which are cultivated in gardens or fields. In Chatham Island all the ordinary vegetables grow very well indeed; potatoes especially succeed so well that in the early days they were to some extent a source of revenue. The first early potatoes are dug at the end of October or the beginning of November. Cereals are not much cultivated, oats alone being grown to any extent. These are sown in August or September and reaped in February, yielding, when grown on good ground, 40 or 50 bushels to the acre. Wheat is not now grown; neither the climate nor the soil is especially suitable, but probably the chief reason for its exclusion is that flour can be more cheaply imported than produced on the island. Certain plants growing in Mr. Cox's garden testify to the mildness of the climate. Amongst these are greenhouse *Pelargoniums* forming large bushes, greenhouse *Fuchsias* of a similar size, *Sempervivum arboreum*, and an arborescent species of *Aloe* not hardy in Canterbury gardens. Growing side by side with the above are most of the indigenous *Olearias* and *Veronicas*, two or three species of New Zealand subalpine *Veronicas*, and a most magnificent specimen of *Olearia lyallii* from the Snares, a plant very difficult to cultivate in many parts of New Zealand. All the ordinary hardy fruit-trees thrive and bear fruit abundantly. At Te Whakaru, only a few metres above high-water mark, is one of the orchards planted more than fifty years ago by the missionaries. The trees at the time of my visit were almost breaking under the weight of fruit. But the most interesting fact about this orchard is that it is quite free from all those kinds of animal and vegetable pests now so common on New Zealand fruit-trees.

History of Man on Chatham Island.

The influence of man through the disturbing factors, which in direct proportion to his degree of civilisation he has introduced into the vegetation of all inhabited lands, is a matter of very great interest and importance. It therefore seems necessary, before discussing the plant-formations in detail, to give

some account of man's history on Chatham Island, so that it can be seen what new factors he has added to the surroundings of the vegetation, and for how long a time they have been influential and to what degree of power they have attained. Then, having pictured as accurately as my limited investigations allow the primeval plant-covering in its various phases, an attempt is made to pourtray the changes in that vegetation which man purposely or accidentally, by means of cultivation, animals, exotic plants, and fires, has brought about. All this is the more interesting since it seems to me that but the merest fraction of the vegetation of civilised or semi-civilised portions of the Old World can be in its primeval condition*—that, for example, forests, and even alpine meadows, which appear to all intents and purposes primeval are but artificial productions after all. But the vegetation of Chatham Island has, ever since it first became isolated on that land, been, prior to the advent of man, exposed to no foreign influences, not even to those attacks of wild herbivorous mammals under the modifying influence of which much of the vegetation of the earth has been developed.

The aborigines of Chatham Island are Polynesians, and appear to be merely a branch of the Maori race. According to Mr. A. Shand they, before the arrival of any other people, had lived on Chatham Island for about seven hundred and seventy years. They did not cultivate the ground at all. The only vegetable foods they made use of were the rhizome of *Pteris esculenta* and the fruit of *Corynocarpus lævigata*. Their settlements were not confined to any one part of the island, but they moved about here and there according to plentifulness of food in certain localities. When the sea-birds came to lay their eggs on the "clears"† in the south of the island they would live in that part. So important was this article of food to them that they made a sort of rude calendar based on the period when any particular egg was most abundant. The egg season over, they would move about the rocky portion of the coast for fish, along the lakes and lagoons for eels, or they would visit those places where the holes of the mutton-birds most abounded; even they would visit in their large canoes the neighbouring islands and rocks in search of birds. All the above would have little effect on the vegetation. The dense

* Mr. W. L. Bray writes regarding the vegetation of western Texas (2, 118): "Under what may be called natural conditions to distinguish them from conditions which prevail under the present era of exploitation the grass-formations held their own in the perpetual struggle against woody vegetation. With the advent of the cattle business, however, this advantage was lost, and the present is an era of the rapid encroachment of timber-formations."

† The name "clears" is given by the white settlers to those places not covered with forest.

forests and bogs the Morioris would avoid, and foot-tracks would come to be formed over the easiest ground, which are possibly identical with the main tracks through the island at the present day. The only way in which they could do any damage to the plant-covering would be through setting the swamp and dry ridge vegetation on fire, for the forest, happily, will not burn; and probably some of the present lakes originated in that manner, through the peat catching fire during the Moriori period.

In November, 1791, Lieutenant Broughton, Commander of H.M.S. "Chatham" (47), discovered Chatham Island. He sailed along the north coast, landing in the neighbourhood of Kaingaroa. There he hoisted the British flag and took possession of the island in the name of King George III. While on shore he had an encounter with the natives and one was killed.

No more white men visited the island until 1834, when a Sydney whaling-ship arrived, which had on board four young Maori sailors. Probably the captain of this ship, or of some of the other whalers which about this time visited the island, introduced the pig; at any rate, in the early "fifties" these animals were more numerous in a wild state than they are at the present time. The four Maoris brought the tidings to their tribe of the excellence of Chatham Island, and, as it offered a haven of refuge from Te Rauparaha, the whole tribe decided to leave New Zealand and settle on the island. Accordingly, in 1835, they seized a vessel and compelled the captain to take them from Wellington to Chatham Island. Two trips were made to the island, and about nine hundred Maoris were landed on its shores. The Morioris, the number of whom has been estimated at from fifteen hundred to two thousand, being essentially a most peaceful race, and in consequence of their isolated position knowing nothing of the art of war, were quickly subdued and reduced to a state of slavery by the invading Maoris, who, moreover, were armed with firearms. The Morioris rapidly decreased in numbers, some hundreds being soon killed by the Maoris. Famine and disease also decimated them, and so they have decreased year by year until now less than a dozen pure Morioris are in existence. The Maoris brought with them potatoes, taro, and kumaras, but found the climate suitable only for the potato, which they cultivated in sufficient quantities to supply their wants.

In the year 1843 five German missionaries, of whom one, Mr. Engst, is still alive, and resided on the island till quite recently, were sent from Berlin by a German missionary society, and with their advent must date the first beginnings of change in the vegetation, for they made gardens, cultivated wheat to

some extent, and a little later on planted orchards. With the fruit-trees came over a grass, Mr. Shand informs me. This I have not seen, but it was probably one of the first introduced plants to spread spontaneously on the island. As the fruit-trees would not grow without shelter, the missionaries made use of the indigenous *Olearia traversii* for this purpose, and it answered admirably.

The most important event for the future of the vegetation was the introduction of sheep, cattle, and horses. In 1841 Mr. Hanson, who had visited Chatham Island on behalf of the New Zealand Company, sent a few cows and a bull to be pastured on the island. At a later date most of these cattle and their offspring were removed to New Zealand, but a few were secured by the missionaries. Shortly afterwards a few merino sheep were brought to the island, but they did not evidently increase to any great extent, for in 1855 there were probably only about two hundred sheep on the island, and these mainly in the neighbourhood of Ouenga. At a little later date than the cattle and sheep, horses were introduced, but for a long time they were scarce, and it was not until the year 1868 that they became wild in the unsettled districts. Cattle must have become wild much earlier, for Mr. Shand tells me that traps were made for them in the early part of the "sixties," and at the present time they are very numerous indeed on the table-land. It was not until the year 1866 that sheep-stations were organized as at present, at which time there would be perhaps two thousand sheep on the island. Since the above date sheep, horses, and cattle have increased enormously, horses as well as cattle being wild in many places and in considerable numbers, while some sixty thousand sheep roam over the whole of the island.

In addition to the animals many exotic plants have come over in the train of the white man, every one of which, when once established, must play a part in altering the aspect of the different plant-formations of which it is able to become a member.

The direct influence of the white man on the vegetation has not been very great, cultivation not having been undertaken on a very large scale.

PLANT-FORMATIONS.

In an island so small as Chatham Island, where herbivorous animals have roamed almost everywhere at their own sweet will ever since their first introduction, and where, moreover, much of the vegetation has been burnt again and again, hardly any of the plant-covering can still be in its virgin condition. On this account the plant-formations may be divided into the recent, or modified, and the original, or

unmodified. From a careful study of the present plant-covering in a large number of places it seems certainly possible in many instances to get a fairly accurate idea of the original formations, especially when aided by the information of those who have resided on the island almost from its first settlement by Europeans. Those small pieces of original vegetation which from their peculiar situation have up to the present been undisturbed also aid most notably in affording a clue to the character of similar formations in other parts of the island; but, of course, the results deduced from such a comparison must be accepted with caution, since a slight difference in edaphic conditions may lead to more or less considerable changes in a formation. In some instances the descriptions of the individual plant-formations which follow are limited to certain stated localities.

Dr. H. C. Cowles very justly observes (14[2], p. 178) that "plant societies must be grouped according to origins and relationships, and the idea of constant change must be strongly emphasized"; and, further, "The laws that govern changes are mainly physiographic; whether we have broad flood plains, xerophytic hills, or undrained swamps depends on the past and present of the ever-changing topography." The above ideas I have attempted to in some small degree carry out, and have taken for the most part the plant-formations in what seems to me their order of sequence, and have sought in some instances to point out their relationships. To have attempted, however, a physiographical classification of the formations with any degree of thoroughness was out of the question. Such would require, in the first place, to be based on what does not yet exist—a description of the topographical geology of the island by a competent geologist; and, in the second place, a very much more accurate study of the formations than I was able to make would be essential.

There are on Chatham Island two distinct regions of vegetation, of which the most marked difference is shown by the forests. The one is confined to the tableland, and the other comprises all the remainder of the island. For this latter I suggest the name "lowland region," a not particularly good name, but sufficiently applicable, since most of its surface is only a few metres above sea-level, while its hills are low isolated volcanic cones. Probably some of the differences between the vegetation of the tableland and lowland regions have been accentuated by fires, &c., while the woods above the north-west and west coast of the southern part of the island seem, so far as a rapid examination showed, to be in some degree a transition between lowland and tableland forest. All the same, the differences between the

vegetation of the two regions is sufficiently well marked, and that such should occur on two adjacent parts of a very small island is a matter of considerable interest.

Sandy Sea-shore.

The only portion of this formation examined with any degree of care was the shore in the north of the island, stretching from Wharekauri to Cape Young. Here the shore gradually merges into the dunes by way of very low mounds and ridges. The conditions for vegetation establishing itself and thriving in such a position are very severe, owing to the looseness and dryness of the soil, exposure to frequent sea-breezes causing drifting of the sand and excessive transpiration from the leaves of the plants, liability to submersion by salt water at periods of abnormally high tides, more or less salt in the soil at all times, and strong insolation. The sand is rather coarse in texture—much more so, indeed, than in some other parts of the island (Waitangi Beach, *e.g.*)—and contains an abundance of very small pieces of minute shells. Just above high-water mark grow *Calystegia** *soldanella* and *Ranunculus acaulis* in patches here and there, but forming only a very thin covering on the loose and easily moved sand. The trailing stems of *C. soldanella*, furnished with a few fleshy leaves, are very short, being rarely more than 4 cm. in length; the rest of the plant is subterranean, with the exception of the flowers. These latter are large, lilac and white in colour, semiprostrate, with their peduncles buried beneath the sand right to the base of the calyx. This small development of *Calystegia* contrasts greatly with the same species when growing on sand-dunes at some distance from the sea in many parts of New Zealand. There it forms great masses trailing over the sand, or, when growing in sheltered positions amongst other plants, it actually assumes a climbing habit of growth. *Ranunculus acaulis* grows in small rosettes, connected together by white underground stems. The leaves, of which there are four or five in each rosette, lie flat on the sand, are ternate in shape, of a rather thick texture, and varnished on the upper surface. The roots are fleshy, seven or eight times as long as the leaves, and descend deeply into the sand. The flower-stem, by the time the fruit is mature, usually arches downwards towards the ground, thus often depositing the ripe achenes below the surface of the sand. This may be merely the result of a mechanical bending of the

* This Hooker (29, p. 198) considered identical with the European and Australian forms of this species, but, as he held the opinion then so prevalent that species were large conjunctive groups, it may quite well be that the New Zealand plant differs from the European, or even the Australian, in certain particulars.

stem by the drifting sand aided by the increasing weight of the fruit, or it may be an adaptation for sowing the seed, thus hindering it from being blown inland into positions where the seedlings would have little chance of maintaining themselves amongst a more luxuriant vegetation. Whether such bending of the stem is hereditary can only be ascertained by experimental culture.

The sandy shore plant-formation is distinctly a modified one, though to the casual observer there is nothing to notify that fact. In its primitive state it might well have received the name of "*Myosotidium* formation." Just* above high-water mark, where the great masses of kelp accumulate, right up to the junction of shore and dune, on to the dunes themselves, and into the open part of the *Myrsine-Olearia* "scrub," formerly extended great clumps and patches of this truly magnificent plant. Not only on the sandy shore was it found, but it occupied low peaty ground near the sea, rocky shores, and rocky ledges of cliffs covered with sand, where, with the immense sow-thistle, it must have struggled for sovereignty. At the present time, as explained further on, it is hardly to be found wild in the island. *Myosotidium nobile* has a stout rhizome creeping either just below the surface of the ground or often with its greater part above the surface, in the manner of the New Zealand *Ranunculus lyallii* or the Californian *Saxifraga peltata*. Such a rhizome in a wild plant which I examined measured 5·2 cm. in diameter. The leaves in shape and form are not unlike those of the garden rhubarb, and consist of a comparatively thin lamina held in position by an extremely strong framework of midrib and veins beneath, and the course of which is defined by channels on the upper surface. The leaves are nearly always bent in the form of a funnel, which must be very advantageous for catching the water of the light showers and conducting it to the channelled petiole, flowing down which it reaches the roots. Petioles, midribs, and veins are very fleshy and juicy. Certain leaves which I measured were 25 cm. by 29·5 cm.; 27 cm. by 22 cm., with petiole 12 cm.; 32 cm. by 38 cm., with petiole 44 cm. The large leaves, after being cast off, very soon become dry, and in course of time a very considerable depth of humus results. The peduncles are stout, and raise the flowers above the foliage. In one case a peduncle measured was 60 cm. tall and 18 mm. in diameter, bearing a close head of racemes 12 cm. in diameter. The central half of the corolla is bright blue, changing afterwards to purple, and the outer half is white. Mrs. Chudleigh, of Wharekauri, discovered a form with white

* According to Mr. F. A. D. Cox.

flowers some years ago, and through her instrumentality this has become fairly common in cultivation. There is a notion prevalent that *M. nobile* cannot be grown inland at any distance from the sea, Mr. A. Bathgate, *e.g.*, stating that it requires the salt air (1[1]), but this is quite a mistake. One of the finest plants I ever saw in cultivation was shown to me by Mr. T. W. Adams in a garden situated at Greendale, on the Canterbury Plains, at a distance of twenty-four miles from the sea, the plant in question having been there for more than ten years, flowering regularly and bearing abundance of seed. It seems to me that most likely *M. nobile* has been thrust into its present maritime position not by choice, but by the pressure of encroaching plants or other enemies. M. Battandier, as the result of eleven years' close study of the flora of Algeria, has come to a similar conclusion with regard to certain maritime plants, and in a most interesting paper details the facts on which his opinion is based (1).

Sand-dunes.

Sand-dunes of considerable extent and varying height occupy a large proportion of the ground adjacent to the sea. They extend along the whole east coast from Te Whakaru in the north to Ouenga in the south, along most of the north coast from Kaingaroa to Waitangi West, and along a very large part of the coast of Petre Bay in the west. Before the introduction of herbivorous animals these dunes were covered in many places with a dense forest, consisting chiefly of *Olearia traversii* and *Myrsine chathamica*, and reaching in many places almost to the water's edge. At that time moving sand-dunes may have been unknown. But now there is a very different state of affairs. True, the forest still fringes the coast-line in many places, but here and there it is broken through by great hills of drifting sand, which have buried wholly or in part the former plant-covering Such moving hills have in some instances passed beyond the limits of the former wooded area, and are encroaching rapidly on the inland meadow land. A striking example of this encroaching sand burying the forest may be observed between Waitangi and Te One. There in places tree-tops project from the summit of the highest dunes. In one spot on the landward side on the flat is a grove of *Olearia traversii* where every stage of burial can be observed, from the tree-tops almost covered, to their bases just covered by the sand. This advance landwards of the sand is very serious from the economic point of view; but happily the settlers have found a remedy within recent years in the planting of marram-grass on the moving dunes. This, as might be expected from the results of planting this grass in other countries, has proved a

very great success, and now, where but three or four years ago was a desert of sand, tall grass may be seen waving in the breeze, each clump so close to the next that no sand is visible. Nor need a grass little relished by stock be alone made use of. *Elymus arenarius* has also been planted, and thrives equally well, and Mr. J. Barker tells me that at Kaingaroa stock eat it with avidity.* Although the sand-dune vegetation has been much changed by the advent of domestic animals, it is possible to get a fairly good idea of what it was like in its original state by examining, in as many localities as possible, those portions which have been the least changed. The dunes abutting on that part of the Wharekauri Beach the plant-covering of which has been described above are well adapted for the purpose in view, insomuch as they are still covered with vegetation almost to high-water mark, the forest forming a wide belt, separated from the sea-shore by a narrow zone, only a few inches in width, of stable dunes covered with certain characteristic sand-dune plants of more lowly growth. And this locality also affords a striking example of the different stages in the evolution of the vegetation of a sandy coast, commencing with the more or less open vegetation of the strand, and passing by way of low dunes fixed by various sand-binding plants to the final higher dunes covered with forest.

Commencing at the junction of shore and dune, the sand at first forms merely low mounds or ridges. The vegetation, though fairly abundant for a medium such as sand, is open, many places being quite bare. On the ridges grows the common New Zealand grass *Festuca littoralis*. This grass casts its "seeds"† in large masses alongside the parent plant, where, being soon buried by the drifting sand, they readily germinate. Behind the *Festuca* are higher mounds clothed with *Pimelea arenaria*, the long cord-like underground stems of which put forth adventitious roots near their extremities, which latter, bending upwards, raise themselves above the encroaching sand. The leaves are closely imbricating near the extremities of the branches, but below are a little more open. They are all most densely silky on the under-surface, a most efficient protection against excessive transpiration. Owing to the leafy extremities of the stems being erect,

* Other plants used for binding sand with success in Europe are *Ammophila baltica*, *Calamagrostis epigea*, *Carex arenaria*, and with these are used various species of *Pinus*, *Picea*, *Betula*, and *Alnus*. (See "Handbuch des deutschen Dunenbaues," P. Gerhardt, Berlin, 1900.)

† For the sake of convenience, the term "seed" is used throughout this paper in its popular acceptation, and includes, of course, various kinds of fruits.

the semi-rosettes of leaves can receive the incident light to the best advantage. Below, the stems are marked faintly with the old leaf-scars, thus defining those portions of the plant which have formerly been terminal. It is probable that the oldest portions of the plant—*i.e.*, the most deeply buried portions—die, while the plant continues to increase by the rooting of its terminal shoots. Such a plant might, then, attain to a very great age, so long as it was able to hold its own against advancing sand or denuding wind. The *Pimelea* mounds are from 1 m. to 1·2 m. in height. Sometimes the *Pimelea* grows unmixed with other vegetation, but more often its protection is taken advantage of by other plants, especially by *Deyeuxia billardieri*, *Isolepis nodosa*, and *Acæna novæ-zelandiæ*. Such a plant of *Pimelea arenaria* as described above averages about 4 m. in length. 3 m. in breadth, and 47 cm. in height. Another abundant plant of this zone is *Carex pumila*, which here grows in association with *Convolvulus soldanella*. This *Carex* has also the power of growing upwards as the sand covers it, and, with its stout, long, creeping rhizomes, assists the dune very materially in resisting the wind and the advancing sand. *Ranunculus acaulis* is also abundant here, playing its part as a sand-binder, and in habit much the same as described before when treating of the strand vegetation. Less abundant than any of the foregoing is *Euphorbia glauca*, which forms small colonies extending sometimes into the more open parts of the adjacent forest. Its seedlings are fairly plentiful on the sand near the parent plants. Although not very abundant on that part of the dunes here treated of, *Scirpus frondosus* is by far the most characteristic sand-dune plant of the island, and, indeed, of the whole New Zealand area. It can form settlements and hold its own in positions where no other New Zealand flowering-plant can exist, and only the most constant and furious winds can destroy a dune where it is properly established. Indeed, for sand-binding power it is probably not equalled either by *Ammophila arenaria* or by *Elymus arenarius*.

The sand-dunes bearing the forest zone are higher than those just described, and extend inland for a distance of 300 m., more or less. The plant-covering consists near the sea entirely of *Olearia traversii* and *Myrsine chathamica;* further inland other trees put in an appearance. *O. traversii* always maintains its character as a low tree, but *M. chathamica* loses altogether its tree-like habit as it nears high-water mark, and under the influence of the numerous and sometimes violent sea-breezes becomes a leafy shrub with dense close branches. The difference in appearance between the two forms of this plant is so great that one might very easily mistake them for two distinct plants.

Originally such dune forests* must have been very dense; even now the trees are quite close in many places. On the dunes facing Petre Bay in more than one locality the liane *Muhlenbeckia adpressa* may be seen climbing over the *Olearias*, with its numerous interlacing, bare, rope-like stems.

Compared with the sand-dunes of most parts of New Zealand† a marked difference lies in the extreme closeness with which the arborescent vegetation of the Chatham Island dunes approaches the shore. This has been brought about, I should imagine, by the general moisture of the atmosphere, the extremely equable climate, and the freedom from periods of drought. In such a climate as this, as long as the dunes are stable, there is little hindrance to trees, especially those of xerophytic habit, establishing themselves and driving the original sand-fixing vegetation towards the sea into an ever-decreasing area, until finally such plants, with their special adaptations against drought and salt in the soil on the one hand and instability of the substratum on the other, would be confined to the narrow zone where in the least changed portions of the sand-dune formation they are now to be found. Moreover, the sand usually, or perhaps always, overlies a layer of peat, and this will be of great benefit for tree-growth. As an example of how a sand-dune forest might originate, my notes furnish the following clue: "On the sand-dunes between Waitangi and Te One *Pimelea arenaria* occurs in large quantities, forming fixed dunes. Where this plant has quite conquered the drifting sand"—this is, of course, recent drifting sand caused by the destruction of the original vegetation by cattle and sheep—"it encourages the growth of other plants—*e.g.*, *Acæna*, *Gnaphalium luteo-album*, and even young seedling plants of *Olearia traversii*." With no enemy to trample it down or feed upon it, and under the shade of the *Pimelea*, *O. traversii*, thanks to its rapid growth, would soon be well established, and with its enormous number of "seeds" and their extreme suitability for wind dissemination, to say nothing of its xerophytic structure, young plants would soon be established in all favourable localities. *Olearia traversii*, as it occurs on the dunes, is a low tree, with a rather dense head of foliage and a bare trunk covered with rough bark. The leaves are 5·5 cm. long by 2·5 cm. broad, or shorter and narrower They are rather thick but soft, of a bright shining-green on the upper surface and with the under-surface clothed with extremely dense

* The more inland part of the dune forests are treated of under the heading "Lowland Forest."

† For an account of certain sand-dunes in the North Island of New Zealand, see Cheeseman (Trans. N.Z. Inst., vol. xxix., p. 364).

white tomentum, as are also the short petioles and ultimate branchlets. The epidermis is two-layered, and the vascular bundles are surrounded by a sheath of stereome.

Probably *Sonchus grandifolius* originally grew in some abundance on the fixed dunes, but at present it is to be found only in a few places. *Tetragonia trigyna* also must at one time have been more or less common. In one place on the inland side of the dunes, near Lake Te Roto, I noticed a few plants of *Dodonæa viscosa*.

Sand-covered Ledges on Rock.

Closely related to the sand-dunes are those flat places and ledges on maritime rocks on to which sand has blown. Red Bluff, on the west coast of Chatham Island, furnishes a good example of the vegetation of such stations. There, just above high-water mark, *Sonchus grandifolius* grows with great luxuriance, its large fleshy leaves pressed closely against the sand. This plant is furnished with a very thick juicy creeping rhizome. The leaves are of very great size, but unfortunately I had no measure with me at the time of observation. According to Mr. T. Kirk (37), they are "from 1 ft. to 2 ft. long by 4 in. to 7 in. broad." The plant is truly a herbaceous one, its aerial portion dying down to the ground every year—an uncommon phenomenon with the plants of New Zealand generally. The young leaves make their appearance in September, and grow with considerable rapidity. The mature leaves are thick and rather hard. The pale-green upper surface is slighty concave, owing to the leaf-segments being bent upwards; the under-surface is glaucous, probably owing to a covering of wax. The florets are pale-purple towards the circumference of the head, assuming a lighter colour toward the centre, where finally they are pale-yellow. The under-surface of the florets is dark-purple near the apex. The outer involucral bracts are extremely thick, and armed with short thick spines. Such spiny bracts, with the addition of those more internal, form an excellent protection to the young bud which would otherwise be exposed to danger of injury from the sand, often blown against it with great violence by the frequent high winds. Growing in company with *S. grandifolius*, and in considerable quantities, are *Apium australe*, *Samolus repens*, *Salicornia australis*, and the remarkable grass *Agropyrum coxii*.* This latter forms large sheets lying on the sand. It spreads by means of rather stout underground stems. Its extremely supple filiform leaves are so much incurved as to

* For the various new species mentioned, see further on, towards the conclusion of the article.

form an almost closed pipe, into which the dry air can with difficulty penetrate. A transverse section of the leaf shows that it is conduplicate, and appearing almost as if terete. The two halves of the leaf are slightly asymmetrical. Between the margins of the leaf is a very narrow opening, which leads into a wider channel in which the midrib projects. On each side of the midrib are one or two, perhaps more, lateral furrows reaching more than halfway to the dorsal surface of the leaf. The epidermis of the dorsal surface has a fairly thick cuticle and three layers of cells; that of the ventral surface consists of one row of rounded cells with thin walls, a few of the cells being drawn out into unicellular hairs. The stomata are situated in the furrows, and the guard-cells are sunk below the level of the epidermal cells The other plants mentioned above, excepting *Sonchus grandifolius*, are all common New Zealand halophytes with thick leaves and much-creeping underground stems.

Besides the sand having blown on to ledges, it is often drifted against the lower parts of rocks, and forms there a plant-station which puts one in mind of some of the slopes of fine limestone *débris* in the Southern Alps of the South Island of New Zealand. In such unstable ground grows the extremely succulent *Atriplex billardieri*, while patches of *Tillæa moschata* are abundant.

Stony Sea-shore.

The only locality where I examined this formation was Te Whakaru. Unfortunately, my notes are so few that I can only give very general and by no means exact details. So far as I can remember, the shore at Te Whakaru varies from large loose slabs of stone piled one upon another to coarse gravelly sand, containing large quantities of broken shells and having very many rocks rising out of it. Such a shore is much more stable than the dry sandy one before described; the presence of stones on the surface helps to conserve the moisture, so offering permanently moist spots for the ramification of roots, and the large rocks afford shade and shelter. In consequence of these altogether more hospitable edaphic conditions, the stony shore formation is richer in species and its plant-covering more dense than the sandy shore, nor are special adaptations against shifting sand or such strongly marked xerophytic structure indispensable. All the same, the rich development of the underground stem and lowly habit of growth to be found in all the species—*Urtica australis* excepted—fits them both for resisting drought and the attacks of sheep.

Growing on the sand close to high-water mark are *Rumex neglectus*(?), with its leaves flattened close to the ground, *Ranunculus acaulis*, *Cotula muelleri*, and an introduced

species of *Trifolium*. Within a few metres of high-water mark the strand, sloping upwards, gradually merges into the gently sloping peaty ground, which in some places is carpeted with grasses, and in others has small belts of *Olearia traversii* coming right down to the shore.

Just at the junction of shore and meadow is a turf of *Selliera radicans*, a plant with a slender stem creeping on or close to the surface of the ground, and with numerous short roots descending into the gravel; its thick leaves also are pressed close against the ground. That very curious umbelliferous plant, *Crantzia lineata*, also forms a turf in similar situations. Its rush-like hollow leaves are described by Asa Gray as "petioles in place of leaves" (22, p. 205), while Hooker, in the "Flora Antarctica" (30), speaking of specimens from the Plate River, remarks that the leaves sometimes expand into a plane linear-lanceolate obtuse lamina. Goebel calls attention to the same fact (21, pp. 45, 46), and shows clearly that the peculiar structure of *Crantzia* is a protection against drought, although the South American form grows in swampy meadows. How efficient such an adaptation is for xerophytic conditions, and yet how it can live also in hygrophytic stations, is well illustrated by the Chatham Island plant, which I collected in very wet swamps, on fairly dry sand dunes, on rocks by the sea exposed to frequent drenching with salt water, on extremely dry limestone rocks, and in the shade of the forest on moist peaty ground. Near New Brighton, Canterbury, New Zealand, it grows in a *Phormium* swamp on the bank of the River Avon, subject to some hours' immersion daily in water, which is often slightly brackish, and even at times extremely salt.

Growing near the rocks which jut out of the stony shore is *Urtica australis*, a very large nettle, which, as will be seen further on, forms thickets in some parts of the island. At Te Whakaru it is not very tall, being 30 cm. to 35 cm. in height, but the leaves measured 15 cm. by 10 cm. Its thick stems, 1·5 cm. in diameter, enable it to resist the wind. Here and there on the shore grows the introduced *Plantago media*, which is so much reduced in size and changed generally that it might easily be taken for a different species, were it not for examples of the type growing in a position more favourable for its development further inland.

No doubt a number of other plants occur as constituents of this formation, but none are mentioned in my notes. But, at any rate, the formation is distinctly a modified one, for not only have exotic plants invaded it, but it must have been much changed by sheep, since Te Whakaru was one of the first European settlements on the island.

Rocky Sea-shore.

This formation, closely related to the stony shore, consists of scattered assemblages of plants living on low and often flat rocks, exposed to sea-spray and subject at times to complete drenching by the waves. The station is eminently xerophytic, but the crevices and hollows often contain a good deal of peaty soil, which easily becomes saturated with water during the frequent showers. The only rock-formation of this character studied was at Te Whakaru. In those places on the rocks where earth had filled up the chinks, crevices, or hollows, is often a fairly dense covering of *Crantzia lineata* and *Samolus repens;* in similar situations are large rounded green patches, 15 cm. in diameter, of *Triglochin striatum* and a small species of *Schœnus*, or occasionally *Tillæa moschata* forms still larger patches. This latter plant has red stems and numerous very small but exceedingly succulent leaves.

In crevices of the rocks where there is not much soil *Senecio radiolatus* and a curious species of *Senecio* with entire leaves and solitary flower-heads grows here and there This latter may be merely a depauperated form of *Senecio lautus*. Seedlings of *Olearia traversii* are not uncommon even on such rocks as are surrounded at high water by the sea. *Pratia arenaria*, a plant occurring in almost every plant-formation on the island, not excepting *Sphagnum* bogs, and a few plants of the trailing *Chenopodium triandrum* complete the list

Maritime Cliffs and Large Rocks.

Here are included only those lower portions of the coastal cliffs which in many cases, at some time or another, are exposed to the sea-spray, the degree of exposure varying considerably according to the proximity of the rock or cliff to the sea, while often the landward side of many large rocks may never be under the influence of the sea-spray at all. Also here are included certain cliffs situated at a little distance from the sea along lagoons, &c., such as at Lake Waikaua, which, originally actual maritime cliffs, have, since the cutting-off of such lagoons from the sea, become clothed with a modified vegetation. The highest portions of certain cliffs, especially those of the south coast, bear an altogether different vegetation, which in the latter region is in many places closely related to "tableland forest." The maritime cliffs offer two different kinds of stations: that of the more or less solid portions of the rock and that of sand lodged on flat places or ledges, already discussed.

The plants of the more or less solid rock are such as can, by means of long roots, penetrate the rock through its crevices,

thus procuring a sufficiency of water, which they store up in certain tissues, or prevent escaping too quickly by special modifications of the leaves. *Veronica chathamica* is the most characteristic plant of this formation. It roots in crevices and clefts of the rocks, which often contain a certain amount of peat, varying in depth in some particular cases from 5 cm. to 6·3 cm. From the crevice issues a rather thick main stem, from which numerous lateral very supple branches proceed, trailing over the surface of the rock in all directions, or hanging downwards over its steeper portions. The leaves in the bud have the usual decussate arrangement of the *Veronicas*, and the first two fully formed leaves are in their normal position; but all the other leaves are more or less twisted at their bases, so as to bring the upper surface to the light, the shoot, viewed from the back, showing only the under-surface of the leaves. Even where a vertical cutting is rooted in a flower-pot the newly formed shoot is plagiotropous almost from the first, being bent at right angles to the parent stem, and with all the leaves twisted at the base, so as to bring them into two opposite lateral rows. In nature the leaves are usually somewhat crowded near the ends of the branches, which are quite bare below. The leaves themselves are rather thick and fleshy, pale-green in colour, and covered with numerous short downy hairs on both surfaces and on the margin. They vary considerably in size, and plants differing markedly in this particular may be observed growing side by side. This variation seems the more remarkable, since the life-conditions to which *V. chathamica* is exposed might well be expected to have produced an invariable species

Geranium traversii, described at some length in the next section, is also common on maritime cliffs in all parts of the coast. In many places the vegetation becomes somewhat luxuriant through great sheets of *Mesembryanthemum australe*, accompanied by smaller sheets of *Salicornia australis* and large green patches of *Apium australe* hanging down and covering the rock. Associated with the above are dotted about plants of *Chenopodium glaucum* and *Atriplex patula*. Occasionally, even in places where the sea-spray reaches at times, are stunted, gnarled specimens of *Olearia traversii*.

The fern *Lomaria dura* probably grows on the maritime rocks proper, as it does, *e.g.*, at the Bluff, in New Zealand; but in Chatham Island it is especially luxuriant on the cliffs bordering the Waikaua Lagoon. Its dimensions vary according to the amount of soil and the moisture of its station. In stations facing south on the very steep cliffs it forms colonies to the exclusion of all other vegetation. The leaves of one plant measured 64 cm. in length by 12 cm. in breadth, and it had a stem like a small tree fern, 21 cm. long. Near this

mass of *L. dura* grows the large nettle, while below *Apium australe* is abundant. On the dry solid rock where soil is altogether absent *L. dura* is of very much smaller dimensions, but I took no measurements.

Shallow Peaty Soil underlaid by Rock.

As the rock weathers away and becomes flatter the vegetation described above becomes more and more abundant until finally a considerable layer of peat results, which supports a plant population different in many respects from that of the original rock. Te Whakaru Island offers an example of such a station, and exhibits the gradual change from the lowly vegetation of the flat ground close to the sea to the grove of *O. traversii* on the higher ground, many of which trees are of the largest size to which that species can attain. The open parts of the island are covered with a dense carpet of *Mesembryanthemum australe*, some of which have red and some green leaves. Here and there where the latter has not taken possession, especially in the rather moist places, are patches of turf consisting of *Crantzia lineata*, *Triglochin striatum*, *Cotula muelleri*, *Pratia arenaria*, *Selliera radicans*, *Schœnus* sp., and *Ranunculus acaulis*. Sometimes the *Pratia* forms large patches unmixed with any other vegetation. Where the surface of the ground is higher and the soil probably deeper grows the endemic *Cotula featherstonii* (Plate XIV.). This plant forms large colonies on the dry peaty ground in which the mutton-birds make their holes, probably the presence of the birds' manure defining the habitat of the plant. It possesses a stout, smooth, upright stem, 13 mm. or more in diameter, which gives off about five branches rather close together, which latter again branch in a similar manner, the whole plant being from 15 cm. to 30 cm. in height The leaves are soft and slightly succulent, but not sufficiently so for water to be squeezed out of them. They are crowded into rosettes at the extremities of the branches, the internodes being very short. The whole plant is of a greyish colour, and puts one in mind of the biennial stock (*Matthiola incana*). The roots are stout, strong, and woody, and form, with their rootlets, a mat, which lays hold firmly of the adjacent soil. As to the duration of life of *C. featherstonii*, there seems little doubt but that the plant is a perennial. At Maturakau *Myosotidium nobile* grows in large clumps near those of *C. featherstonii* (Plate XV.), all the rest of the ground being covered by *Mesembryanthemum australe*, which also hangs in sheets from the adjacent cliffs. On Te Whakaru Island a few plants of *Phormium tenax* on the peat and others on the rocks testify to the former greater abundance of this plant;

indeed, the whole formation, especially as seen at Te Whakaru, must have been enormously modified.

Limestone Cliffs and Rocks.

These cliffs bound the shore of the great lagoon in various places, while often rocks extend from their base into the water. At one time the base of the cliffs was laved by the waters of the ocean, so that they are closely related to maritime cliffs. From such cliffs, as before described, they differ in their inland position and consequent freedom from the influence of salt water, also in the very different nature of the rock. Many of their plant inhabitants are doubtless part of the original flora, while others have come from the neighbouring inland formations, their seeds blown into crevices of the rocks or brought by birds, while the xerophytic structure of the plants has enabled them to hold their own in such a position.

Taking the case of New Zealand, it seems well established that sea-coast plants can continue to occupy an inland ancient maritime station. Mr. T. Kirk has called attention to such an instance (42[2]), and I have also shown that *Angelica geniculata* occurs at the lower Waimakariri Gorge, on the upper Canterbury Plains (10[2], p. 101), a station which Captain Hutton brings good evidence to show was formerly maritime (33[2]).

As in all rock-formations, there is here no struggle for existence amongst the plants. Any plant which can gain a foothold will be unmolested by its neighbours. Many parts of the cliffs are quite bare; others are clothed with a fairly abundant vegetation. Very characteristic of this formation is *Veronica dieffenbachii*, the branches of which spread out laterally or hang downwards from a thick main stem firmly embedded in some crevice. Its leaves are confined to the extremities of the branches. They are rather thick and fleshy, 6·5 cm. long by 1·9 cm. broad. The shoots, unlike those of *V. chathamica*, are not at all dorsi-ventral, and the branches are so extremely pliant that a twig 4 mm. in diameter can be rolled round and round the finger without breaking. Other plants growing in company with *V. dieffenbachii* are—*Linum monogynum* var. *chathamicum*, its white flowers striped or flaked with pale-blue; *Senecio lautus; Phormium tenax; Leucopogon richei; Acæna novæ-zelandiæ.* In hollows in the cliff *Adiantum affine* is very abundant, while in some places its delicate fronds form great sheets of greenery on the rocks. *Geranium traversii*, another common plant of this formation, can thrive in extremely dry positions; for example, I noted it growing on a perfectly dry limestone rock near the margin of the lagoon. Its roots are very thick and stout; one example measured was 1·5 cm. in diameter, and at 10 cm. from the

base of the root 7·5 mm. This particular root was 70 cm. long, and three other roots of nearly equal length and thickness were given off from the root axis. The main stem is usually very short and stout; in one case measured it was 1 cm. long and 9 mm. in diameter. From this stem arise radical leaves and trailing stems. The radical leaves are furnished with very thick petioles, 6·5 mm. in length and 4 mm. in diameter. The petioles are pale-pink in colour, especially below, and densely pubescent with short white hairs; at the base they are sheathing, and furnished with triangular stipules. The leaf-blade is reniform-orbicular and deeply lobed, rather thick, and on each surface is covered with pubescence, which gives it a somewhat silvery appearance. Cultivated specimens, which have originated from self-sown seed in my garden, have the leaves much less succulent than the wild plant, the petioles very much longer, more slender, and without a trace of the red colouring.

Limestone Forest.

The limestone cliffs do not form an unbroken precipitous wall all round the lagoon, but they are separated by steep banks and hollows, arising probably from weathering of the original rock. In such places certain trees grow in association, so as to form small woods. The undergrowth of these woods is almost entirely destroyed by the ravages of stock, and possibly the proportion of the species of trees is no longer what it originally was. But what gives special interest to the formation is the presence of *Sophora chathamica*. Regarding this tree Mr. H. H Travers wrote (51, p. 178): "In connection with the recent introduction of the New Zealand pigeon,* I may mention that in a small tract of bush on the margin of the great lagoon I found three trees of the *Edwardsia microphylla*, all growing close together, and being the only specimens of that plant which I saw on either island. They were not in flower or fruit at the time. They were apparently all of equal age, and were about 5 in. in diameter and 15 ft. in height. Mr. Hunt, to whom I pointed them out, stated that he had never seen the plant before. During my residence at Pitt Island I was in the habit of examining the coast of the bay in which Mr. Hunt's house is situated twice a day for some months, and on one occasion I saw a sawn plank of totara, and on another a seed of the *Edwardsia*, which had evidently been washed from New Zealand. The

*I may point out that the pigeon is a distinct species from that of New Zealand (see remarks on this species, *Carpophaga chathamiensis*, Rothschild, by Sir W. Buller, in Trans. N.Z. Inst., 1892, vol. xxiv., p. 80).

seed was hard and apparently sound. I gave it to Mr. Hunt, who sowed it, but I have not yet heard the result." This statement of Travers's has seemed so reasonable that Mr. Hemsley writes of "the doubtful occurrence" of *Sophora* in the Chatham Islands (28). That *S. chathamica* is indigenous in Chatham Island there can, however, be no doubt. Even if, unaided by man in any way, it had arrived a few years before Mr. Travers's visit it would have been indigenous, of course; but it has probably occupied Chatham Island since that land was first colonised by its arborescent plant inhabitants. It occurs abundantly in all the small woods along the lagoon, and in quite as great a proportion as the other trees. Moreover, its seedling form is different from that of any other species or variety of the genus, as I pointed out some years ago (9, p. 337); and so far as I have been able to ascertain, both from Mr. Cox and from personal observation, it does not at any period of its existence assume a xerophytic habit of growth (10, p. 279). Concerning this latter matter, as mentioned towards the end of this paper, I hope before long to make a definite statement. The other forest trees found in conjunction with *S. chathamica* are *Plagianthus chathamicus*, *Pseudopanax chathamicus*, *Coprosma chathamica*, *Olearia traversii*, *Myrsine chathamica*, and *Corokia macrocarpa*, of which the *Sophora*, the *Plagianthus*, and the *Pseudopanax* are the most abundant.

Why *S. chathamica* should be confined to the limestone and found in no other part of Chatham Island, when a closely allied species grows abundantly over volcanic rock in New Zealand, is a very difficult question to answer. It may simply be that it cannot compete in a wet position with the other forest trees, and that the limestone forest is drier than any of the other forest-formations on the island. At any rate, it is a very striking example of the local distribution of a plant, and of how a fall of a few metres in the general level of Chatham Island would probably exterminate the species. The seeds of *Sophora* found on the beaches by Travers and others were most likely merely from the trees by the lagoon, and had never come from New Zealand at all.

Lagoon.

If a portion of the sea be cut off from the main body of water by an enclosing barrier of sand a lagoon is the result, of which Te Whanga is the most important example. Its waters are usually shallow for a considerable depth from the shore, and so are favourable for plant-life; but, being brackish, only a limited number of phanerogams can exist in this station, while frequent winds agitate the surface of the water to such a degree that only those plants specially adapted to

resist the action of waves can exist. In consequence the lagoons of Chatham Island possess only a very small phanerogamic flora; nor so far as observed were *Algæ* numerous. *Ruppia maritima* often occupies large portions of such shallow places in lagoons, and its leaves and stems, floating at times on the surface of the water, form a mat of such density as to have attracted the attention of the Maoris, who call it the "eels' blanket." The floor of the lagoons consists of sand or of sandy peaty mud, formed from the decay of many generations of plants. Such muddy peat is the commencement of a transition from the bed of a lagoon to salt meadow, for as it gradually accumulates it rises out of the water and becomes at once occupied by an abundant plant population. Such a spot forms the line of tension between lagoon and salt meadow. In several places Te Whanga Lagoon is, as before pointed out, sufficiently shallow to be crossed on horseback, the depth of water at the crossing varying according to the direction of the wind; and with a north-west wind blowing in summer it may be quite dry, and clouds of dust and sand mark its position. On this portion of the lagoon-bed large round patches of *Samolus repens* are abundant; so here is one of the most characteristic of salt-meadow plants taking possession of the ground almost before the station is fit to receive it. A very slight rise indeed of the land and the bed of the lagoon would be transformed by nature into salt meadow, which probably might be succeeded by forest, especially if the land were elevated a little more. It is also easily conceivable how such a lagoon could be transformed into a bog, and it seems very probable indeed that the low-lying boggy ground in the north-west of the island has had this origin, as suggested by Haast (23).

Lagoon-shore.

The vegetation of the lagoon-shore, as shown above, is not directly related to that of the sea-shore proper, but is rather an embryonic salt meadow. Of course, originally, before the lagoon was cut off from the ocean, it must have been true sea-shore, though possibly its plants might even then have been affected by the lime in the soil.

I had only an opportunity of examining a portion of the western shore in one or two places, and have no notes at all regarding the eastern shore. The soil consists of sandy peat usually very wet, but varying considerably in its water-content. That portion within reach of the wash of the waves is sopping wet, and so soft that one cannot tread on it without sinking halfway to one's knees. There *Crantzia lineata* grows most luxuriantly, forming large green masses. *Callitriche muelleri*, *Limosella aquatica*, var. *tenuifolia*, *Cotula*,

muelleri, *Cotula coronopifolia*, and *Eleocharis gracillima* are also abundant, and form a kind of turf on the peaty mud. Drier parts of the shore are occupied by thickets of *Urtica australis*, while in other places are very large patches of *Samolus repens*. Where the shore is drier still, and altogether out of reach of the water at any time, is a grassy flat made up of certain grasses, of which I have no specimens—*Cotula muelleri*, *Samolus repens*, *Selliera radicans*, *Crantzia lineata*, *Pratia arenaria*, and probably a number of other plants not specially noted.

Salt Meadow.

Along the great lagoon, especially on its eastern side, are large stretches of flat land bordered on the east by forest, at one time probably the bed of the lagoon, but now, so far as I can remember, salt meadow. Unfortunately, I had no opportunity of examining this interesting formation, and so must leave it undescribed for the present.

Running Water.

Chatham Island, with its many lagoons, lakes, and streams, might reasonably be expected to contain a considerable number of phanerogamic water plants. On the contrary, as pointed out by Travers (51, p. 177), these are by no means plentiful. Most of the streams are very sluggish, their slowly moving water is of a dark-brown colour, and their bed a deep layer of peaty mud. During the rains of winter they often overflow, and so give rise to numerous swamps of greater or less extent, which, if in a forest, contain the characteristic swampy forest trees. Such streams sometimes contain no vegetation beyond certain *Algæ*; in others *Myriophyllum elatinoides* and *Polygonum minus*, var. *decipiens*, grow in company with one another; while in the very still pools of forest streams *Callitriche muelleri* is sometimes abundant, growing at 0·5 m. or more below the surface of the water and extending on to the damp floor of the forest. *Potamogeton natans* is by no means common, though it is occasionally met with in shallow streams and in pools formed from their overflow. The introduced watercress (*Nasturtium officinale*) is abundant in many of the small streams, but it does not seem to attain to anything like the same dimensions as in certain South Island waters. On the margin of the streams, growing right in the water, are usually a number of swamp plants—*Carices*, *Coprosma propinqua*, *Arundo conspicua*, &c.—or, if the stream be within a belt of trees on the tableland, *Myrsine coxii* is often abundant, growing right in the water. A station of this kind offers much the same conditions as a swamp, but is more favourable for plant-life, the constantly moving water preventing

stagnation. Rapidly flowing streams are very rare, and, unfortunately, I have no notes regarding their plant-life.

Swamps.

The swamp formation occurs principally in the lowest portions of the central and northern part of Chatham Island, in the immediate vicinity of lakes, lagoons, or sluggish streams, and is distinctly a transition, in some cases, between lake and forest; indeed, the line of tension may be often observed where swamp and forest plants intermingle. The swamp at the southern end of Lake Huro is easy to examine, and is of especial interest, since it offers every transition from the waters of the lake to the ordinary lowland forest. The vegetation of the swamp seems determined by the average depth of the water which more or less covers its floor. Where the water is deepest there is to all intents and purposes an original formation, for the ground is altogether too boggy to permit the inroads of cattle; but in all other parts the trampling of cattle and horses has consolidated the ground more or less and reduced its water-content, thus making it suitable for other plants, both indigenous and introduced. The floor of the swamp in its unchanged portions consists of black peaty mud, upon which it would probably not be safe to walk. Everywhere are large pools of water, 50 cm., more or less, in depth; while in winter the whole floor of the swamp, I learn from Mr. Cox, is under water. Here there are no shrubs of any kind. The vegetation consists of the curious restiaceous plant *Leptocarpus simplex*, a well-marked xerophyte, which in New Zealand occurs in salt meadows and sand-dunes (12[2], p. 119). In this formation *Leptocarpus* often forms very large patches, to the complete exclusion of every other plant. Growing near but not mixed with the *Leptocarpus* is *Carex secta** in great quantities, its "trunk" composed in large part of dead rhizomes and roots matted together, on the summit of which the living plant, raised out of the water, can avoid excess of moisture, sending its roots far down into the decayed and semi-decayed "trunk."

As the water of the swamp decreases in quantity the ground becomes quite covered with vegetation and decaying vegetable matter. There the floor is very uneven, with its many mounds of peat and decaying vegetation separated from one another by holes full of water. In such a part of the swamp *Coprosma propinqua* is very abundant, making a sub-

* Pastor G. Kukenthal, who is preparing an account of the genera *Carex* and *Uncinia* for "Das Pflanzenreich," informs me that he considers *C. secta* distinct from the European *C. paniculata*, to which Cheeseman had previously referred it as a variety (8).

formation which occurs so frequently on the island as to have attracted the notice of the settlers, who call it "Mingimingi scrub." Mixed with the *Coprosma* are the tall grass *Arundo conspicua*, *Phormium tenax*, *Carex secta*, *Carex forsteri(?)*, *Deschampsia cæspitosa*, and quantities of *Epilobium pallidiflorum*, *E. billardierianum*, *E. chionanthum* var., and a large species of *Astelia* which is perhaps new.

As soon as the swamp becomes a shade drier small trees make their appearance, and this point is evidently the line of tension between swamp and forest. The first tree to appear is the xerophytic *Olearia traversii*; then *Dracophyllum arboreum* becomes abundant, mixed with *Coriaria ruscifolia*, *Pseudopanax chathamica*, and *Myrsine coxii*. *Hymenanthera chathamica* and *Senecio huntii* also occur to some extent. Mixed with this arborescent vegetation are all the swamp plants mentioned before, *Leptocarpus simplex* excepted, and large quantities of the fern *Lomaria procera*. Such a "scrub" is often extremely dense, and almost impossible to be traversed. On the banks of Sandstone Creek a very dense formation of this kind, almost in its virgin state, may be seen.

As the water-content of the swamp gradually decreases, through accumulations of vegetable matter becoming peat, so do the trees become more and more numerous, until finally, as in the case of Lake Huro, mentioned above, a true forest makes its appearance. The trees of the formation need not be reduced to mere shrubs; on the contrary, the *Pseudopanax*, *Coriaria*, and others, attain in the Huro Swamp a height of 6 m. Wherever a sluggish stream flows through a lowland forest, and at times inundates the neighbouring ground, the character of the forest changes, and a formation of *Corynocarpus lævigata*, *Coprosma chathamica*, *Rhopalostylis baueri(?)*, *Hymenanthera chathamica*, and *Myrsine chathamica* changes to one of *Myrsine coxii*, *Dracophyllum arboreum*, and *Olearia traversii*, this latter plant being of more lowly growth than when growing in the drier forest.

Those of the swamp plants which differ little from the New Zealand forms of the same species growing under similar conditions need not be further dealt with here; *Dracophyllum arboreum* and *Senecio huntii* are treated of at some length further on, when dealing with the "tableland forest," so there only remains *Myrsine coxii* for special mention. This is a rather twiggy shrub, attaining under favourable circumstances a height of 3 m. or 4 m. Its leaves are close together, and form rather a dense mass at the ends of the branches. They are small, averaging about 1·8 cm., including the leaf-stalk, by 8 mm., and are narrow-obovate in shape. The fruit is of a beautiful mauve colour, and was doubtless originally distributed by means of native birds. These latter,

however, are for the most part nearly extinct, so this method of distribution no longer exists. However, as Mr. G. M. Thomson points out for New Zealand, introduced birds (50, p. 317) are now playing a most important *rôle* in the spread of plants; indeed, they may very well supply the place of the indigenous birds in this particular. *Myrsine coxii* is the first of all the Chatham Island trees to come into bloom, flowering as it does from the end of July.

Most of the swamp formation of Chatham Island has been much modified through consolidation of the soil consequent on the trampling of cattle and horses, which also destroy the trees which otherwise would seize on the "reclaimed" ground; so instead of following its natural course and becoming a forest the swamp becomes gradually transformed into meadow land, in which certain native and introduced plants which are not destroyed by the grazing of animals become dominant and form a turf.

Lowland Forest.

The climate of Chatham Island is distinctly a "forest climate" (48, p. 178)—that is, the whole island would be covered with forest were the edaphic conditions suitable. These conditions vary much for different kinds of trees, but, generally speaking, the soil must be deep enough for the trees to become firmly fixed; it must be firm, but loose enough to contain a sufficiency of oxygen; it must be well watered, but not saturated with water; and there must be enough drainage to forbid stagnation. In addition, humus is usually present in large quantities, while nitrifying bacteria and various fungi abound. Finally, there must not be too great a quantity of inorganic salts or of humic acids in the soil (53, p. 292). From the above it is easy to see the reason why, notwithstanding its forest climate, so much of Chatham Island is without trees, since so large an area is occupied by swamps, bogs, and wet ground. It is not quite so easy to understand how a large area quite suitable for tree-life is also treeless, being occupied chiefly by the fern *Pteris esculenta*. In the section of this paper dealing with burning of the vegetation an explanation of this anomaly is suggested.

The lowland forest of Chatham Island, though consisting of trees very much smaller in their dimensions than those which make up the forests of New Zealand, are distinctly forests nevertheless, and not mere assemblages of large shrubs. Below, all the trees have bare trunks, sometimes of considerable thickness, and above, spreading branches covered with abundant foliage. Seen from a distance the forest is blackish-green in colour, but not nearly of so dark a hue as is the sub-alpine *Fagus* forest of New Zealand. If a forest be viewed

from an eminence, so that the tree-tops can be looked down upon, it will be noticed that these form a compact and level mass of greenery, no one tree rising above its fellows. Within the forest the customary shrubby growths of the New Zealand mixed forest are absent; here, indeed, are no shrubs of any kind, if *Piper excelsum* be excepted, their place being taken up entirely by tree ferns, many of which are of very great dimensions. The ground itself may be bare, or covered with ferns or various lowly plants. On the stems of the tree ferns grow many epiphytes, seedling plants, and even young trees of no small size. Two lianes, *Rhipogonum scandens* and *Muhlenbeckia adpressa*, climb to the tree-tops and mingle their foliage with that of the trees, while the bamboo-like stems of the former and the rope-like stems of the latter form at times a complete entanglement which it is very difficult to penetrate.

The soil of the forest consists sometimes of "red clay," sometimes of peaty loam, or, in the case of the coastal forest, of sand underlaid by peaty loam, while a considerable surface layer of humus, resulting from the decaying vegetation, is always present. The trees, with one exception, are evergreen, their leaves numerous, of fair size, and in some cases rather thick. Here and there the palm, *Rhopalostylis baueri*(?), raises up its huge and graceful leaves to the light through the leafy canopy. The dense foliage of the tree-tops tends to keep the interior of the forest moist and its atmosphere damp. This is plainly manifest by the filmy ferns, liverworts, and mosses, formerly common in many places, but now somewhat rare in lowland forests; indeed, their presence or absence may be taken as a measure of the average humidity of the atmosphere.

As is well known, the New Zealand lowland forest consists usually of a very great number of trees and shrubs, but that of the Chatham Islands, on the contrary, consists of quite a few species, and these occur in remarkably equal quantities. To enumerate them in what is perhaps their order of most frequent occurrence these are: (1) *Corynocarpus lævigata*, (2) *Olearia traversii*, (3) *Coprosma chathamica*, (4) *Hymenanthera chathamica*, (5) *Myrsine chathamica*, (6) *Corokia macrocarpa*, (7) *Pseudopanax chathamica*, (8) *Veronica gigantea*, (9) *Piper excelsum*, (10) *Rhopalostylis baueri*(?). Besides the above, *Plagianthus chathamicus* is abundant in some localities. This is a very different combination indeed from that of any New Zealand forest. Of the eleven trees six are endemic; the palm is perhaps the same as that of the Kermadecs, *Hymenanthera chathamica* is recorded from only one locality in New Zealand, and *Myrsine chathamica* from one station in Stewart Island. All the trees vary in size according to the character of the soil and extent of the forest. In

the "bush" between Te Whanga and Petre Bay there are trees 15 m. in height or more, but usually they are smaller, and vary from 6 m. to 13 m. On the outskirts of the forest, and occasionally within its interior, especially in very wet ground, *Senecio huntii* and *Dracophyllum arboreum* occur in greater or less abundance. These do not properly belong to this formation at all, and such portions may perhaps be looked upon as remnants of a former tableland forest.

Although the conditions under which the lowland forest plant-formation exists are distinctly hygrophytic, and the formation a hygrophytic one, belonging to Schimper's great class of "rain forests," yet that part of the formation which is exposed to almost constant and often very severe winds—viz., the tree-tops—shows in its general form and in the structure of the leaves of most of its members certain xerophytic adaptations. Thus the general closeness of the tree-tops, the density of the foliage, the remarkable uniformity of height of the trees, and the lowness of their growth are in direct relation to the strong sea-breezes which by turns strike the forest from every side. Such direct action of the wind is very markedly shown in those isolated groves of *Corynocarpus lævigata* which have been left in certain places when the remainder of the forest has been destroyed by human agency, their branches and leaves on the windward side forming a dense flattened mass, in striking contrast to the more open growth on the sheltered side.

Regarding the leaves themselves of the forest trees, those of *Corynocarpus lævigata* are in appearance not unlike those of the North American *Magnolia grandiflora*. They are rather thick and leathery, bright-green in colour, oblong-lanceolate or sometimes obovate in shape. Their size varies; certain leaves measured varied in size of blade from 12 cm. by 6 cm. to 9 cm. by 5·4 cm. The epidermis is three-layered. *Pseudopanax chathamica* has thick leaves, dark dull-green in colour on the upper surface, but much paler beneath. The leaf-blade measures 15 cm. or 16 cm. by 3·6 cm., and points upwards at an angle of about 45° to the axis of the shoot. The petiole is short and very stout. There is a four- or sometimes three-layered epidermis on the upper surface; the outer wall of the first layer is strongly cuticularized. *Myrsine chathamica* has leaves rather thick and leathery, obovate or obovate-oblong, their lamina 5·5 cm. by 3 cm., rather dull-green in colour, and crowded at the ends of the branches. *Corokia macrocarpa* has leaves lanceolate or oblong-lanceolate in shape, with the lamina 7·2 cm. by 3 cm., or rather shorter, and the upper surface of a shining dark-green colour. The under-surface is white, with very dense tomentum. The margin of the leaf or the

sides of the lamina are often much recurved or rolled back, rendering the under-surface of the leaf concave. The epidermis has a much-thickened outer wall, and the cells are equal in length to those of the palisade parenchyma, while their long axis is at right angles to the surface of the leaf. *Hymenanthera chathamica** has lanceolate leaves, which are thick and coriaceous, and the lamina is 8 cm. by 2·7 cm., more or less. They are of a rather pale-green colour. The epidermis of the upper surface is three-layered, the lateral walls of the two inner layers being very thin. A stereome sheath surrounds the vascular bundles, and adjacent to some of them is a colourless water-tissue. *Coprosma chathamica* has leaves rather thinner in texture than most of the other forest trees, oblong or obovate in shape and variable in size, the lamina often being about 4·9 cm. by 2·3 cm. They are dark-green and shining on the upper surface, and very pale on the under-surface. The small pits ("*Domatia*") common on the under-surface of the leaf of *Coprosmas*, and first called attention to by Cheeseman (7), at the junction of a vein with the midrib, are very distinct. Mr. Hamilton has written about them more recently (32), but has added nothing to our knowledge of their function. The epidermis is two-layered, and a transverse section of the leaf shows a layer of water-tissue stretching from the epidermal cells to the vascular bundles through the palisade parenchyma. *Veronica gigantea* has narrow-lanceolate, quite sessile leaves, averaging probably about 8·3 cm. by 1·8 cm. They are soft, bright-green in colour on the upper surface, thicker in texture than any form of *V. salicifolia* with which I am acquainted, and crowded together rather closely at the ends of the branches. *Piper excelsum* is distinctly a hygrophyte. It has very thin dark-green leaves, with their laminæ 10·6 cm. long by 9·3 cm. broad, and the apex drawn out to a fine point.

With the exception of *O. traversii* and *Corokia macrocarpa*, the former having multitudes of white daisy-like flower-heads, and the latter many small but bright-yellow flowers, the trees of the lowland forest have very inconspicuous blooms. Their fruits, on the contrary, are often large and showy. For example, *Corynocarpus lævigata* has great clusters of very large fruits, each measuring 4 cm. by 2 cm.; *Myrsine chathamica* has the naked branches below the leaves covered with most beautiful mauve-coloured drupes, which, according to Mr. Cox, take fully a year to develope their brilliant colour. The bare stems of *Hymenanthera chathamica* are similarly covered with large white berries. *Corokia macrocarpa* is frequently

* Diels's figure of the anatomy of the leaf of *H. latifolia* (16, p. 230) shows almost identical structure with that of the Chatham Island plant.

covered thickly with its bright-orange drupes, and *Coprosma chathamica* has large drupes, 12 cm. by 9 cm., which are probably of a yellow colour.

The tree ferns composing a large part of the forest undergrowth are chiefly *Dicksonia squarrosa* and *D. antarctica*. Besides these *Cyathea dealbata* and *Cyathea medullaris* occur, but more sparingly. Sometimes the tree ferns grow very closely, and do not permit many other plants to spring up amongst them; at other times they are further apart, and the ground is then densely covered with ferns similar to those of the New Zealand forest growing under the same circumstances, such as *Asplenium bulbiferum*, *A. falcatum*, *Lomaria lanceolata*, *Aspidium aculeatum*, *Hymenophyllum demissum*, and others.

Besides the ferns, *Epilobium rotundifolium*, *E. linnæoides*, *Uncinia australis*(?), a few grasses, a species of *Hydrocotyle* with very large leaves, which is either *H. robusta* or an undescribed endemic species, and often great numbers of seedling trees, form the general carpet of the forest. In places where the humus is deep are the orchids *Pterostylis banksii* and *Acianthus sinclairii*. On the floor of very damp forests, in places where stock have access, and where much of the original vegetation is destroyed, *Callitriche muelleri* and *Crantzia lineata* carpet the ground, mixed with considerable quantities of *Ranunculus rivularis*, the *Crantzia* being of very great size. At the present time the forest carpet is in many places almost obliterated by the trampling and grazing of stock; indeed, in no place now on the island is the lowland forest in its virgin condition.

The stems of the tree ferns hold in their matted roots and the bases of their stipes a good deal of water, and also no inconsiderable amount of fine humus, which must have originated from the decay of the leaves. Thus it is that many plants, crowded out probably from the soil by more vigorous competitors, have chosen the stems of the tree ferns for their permanent home; others live equally well either upon the ground or on the fern-stems. The tree-fern stems, with their good drainage conditions and the abundant food-supply from the humus, offer a most excellent station for the germination of all kinds of seeds; indeed, seedlings of the forest trees abound in such a situation. This is still more marked in the "tableland forest," under which head the matter is further discussed. Amongst the plants growing on the tree-fern stems are *Tmesipteris tannensis*, *Trichomanes venosum*, *Polypodium billardieri*, *P. pustulatum*, *Aspidium capense*, and *Earina mucronata*. Several of these plants also grow on the trunks of the forest trees, in which position the xerophyte *Polypodium serpens* is very common. Although

this latter plant grows at times on all the forest trees, it is by far most frequently met with on the smooth bark of *Corynocarpus lævigata*. Even where *Corynocarpus* is without the forest it often affords a home for this fern, which in such stations of extreme dryness grows most luxuriantly.

The lowland forest occurs in all parts of the island except on the tableland In the neighbourhood of the Horns and at Te Awatapu the forest is intermediate in type between that of the lowland and tableland, the result perhaps of intermediate edaphic conditions. The most extensive lowland forest now existing is that between Petre Bay and Te Whanga. The volcanic hills, Korako, Wharekauri, and Maunganui, are forest-clad. In the neighbourhood of Whangamarino there is a forest of considerable size bordering on Lake Huro and covering the adjacent slopes; and finally lowland forest fringes much of the coast-line, as was shown when dealing with the sand-dunes. It has been explained how a forest may originate in a swamp; but, besides this, the beginnings of forest may be seen in those patches of "bush" which line the bottoms and sides of gullies, such gullies having been hollowed out by the action of streams. In such sheltered positions, where the drainage conditions are good, trees can easily take possession of the ground, and from thence may spread out on to the neighbouring slopes or flat land.

Heath.

One of the most important factors which determines the presence or otherwise of forests is wind. Where constant high winds are the rule, even though every other condition is eminently favourable, very few trees can gain a footing on the ground, while if such have in addition to contend against other plants better equipped for the contest, especially such as are provided with strong subterranean members, they must succumb. This accounts, I believe, for the absence of forest over much dry ground quite suitable for its reception and maintenance. For the plant-formation of such ground I propose the term "heath" rather than "meadow," since the latter name suggests the presence of grasses as the dominant plants, whereas here these latter are in the minority, and bracken fern is the most important constituent. The whole of this formation, no matter where it occurs on the island, is a modified one, so no exact presentation of its original aspect is possible. It seems to follow directly after the bog formations, and it may, I think, replace them without any intermediate stage of *Olearia-Dracophyllum* bog or *Dracophyllum* scrub having occurred.*

* For meaning of these terms, see "Bog Formations," further on.

The presence of the heath plant-formation seems to depend upon the amount of water in the soil, and, as mentioned above, upon the exposure of the station to wind, while, according to the relative dryness of the substratum, certain plants may be present or absent. Thus, the following occur only on the driest ridges: *Leucopogon richei, Cyathodes robusta, Pimelea arenaria, Isolepis nodosa, Libertia ixioides,* var. In such a position *L. ixioides* at times almost constitutes a subformation, forming, thanks to its power of spreading by underground stems, very large patches. Its xerophytic, coriaceous, vertical, iris-like leaves also help to maintain the plant in its dry station. Growing in these *Libertia* patches, but in very limited quantities, are *Agrostis æmula, Gnaphalium involucratum, Acæna novæ-zelandiæ,* and a few stunted plants of *Dracophyllum paludosum* and *Pteris esculenta.* In many places the heath consists of nothing but *Pteris esculenta,* which often grows with great luxuriance, and attains a height of 1·5 m. or more. Where the fern is not so tall a number of other plants are found in association with it. In such positions the following were noted: *Epilobium* sp. (perhaps related to *E. novæ-zelandiæ*), *Lagenophora forsteri, Gnaphalium filicaule, Oreomyrrhis colensoi, Gentiana pleurogynoides* var. *umbellata, Pratia arenaria, Isolepis nodosa, Acæna novæ-zelandiæ, Hydrocotyle moschata, Danthonia semi-annularis, Dichelachne crinita, Thelymitra longifolia, Microtis porrifolia, Luzula* sp. Also plants of *Dracophyllum paludosum* and *Olearia semidentata* are occasionally present, a remnant of the original bog formation.

The soil of this formation is usually peaty loam, varying much in the amount of water it contains, but except on the ridges mentioned before it is never really dry. Formerly there was probably, as pointed out further on, only a limited extent of heath, with bracken as the dominant plant, and undoubtedly *Phormium tenax* would play a very important part in the vegetation. A proof of this is afforded by *Phormium* occurring in very large quantities in the hollow before mentioned, where the peat had been burned, and the steep sides of which prevent the entrance of grazing animals.

Except on the southern tableland the heath formation is found in all parts of the island; indeed, so far as I can judge, it occupies a larger area than any other formation. On the large extent of flat land raised a little above sea-level, marked "Kekerione" on the map (49), and intersected here and there by puny watercourses, wherever the surface sinks a little below the general level is boggy ground; but all the remainder, by far the greater part, is covered with bracken, varying from a vegetation of almost pure *Pteris*

esculenta to one in which that fern and *Gleichenia circinata* occur in almost equal quantities.

Lakes.

It may be remembered that I included the lowland lakes with the lagoons; the lakes here to be considered are those of the tableland. It seems very probable that such sheets of water were more numerous earlier in the history of Chatham Island, and that now they are transformed into bogs; but I can bring forward no direct evidence on this point. At the present time, in one instance—that of Lake Te Kua Taupo—the water is on one side actually gaining on the land through the beating of its waves against the soft peaty ground, which falls in large masses into the lake, bearing with it its vegetation. Where this steep bank of the lake possesses an unbroken surface grow in considerable quantities a species of *Veronica* of a spreading habit and *Aciphylla traversii*, both of which plants are in such a position safe from the attacks of sheep. The water of these lakes is, like all the other water of the island, dark-brown in colour. I noted no aquatic plants of any kind. In the shallow water near the margin of Lake Rangatapu, the largest of the tableland lakes, grow *Carex* sp. and stunted *Phormium tenax*. Here lake and bog join—the one gradually merging into the other.

Aciphylla traversii was evidently originally a bog plant, as evidenced by its reproduction in certain bogs after fire, but to which formation it belonged I cannot say. Its leaves are certainly altogether more flaccid than the New Zealand *A. colensoi*, but they are more rigid than I had been led to expect. The apex of the leaves is pointed, but it is quite soft, and will not prick the skin even when forcibly pressed against it. The plants vary considerably in size, and the female plant is taller than the male. The largest plants seen measured 80 cm. tall for the female and 33 cm. for the male. The leaves of the female were 34 cm. long, with pinnæ 17 cm. long. A transverse section of the leaf shows an extreme xerophytic structure. The guard-cells of the stomata are sunken, the cuticle is extremely thick; wedge-shaped masses of stereome abut on the resin passages, and these on the vascular bundles, alternating with and separating the palisade parenchyma, while the interior of the leaf consists of rather loose spongy parenchyma, which is completely surrounded by the stereome and palisade parenchyma. This xerophytic structure of *Aciphylla* in the Chathams was considered by Diels as quite out of keeping with the present climatic conditions (16, p. 288), and that is quite true; but, as I show, the edaphic conditions are eminently xerophytic, and can well account for its structure.

Bog Formations in General.

A very large proportion of the tableland and a considerable part of the lowland, especially on the north-west peninsula, consists of boggy ground. The vegetation of the bogs has been burnt in some places again and again, in others only occasionally, but in very few places indeed is it still in its primeval condition. To tell whether a portion of vegetation is primitive or modified is not easy. Much of the plant-covering, looking to all intents and purposes unmodified, Mr. W. Jacobs assures me has been burnt at any rate once, although that may have happened twenty years ago or more. *Phormium tenax*, which certainly played a very conspicuous part originally in the plant-covering of all places except the very wettest, is now almost extinct, and the exclusion of so large and characteristic a plant from a formation must have led to far greater extension of others with which it formerly shared the ground. The bog soil consists of peat, varying considerably in its water-content, thus leading to several distinct combinations of plants, one combination giving place to another according as the ground becomes drier, until, commencing in the wettest part with a *Sphagnum* bog and passing through various shrubby stages, a "tableland forest" may finally replace the bog. Below, the bog formations are treated of in what I take to be their order of development, beginning with the earliest, the *Sphagnum* bog, which for its part would originate in a lake or low-lying ground covered with water.

Sphagnum Bog.

At one time in the history of Chatham Island the *Sphagnum* bogs must have been very extensive; even when the white man first arrived *Sphagnum* must have been much more abundant than it is at present. Here and there on the tableland primitive *Sphagnum* bogs may be encountered; others of considerable extent occur in other parts of the island, of which one on the high ground between Whanga marino and Te Whanga is of great interest, but most likely even this is not by any means in its primitive condition. The *Sphagnum* bogs of the tableland usually form small islands in the midst of the second stage of bog, the *Lepyrodia* formation, described in the next section. The *Sphagnum*, perhaps an undescribed species peculiar to Chatham Island, is extremely wet, and, in the centre of the bog, pools of water lie on the surface. Walking on the surface one sinks up to the ankles, and in the centre of the bog much deeper still. Growing on the *Sphagnum*, in the very wettest places, is a small quantity of *Isolepis* sp. and *Carex* sp. Where the bog is a little drier *Hierochloe redolens*, *Poa chathamica*, and *Pratia arenaria* are

scattered about here and there. Just where the *Sphagnum* formation abuts on the *Lepyrodia* formation stunted plants of *Olearia semidentata* and *Dracophyllum paludosum*, two very characteristic plants of this latter formation, make their appearance, showing the line of tension between the two formations. Growing on the *Sphagnum* the two plants mentioned above remain very small, and often flower when only 10 cm. or less in height. Similar dwarf plants are common in peat bogs elsewhere, Professor Conway McMillan, for instance, mentioning spruce-trees in the bogs of Minnesota seventy-five years old, and but little more than 1½ in. in diameter (44, p. 460). It must have been such miniature plants of *Dracophyllum paludosum* that Buchanan referred to *Drac. rosmarinifolium* in his list of Chatham Island plants (3, p. 338).

In the bog on the Whangamarino Run the *Sphagnum* forms large rounded mounds, on which grow many plants of *Gleichenia circinata* and a few of *Pteris esculenta*. Growing in the hollows between the *Sphagnum* mounds are *Myriophyllum pedunculatum*, *Drosera binata*, *Utricularia monanthos*, *Pratia arenaria*, and *Poa chathamica*. In many places the *Sphagnum* becomes less abundant; here the soil consists of imperfectly decomposed remains of moss and other vegetable matter 1·2 cm. in depth, below which is black rather sticky peat of a fairly firm consistency. In the upper layer *Myriophyllum*, growing to a height of 4·5 cm., and forming a dense mat on the ground, stretches its rhizomes, while its roots penetrate for a distance of 5 cm. into the black peat. Growing through the *Myriophyllum* are many tufts of the *Isolepis* and *Eleocharis gracillima*. In places the *Isolepis* becomes so abundant as to almost conceal the *Myriophyllum*. At times also that extraordinary fern *Schizæa fistulosa* puts in an appearance. Where the *Sphagnum* appears the substratum is much wetter, the decayed remains of the *Sphagnum* being wringing wet. In such places *Isolepis* almost altogether replaces *Myriophyllum*. Where the ground is a little drier *Gleichenia circinata* forms an unbroken sheet; and growing in company with it are all the bog plants enumerated above, together also with many stunted plants of *Dracophyllum paludosum*, like those before described. Many of these latter tiny plants were in full bloom.

Lepyrodia-Olearia Bog.

This formation appears to follow on directly after the *Sphagnum*, so soon as the ground has become a shade drier. It is now altogether a more common formation than the *Sphagnum* proper, but it also is rapidly being destroyed, chiefly through the agency of fires. Although *Lepyrodia*

traversii itself is by no means uncommon in the northern part of the island, the formation there, although at first sight looking distinctly a primitive one, has probably been burnt, but reproduced almost unchanged. Even on the tableland there was only one small piece of this formation that I could feel sure had never been exposed to the influence of fires and stock. This is situated on the south bank of Lake Rangitapu and occupies a space of an acre or more.

The soil consists of peat completely saturated with water, into which a stout stick 2 m. in length can be thrust up to the hilt with the greatest ease. Water can be squeezed out of this soil as from a very wet sponge by quite a slight pressure of the hand. At a depth of 20 cm. the soil is rather of the consistency of porridge. So powerful is the water-holding capacity of such a soil that, if a deep drain is cut through ground such as the above, it will remain saturated with water for years right up to the margin of the drain; even the abundant natural drainage by means of many creeks flowing at a considerable depth below the surface of the peaty tableland, and having a final fall of 210 m. into the sea, have no apparent effect on reducing the water of the bogs.

The vegetation of the formation is extremely dense in most places, and consists of *Lepyrodia traversii* mixed with *Olearia semidentata* and *Dracophyllum paludosum*. In such a dense patch one has to walk right on the top of the *L. traversii*, which sinks with every step; but it is then not on the ground that one is walking, but on the *Lepyrodia* itself, while the soil is at a considerable distance beneath. In such a place *L. traversii* reaches to one's neck. Neither *O. semidentata* nor *D. paludosum* are usually quite so tall as the *Lepyrodia*, though in some places the *Dracophyllum* is the tallest of all. The lower parts of the *Dracophyllum* and the *Olearia* are usually quite leafless, owing to the density of the *Lepyrodia*. In such a dense portion there is no visible undergrowth on the wet, black, peaty ground, nothing being there but the remains of the decaying vegetation and the many matted roots. If a small hole be scooped out in this soil, it will very quickly become filled with water.

The surface of the formation is not all at one level. The *Lepyrodia*, being bent downwards either by the wind or owing to its rigidity not being sufficient to keep it upright, overlies and becomes entangled with the other shrubs, its shoots lying mostly towards the south, owing to frequently violent north winds. In places, not quite so dense as that described above, *Gleichenia circinata* puts in an appearance, its long wiry leaf-stalks raising up the laminæ to within less than 50 cm. of the surface of the vegetation. Here, or more frequently in more open places, the surface of the ground is covered with various

liverworts and mosses, especially with *Sphagnum*, a relic of the parent *Sphagnum* formation. In places where the three dominant plants are growing more thinly still, and the underlying *Sphagnum* is exposed to the light, seedlings of *Olearia* and *Dracophyllum* occur; also *Drosera binata* and *Gentiana umbellata* make their appearance, but these two latter are by no means numerous.

In some places the original *Sphagnum* is still quite thick; there the shrubby growth becomes at once much reduced, and its height quite one-half less. In such a place the sunlight can have some effect, and in consequence more plants appear. For instance, *Corysanthes macrantha* and *Carex* sp.; while *Gentiana*, *Drosera*, and *Utricularia* occur in greater numbers.

Here and there through the formation are a few stunted plants of *Phormium tenax* which have strayed from the drier ground, but which certainly do not really belong to this formation. The most important constituents of this formation are *Lepyrodia traversii*, *Olearia semidentata*, and *Dracophyllum paludosum*. Of these *Lepyrodia traversii*, a strongly marked xerophyte—as, indeed, are the other dominant plants—occurs only in very wet bogs, and a slight diminution in the wetness of the ground will cause it to disappear. It is furnished with a strong rhizome 3 cm. in diameter, which creeps through the *Sphagnum* or the peaty ground at a depth of 5 cm. From this rhizome upright rush-like shoots are given off at intervals, each bare for the lower third of its length, but above branching laterally. These upper branches are terete, dull-brown in colour, very smooth, stiff but quite flexible, and about 1 mm. to 1·5 mm. in diameter. These stems function as leaves, and are provided with a dense palisade parenchyma. A transverse section shows an irregular-shaped lacuna in the centre of the stem, surrounded by a large-celled parenchyma. This, again, is enclosed in a ring of stereome, and round the periphery is a one-layered epidermis with a very thick cuticle. The strong rhizome is of great importance to the plant in assisting it to spread, and in so preventing the advent of other plants. Whether *L. traversii* is able to grow on dry ground like its relative *Leptocarpus simplex* only experimental culture will prove, though its structure should certainly fit it for very dry stations. Mr. Cheeseman, who first pointed out that *L. traversii* occurred in New Zealand as well as the Chatham Islands, where it was thought to be endemic, thus writes (4, p. 325): "In the Ohaupo locality *Sporadanthus*"—the genus under which the plant was then placed—" is seldom found near the margin of the swamp; but towards the centre, where there is a great depth of peat, which affords ample room for its creeping

rhizomes and long stringy roots, it occurs in immense abundance, often covering hundreds of acres to the exclusion of all other vegetation. Mr. J. Stewart, C.E., informs me that the workmen engaged in constructing the railway dreaded to encounter it, as its thick matted roots not only made it difficult to open out the drains, but were always a sure sign of a very bad part in the swamp."

Olearia semidentata varies in form according to the position in which it is growing. When it forms a constituent of the wettest portion of the *Lepyrodia* bog it is of a straggly growth, its lower part leafless and concealed by the thick mass of *Lepyrodia*, while only the ends of the branches, which project into the light, bear leaves. When growing where it has more room to spread it forms rounded bushes sometimes 85 cm. in height and 1·24 m. in breadth. Such plants, as I have pointed out elsewhere (12[8]), bear a rather close resemblance to certain cultivated species of south European *Cystus*. The leaves are variable in size, thick and coriaceous, slightly cottony and shining on their upper surfaces; but the lower surface, which alone contains stomata, is thickly covered with white tomentum. The ultimate branchlets are so dense as to touch one another. Usually the flowers of New Zealand plants are either white or yellow, but *O. semidentata* is a notable exception, the ray-florets being of the most brilliant purple (see coloured plate, 23[2], pl. ii.); indeed, a group of these shrubs covered with heads of blossom each 4 cm. in diameter is a most beautiful spectacle. The roots, which are of considerable length, project laterally, and not vertically, downwards. This manner of growth is evidently strongly hereditary, since it appears in the seedling at quite an early stage. It would be thought that a plant such as *O. semidentata*, growing under edaphic and climatic conditions of extreme constancy, would vary little. On the contrary, so far as the leaves are concerned, the amount of variation is very great. I specially measured the leaves of a considerable number of plants growing near one another in the vicinity of Lake Rangatapu. The largest measured 6·5 cm. by 1 cm., and the smallest 3·6 cm. by 7 mm. The following measurements give examples of the variability of length with regard to breadth: 6·5 cm. by 1 cm.; 5·1 cm. by 1 cm.; 4 cm. by 1 cm. The tomentum on the upper surface of the leaf varied, according to my notes, from "none" to "very abundant." The number of teeth on the margin are also very variable, both on different leaves and on the opposite sides of the same leaf, some leaves having no teeth at all and some as many as nine, while others showed all the intermediate numbers. My notes on this subject conclude thus: "Where I write, three plants

are growing side by side, which, so far as general appearance goes, might be taken for three distinct species."

Dracophyllum paludosum, like *O. semidentata*, when growing amongst *L. traversii*, is only leafy on those stems which emerge from that latter plant. It often occupies much drier ground than even *O. semidentata*. When fully grown and under the most favourable conditions it may be about 1·8 m. in height, and is of rather a fastigiate habit.* It has long creeping woody underground stems, giving off numerous strong cord-like roots. Seedling plants also show this rhizomatous habit. This spreading of roots or underground stems near the surface of the bog is a special characteristic of bog plants all over the world, for in such a position it is possible to get the supply of oxygen for these underground organs which is so deficient in the deeper layers of the boggy peat. Professor W. F. Ganong describes how he traced a stem of *Rubus chamæmorus* in a New Brunswick peat bog for a distance of 17 ft. without finding an end (19, p. 142). The leaves of *D. paludosum* are much like those of certain other New Zealand *Dracophyllums*, being needle-shaped and stiff. They are 4 cm. long by 1 mm. broad, and have a short sheathing base. Usually they are semivertical, but sometimes almost quite vertical. The upper surface is slightly concave and the under-surface convex; both surfaces have a strong cuticle, and possess stomata. The vascular bundles are surrounded by stereome, which extends from one surface of the leaf to the other, and alternates with the chlorenchyma.

Originally the *Lepyrodia* formation must have occupied very large areas not only on the southern tableland, but on other parts of the island, especially on the low-lying ground in the north, where many relics of this formation still exist; such, for example, may be seen in abundance in the boggy ground south of Wharekauri Hill. In another part of the flat land of the north-west peninsula several acres which had evidently once been this formation were covered with young plants of *Olearia semidentata*. On these northern bogs *Cladium gunnii* is often quite common.

The xerophily of bog plants is a most astonishing phenomenon, and has received various explanations, none of which, however, seem to me altogether satisfactory. The most generally accepted at present is that of Schimper (48, p. 18), which is thus stated by Dr. Cowles (14², p. 145): "Schimper believes that these structures"—*i.e.*, xerophytic structures—

* Compare Kirk's remarks (42, p. 225) on *D. scoparium*, which, of course, may be the same species as the Chatham Island plant: "It is a compact plant of fastigiate conical habit of growth, exactly like that of *Cupressus sempervirens*, and quite unlike that of any other plant."

"are due to the difficult absorption in peaty soil, the humus acids and the lack of oxygen being detrimental to normal root activities. For similar reasons the normal soil activities of bacteria and fungi are lessened, and, as a result of this relative lack of decay, great quantities of peat accumulate."

Olearia-Dracophyllum Bog.

How far this may be considered a primitive formation I cannot tell, but certainly at the present time the majority of the bogs of the tableland are of this character, and it seems likely that, though all or nearly all of these have been burnt more than once, they have reproduced themselves in large measure as they originally were. On examining such an area after fire it looks at first as if *O. semidentata* was going in large measure to replace *D. paludosum;* but this appearance is more apparent than real, and depends on the more rapid growth of *Olearia*, and upon its greater distinctness of aspect, owing to its whitish leaves.

The soil of this formation is not quite so boggy as that of the *Lepyrodia* bog, therefore there must be slightly better drainage. All the same, the ground is extremely wet; water can be always wrung out of the soil, while after a shower of rain the small holes made by the hoofs of cattle and horses remain full of water for many hours.

Probably this formation originally contained a good deal of *Phormium tenax*, but that plant at present, as will be seen later on, is almost altogether absent. The undergrowth is much the same as in the *Lepyrodia* formation. The relative proportion of *Dracophyllum* and *Olearia* depends entirely upon the water-content of the soil—the wetter the bog the more plentiful the *Olearia*. Finally, when the ground becomes a little drier still, the *Olearia-Dracophyllum* bog merges into the next formation to be described, the *Phormium* bog, or, if the ground be still more dry, into the *Dracophyllum paludosum* formation, a transition between bog and forest.

Phormium Bog.

This formation, so I learnt from Mr. W. Jacobs, and could also see from its scattered remains, was at one time one of the most important bog formations of the tableland, while *P. tenax* also, in other parts of the island, was, according to Mr. A. Shand, very abundant in bogs, swamps, and even on the drier ground. At the present time a piece of primeval *Phormium* bog is almost unknown, even on the tableland. On a semi-dry ridge near Lake Rangatapu still remains a very small piece of *Phormium* bog, while all around are the blackened remains of burnt plants. Here *Phormium tenax* is easily the leading plant. Mixed with it in large quantities is *Olearia*

semidentata and *Dracophyllum paludosum*, the whole growing quite as closely as do the plants in the *Lepyrodia* bog. My notes give no list of the undergrowth; possibly in so dense a mass there could not be much.

Phormium, before it was eradicated, grew in especial profusion on the banks of the tableland streams, where the drainage would be better and the humus acids of the soil less than in the more stagnant parts of the bog. Such a stream may have the water visible in the centre of the channel, the rest of its bed being full of *Sphagnum*, while growing just in the water and on both sides of the creek are *Phormium tenax*, *Carex secta*, *Hierochloe redolens*, the whole mixed with *Dracophyllum paludosum* and *Olearia semidentata*. Growing on the *Sphagnum* is *Cotula asiatica*, *Isolepis* sp., *Poa chathamica*, and *Juncus planifolius*.

Phormium tenax of the Chatham Islands differs from the forms usually seen in New Zealand in that its leaves are not so stiff, are broader, and usually droop considerably at their extremities.

Dracophyllum paludosum Formation.

This formation seems to be a distinct transition between bog and forest. It is usually found adjacent to the forest, and consequently on the summit of a ridge, for the forest occupies the sides of gullies. The dominant plant is *Dracophyllum paludosum*, mixed with which are here and there small trees of *D. arboreum;* or juvenile plants of this latter nearly as tall as the *D. paludosum* may be abundant, and which still possess only their broad leaves. The *D. paludosum* is about 1·6 m. tall, and the shrubs so close together that one has to force them apart in walking through the formation. On the ground grows *Poa chathamica*, *Gentiana umbellata*, *Pratia arenaria*, *Pteris esculenta* (occasionally), and a few seedlings of both forms of *Dracophyllum*. Not unusually seedlings of other of the forest trees are present, and there is no reason why, when they attain a larger size, they should not destroy the adjacent *D. paludosum*. Here and there are also a few full-sized plants of *Olearia semidentata*, but in this drier ground that plant cannot compete with the *Dracophyllum*. The part most adjacent to the forest contains the greater number of *D. arboreum*, and that zone may be considered the line of tension between forest and bog.

The Tableland Forest.

Greater moisture and a more peaty soil with a great capacity for holding water seem to be the chief œcological factors which have separated this formation from the lowland

forest as a distinct plant-formation. As a proof of this we find the two trees which give the distinctive character to this forest, *Senecio huntii* and *Dracophyllum arboreum*, occurring in lowland swamps and in swampy forests, but they are almost absent from the drier ground. It is true that other Chatham Island trees also grow in swamps (see "Swamp Formation"), but they most likely are merely the plants of a line of tension between forest and swamp, and would be readily eradicated by trees better adapted for wet surroundings. Thus, *Olearia traversii*, *Corynocarpus lævigata*, and *Rhapalostylis baueri* are absent from the tableland forest; *Hymenanthera chathamica* is rare; and, with the exception of *Veronica gigantea*, the other trees of the lowland forest are much inferior in numbers to the two above-mentioned dominant species. The largest forest on Chatham Island belongs to this formation. It occupies the whole of the south-west corner of the island, extending north-wards to a line connecting Tuku and Pipitarawai. All the gullies of the tableland are also filled with this class of forest; and in some cases, these gullies becoming deep as they approach the sea, their forests are of considerable size. In most other cases the trees of the tableland gullies form merely patches or long lines. The most abundant tree of the formation under consideration is *Dracophyllum arboreum;* next comes *Senecio huntii*, which, besides occurring in the interior of the forest as a regular constituent, forms the outermost row of trees, almost to the exclusion of all others, near the line of tension between forest and bog. Such a line of *Senecio huntii* is a magnificent spectacle when the trees are covered with their masses of yellow blossoms. *Veronica gigantea* occurs also very abundantly, while the remaining forest trees, *Coprosma chathamica*, *Myrsine chathamica*, *Pseudopanax chathamica*, and *Corokia macrocarpa*, are found in smaller but still very considerable numbers. These seven trees do not by any means always occur in the proportion just stated; indeed, almost any one of them may become of more importance in the small patches of forest. The central portion of the large forest mentioned above has only quite recently been disturbed, a sheep-track having been cut through it about a year prior to my visit. This had been very little used, so, with the exception of some trifling damage by wild pigs, that part of the forest was fairly unmodified. Its trees are low, varying in height from 6 m. to 9 m., and their foliage forms a flat upper surface, as does that of the lowland forest before described, except that here and there *Dracophyllum arboreum* raises its needle-like leaves slightly above the general level. The tree-trunks are rarely straight, but lean at various angles. The soil consists of black peat with a layer of brownish humus

on its surface. Everywhere the floor of the forest is very uneven, and is covered with many dead and decaying stems of trees or tree ferns and mounds of humus. Every tree-trunk, tree-fern stem, and dead tree is covered with multitudes of filmy ferns. The lowest layer of vegetation consists of young tree ferns, especially of *Dicksonia squarrosa* and other ferns such as were enumerated before for the lowland forest. Here and there at certain seasons of the year the small red fruit-body of a fungus is abundant. The next layer of vegetation is composed of the fully grown tree ferns *Dicksonia squarrosa* and *Dicksonia antarctica*. Many of these latter are more than 4·5 m. in height, and their huge spreading fronds serve to intensify the shade of the forest and to conserve the moisture of the atmosphere. This undergrowth of tree ferns is often so dense that their stems almost touch each other. Epiphytic on the tree-fern stems are *Trichomanes venosum*, *Hymenophyllum multifidum*, *H. dilatatum*, *Trichomanes reniforme*, *Aspidium capense*, *Asplenium lucidum*, and various seedling trees. The filmy ferns are often so thick that they completely hide the trunk of tree or fern on which they grow. In many places the ground also is covered with a thick carpet of these delicate plants. In deep forest-clad gullies, where a stream at the bottom and the wet ground constantly discharge water-vapour into the air of the forest, where it is confined by the double shade of tree-tops and fern-fronds, it can readily be seen that such a gully is a station of the most intensely hygrophytic character, especially if the climate of Chatham Island, with its many morning mists and light showers, be borne in mind. In such a place, too, the wind, that factor nearly always to be reckoned with when considering New Zealand plant forms or distribution, can have but little drying influence. In such a station *Trichomanes reniforme*, the kidney fern, often grows with extreme luxuriance, the ground, fallen trees, tree-trunks, and tree-fern stems being covered with its great almost round green leaves, the younger ones of which are much brighter green and so thin as to be almost transparent. In many places this fern receives a considerable amount of sunlight; but this can do no damage, since the air which surrounds the fronds is always sufficiently moist.

It has already been pointed out what an excellent station for the welfare of seedling plants tree-fern stems offer—a very much better one, indeed, than the crowded and sometimes not too well-drained forest floor. Such seedling trees very frequently reach a large size, especially *Dracophyllum arboreum*, the roots of which plant, penetrating deeply into the soft mat of aerial roots of the fern, finally reach the ground. The plant then grows with redoubled vigour, and in the

end the tree fern, enclosed between these now very thick roots, slowly dies, and *Dracophyllum arboreum* remains in its place as a forest tree, its former roots now playing the part of a stem. Sometimes a large number of roots growing so closely together as to apparently coalesce make up such a "root-stem," to use a term from a letter of Mr. H. Carse. In one instance where a tree of *D. arboreum* had been felled while making the forest track, thus giving an opportunity for examining its structure, I counted thirty roots, which varied in thickness from 16 cm. by 7 cm. to 5 cm. by 3 cm., or even smaller, and, as seen from the above measurements, longer in one direction than the other, owing to the pressure, the whole making a "root-stem" 45 cm. in diameter. The similar behaviour of certain trees, notably of *Panax arboreum*, in the New Zealand forest is well known, and the Rev. W. Colenso has gone into the matter at considerable length so far as the Seventy-mile Bush, in Hawke's Bay, is concerned (13, p. 252, *et seq.*). Mr. H. Carse, who very kindly sent me some notes on this subject, taken in the forest near Mauku, Auckland, has written an account of this interesting matter, which I anticipate will appear in this volume, so there is no need to go into the subject at greater length here.

Dracophyllum arboreum, the dominant tree of the tableland forest, is especially interesting because of the changes which it exhibits during its life-history. In its final form it is a low tree, attaining at times a height of some 9 m. It has a short thick trunk below, and, above, spreading branches bearing masses of needle-shaped leaves, resembling much those of *Dracophyllum paludosum* before described. Besides occurring in the tableland forest, the tree is found in lowland swamps and in the drier portions of the bogs, where it marks either a retreat or advance of the present forest. The early seedling leaves are very much broader than the adult, and resemble the seedling leaves of *Dracophyllum paludosum*, which, however, are rather narrower. The early seedling form persists for a long time in the ontogeny of the individual, and young plants are quite common 1·5 m. in height possessing only the broad leaves, as shown in the photograph I took in the neighbourhood of Lake Te Kua Taupo (Plate XIX.). Usually when a plant has attained to this size it suddenly puts forth leaves of the adult type, and both leaf-forms exist upon the same individual at the same time. As the tree continues to develope all trace of seedling leaves may vanish, and finally there will be a plant merely with the needle-like leaves, looking like a very large spreading specimen of *Dracophyllum paludosum*. Usually, however, many "reversion shoots" of the most extreme

juvenile type make their appearance from any part of the tree—indeed, it is uncommon to see a tree without these "reversion shoots."

Senecio huntii, second only in importance to *Dracophyllum arboreum* as a constituent of the tableland forest, grows to about the same height as the latter. It has a stout erect trunk, varying in thickness according to the size of the tree. The trunk at a distance of 1 m., more or less, from the ground divides, giving off two or more branches, which at first spread out laterally, but finally bend upwards. These branches divide again and again into smaller ones, which always at first spread out laterally, the whole branch system from beneath looking not unlike the ribs of a huge umbrella. At the extremities of the branches are rosettes of leaves. These consist usually of from twenty to twenty-four leaves inserted so closely together that the whole occupy 2 cm. or rather more of the end of the branchlet on an average. In some cases, however, the internodes are more greatly developed; in the most extreme case measured twenty-three leaves occupied a space of 10 cm., while an opposite case gives twenty-seven leaves for 2 cm. These ultimate branches are suffruticose, and 2 cm. in diameter. The leaves themselves are lanceolate and sessile, 12 cm. long by 3·5 cm. broad in the broadest part. Their upper surface is pale, bright shining-green in colour, except where covered by a thin pellicle of whitish cobwebby tomentum. The under-surface is of a paler colour, being greyish-green, and provided with numerous short glandular hairs. The margins and adjacent portions of the leaves are often more or less recurved, thus rendering the under-surface of the leaf concave. So flexible is the leaf that it can be rolled up into a spiral from apex to base without tearing or breaking it in any way. On the under-surface of the leaf is a strong keeled midrib, which is of great importance, since it serves to maintain the rather flaccid blade in the best position with regard to the light. Each ultimate leaf-bearing or flower-bearing branchlet increases in length until it has brought its leafy portion side by side with the neighbouring rosettes of leaves; and in order to get its leaves into a suitable position with regard to the light such a branchlet is often arched first downwards and then upwards. Thus all the rosettes are brought side by side, touching but not getting in the way of each other, the whole leafy head of the tree having the form of a half-globe. Seen at a distance, the foliage of *S. huntii* forms a dense bluish hemispherical mass, which when in full bloom exhibits leaves and bright-yellow flowers in an equal proportion. The branches are extremely brittle, a sudden snap quickly breaking them; but yet they are not easily broken by the wind, their great weight of foliage notwithstanding,

since they are at the same time more or less elastic, while the suffruticose extremities of the ultimate branchlets can yield very considerably to the wind-pressure. The branches are marked with many old leaf-scars and covered with a pale bark, which is somewhat papery and readily peels off. The flower-heads are in subcorymbose panicles, pyramidal in shape, 10 cm. to 14 cm. long by 10 cm. broad through the thickest portion. Flower-stalks and involucres are densely covered with glandular hairs, which, together with those of the leaves, give out a peculiar aromatic odour to the atmosphere.

Te Awatapu Forest.

Standing on the edge of the cliffs not far from the Trig. station which marks the highest point on Chatham Island, one looks down upon a large piece of forest lying in a basin far below. This basin is formed from a great mass of the upper surface of the tableland, which, probably undermined by water, long ago fell into the sea below. In some places perpendicular cliffs, still devoid of vegetation, show whence this great mass of land must have fallen. In other places the cliffs are covered with a good deal of soil, in which is growing a luxuriant vegetation. This forest at the time of my visit was in its virgin condition. A few sheep certainly had just previously found their way down the steep cliffs, but their presence was not felt by the vegetation. Recently the forest, as mentioned in the introduction, has been opened up to stock by means of a cut track, so it seems very necessary to put on record its general appearance.

The ground of the forest consists of clay mixed with a certain proportion of peat, the clay being derived from that stratum which doubtless underlies all the tableland bogs. The surface, which as a whole slopes to the sea, from which it is separated by a jagged wall of rocks, is very uneven; the soil at the time of the landslip must have been heaped up in some places, and with corresponding hollows in others. This unevenness has also been accentuated by erosion. Through the centre of the forest a stream flows, which puts one in mind of some small New Zealand mountain torrent. This stream is fed by the never-failing supply of water from the bogs above, whence the main branch leaps down the precipitous cliffs as a waterfall.

The forest, as pointed out before, resembles in part the tableland and in part the lowland forest. It differs from the tableland forest in that it contains *Plagianthus chathamicus*, *Piper excelsum*, and *Rhipogonum scandens*, in large quantities; but, on the other hand, *Dracophyllum arboreum* and *Senecio huntii* are plentiful. The presence of *Coriaria ruscifolia*, here quite a tree, also separates this formation

from that of the tableland. The undergrowth of ferns is greater than I observed elsewhere on the island. *Polypodium rugulosum* with fronds 1·5 m. in length, *Aspidium oculatum* of nearly equal size, and *Lomaria procera* with fronds rather larger than either of the above, form dense masses on the steep well-drained slopes. *Asplenium bulbiferum* was extremely proliferous; on one pinna were as many as fourteen young ferns, several of which were 3·2 cm. long. Some of such young ferns had fronds 8 cm. long, with sometimes three together. This proliferous habit of *Asplenium bulbiferum* seems evoked by excessive moisture in the atmosphere, for such ferns are met with only in the dampest forests; but this has not been established experimentally as yet. Tree ferns so tall as to reach into the tree-tops are, as in all Chatham Island forests, very abundant, and, as usual, their stems have a large plant population.

The most striking feature of the forest is the enormous number of the climbing stems of *Rhipogonum scandens*. These, together with the closely growing thin liane-like stems of *Piper excelsum*, made travelling through certain parts very laborious, one having actually in many cases to crawl along the ground for considerable distances.

Besides ferns, the floor of the forest is covered in many places with the thin-leaved *Australinia pusilla*, while seedlings of the different trees are very abundant. Within the forest there are two natural ponds, and one or most likely more open spaces. The ponds, though plainly visible from the summit of the cliffs, I unfortunately missed finding, owing to the density and difficulty of the "bush."

The open space was covered with *Polypodium rugulosum* 1·4 m. tall, *Carex ternaria*(?), and *Agrostis æmula*, with *Acæna novæ-zelandiæ* climbing through the whole. Such an open space, taken in conjunction with the ponds and their surroundings, looks like a remnant of the original vegetation which first took possession of the ground after the landslip and prepared the way for forest trees. This view is supported by the fact that young trees of *Plagianthus chathamicus* are growing on the open space mentioned above, and that such a place consequently at no very distant date would, if not disturbed, become uniform with the rest of the forest.

Olearia chathamica Formation.

This formation is œcologically related to the drier phases of *O. semidentata* bog, but to what formation it is related genetically I cannot suggest. If the structure of the leaf and the general habit of the plant be taken into consideration, there seems no reason why *O. chathamica* should not share the same station with *O. semidentata;* indeed, from its larger

stature and robustness it would seem the more powerful of the two in "the struggle for existence." Be this as it may, *O. chathamica* is almost exclusively confined to the drier ground just at the edge of the cliffs, in which places *O. semidentata* is not abundant. Here *O. chathamica* forms dense thickets, unmixed for the most part with any other shrubs; or, if growing more in the open, each plant forms a large rounded bush. The branches radiate upwards and outwards from usually several short thick main stems, and are leafy only at their extremities for a distance of about 18 cm. or so. Their ultimate branches are covered with dense white pubescence. The leaves vary in shape, some being merely lanceolate, but others much broader. On the upper surface they are of a vivid green, and either glabrous or show the remains of a pellicle of tomentum; on the under-surface they are exceedingly tomentose with white tomentum. A transverse section of a leaf shows an extreme xerophytic structure—viz., a thick cuticle on the upper surface, a two-layered epidermis, four rows of very close palisade parenchyma of much greater breadth than the spongy parenchyma, strong stereome round the vascular bundles, and the stomata on the under-surface of the leaf protected by the densely interwoven hairs. The leaves spread out horizontally, but point a little upwards.

Growing underneath the plants of *O. chathamica* is a variable amount of vegetation, consisting of *Lomaria procera*, *Hydrocotyle* sp., *Uncinia* sp., *Pteris esculenta*, and here and there a young tree fern. Mr. W. Jacobs tells me that *Phormium tenax* used to grow abundantly amongst the *Olearia chathamica*, and that probably the shrubs which I was examining, now 1 m. to 2 m. in height, are simply a new growth since a first burning, perhaps twenty years ago or more. Whether this is so or not, there is at the present time a distinct zone of *O. chathamica* extending for a distance of 12 m. or more along the south cliffs of Chatham Island, and following the dry ridges inland, but usually only for a short distance; and there are no traces of this formation elsewhere in the island, except that an isolated plant or two have been found on his run by Mr. Cox. In the north of the island *O. chathamica* is altogether absent. On Pitt Island it is represented by the very closely allied species or variety which I am naming *dendyi*, and which has purple and not white flowers, and a different kind of tomentum on the under-surface of the leaf.

Tableland Dry Ridges.

The word "dry" is used merely as a comparative term to distinguish the soil of this formation from that of the wet bogs; but it is only dry insomuch as, although very moist, water cannot be squeezed out of it. The summits of many

tableland ridges are covered with this formation, and it seems probable that much of the bracken-covered ridges of other parts of the island was originally of this nature. Whether the formation is almost a primitive one or whether it has become considerably modified I cannot say; probably at one time it contained a good deal of *Phormium tenax*.

The most characteristic plant is *Cyathodes robusta*. This forms large rounded bushes of considerably greater breadth than height, with the leaves all touching, and forming quite a dense mass. The leaves are 15 mm. long by 3 mm. broad, more or less, stiff, coriaceous, green on upper surface, but with the under-surface marked with parallel ridges separating about nine furrows, which are covered with wax. The drupes are large and very abundant; on some bushes they are red and on others white, when ripe. The bushes of *C. robusta* are situated at some distance apart, and growing in the open ground between them are tussocks of *Uncinia* sp.; *Gentiana pleurogynoides* var. *umbellata*; *Acæna novæ-zelandiæ*; *Gnaphalium filicaule*, forming large round silvery patches after the manner of the *Raoulias* of New Zealand river-beds; *Lomaria procera*; *Hydrocotyle asiatica*; *Pteris incisa*; *Pteris esculenta*; *Lagenophora forsteri*; *Luzula* sp.; *Pratia arenaria*.

The ridges on which this formation occurs are much exposed to the wind, which may account for the ball-like shape of the *Cyathodes*. Growing close to the *Cyathodes* formation on one ridge examined was a small patch of trees of *Coprosma chathamica*, *Myrsine chathamica*, and *Corokia macrocarpa*; while at the margins of the formation the vegetation became mixed with *Dracophyllum paludosum* and *D. arboreum*. It seems from this that here, as in the bracken formation of the lowland, wind is the factor which decides whether forest shall take final possession of the soil. There are certainly a number of plants in this formation which are not included in my notes, but here, as elsewhere, only those are quoted which were actually written down, and throughout this paper no exhaustive list of plants is anywhere attempted.

Rock.

Leaving out of the question the mosses, the lichens, and those other cryptogams which are the first plants to clothe the naked rock, and consequently a most primitive plant-formation, the phanerogams and ferns which inhabit unshaded rocks are only such as, aided by special xerophytic adaptations, can tolerate a position of such extreme dryness. They usually consist of such plants as can be brought readily by birds or wind. Some of these come doubtless at first as mere casual visitors, but, being able to maintain themselves by various

temporary adaptations, have stayed, and in the course of many generations have become specially differentiated for the rock life. Others, again, belonging naturally to xerophytic stations, may have been driven on to rocks by certain aggressive plants, which have ousted them from their original position. The study of such matters as this latter is, with regard to New Zealand plants, in its infancy, and little can be said of any scientific value. Chatham Island, however, furnishes one very interesting case where a plant once very abundant is almost driven from its principal stations, and will before many years be found only in two places of the most opposite character—viz., rocks and margins of lakes. From what has gone before it may readily be guessed that I allude to *Phormium tenax*. How its destruction has come about and how it has settled in its new quarters will be explained in another section. I need only say here that, although in this case human influence has been the chief agent, how can one tell that such also has not been a determining factor in bringing about certain local distributions of plants in the Old World? Also, it is well known that without human agency of any kind one plant can replace another.

The cone-like volcanic hills have in some instances rocky summits. On such bare volcanic rock grow the orchid *Earina autumnalis* and the very thick-leaved fern *Polypodium serpens*, both of which are also epiphytes of the forest. The decay of the earlier lichens and mosses paves the way for this later vegetation. In such vegetable matter on the perpendicular side of Maunganui Hill grows a short-leaved form of *Asplenium flaccidum* in company with *Polypodium serpens*. The roots of the *Asplenium* are densely covered with hairs, and form a mat spread out for a distance of 15 cm. No station much more dry can be conceived than the face of such a perpendicular volcanic rock. Of course, in wet weather the decayed vegetable matter will absorb water readily, but at the time of examination it was as dry as dust, and certainly the plants would not be able to absorb any moisture from it whatsoever. Under such circumstances these plants must depend entirely upon the water stored up in their thick leaves. On the summit of another rock near by I saw a number of both young and old forest trees, the latter much stunted, growing in peat, then quite dry, of not more than 20 cm. depth.

The Horns is the name given to a volcanic hill at the south-west corner of the island, and which receives its name from there being two rocky cones rising close to one another, and much of the same height. On the steep rocky face of the more easterly horn are growing *Phormium tenax*, *Polypodium billardieri*, *Veronica* sp. (neither *V. dieffenbachii* nor *V. chathamica*), *Muhlenbeckia adpressa*, *Linum monogynum*

var. *chathamicum, Cyathodes robusta, Pteris esculenta, Olearia chathamica,* and a form of *Coprosma propinqua,* this latter being a most remarkable plant. As usually seen in Chatham Island it is the principal constituent of one part of the swamp formation; but here, if the species be the same, it is a prostrate shrub with long, trailing, slender branches, which in places send down adventitious roots into the rock-crevices. The whole plant is flattened close against the rock; indeed, it bears no resemblance at all to the erect bushy swamp plant. In certain of the bogs also what I took to be the same form of this species of *Coprosma* assumes a trailing habit not unlike the rock form just described. The *Muhlenbeckia* mentioned above was growing over the *Coprosma,* and to some extent they would mutually protect one another from the wind. How far this peculiar adaptation to the rock mode of life is fixed, or if it is merely the effect of wind, &c., and is not hereditary, I cannot say. The plants secured for testing this question unfortunately died.

It is on the cliffs of the south coast that the richest rock vegetation of Chatham Island is to be found. Here a good deal of accumulated vegetable matter and soil in places, great unevenness of surface, and a south aspect promoting moisture, with much soakage from the wet tableland, have given far more favourable conditions for vegetation, with the consequence that the greater part of the coast cliffs are clothed with a beautiful green mantle. This covering is closely related to the tableland forest, but, owing partly to the greater amount of light which can penetrate the vegetation, some of the other plants of the tableland are abundant, notably *Phormium tenax* and *Olearia chathamica.*

Effect of Introduced Animals on the Plant-covering.*

As I have suggested when speaking of the aborigines, very little change would be wrought in the vegetation of the island by either Moriori or Maori. They would have little object in setting fire to large tracts of country; and, even in case of such being burnt, there would be neither the foreign plant nor animal factor to cause a marked change in the reproduced vegetation. Even at the present time it is almost impossible to discriminate between a piece of bog vegetation which has been burnt many years ago and a piece of the primitive formation. It may therefore be assumed that, to all intents and purposes, the plant-covering of the island at the time of the advent of the missionaries was precisely as it had been for

* In connection with this, and with the effect of burning on the vegetation of New Zealand, the interesting paper of Canon Walsh may be studied (53).

a very long period. But as the animals which were introduced increased in number and spread over the entire island a very different state of affairs arose for the indigenous plants. They too, like the Moriori, had been long isolated, and the various species had become finally differentiated without any regard to the attacks of grazing animals. Cattle and horses roaming over the sand-dunes would loosen the sand, and also feed in many instances on those plants which bound the sand together.

There are few balances more finely adjusted than that between sand blown inland and its fixation by plants. Once disturb that balance, no matter how slight the disturbance may be, the equilibrium will be destroyed, and the resistance of the sand-binding plants overcome. Thus the destruction of a few plants growing on the dry sand of the shore just above high-water mark, the great source from which all inland-blown sand arises, will increase the volume of wind-driven sand against which the dune plants have to contend.

In Chatham Island, as pointed out before, quite a number of plants grew on this upper strand, conspicuous amongst which was the majestic forget-me-not *Myosotidium nobile*. The leaves of this plant are much relished by sheep, and so, as the settlements of both white man and Maori are usually near the coast, this plant would very early on be attacked. Not only do sheep eat the leaves, but pigs dig up and feed on the great rhizomes, with the natural consequence that the endemic *M. nobile*, one of the most magnificent and interesting plants in the world, is now all but extinct in the wild state. A few plants still exist on the north coast of the island, notably near Matarakau and Waikauia, and there are a few in the neighbourhood of Red Bluff, while below Te Awatapu there is a bed of plants still in its virgin state; but the long line of this plant on the sea-shore, with its huge shining green leaves and great heads of blue flowers, is lost to the world for ever. Happily the plant is very amenable to cultivation in favourable localities, and almost every settler's garden contains some fine examples. Were a piece of ground fenced in from sheep, &c., the plant would again reappear, as in the case of an old Moriori grave-yard fenced in by its owner, Mr. H. Grennel, and described by Professor A. Dendy in a paper read at a recent meeting of our Institute (15). The sand, no longer held by the strand plants, blew inland, became piled up against the dune forests, and, gradually accumulating and advancing inland, it finally buried them, so that now, instead of a fringe of trees all round the sandy parts of the coast, there are high moving dunes in many places.

In the forest cattle and horses eat the foliage and bark of the trees, at the same time breaking down the undergrowth and

the lianes. I was much struck when first examining Chatham Island forests by their want of undergrowth and lianes, which did not accord at all with Travers's description when writing of the Moreroa Bush, thus: "The whole so interwoven with our old friend the supplejack as to be almost impenetrable" (51, p. 176). However, when visiting the Te Awatapu Forest I saw clearly that the lowland forests were no longer in their primitive condition. Messrs. Chudleigh, Shand, and Cox have also all assured me that the forests were formerly very much denser and lianes more abundant than is now the case. In addition, at the present time the forest on the Horns is undergoing an early stage of destruction by cattle, which have only reached that part of the island recently. Almost everywhere are trees broken or, in the case of *Piper excelsum*, uprooted, while the ground is much trodden and seedling trees and young ferns destroyed.

Another change which concerns the proportional representation of species in a forest-formation is destruction of certain trees through animals eating the bark. *Pseudopanax chathamicus*, *Plagianthus chathamicus*,* and *Coprosma chathamica* very often suffer through this cause. Such trees being destroyed, others easily and rapidly produced from seed take their places, and so are now more numerous than formerly. Mr. W. Jacobs tells me that, owing to this cause, the constituent trees of the Moreroa Forest no longer exist in the same proportion as they did twenty years ago. Certain plants have been almost eradicated by grazing and uprooting. The case of *Myosotidium nobile* has been already referred to. *Aciphylla traversii*, another very characteristic Chatham Island plant, is now very scarce. Its leaves are greedily eaten by sheep, and its thick tap-root is devoured by pigs. At the present time isolated plants may be found in boggy ground in all parts of the island, but large areas may be traversed without encountering a plant. Even in the fairly primeval tableland district it only exists in any quantity on the steep banks of some of the small lakes which are not easily reached by stock. *Veronica dieffenbachii* and the other forms of *Veronica* closely allied to that species are, according to Mr. Cox, greedily eaten by sheep. These *Veronicas*, in consequence, are now confined to rocks and banks of creeks or lakes; doubtless at one time they were much more plentiful. It is probable also that the great sowthistle, *Sonchus grandifolius*, found now chiefly in places inaccessible to stock, was at one time much more abundant on the sand-dunes; but I have no proof as to

* This plant is also destroyed by the settlers, who at times use the bark for making hats. The same remark also applies to the palm. Other trees, especially *Olearia traversii* and *Pseudopanax chathamica*, are cut down for fencing-posts and firewood.

whether it has been reduced through being eaten by stock or through instability of the dunes. At any rate, either cause can be traced to the advent of domestic animals.

Besides changing the vegetation through feeding upon it, horses and cattle have also had a very great influence on the water-content of the soil. Wandering over the swampy and boggy ground in search of the food which was originally very plentiful there, they gradually consolidated the surface of the ground. By this means many of the swamps of the island have been turned into rich grazing land. The racecourse at Waitangi is an excellent example, and such "reclamation" of ground by grazing animals can be observed in every state of progress from quite dry meadow to almost primeval swamp. In this particular instance, too, the effect of the final close cropping of the herbage by sheep may be observed, and the change wrought by this on the vegetation estimated. Certain plants which formerly did not form any large percentage of the original vegetation, or which were altogether absent, now make up the meadow land of the racecourse and the ground between the low forest and sand-dunes from Waitangi to Te One. On this piece of ground sheep in very large numbers are constantly grazing, and yet the present vegetation manages easily to hold its own, and has entirely replaced that of the original swamp, which must in large measure have been similar to that described under the heading "Swamp Formation." The plants consist almost entirely of those which possess a far-reaching and rapidly growing prostrate or subterranean stem-system, which, through the great power of vegetative increase which it gives, the abundant food-supply which it contains, and its being secure from damage, enables its possessors easily to resist the attacks of grazing animals. At present the Waitangi Racecourse is a flat meadow marked with many small hillocks or unevennesses, which proclaim the presence of former clumps of swamp vegetation. Everywhere the ground is covered with a thick turf. This is composed of *Crantzia lineata* in very large quantities; also *Pratia arenaria*, the introduced *Poa pratensis*, a small species of *Juncus*, *Potentilla anserina*, all in large quantities; *Hydrocotyle asiatica* abundant, but hardly so much so as the preceding; a variety of *Epilobium cæspitosum*, *Myriophyllum pedunculatum*, *Lagenophora forsteri*, *Eleocharis gracillima*, and *Gnaphalium collinum*, also fairly plentiful. On the driest portions of the hillocks is abundance of *Gnaphalium filicaule*. The whole of these plants have stems which are either underground or creep close to the surface, and several, as we have seen, have great powers of adaptation either to wet or dry conditions of soil. Also, some may not be much eaten by sheep, but it is significant that the two which are especially

abundant, *Crantzia lineata* and *Pratia arenaria*, are considered by Chatham Island sheep-farmers* most valuable pasture plants; and there seems little doubt that these two plants at any rate, owing to former plant adversaries having been removed, partly through changed edaphic conditions and partly through close grazing by animals, have become very much more abundant in Chatham Island generally than was formerly the case—helped, of course, by the great vegetative increase of their stems rendering them safe from the attacks of sheep. But if a plant be isolated and there is no other food for the grazing animals it may not be able to hold its own. Thus *Poa chathamica*, notwithstanding its strong wire-like rhizome, cannot resist close grazing on the tableland bogs, where no other food is present for the hungry animals, and it may be eradicated for a time.

Besides domestic animals, certain European birds have been brought over to the island, and others, strange to say, amongst which are the sparrow and blackbird, are said to have made their way from New Zealand unaided. Such birds play a much more prominent part with regard to the introduced than to the indigenous vegetation, doing a great deal of damage to the crops and gardens of the farmer. They also carry and distribute the seeds of both native and introduced plants; in this case, as pointed out before, doing the work of the former indigenous birds, which now for the most part have become very limited in number. Perhaps the greatest work such birds are performing is that of spreading the blackberry all over the island, but this matter concerns the next section.

As for the effect of introduced insects, I procured no information; probably the hive bee plays an important part in fertilising certain of the introduced plants, and so causing their spread.

EFFECT OF INTRODUCED PLANTS.†

With regard to the influence of introduced plants on the vegetation of Chatham Island I can say little, the time at my disposal not permitting me to collect examples, or even make a list of the species. Mr. T. Kirk published a list of those introduced plants which Travers collected (35), but it contains only twenty-eight species. Probably there were even then

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* Mr. E. R. Chudleigh, for instance.

† On the importance of this subject Mr. Hemsley, speaking of the work of the late Mr. T. Kirk (38), writes in *Nature* (27): "He"—Mr. Kirk—"has put on record facts connected with the introduction and colonisation of exotic plants in New Zealand that positively throw a new light and suggest new ideas on the present distribution of plants in cultivated countries generally."

a great many more, and most certainly others must have put in an appearance during a period of more than thirty years. All the same, speaking generally, I do not think introduced plants have taken possession of the soil to anything like the same extent as in both Islands of New Zealand. When Chatham Island vegetation is destroyed by fire or cultivation, thus making way for introduced plants, it is certain indigenous plants which have become weeds rather than those which are introduced. For example, *Acæna novæ-zelandiæ* now abounds everywhere, becoming an actual torment to the pedestrian during certain seasons of the year, one's lower garments becoming completely concealed in a few minutes with a dense brown mass of its barbed fruits Again, the extremely wet character of the soil is antagonistic to the spread of many of those plants which have replaced the vegetation of New Zealand; while, on the other hand, the shade of the forest demands special adaptations from those plants which seek to get a foothold.* Certain plants, however, have spread very considerably. Of such the blackberry (*Rubus fruticosus*) seems to be the only one which is a menace to any large proportion of indigenous plants. At first it was planted for hedges; but these hedges have now exceeded all bounds and are hedges no longer, but dense thickets. Were this all little harm would accrue, but through the agency of introduced birds the plant is spreading all over the island, especially within the forest areas. I noticed seedling plants in many places, even in the partly primitive tableland forests. On the banks of the Waitangi River are enormous thickets which hang right down into the water; indeed, in certain places considerable areas are occupied by this plant, and the original vegetation is entirely replaced. It is possible, if the spread of this plant is not checked in some manner or another, it may destroy the forest undergrowth entirely, as well as seize on large areas of open ground.

Poa pratensis is much valued in Chatham Island as a pasture grass; it has spread considerably in many places, and has even taken possession of certain stable sand-dunes, covering them with a turf. In wet meadows, such as the

* Introduced plants spread especially where the indigenous vegetation has been more or less disturbed. Where the plant-covering of a region is in its virgin condition, and there is nothing to bring any introduced plants except the wind, they often fail to become established. Thus Mr. T. F. Cheeseman saw only two naturalised species on the summit of Pirongia Mountain (5, p. 321), and these, he writes, "had in all probability been accidentally brought by the surveyors." At the source of the River Poulter, in Canterbury, South Island of New Zealand, I saw no introduced plants of any kind in places where man, sheep, or fires had never been, although such country was fully exposed to the north-west wind, which must bring many light "seeds" from Westland (12).

racecourse before described, although it has become a distinct component of that recent plant-formation, it is no more dominant than some of its indigenous competitors. On dry slopes, where fires are constantly opening up room for the advent of introduced xerophytes, none have yet arrived which can make the slightest headway against *Pteris esculenta*.

Certain other causes distinctly operate in checking the spread of introduced plants, amongst which may be mentioned—the small area of cultivated land; the absence usually of roads, there being merely horse-tracks over the greater part of the island; the small amount of traffic with other countries; and, finally, the large number of sheep which graze on such land as introduced plants could best establish themselves on.

EFFECT OF FIRES ON THE PLANT-COVERING.

Of all the factors which have changed the plant physiognomy of Chatham Island, fires have been by far the most important. In order to provide young growths of grass for his sheep, the farmer sets fire to the bracken fern of the heath or the *Dracophyllum* of the bog. Such fires in dry weather spread over very large areas, and the whole of the vegetation is burnt right down to the ground, leaving only the blackened bases of the plants. This destruction leads to the spreading of certain plants which had been kept in check by others. It also leads indirectly, especially when aided by the trampling of stock, to the drying up of the ground in wet places.

Of all the plants which gain an ascendency after burning none can approach *Pteris esculenta*. As burning succeeds burning so does the *Pteris* increase, until at the present time it must occupy a very much larger area than it did originally; indeed, it seems to me hardly an exaggeration to affirm that it occupies ten times its original area. In this opinion I am supported by Mr. E. R. Chudleigh, who tells me that "bracken has increased enormously since the advent of the white man, and, owing to burning, stocking, and other causes, it has replaced much of the original vegetation." Even after burning the *Sphagnum* formation bracken takes the place of *Gleichenia circinata*, and with repeated burnings the *Sphagnum* altogether disappears and the ground becomes dry and covered with a thick mantle of bracken. Mr. D. Petrie also writes (50, p. 323), speaking of the spread of certain plants in the Auckland Province: "The most aggressive plant of all is *Pteris aquilina*, which is rapidly overrunning much of the land that has been cleared of bush, and which permanently establishes itself before roots are sufficiently decayed to admit of ploughing."

It is only by studying the plant-formations of the table-

land that the change wrought by constant burning can be properly estimated. Nor is it burning alone, as already pointed out, which brings about changes in the vegetation, but rather burning *plus* the attacks and trampling of animals. As to the effect of these two causes combined upon the plant-covering, no plant is so instructive as *Phormium tenax*. This, once extremely common nearly all over "the clears' of Chatham Island, as shown before is now almost extinct. How this came about seems worthy of a detailed explanation, since misstatements regarding the causes which lead to the eradication of *P. tenax* have been circulated so often as to be accepted by the scientific world as fact. Thus Wallace writes: "White-clover (*Trifolium repens*) spreads over all the temperate regions of the world, and in New Zealand is exterminating many native species, including even the native flax (*Phormium tenax*), a large plant with iris-like leaves, 5 ft. or 6 ft. high" (52, p. 29).

If we consider the stations in New Zealand where *P. tenax* grows, we find that in several of them white-clover can only grow with difficulty or not at all. Such are rocks, very dry river-terraces, sand-dunes, and very wet swamps, this latter a most characteristic station. Moreover, the reclaimed *Phormium* swamps in which white-clover is now established and *Phormium* eradicated have usually been artificially drained, and the *Phormium* itself constantly set fire to, thus bringing about a very different state of affairs for the white-clover to become established than an undrained swamp.

But the introduced-plant factor and the fire factor would be of no avail to destroy *Phormium* and lead to its replacement by a comparatively insignificant plant did not stock eat its leaves with avidity, especially the young and comparatively tender ones which spring from its rhizome after burning, with the result that, the growing-point being destroyed again and again, the rhizome finally rots and the plant dies. This is what has happened to the *Phormium* in Chatham Island. After fire its succulent leaves are almost the only food available for the hungry stock; they are eaten and the plant perishes. So also every seedling that cannot establish itself out of harm's way is destroyed. In the lowland swamps, out of reach of the stock, young plants of *Phormium* may be occasionally seen on the stems of *Carex secta*. With the draining of the swamps that haven of refuge will be gone, and *Phormium* will only be met with on rocks and in shallow lakes, where under the two opposite conditions there seems every chance for two new species being evolved.

In the place where *Phormium* originally grew there is no reason why white-clover, or any plant whatsoever that can maintain itself against other competitors, should not re-

people the ground; but this is certainly not an example of one plant exterminating and so replacing another. As an example of the power of *Phormium* growing in ordinary soil to resist aggression, a plant in my garden has grown luxuriantly for nine years in ground which is a complete mat of the rhizomes of *Triticum repens*, almost the most aggressive introduced garden weed with which I am acquainted.

To give an exact account of the changes which come about in a plant-formation after repeated burnings would require close observation extending over a considerable period of time. All that my limited stay on Chatham Island permitted was the examination in a number of places of vegetation reproduced after fire growing by the side of portions of original vegetation, or of a vegetation burned at an earlier date, as the case might be. The following are extracts from my notes on this matter:—

(a.) "Clear" in Forest at South-west of Island; burned about fifteen months.—Such an open spot as this is probably the remains of a bog once much more extensive, but which is now nearly all replaced by forest. Everywhere the blackened stumps and burnt shrubs are standing, while in the wettest ground the burnt *Sphagnum* forms large round hummocks. The original vegetation was *Olearia semidentata*, *Lepyrodia traversii*, and *Dracophyllum paludosum*, with the characteristic undergrowth of this particular plant-formation. In the driest places are *Lomaria procera*, *Lepyrodia traversii* 15 cm. tall from old rhizome, and also seedlings 3 cm. tall, seedlings of *O. semidentata* 8 cm. tall, and *D. paludosum* seedlings 1 cm. tall. In the moister places towards the centre of the "clear" are *Carex* sp., often forming large green masses, *Gleichenia circinata*, *Lepyrodia traversii*, *Drosera binata*, and seedlings of the *Dracophyllum* and *Olearia* as before. The *Dracophyllum* seedlings are so close together as to touch one another. In 20 cm. by 20 cm. of ground are twenty *Carex* sp. + one hundred *D. paludosum* + nine *O. semidentata* + forty stems of *L. traversii* + one *Gleichenia circinata*, but the *Olearia*, being much larger than the *Dracophyllum*, is more conspicuous in the formation generally. From the above it seems that in this case a formation closely akin to the *Lepyrodia* formation will replace the original pure *Sphagnum* formation, while in other parts perhaps there will be little change.

(b.) Boggy Ground near Lake Te Kua Taupo; vegetation burnt three years ago.—From the remains of the burnt vegetation still standing it can be seen to have originally consisted of *Olearia semidentata* 1·8 m. tall, and *Dracophyllum paludosum* perhaps hardly so tall, and probably with the undergrowth common to such a combination. The reproduced

plants on the wettest portion of the ground are *O. semidentata* 35 cm. tall, sometimes in clumps of three or more, and 1 m. or 2 m. apart. Between the *Olearias* is a carpet of *Cotula asiatica*, tussocks of *Uncinia* sp., *Epilobium novæ-zelandiæ(?)*, *Acæna novæ-zelandiæ*, *Pratia arenaria* in very large quantities, and *Marchantia* sp. Here and there *Pteris esculenta* and *Gentiana pleurogynoides* var. *umbellata* are on the driest places. On the still drier ground the vegetation originally consisted of *D. paludosum* and *O. semidentata* 1 m. or so in height, and in about equal proportions. The present vegetation is *O. semidentata*, 20 cm tall and nearly as much through, and vast numbers of *D. paludosum*, while nearly the whole ground is green with *Pteris esculenta* and *Gleichenia circinata*. Where bare patches not seized on by the above ferns occur are *Pratia arenaria*, *Gentiana umbellata*, *Isolepis* sp., and *Cotula asiatica*. In the moister hollows of the drier ground *O. semidentata* is in greater number, while the green carpet of ferns is entirely absent, and in its stead is *Carex* sp., a little *Lomaria procera*, and a smaller quantity of *Lepyrodia traversii*. On the driest part the fern is quite 23 cm. tall, and covers the *Dracophyllum* seedlings. This is a very instructive list, and shows clearly how greatly *Gleichenia*, and especially *Pteris esculenta*, increase after fire. The increase of *Pratia arenaria* is also important. Were a number of hungry cattle to wander for a time over such a burnt tract there would be little chance of the original bog vegetation ever returning, while the fern would increase in power.

(c.) Boggy Ground formerly occupied by Phormium tenax + Dracophyllum paludosum + Lepyrodia traversii + Olearia semidentata + Lomaria procera; burnt perhaps eighteen months before.—The new vegetation consists of *O. semidentata* and *D. paludosum* seedlings in abundance, *Carex* sp., *Gleichenia circinata*, *Drosera binata*, *Utricularia monanthos*, *Lepyrodia traversii*, *Lomaria procera*. Here no more *Phormium* has appeared, and *Gleichenia* is in greater abundance than formerly.

(d.) Hollow near Lake Rangatapu formerly occupied by Olearia-Dracophyllum Formation, and burnt quite recently.—The ground is fairly firm on the surface, but it is a quagmire below, and water can be wrung out of the surface-soil. The ground is rapidly becoming covered with a green carpet of plants 3 cm. or less in height. *Gleichenia circinata* is everywhere; so are innumerable seedlings of *Dracophyllum paludosum* with ten leaves, more or less, 1 cm. to 1·5 cm. tall, and with one or two branches from the base. *Olearia semidentata* is not so abundant as the *Dracophyllum*, but 11 cm. tall. *Carex* sp. is extremely abund-

ant, and about the same height as the *Olearia*. *Lepyrodia traversii* is reappearing, but to much less extent than in the original formation. *Gentiana umbellata* is more plentiful than before. Finally, there is a certain amount of *Drosera binata*, *Utricularia*, *Pratia arenaria*, and *Isolepis* sp.

(e) Dry Ridge near Lake Rangatapu; burning quite recent.—Original vegetation, *Phormium tenax*, *Dracophyllum arboreum* and *D. paludosum*, *Cyathodes robusta*; undergrowth of *Lomaria procera*, *Luzula* sp. in large quantities, *Pteris esculenta*, *Gnaphalium filicaule*. The reproduced vegetation consists of *Pteris esculenta*, *Hydrocotyle moschata*, *Gentiana umbellata*, *Erechtites* sp., *Gnaphalium luteoalbum*, *Lomaria procera*, *Acæna novæ-zelandiæ*, *Epilobium novæ-zelandiæ*.

(f.) Burnt Forest.—It is almost unknown for forest to be burnt in Chatham Island, but this was an isolated patch round which the bog fire must have raged furiously Where the forest stood is now one dense mass of tree ferns coming into leaf.

(g.) Burnt Vegetation of Tableland Dry Ridges.—On the very driest ground, where formerly *Cyathodes robusta* was the leading plant, the vegetation of which has probably been burned several times, *Pteris esculenta* is very abundant. Also in fair numbers are *Dracophyllum paludosum* seedlings, *Lomaria procera*, *Epilobium pedunculare*, *Acæna novæ-zelandiæ*, *Luzula* sp.

(h.) Piece of Vegetation near Lake Te Kua Taupo; probably burnt only once, and that many years ago.—*Dracophyllum paludosum*, 38 cm. tall, forms to the eye the almost entire vegetation, except for here and there a few plants of *Olearia semidentata* of nearly the same height. All the plants of *D. paludosum* grow very closely together, but here and there are small patches where *Dracophyllum* is absent. In such places *Gleichenia circinata* 21 cm. tall, mixed with a small quantity of *Pteris esculenta*, is present. Where the *Gleichenia* is lower and without any dead fronds at its base the bare black soil becomes exposed, and in it are growing *Caladenia bifolia* and *Gentiana umbellata*. On one patch 59 cm. by 29 cm. are fifteen plants of the orchid and four of the gentian. Often through the tall *Gleichenia* a few plants of *Dracophyllum* emerge for a distance of 12 cm. The ground in which the *Dracophyllum* is growing is covered for a depth of perhaps 2 cm. with shed leaves, growing amongst which is *Pratia arenaria*. In places a little *Gnaphalium filicaule* is present, and in some of the open patches *Pteris esculenta* is more abundant than *Gleichenia circinata*. In the largest open patches *Uncinia* sp. and *Acæna novæ-zelandiæ* are present; also *Gentiana umbel-*

lata, Pratia arenaria, and *Lomaria procera.* Such an open place of 1·25 square metres has *Gleichenia* scattered through it, a few plants of *Dracophyllum paludosum,* one plant of *Uncinia* sp., abundance of *Lomaria procera* 2 cm. or 3 cm. tall, seven plants of *Gentiana umbellata,* some *Acæna* and *Pratia,* a few plants of *Caladenia, Epilobium novæ-zelandiæ(?),* two plants of *Luzula* sp. Wherever the ground is more boggy *Olearia semidentata* becomes more abundant and *Lepyrodia* appears. Here also *Carex* sp. puts in an appearance.

(i.) Example of Reproduction after burning twice.—Where the recent formation described under the heading (*h*) has been burnt we have an example of reproduction of bog vegetation after two burnings. The ground is not so boggy as in the original bog, although it sinks slightly when trodden upon. Here the principal vegetation is a carpet of *Gleichenia circinata* mixed with *Pteris esculenta* 75 cm. tall. There is more of the *Gleichenia* than of the *Pteris.* All over the ground are the burnt dead stems of *D. paludosum.* Here and there the fire has missed a few patches of secondary *Lepyrodia-Dracophyllum* formation. Through the *Gleichenia* projects *Poa chathamica, Lomaria procera,* and *Gentiana umbellata.* On the barer spots, where the fern is absent, occur numerous seedlings of *Dracophyllum paludosum* about 6 cm. tall. In other places, on bare spots, are *Cotula asiatica, Caladenia bifolia, Drosera binata, Utricularia monanthos, Epilobium novæ-zelandiæ(?),* and *Pratia arenaria.* In some places seedlings of *D. paludosum* are very numerous—*e.g.,* on a piece of ground 32 cm. by 25 cm. are sixty plants of various sizes.

(k.) Plants occurring immediately after burning Pteris esculenta on the Ridge between the River Makara and the River Awainga; the bracken here must have been burnt many times.—The fern had been burnt very recently, and new growth of other plants was just commencing. The chief plants appearing were *Gnaphalium filicaule,* the first plant of all to appear; *Luzula; Acæna novæ-zelandiæ; Hydrocotyle asiatica; Ranunculus plebeius; Microtis porrifolia; Pratia arenaria.*

(l.) Where two or three burnings have taken place on a boggy flat piece of ground a mile or so to the south of Lake Rangatapu *Poa chathamica* was growing in tufts 15 cm. or less apart, the whole ground looking not unlike a field of oats. The culms were 58 cm. tall, and in each tuft were twelve to twenty leaves each 20 cm. in length. Mr. Cox, who was with me at the time, had never seen this grass growing in such profusion before, and was much struck with its evident capability of being used as a fodder plant on very boggy country.

Speaking generally, the following seem some of the most

important effects of fire upon the vegetation of Chatham Island :—

(1.) Small plants which in the original formation are prevented from spreading get a foothold, and at first, at any rate, form a much larger proportion of the vegetation than formerly.

(2.) The ground, being exposed to wind and sun, gets drier on the surface, and so becomes occupied by plants which could not thrive so well on the wetter ground, consequently the plants of the wetter ground become fewer in number. Thus repeated burnings substitute *Dracophyllum paludosum* for *Olearia semidentata*, while at the same time *Gleichenia circinata* and *Pteris esculenta* increase in quantity.

(3.) The ground being cleared of vegetation allows the inroad of grazing animals, which consolidate the ground and feed upon certain plants, which consequently decrease, while others untouched will increase. This leads finally to the destruction of certain plants altogether, such as *Phormium tenax*, as before mentioned. On the other hand, the *Uncinia* is not touched at all by stock, and it increases very considerably, especially on the outskirts of forests; but *Pteris esculenta* increases most of all.

(4.) One or two burnings may make very little change indeed in the vegetation of a bog, so that after a lapse of many years it is quite impossible to tell whether such a formation has been burnt at all; and it is, moreover, very likely that the early changes after a first or even a second fire may not be permanent, and that the original formation may be to all intents and purposes reproduced. But this, I fancy, will depend a good deal upon the number of grazing animals in the neighbourhood, while their influence is regulated by the nature of the soil. Thus some pure *Sphagnum* formations are too boggy for sheep, which, however, can walk with safety on the soil of any of the other formations Many places are quite inaccessible to cattle, and still more so to horses.

Before concluding this section I must again emphasize the fact that, in considering the changes which have taken place in the vegetation of any region since the advent of man, it is conjointly and not separately that the influence of exotic plants, introduced animals, and fire must be considered.

HISTORY OF THE VEGETATION OF THE CHATHAM ISLANDS.

I do not intend to discuss at any length the history of the vegetation of the Chatham Islands, and the affinities between its species and those of other parts of the New Zealand area. A comparison of the species common to New Zealand and the Chatham Islands, detailing exactly any differences, however

slight, which distinguish the forms of the Chathams from those of New Zealand, would be a matter of high biological interest, but one which is hardly possible in the present state of knowledge regarding the plants. Judging by previous experience, species of the Chathams supposed to be endemic may be eventually shown to exist in other parts of the New Zealand biological area* when its botany is more fully investigated; while unrecorded species of local distribution may very possibly be discovered in the Chatham group. So far as genera are concerned, the Chatham Islands possess only one endemic genus, *Myosotidium*. Taking next the species of Buchanan's list (3), omitting a few the occurrence of which appears doubtful and adding others recorded here and elsewhere (37, 39, 40, 41) since its publication, there are about 166 species and distinct varieties of flowering-plants and fifty-one of vascular cryptogams in the Chatham Islands, giving a total of 217,† of which about thirty-one—*i.e.*, 14 per cent.—are considered by me to be endemic, while one, *Leucopogon (Styphylea) richei*, is, according to Baron Von Mueller, identical with an Australian species. All the remainder occur in some part or other of the New Zealand region; indeed, with the exception of *Rhopalostylis baueri(?)*, *Myrsine chathamica*, and *Pratia arenaria*, they are all to be met with in New Zealand proper. But many of the endemic species are so very closely related to New Zealand forms that it will always be a matter of opinion whether such are at best varieties, and not species at all.

From the above it may be seen clearly that there is little difference so far as species are concerned between the Chatham Islands and New Zealand, and, if the differences between related plants be taken as a measure of the length of time since they deviated from a parent stock, it seems right to consider the flora of the Chathams as a recent offset from that of New Zealand.

As to how the New Zealand plants made their way to the Chathams in the first instance geology teaches us that New Zealand at one time extended very much further to the east than at present, and that it is not unlikely that there was actual land-connection between the two groups of islands (33, p. 177), or if not land, then merely a narrow piece of sea across which the plants could easily migrate by means of birds, wind, and the other agencies discussed by Hemsley (28). Even if the ocean barrier had always been as wide as at present it seems quite possible that plants could find their

* *Lepyrodia traversii*, *Hymenanthera chathamica*, and *Myrsine chathamica* were formerly considered endemic. The latter was collected by Mr. G. M. Thomson at the head of Wilson Bay, Stewart Island (50A).

† Drude gives only sixty-two indigenous phanerogams (17).

way from New Zealand to the Chathams without much difficulty. The sparrow and the blackbird, both now a nuisance on Chatham Island, reached that land, as pointed out before, unaided by man; the smoke of bush-fires from the North Island of New Zealand at times fills the air of Chatham Island when the wind blows from the north-east; finally, logs have again and again been cast up on all the sea-beaches. Old logs of *Podocarpus totara* are to be found in considerable numbers in the vicinity of the north coast buried under sand and in the beds of creeks, while in some places they occur at some distance inland, although there is no reason to think that such trees grew on the island.

But I do not think we need postulate any carriage over a broad tract of ocean for the Chatham Island plants; on the contrary, the geological evidence in favour of a wide extension of New Zealand eastwards is very strong, while zoological* and botanical support is not wanting. With regard to this latter, I am not in a position to make any further additions, either confirmatory or the contrary, to my recently published statements (10) regarding the difference in the life-history of certain so-called species according as they are indigenous to New Zealand or the Chatham Islands, so I reserve dealing with this part of my subject until such time as a number of seedling plants now under control are sufficiently developed for me to speak in a definite and exact manner as to their behaviour. All that can be said now on this head is that an examination of the conditions of life on Chatham Island has convinced me that local edaphic influences have played a greater part in modifying the vegetation than I had supposed, and that in consequence, although some of the plants of the Chatham Islands may much resemble certain Pliocene plants of New Zealand, the flora as a whole is not identically what it was in the Pliocene period, for some species must have deviated very considerably from the original type.

One of the difficulties that suggests itself in the way of accepting actual land-connection between New Zealand and the Chathams, and which supports the view that the breadth of ocean between the two lands must always have been wide, is the absence in the Chatham Islands of so many characteristic New Zealand genera; for it seems inconceivable, for example, that so common a New Zealand plant as *Cordyline australis*, or that so few of the other New Zealand species having fruits readily carried by birds, should not have reached the Chathams, even if there had

* One of the strongest zoological proofs is the migration from Chatham Island of the New Zealand shining cuckoo, a New Zealand migratory bird. As to the significance of this, see Captain Hutton's paper, "Our Migratory Birds" (33[3])

been a narrow piece of water to cross. If, however, a large area containing an abundant plant population becomes by degrees much restricted the struggle for existence must become much keener, and only those plants can survive, as certain stations become of very limited area, which can drive their competitors out of such stations; or, if themselves forced to move elsewhere, possess powers of rapid adaptation to the new conditions; or, what is often more important, some structure designed primarily for another purpose may, being put to a secondary use, enable them to hold their own in another station. Under the above circumstances many plants must be eradicated altogether, and others must take refuge in the most inhospitable places, while others, again, may easily occupy a quite different station from that to which they are accustomed. According to this view, the species of plants in the Chatham Islands must have decreased enormously in numbers since the time when the Chathams formed part of Greater New Zealand.*

How a very slight change in edaphic and climatic conditions can affect the vegetation of Chatham Island is exhibited by the two distinct regions of vegetation, the tableland and the lowland, each of which contains plants unknown or very scarce in the other. With quite a small modification of the above conditions numbers of plants would perish.

Several plants are extremely local; for instance, *Gunnera monoica* has been found in only one place in Chatham Island (11), although the ground in many places would seem to be an ideal station for it. There seems no reason why there should be only a very few trees of *Coprosma robusta* on the island when *C. chathamica* is one of the commonest trees. *Discaria toumatou*, found now in one or two places, should surely have become established on the fixed sand-dunes; but these, being suitable for forest growth, would not allow it to occupy what is a characteristic habitat in New Zealand. Other trees or shrubs of very limited distribution are *Dodonæa viscosa*, *Myoporum lætum*, *Leptospermum scoparium*, and *Plagianthus divaricatus*. Make the tableland a little wetter and *Olearia chathamica* would become simply a rock plant, and with the weathering of the rock on which it grew might be eradicated. Reduce the level of the island a few metres and *Sophora* would exist no longer. Bearing facts such as the above in

* For a different view of the case, see Mr. Cheeseman's paper on the "Flora of the Kermadec Islands" (6). The occurrence on Chatham Island of *Coprosma chathamica*, so closely related to *C. petiolata* of the Kermadecs, and of *Rhopalostylis baueri* in both regions, if the identification of the latter be correct, suggests that they travelled along the coast, which would, in the event of an east and north-east extension of New Zealand, join the Kermadecs and the Chathams.

mind, it is not unreasonable to suppose that Chatham Island contained at one time many more species than is now the case, and that even such a ubiquitous tree as *Cordyline australis* may have been there and been destroyed in the struggle for existence caused by the shrinking of the land.

NEW SPECIES OR VARIETIES MENTIONED IN THIS PAPER, WITH NOTES OR DESCRIPTIONS.

The material at my disposal is in nearly every case quite insufficient to enable me to draw up satisfactory diagnoses, so for the present it must suffice to point out what seem to be differences between the species considered to be new and those to which they are most closely allied. In some cases differences in the seedling form are used as a specific character, and such seem, indeed, to me to be among the very best characters that can be presented, showing a distinction between species which is constant, and not one which depends so much on environment as the leaf-form of the adult, or at times even the flower.

1. *Coprosma chathamica*, sp. nov.

A low tree attaining a maximum height of 15 m., never a trailing shrub. Extremities of ultimate branchlets pubescent with short greyish-white hairs; bark brown, wrinkled and glabrous below.

Leaves oblong, obovate, obovate-oblong, or sometimes lanceolate, tapering gradually into the short petiole, often about 4·9 cm. long by 2·3 cm. broad; glabrous except for pubescence on short petiole, and a few scattered hairs on midrib and margins; upper surface dark-green and shining; undersurface very pale, strongly marked by reticulations of veins.

Female flowers: Calyx-limb truncate; corolla deeply divided into four lobes; lobes 3·5 mm. to 4 mm. long; drupe large, ovoid, 1·2 cm. long by 9 mm. through its thickest portion.

Seedling: Cotyledons large, 3 cm. by 1·8 cm., or larger or smaller, obovate, obtuse, glabrous except on short petiole; early seedling leaves larger than the cotyledons, oblong, acute, thin, densely ciliated and hairy on petioles and midrib, with hairs scattered also over surface of lamina; lamina 3·4 cm. by 1·9 cm. to 2·25 cm. by 1·2 cm., or larger or smaller. Stem and upper part of hypocotyl pilose, with hairs similar to those of leaf; hairs white, but sometimes red.

This species is *C. baueriana* of Buchanan's list. It is referred to *C. petiolata*, Hook. f., by Mr. T. Kirk (37, p. 232). Mr. T. F. Cheeseman has kindly sent me specimens of the latter species, collected by himself in the Kermadec Islands, for comparison. These have shorter pubescence than *C.*

chathamica, giving a grey colour to the twigs; the corolla lobes are very short, and the stigmatic hairs are much shorter than in *C. chathamica*. *C. chathamica* is also always a tree, and never a shrub, as is the case with *C. petiolata*. Seedlings of *Coprosma petiolata* are much wanted.

2. *Dracophyllum arboreum*, sp. nov.

Always a low tree, never a shrub Passes in course of development through a broad-leaved juvenile form, which persists until plant is 3·5 m. tall, when the adult shorter needle-shaped leaves make their appearance. Adult trees usually have some shoots bearing only juvenile leaves. Juvenile leaves 20 cm. long by 1·5 cm. broad, gradually tapering from base to a fine point. Adult leaves needle-shaped, 7·5 cm. long by 2 mm. broad. Both forms of leaves tomentose on margin. Flowers very similar to those of *D. scoparium*. See coloured plate in "Flora Antarctica" (30).

If *Dracophyllum scoparium*, to which this plant was referred by both Hooker and Buchanan, does not go through the same remarkable changes, I cannot see that they can possibly be the same species, notwithstanding similarity of flowers.

3. *Dracophyllum paludosum*, sp. nov.

After a good deal of hesitation I decided to give a name to this species, for it was necessary to have some name to distinguish this plant from *D. arboreum*. From the latter species it differs in its shrubby habit, and especially in its never passing through an extended juvenile stage with broad leaves. Its racemes are rather shorter than those of *D. arboreum*, and its flowers rather smaller. Perhaps this plant may prove identical with *D. scoparium* or with some of the forms of *D. urvilleanum*.

4. *Myrsine coxii*, sp. nov.

A shrub with ultimate branchlets pubescent and leaves forming rather a dense mass, reaching a maximum height of about 4 m., but often very much lower.

Leaves narrow-obovate, tapering gradually at base into a short petiole, averaging about 2·4 cm. by 9 mm.

Flowers in fascicles of three or more, rarely in pairs, crowded together on the naked portions of the ultimate branches, occasionally 1-flowered in the axils of the upper leaves; almost sessile, but pedicels lengthening a little in fruit.

Calyx 4-fid to slightly below middle; segments ovate, with broad base, pale-green, ciliated, marked with a few red glandular dots, acute.

Petals 4, narrow obovate-oblong, 3·25 mm. by 2 mm., pale yellowish-green with margin stained pale-purple, much more purple in bud, ciliated, marked towards apex with several glandular red dots, obtuse.

Fruit globose, bright mauve-coloured, 5 mm. long, by 6 mm. broad.

This plant is probably the *Myrsine nummularia* of Buchanan's list, to which it bears no resemblance whatsoever. It differs from *M. chathamica* in several points, the latter plant being a small tree with a thick trunk, with leaves larger and proportionately broader than *M. coxii*, and having flowers in fascicles of more than three, with distinct pedicels. It also comes into bloom a month later than *M. coxii*. It gives me great pleasure to call this species after my friend Mr. F. A. D. Cox.

5. *Veronica gigantea*, sp. nov.

This is *V. salicifolia* of Buchanan's list. It differs from *V. salicifolia* in being always a low tree with a distinct trunk. Its seedling form also is quite distinct from that of any form of *V. salicifolia* examined by me. The early leaves are very coarsely and deeply toothed, and their margins are evenly and closely ciliated with hooked white hairs. The stem is extremely pubescent, and even the hypocotyl is quite downy. Later juvenile leaves are larger than the adult leaves, lanceolate, sessile, entire, acute, ciliated, and with still longer hairs on the prominent midrib, and such are found on a plant 32 cm. tall or even much taller. The stem is usually purple, rather soft, and covered with many long soft hairs pressed to its surface. My notes say, "The intense hairiness of this plant even at this stage is very remarkable." The juvenile plant much resembles *V. pubescens* of New Zealand, for a specimen of which rare plant I am indebted to Mr. Cheeseman, but the inflorescence brings it closer to *V. salicifolia*. The adult leaves are narrow-lanceolate, quite sessile, 8·3 cm. long by 1·8 cm. broad, minutely ciliated, and with the midrib not nearly so much keeled as in *V. salicifolia*.

6. *Plagianthus chathamicus*, sp. nov.

I have separated this plant from *P. betulinus* because they differ in the seedling state, and *P. chathamicus* is also never furnished with reversion shoots. I have gone at some length into this matter elsewhere, and have, as before stated, nothing further to add at present (10).

7. *Sophora chathamica*, sp. nov.

Exactly the same remarks apply to this species as those made above with regard to *Plagianthus chathamicus*. I have

already published a note as to its seedling form (9, p. 373), and shown it to be probably distinct from that of any other hitherto described New Zealand species of *Sophora*.

8. *Geranium traversii*, Hook. f., var. *elegans*, var. nov.

Petals pink, veined on upper surface with fine lines of darker pink. The typical *G. traversii* has white flowers.

9. *Linum monogynum*, Forst., var. *chathamicum*, var. nov.

Petals broadly striped or flaked with pale blue. The type has white flowers.

10. *Olearia chathamica* var. *dendyi*, var. nov.

Tomentum (when dry) yellower and denser than that of the type. Florets purple. The type has white florets, which, when fading, are of a purplish colour.

Hab. Pitt Island. Collected by Professor A. Dendy, after whom I have much pleasure in naming this variety.

11. *Agropyrum coxii*, Petrie, sp. nov.

A description of this very distinct grass by Mr Petrie is, I understand, to appear in the same volume of the Transactions as this paper.

12. *Poa chathamica*, Petrie, sp. nov.

Mr. Petrie considers this grass closely related to *P. anceps*. A description is included in the same paper as that containing *Agropyrum coxii*.

PLANTS COLLECTED DURING THE AUTHOR'S VISIT WHICH HAD NOT BEEN PREVIOUSLY RECORDED FOR THE CHATHAMS.

Acæna novæ-zelandiæ, T. Kirk.
Cladium gunnii, Hook. f.
Epilobium cæspitosum, Hausskn.
" *pedunculare*, A. Cunn.
" *insulare*, A. Cunn.
" *chionanthum*, Hausskn., var., perhaps var. nov.
" *novæ-zelandiæ*, Hausskn(?).
Galium tenuicaule, A. Cunn.
Gunnera monoica, Raoul.
Hydrocotyle robusta, T. Kirk. This may be a new species, and not *H. robusta*.
Limosella aquatica, L., var *tenuifolia*.
Myosotis spathulata, Forst. So named in Kirk's handwriting in the herbarium of Christchurch Museum.

There are probably also one or two undescribed species of *Veronicas* amongst my collection.

SPECIES RECORDED IN BUCHANAN'S LIST THE OCCURRENCE OF WHICH SEEMS VERY DOUBTFUL.

Epilobium confertifolium, Hook. f., var. α.

Aciphylla lyallii, Hook. f., and *Aciphylla monroi*, Hook. f. These two are most likely forms of *A. traversii*.

Coprosma baueriana, Endl. = *Coprosma chathamica*, sp. nov.

Brachycome sinclairii, Hook. f. = perhaps *Lagenophora forsteri*.

Pratia macrodon, Hook. f. = *Pratia arenaria*, Hook. f.

Dracophyllum rosmarinifolium, Hook. f. = depauperated forms of *D. paludosum*, sp. nov.

Gentiana pleurogynoides, Griesb. = G. *pleurogynoides* var. *umbellata*, Kirk, which is probably a distinct species, as suggested to me as possible by both Mr. Petrie and Mr. Cheeseman.

Veronica salicifolia, Forst. = *V. gigantea*, sp. nov.

Myrsine nummularia, Hook. f. = *M. coxii*, sp. nov.

Areca sapida, Sol. = *Rhopalostylis baueri*, Wendl. and Drude(?). Whatever species the Chatham Island palm may be, it is not *R. sapida*, for it differs altogether from that species in the seedling form.

Astelia cunninghamii, Hook. f.

Poa foliosa, Hook. f., var. α.

Trisetum subspicatum, Beauv.

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EXPLANATION OF PLATES XVI.–XIX.*

PLATE XVI.

Cotula featherstonii growing under cliffs at Matarakau. In foreground is *Mesembryanthemum australe.*

* Reproduced from original photographs by the author.

PLATE XVII.

Myosotidium nobile, growing in same locality as *Cotula*, in Plate XVI.

PLATE XVIII.

Isolated plant of *Olearia semidentata*, with formation of *Dracophyllum paludosum* in background. Tableland south of Chatham Island.

PLATE XIX.

Portion of formation shown in Plate XVIII., with juvenile plant of *Dracophyllum arboreum* in foreground still in the broad-leaved stage. In background is *Dracophyllum paludosum*.

ART. XXIX.—*On a New Zealand* Isotachis *new to Science.*

By ERNEST S. SALMON.

Communicated by Robert Brown.

[*Read before the Philosophical Institute of Canterbury, 6th November, 1901.*]

Plate XX.

THE following description of a New Zealand *Isotachis* by Mr. E. S. Salmon, of Charlton House, Kew, was taken from specimens which I sent to him for determination. His description (which I am able to confirm) was published in the *Revue Bryologique* for June, 1901, at page 75. He has sent me copies of his paper, with drawings, one of which, with specimens of the plant, has been placed in the Museum at Christchurch.

Isotachis stephanii, sp. nov.

Robusta, dense cæspitosa, flaccida, sordide badia; caule usque ad 8 cent. longo flexuoso supra in ramulos subjulaceos partito interdum simplici inferne sordide badio apice læte badio, foliis distichis dense imbricatis flaccidis tenuibus erectis vel erecto-patentibus amplexicaulibus subcomplicatis late oblongis 3–3·5 mm. longis 2·5–3 mm. latis basi ventricosis margine integro vel obtuse dentato ad 1/7 bifidis sinu infra plus minus angustato segmentis late triangularibus plerumque minute apiculatis cellulis superioribus firmis quadratis et breviter rectangulis 30–50 μ longis 12–20 μ latis parietibus plus minus incrassatis trigonis nullis, cellulis inferioribus elongato-rectangulis, amphigastriis foliis paulo minoribus 2·5–3 mm. longis 2 mm. latis parum concavis cæteris conformibus.

Reliqua ignota.