Poa trivialis, *L.*, Britain.
Glyceria aquatica, *Sm.*, Britain.
" fluitans, *R. Br.*, Britain.
" maritima, *Sm.*, Britain.

Since the foregoing was written I have collected the undernoted species, some of which have been identified by Professor Cheeseman, F.L.S., and Mr. G. M. Thomson, F.L.S. *Pyrus aucuparia* was inadvertently omitted from the above list.

Salsola kali.
Silene armeria.
Dipsacus sylvestris.
Lepidium draba.
Cynara cardunculus.
Hieracium subaudum.
Crepis taraxifolia.

ART. XXVI. — *A Botanical Excursion during Midwinter to the Southern Islands of New Zealand.*

By L. COCKAYNE, Ph.D.

[*Read before the Philosophical Institute of Canterbury, 4th November, 1903.*]

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Introduction.

The Southern Islands of New Zealand consist of several groups of small islands — namely, the Snares, Auckland Islands, Campbell Island, Macquarie Island, Antipodes Islands, and Bounty Islands—lying in the South Pacific Ocean between the parallels of 54° 44′ and 47° 43′ south latitude and 159° 49′ and 179° east longitude. The distance and direction of each of these groups from the South Cape of Stewart Island is respectively: The Snares, 60 miles S.W.; the Auckland Group, 190 miles S. by W.; Campbell Island, 330 miles S. by E.; Macquarie Island, 570 miles S.W. by S.; the Antipodes Islands, 490 miles E.S.E.; the Bounty Islands, 490 miles E.

As is well known, these Southern Islands of New Zealand form a part of that ring of small islands which stretch right round the globe between the parallels of 45° and 65° south latitude, frequently at very great distances from one another, but which nevertheless have certain Fuegian* species of plants in common. Of these latter, the Southern Islands of New Zealand possess by far the smallest share, their flora as a whole being very closely allied to that of New Zealand. This latter extremely important fact was discovered by Sir Joseph Hooker, who on that account separated the islands lying to the south of New Zealand from the other so-called "Antarctic islands," and devoted the first volume of his magnificent "Flora Antarctica" (46) to their botany. This work, published in 1847, was the outcome of collections and observations made by the distinguished author himself, assisted by Mr. Lyall, during the stay of about one month in Auckland and Campbell Islands (19th November to 17th December, 1840) of the Antarctic expedition commanded by Sir James Ross (91). Prior to this—in the previous year, indeed—the Auckland Islands had been visited by two other scientific expeditions—the French Antarctic expedition under Admiral D'Urville and the American Wilkes expedition. Of these two, the French was by far the most important from the botanical point of view: the collections were large, although not nearly equal in extent to those of Hooker; while, on the other hand, the American expedition did little botanically. Had this latter, as originally intended, been accompanied by Asa Gray the botanical results would doubtless have been very different, but owing to the many delays hindering the expedition setting forth the great American botanist finally declined to accompany it (25).

The botanical collections of the French expedition were made in part by MM. Hombron and Jacquinot and in part by the

* For explanation of the term "Fuegian," see "History of the Flora," further on.

admiral himself. In all 269 species were collected, of which twenty-one were spermaphytes or pteridophytes. These were published in 1852 as a part of the great work "Voyage au Pole Sud," a splendid folio volume (44), containing figures of the different species and names given by Hombron and Jacquinot, but without descriptions. The text was published separately, Tom. I., in 1845, containing descriptions of the *Muscineæ* and *Thallophyta* by M. C. Montagne (78), and Tom. II., in 1852, containing descriptions of the vascular plants by M. J. Decaisne (26). This latter author changed some of Hombron and Jacquinot's names, as they were not in accordance with the rules for botanical nomenclature. Between the publication of the "Flora Antarctica" and the "Handbook of the New Zealand Flora" a few additions to the flora of the Auckland Group were made by General Bolton, and such appear in the Handbook.

In November, 1880, Dr. J. H. Scott paid a visit to Macquarie Island, the flora of which was known only from a small collection of plants, seven in number, sent many years previously to Sir W. Hooker by Mr. Fraser, of Sydney. Scott published his results in a very valuable paper (93) which appeared in the "Transactions of the New Zealand Institute" for 1883, from which a good idea of the physiognomy of the vegetation may be obtained. His collection numbered 16 spermaphytes, 3 pteridophytes, 8 musci, 7 lichens, and 6 fungi—40 species in all. "I was there in November," he writes (93, p. 487), "and in these latitudes spring is but little advanced in that month. I therefore found comparatively few plants in flower. This, of course, has added much to the difficulty of identifying my specimens, and, combined with the thick weather, has helped to make my collection smaller than it might have been under more favourable circumstances."

In December, 1883, Mr. J. Buchanan visited Campbell Island in order to procure a collection of living plants for the various botanical gardens of New Zealand and an herbarium collection for the Colonial Museum, Wellington. He published his results in a short paper, two pages only, in the "Transactions of the New Zealand Institute," 1884 (9), publishing a new species of *Pleurophyllum (P. hookeri)* in the same volume (10). The former of these papers also contains some interesting drawings of the coast of Campbell Island.

In the summer of 1890 Mr. T. Kirk visited the whole of the Southern Islands, excepting Macquarie Island, and was in consequence able to publish an account of the botany of the Snares and Antipodes Islands for the first time—a much-needed and most valuable work. He also dealt with the botany of the Auckland Group and Campbell Island, and summed up what was known regarding the flora of Macquarie Island.

His papers on the different islands appeared in various publications mentioned in the bibliography; but they are all virtually the same, and appear all together in the Report of the Australasian Association for the Advancement of Science for 1891 (56). Mr. F. R. Chapman, now Mr. Justice Chapman, visited the islands at the same time as Kirk, and his paper entitled "The Outlying Islands south of New Zealand," though published amongst the miscellaneous papers in the "Transactions of the New Zealand Institute," 1891, is a very valuable contribution to botany (16).

Mr. H. J. Matthews, now Chief Government Forester, in 1895 made a very extensive collection of living plants from the various islands, and, I understand, succeeded in sending a large number to the Royal Botanic Gardens, Kew, in excellent condition. Moreover, he has cultivated for many years a large percentage of the Southern Islands' plants with success, a matter by no means easy.

Macquarie Island was examined botanically a second time by Mr. A. Hamilton in the summer of 1894. He added fourteen species to the list of Macquarie Island plants, bringing up the number of spermaphytes and pteridophytes to thirty species, if those which are doubtful in Scott's list be eliminated. According to Hamilton (39) the island is entirely without trees: "there is not a shrub or plant large enough to make a penholder." "The large *Poa* tussocks are the great feature of the low levels, and on the hill-tops the special feature is the *Azorella*, forming bright-green closely growing convex masses of stems and leaves." *Coprosma repens* and *Polypodium australe pumila* grow on the *Azorella* cushions. Between the tussock-belt and the *Azorella* is a zone of *Stilbocarpa polaris* and *Pleurophyllum hookeri*.

What is known about the geology of the islands is the outcome of collections made by Mr. H. Armstrong in 1868 and Mr. J. H. Baker in 1865, of a lengthy stay on Campbell Island by the French Transit of Venus Expedition in 1874, and of a visit paid to the various islands by Sir James Hector during a trip of the "Hinemoa" in 1895.

Besides scientific expeditions, even from the time of their discovery, the various islands have been visited by whaling-ships, by sealing expeditions, and by vessels sent for the purpose of looking for castaways. This latter has arisen from the number of disastrous wrecks which have taken place in the Southern Islands, especially in the Auckland Group. Of these, one especially concerns us here, that of the "Grafton," details of which are given below when treating of Auckland Island. This wreck led to the brig "Amherst" being sent to examine all the islands for castaways in 1868, and in his report (2) Mr. H. Armstrong published for the first time some informa-

tion regarding the plants of the Snares and Antipodes Islands, using certain Maori or colonial names for the plants. Amongst others, he stated that there was abundance of the "McQuarrie cabbage"—"of fine growth, the leaves measuring two feet in diameter." Now, the above name is also given to *Myosotidium nobile*, of Chatham Island, and this has led to a curious mistake, for it was concluded that this latter plant was the one in question. Hence arose the statement that *Myosotidium* occurred both on the Snares and Chatham Island, a somewhat remarkable distribution had it been so. Kirk,* *e.g.*, described *Myosotidium* as abundant on the Snares, and this most pardonable error has been copied into all works on general plant-geography. In 1865 the Victorian Government s.s. "Victoria," commanded by Captain Norman, visited the Auckland, Campbell, and Antipodes Islands, landing various domestic animals and planting certain trees, details regarding which are given further on. Finally, provision-depots and boat-sheds were erected for the use of castaways by the New Zealand Government. In connection with these depots the "Hinemoa" or some other boat visits all the islands, excepting Macquarie, twice a year, this latter, although biologically, yet not politically belonging to New Zealand. The depots were built at different times. Captain Bollons writes to me, "Provisions were left in various places in cases as early as 1865, but the present boat-sheds and depots date from 1887." In connection with these depots cattle, sheep, and goats have been landed from time to time, and seeds of exotic plants sown, both most important matters for the indigenous vegetation. More important still was the Enderby Settlement in the year 1850, which lasted for three years, during which time three hundred people resided in the north of Auckland Island and on Enderby Island. Then many domestic animals were introduced, portions of the forest were cleared, grasses were sown, and gardens made. But by far the most important event, so far as the plant-life is concerned, has been the establishing a sheep-run on Campbell Island in 1896, the effect of which upon the vegetation is described at some length further on.

Up to the time of my visit all the botanical observations in the Southern Islands had been made in spring or summer. It was therefore with very great pleasure that I joined the "Hinemoa" at Lyttelton in the middle of June, 1903, for the purpose of making a winter botanical excursion to the islands, the winter aspect of the vegetation as a whole being undescribed and, so far as the endemic plants were concerned, unknown.

* Trans. N.Z. Inst., vol. x., p. 410. 1878.

Unfortunately, although we waited some days at Port Pegasus, in Stewart Island, for favourable weather, the sea at the Snares was altogether too rough to allow a landing to be attempted; but, with the exception of Macquarie Island, I visited portions of all the other islands. Interesting as a visit in midwinter is, the days are so short, the number of places to be visited by the steamer so many, and the time which can be spared for the excursion as a whole so limited, that in nearly every instance only a quite cursory examination of the plant-formations and of their members was possible. All the work, moreover, under such circumstances had to be done in feverish haste, for in a given number of all-too-short hours, or even minutes in some instances, notes had to be written, perhaps with numbed fingers or in a driving mist, photographs hastily taken, plants both for drying and cultivation collected, while in many places the country to be traversed was of extreme difficulty. If under such circumstances errors creep into one's work, or if many important observations are neglected, it is perhaps not to be wondered at. In some instances, chiefly with regard to grasses, it has been impossible to identify my specimens. On Campbell Island, owing to the density of the scrub, I found it quite impossible to make any headway burdened with a heavy bag of plants. Night was coming on, and to my intense regret I had to throw away nearly the whole of the plants collected on Lyall's Pyramid. Much of the work in this paper is preliminary and provisional, but it may perhaps lead to a more thorough treatment before long of the vegetation of this, the most interesting region in the New Zealand biological area. The plant-formations are the edaphic formations of Schimper, but their limits as defined by me are far from satisfactory In some few instances I have distinguished the smaller groups in a formation under the term "plant-association," meaning by this a small collection of two or more plants which usually occur associated together, and which I agree with Kearney* and Ganong† in considering a distinct ecological conception.

In what follows, the term "New Zealand biological region" includes the Kermadec Islands, the North and South Islands of New Zealand and their adjacent small islands, Stewart Island, the Chatham Islands, and the Southern Islands, while by "New Zealand" is meant the North and South Islands of New Zealand, Stewart Island, and the adjacent small islands.

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* "Report on a Botanical Survey of the Dismal Swamp Region," Contr. from the Nat. Herb., vol. v , No. 6, p. 359. Washington, 1901.

† "The Vegetation of the Bay of Fundy Salt and Diked Marshes," Bot. Gaz., vol xxxvi., p. 301. 1903.

Before concluding this introduction I must offer my most sincere thanks to the Hon. W. Hall-Jones, M.H.R., Minister of Marine, for affording me facilities to visit the Southern Islands. Also, I must express my great obligation to the following for most valuable assistance in many ways: Professor Charles Chilton, D.Sc.; Mr. George Laurenson, M.H.R.; Mr. R. Speight, M.A., B.Sc.; Mr. D. Petrie, M.A.; Mr. H. Woods; Mr. W. Joss; and Mr. J. Gordon. Finally, I am bound to express my gratitude to Captain J. Bollons, of the Government s.s. "Hinemoa," who did all in his power to assist my work, and who, in addition, has given me much valuable information regarding the Southern Islands.

I. THE AUCKLAND ISLANDS.

GENERAL REMARKS.

The Auckland Islands lie between the parallels of about 50° 30′ and 50° 55′ south latitude and the meridians of 165° 55′ and 166° 20′ east longitude (90, p. 405). They were discovered by Captain Abraham Bristow on the 18th August, 1806, during a whaling voyage in the ship "Ocean," a vessel belonging to Mr. Samuel Enderby. The group was named by its discoverer after Lord Auckland. In 1807 Captain Bristow visited the islands for a second time, and on that occasion took formal possession of the group.

Since its discovery, the Auckland Island Group has been repeatedly visited by sealers and whalers, the former having lived for months at a time on the main island, and made tracks across the mountains to the "seal-rookeries." During the years 1839–40 three scientific expeditions visited the northern part of the group, the botanical results of which have been already dealt with. In the year 1850 the Messrs. Enderby made the Auckland Islands the headquarters of the Southern Whale-fishery Company (31), the islands "having been granted by Her Majesty's Government" [so runs the prospectus of the company] "to Mr. Enderby and two of his brothers." Accordingly Mr. C. Enderby formed a settlement, consisting of three hundred Europeans and Maoris, in the neighbourhood of Port Ross; but the company was not successful, and after three years the settlement was abandoned. Shortly before the Enderby Settlement a number of Maoris from Chatham Island had taken up their abode in the north of Auckland Island, but these also did not stay long. During the Enderby Settlement a considerable piece of forest was cleared. This clearing is referred to later on.

Since the Auckland Islands lie in the direct route of sailing-vessels to Cape Horn it is not surprising that several disastrous shipwrecks have taken place. These led to the

New Zealand Government erecting depots for castaways in several parts of the group, and boat-sheds on some of the smaller islands. Thus, there are now provision-depots and boat-sheds at Port Ross, in the north of the main island; at the head of Norman Inlet; and at Camp Cove, Carnley Harbour; while on Enderby Island, Rose Island, and Ewing Island are boat-sheds, boats, and a small quantity of food. At the beginning of January, 1863, the "Grafton," a small schooner of 75 tons (83, p. 37), engaged in sealing, was wrecked, as stated in the introduction, in Carnley Harbour. The officers and crew, five in all, landed safely, and lived in the south of Auckland Island for more than a year and a half. Finally they managed to patch up the dingey, and in this frail craft Captain Musgrave, Mr. F. E. Raynal, the mate, and one of the crew reached Stewart Island. The remainder of the crew, two in number, were subsequently rescued by the "Flying Scud," the cost of the rescue expedition being met by public subscription from the people of Invercargill (83, p. 98). Both Musgrave (83) and Raynal (87) wrote an account of their sojourn on the island, and Musgrave's is of distinct scientific value, since he kept, with more or less regularity, a record of the climate. The botanical history of the Auckland Islands has been dealt with in the introduction, so no more need be said on that head.

PHYSIOGRAPHY.

The Auckland Islands consist of one large island, Auckland Island, and several smaller ones separated from the main island by more or less narrow channels. The entire group is some twenty-seven miles in length by fifteen miles in breadth. The shape and relative size of the various islands may be seen from the accompanying map (Pl. XXIII.), and an excellent idea of the coast-line is afforded by the sketches of headlands and harbours of the Auckland Islands made to accompany a map by officers of H.M.S. "Blanche" in 1870, and reproduced on a smaller scale in plates Nos. 47–49 accompanying Chapman's paper (16). Auckland Island, Adams Island, and Disappointment Island are extremely hilly; indeed, Adams Island consists entirely of a ridge 609m. in height, its southern cliffs rising abruptly out of the sea, but its northern side consisting of long spurs sloping towards Carnley Harbour. The hills of Auckland Island vary from 280m., the height of the Hooker Hills in the north, to summits reaching to 457m. or more in the south. Seen from the sea, on the north and eastern sides are long grassy slopes of no great steepness, very similar in appearance to those of Banks Peninsula, in the South Island of New Zealand. In the south the hills are rather more abrupt. The whole of the western side of the main island consists of

a precipitous wall of cliffs varying from 60m. to 243m. in height, and which can be climbed with extreme difficulty, according to Mr. W. Joss, in one or two places. The eastern coast, on the contrary, is deeply cut into by numerous inlets, resembling the west coast sounds of the South Island of New Zealand in miniature. Norman's Inlet, the most southerly of any size, and the largest, penetrates into the island for a distance of about six miles. Port Ross, in the north, and the North Arm of Carnley Harbour, in the south, also extend for about a similar distance inland. This irregularity of the eastern seaboard is of considerable phytogeographical importance, since it leads to an extensive coast-line, and to many stations differing considerably with regard to exposure to sun and wind. The numerous gullies which lie between the spurs of the hills or seam the hillside contain streams of considerable size if the small extent of land-surface of the island be considered. Enderby Island, Ewing Island, and Rose Island are flat or undulating, but they also have many coastal cliffs. Disappointment Island is high land clad with meadow and low forest or scrub. It has never been visited botanically.

GEOLOGY.

The following is extracted from a paper by Sir James Hector entitled "Note on the Geology of the Outlying Islands of New Zealand," (41) which contains the results of his observations made during the visit to the Southern Islands in 1895 mentioned in my introduction: "Auckland Island is clearly connected with the Snares by a ridge or plateau, the soundings ranging from 86 fathoms to 196 fathoms only. So far as seen Auckland Island is altogether volcanic, and closely resembles the rock-structure of Banks Peninsula." "Along the east coast there is a succession of harbours or inlets like those in Banks Peninsula, the steep shores of which are formed of successive sheets of basaltic lava often columnar and varying from 10 ft. to 80 ft. in thickness. These are separated by brightly coloured layers of volcanic tufa or ashes containing blocks of all sizes." "Disappointment Island is probably a 'neck' or 'dyke' through which some of the igneous rocks have been extruded." "The south side of Adams Island is the most exposed part of the Aucklands, and presents cliffs composed, as exposed in sections, of horizontal layers of basalt and tufa to a height of 1,900 ft., some of the cliffs being 1,400 ft. sheer down. The lava-sheets vary in thickness from 10 ft. to 80 ft., and there is evidence of not less than seventy distinct outpourings still preserved above the sea-level. Soundings three miles off shore from the South Cape gave 95 fathoms (575 ft.). The average dip of the lava-flows to the eastward is 7°. The width of the island in this

section is ten miles and the height of the western cliffs 1,000 ft.; so that by adopting the usually accepted curve for volcanic deposits we have the following result: Auckland Island is the remnant of a great volcanic cone that was 12,000 ft. in height and 50 miles in diameter in early Tertiary times, the chief centre having been about eight miles west of Disappointment Island. Four-fifths of the original mass has been removed by the denuding force of the westerly waves."

CLIMATE.

"The temperature is very equable," writes Mr. C. Enderby, "the snow never lying more than three days on the ground, except on the summit of the hills. The winds are violent and of long duration; the gales are mostly from the north-west, although I experienced two from the eastward unusually strong. They mostly commence at north with a falling barometer, veer gradually to west and west-south-west, and at times blow most violently. When the barometer begins to rise the gale ceases at south or south-south-west." Captain Benjamin Morrell, writing in 1830, states (90), "The climate is mild, temperate, and salubrious. In the month of July, the dead of winter, the weather is mild as respects cold, the thermometer never being lower than 38° Fahr. in the valleys; and the trees at the same time retain their verdure, as if it were midsummer. In December and January the thermometer was 78° Fahr." Hooker thus writes of the climate (46, p. 2), "The climate is rainy and very stormy, so that on the windward side the plants are stunted and checked, and resemble those of a higher southern latitude or of an elevation of several hundred feet above that which the same species inhabit on the sheltered parts." Some extracts from Musgrave's journal (83) give some idea of the climate in the south of Auckland Island: "Sunday, 14th February, 1864.—During the first part of the past week we had very heavy and almost constant rain; wind moderate." "This is a dreadful place for rain; but still we appear to have got to a place where it falls least." "There is one place where it scarcely ever ceases raining; this is caused by the form of the land in that particular place (which we have named Rainy Corner), which is backed by a very high mountain, which bursts the low clouds as they pass over it." "Sunday, 6th March, 1864.—The first part of the past week was very fine, but since Wednesday we have had continual drizzling rain, with light westerly winds, until midnight last night, when it came on to blow a very heavy gale, and continued ever since, with frequent showers." "Sunday, 20th March, 1864.—During the last week we have had nothing but a succession of westerly gales, which only cease for a few hours and then blow again

with great fury; and it has also rained almost constantly until yesterday at noon. Since then we have had frequent falls of hail and snow." "Sunday, 3rd July, 1864.—Blowing a strong gale at W.N.W." "It has been stormy during the whole of the past week. On Tuesday and Wednesday a considerable quantity of snow fell—all the ground was covered; but since midnight of Wednesday we have had a heavy gale from the W.N.W., with much rain, which still continues." "Sunday, 7th August, 1864.—During the whole of the last week the weather has been very bad; it has been blowing a very heavy gale from between west and north-west, with either hail, rain, or snow continually falling. From noon yesterday till 3 o'clock this morning the gale was at its height; it blew a hurricane, and was the heaviest I have ever seen while on shore. Our house is elevated about 30 ft. above the mean tide-level, and is about 50 yards from the water, and during the height of the hurricane the spray was frequently dashed against it in heavy showers. Had it not been well built, and securely, it would inevitably have been blown down." "Sunday, 21st August, 1864.—During the greater part of the past week the weather has been very fine." "Sunday, 26th March, 1865.—The sea booms and the wind howls. These are sounds which have been almost constantly ringing in my ears for the last fifteen months, for during the whole of this time I dare venture to say they have not been hushed for more than a fortnight together."

From Mr. W. Joss, who has spent at different times many months sealing on Auckland Island, I have been able to learn the following regarding the climate of spring, summer, and autumn: The rainfall is not very great, nor are the separate downpours heavy, but there are a very great number of days on which rain falls—indeed, generally speaking, it rains more or less every day. Should it rain in the morning it will most likely be fine in the afternoon, and *vice versâ*. During the summer months there is perhaps one day in each week on which no rain falls. The rain is usually accompanied by wind. There is no frost at sea-level during spring, summer, or autumn. In the sunshine it is hot, but a perfectly clear sky is a very rare event.

During my short visit to the Auckland Islands it rained slightly every day, the rain accompanied by squalls of wind. There was a slight frost at sea-level, and a small amount of snow fell. On the hills, both in the north and south of the group, were patches of snow, but Captain J. Bollons informed me that he had never seen more snow on the hills in the neighbourhood of Port Ross during any winter visit of the "Hinemoa" than was then present.

From the above details regarding the climate of the Auck-

land Islands, and from the aspect of the vegetation and the species of which it is composed, I think the following may fairly be concluded: (1.) There are a great number of rainy days. (2.) The moisture, which can easily permeate the peaty soil, will not readily evaporate owing to the almost constant cloudy skies, these also tending to keep the air full of moisture. (3.) There are very frequent winds, sometimes of great violence, accompanied by rain or sleet. (4.) The winter climate is extremely mild, much milder, indeed, than that of certain parts of the South Island of New Zealand at sea-level, as, *e.g.*, the Canterbury Plains. Of course, when in winter a south-westerly wind accompanied by sleet is blowing one feels bitterly cold, and under such circumstances an observer is apt to overestimate the coldness of the climate.

THE PLANT-FORMATIONS.

With regard to the plant-formations of the Auckland Islands, and, indeed, those of the other Southern Islands visited by me, I can only speak in quite general terms. The small extent of country which I was able to examine in a very limited time made it quite impossible to separate the vegetation as a whole into its component formations, or to properly limit or define those which were so hastily examined. Therefore most certainly only a part of the plant-formations are here dealt with, and these may in some instances include more than one formation, or, on the other hand, be too narrow in their application. There must certainly be a number of formations which I never saw at all, such as subalpine rocks, subalpine bogs, running-water formations, &c., while the open country, both of the high and low lands, most likely contains more than one formation. The formations here dealt with are: (1) Sand-dunes; (2) coastal rocks; (3) forest, divided into (*a*) rata forest, (*b*) *Olearia lyallii* forest; (4) lowland tussock; (5) *Pleurophyllum* meadow; (6) subalpine meadow; (7) subalpine scrub.

1. *Sand-dunes.*

Nothing is said regarding the sand-dunes either by Hooker or Kirk. The former author certainly speaks of (46) *Pratia arenaria* as "creeping over the open sandy shores of Enderby Island"; but this information was supplied by Lieutenant H. Oakely, so probably Hooker himself did not visit Enderby Island, the only locality in the group, so Captain J. Bollons informs me, where sand-dunes occur. These are situated on the south coast of Enderby Island, and in front of them is a somewhat extensive sandy beach (Pl. XI.),

the rendezvous of numerous sea-lions. At the time of my visit there were perhaps forty of these large animals on the beach, while others were encountered on the dunes The heavy bodies of these creatures dragged over the ground must have some effect on the vegetation, especially as they are wont to roll about on the sand. At the present time the sand-dune formation cannot be considered quite a primitive one, since already cattle, and perhaps rabbits, have loosened the sand, so that dunes originally stable are now moving inland, and have already invaded the forest zone, destroying some of its outermost members. This fact is the more interesting because, as will be seen from what follows, the dune-plants are none of them true sand-binding plants, such as *Scirpus frondosus* of New Zealand or *Elymus arenarius* of the Northern Hemisphere, the extreme moisture of the climate, in conjunction with the short periods of sunshine, keeping the sand sufficiently moist on the surface to promote in many places the growth of a turfy covering, which is quite sufficient to keep the sand from drifting, in the absence of introduced herbivorous mammals. Even where the dunes are quite bare the climatic conditions probably would suffice to keep them stable. All the same, the absence of such a widely spread sand-binding plant as *Scirpus frondosus*, which extends even to Chatham Island, is a matter for considerable surprise.

The dunes are traversed by deep gullies, down which small streams of water flow, the drainage from some swampy ground between them and the "rata forest." Such gullies furnish plant-stations having considerable shade and moisture. On the summit of the dunes are great numbers of small stones, said to be part of the excreta of the sea-lions. Musgrave (83, p. 148) refers also to such stones, and states that he found a deposit of them in peaty soil 6½ ft. below the surface of the ground.

The dune vegetation varies from an open to a quite close formation, this latter appearing as a green sward, even when viewed from some distance (see the dark patches in Pl. XII.). The open portion of the formation appears, of course, in those places most exposed to sun and wind, and has for its plant-members a species of moss of a dense habit of growth, specimens of which I unfortunately failed to procure, stunted *Tillæa moschata*, *Ranunculus acaulis*, and *Rumex neglectus*. As all these spermaphytes are also quite common at various places on the New Zealand coast a detailed description of their life-forms is unnecessary; suffice it to say that *Rumex neglectus* and *Ranunculus acaulis* have both creeping underground stems, those of the former of considerable dimensions, by which they can easily spread in the sandy ground, while the

succulent *Tillæa moschata* roots readily from the axils of its leaves. Where such a portion of the formation has been disturbed by grazing animals, and its vegetation more or less destroyed, *Rumex neglectus* is in many places taking entire possession, and a pure formation of this plant, foreign to the primitive vegetation, may in such places occupy the ground for some time to come, thanks to its power of rapid increase by means of stout underground stems.

On the shady side of the gullies, and extending thence on to the summit of the dunes, is a close turf of the moss before mentioned associated with the endemic *Epilobium confertifolium*, *Pratia arenaria*—a species very common in Chatham Island, but probably not found in New Zealand proper—*Lagenophora forsteri*, and *Ranunculus acaulis*. The leaves of the *Pratia* were more or less withered, but the other members of this formation were quite green, especially the moss species, which is the dominant plant, and gives the distinct green colour to the formation, as stated above. Of the above species the only one to be spoken of here is *Epilobium confertifolium*. This is a creeping-plant which frequently forms rather dense patches on the surface of the ground. It is by no means confined to the dunes, but occurs in the forest, the meadows, and probably in other stations. A New Zealand mountain *Epilobium* is frequently referred to this species, but Mr. D. Petrie has more than once informed me that he considers the two as quite distinct, and with this I most certainly agree. The old shoots are prostrate and dorsi-ventral, the leaves being inserted on their flanks; but the young shoots are raised slightly from the ground, and here the leaves are in a spiral The creeping stem is green, and $\pm$ 1·75 mm. in diameter. The leaves are slightly fleshy, bright-green in colour, and provided with a short but rather stout petiole. The leaf-blade is $\pm$ 12 mm. $\times$ $\pm$ 6 mm., and has a rounded apex and a slightly toothed margin. The young shoots in spring grow closely together. Roots $\pm$ 4·6 cm. in length are given off here and there from the prostrate stem. Seeds germinate very readily in cultivation. The flowers are bright-pink in colour, and the peduncles are extremely short. Plants brought from the Southern Islands came into bloom on the Canterbury College rockery early in November. Although growing on a sand-dune, the short roots are sufficiently long both to anchor the plant and reach the water. Whether the distichous arrangement of the leaves is hereditary or whether it is merely a non-hereditary light relation only experiment can show. The colour of the flowers is an uncommon one amongst New Zealand plants, and is dealt with further on:

2. *Coastal Rocks.*

Here is included both the flat rocky shore and the basaltic cliffs, which latter are frequently perpendicular, but contain many ledges, crevices, and hollows, on or in which peat, so easily and quickly formed from decaying vegetation in the climate of all these islands, can lodge. This plant-formation of the rocks is a most important one in the Auckland Group, since by far the greater part of the coast-line consists of cliffs, which must offer the most varied situations for plant-life. On this account a detailed account of the distribution of their plant-inhabitants with regard to the various ecological factors would be of considerable phytogeographical interest. My observations, however, were confined to a very rapid examination of a few coastal rocks at Ewing Island and Rose Island. I also walked for some short distance along the stony shore of the north coast of Adams Island, and spent a few minutes on the summit of those rocks at its western corner where the narrow strait connects Carnley Harbour with the Southern Ocean. Thus, since it was impossible, under the circumstances, to obtain any true conception of a typical rock-formation, and also as the composition and physiognomy of this formation will probably vary to some extent in various parts of the group, it seems best to deal with each locality separately.

On the flat rocky shore of Ewing Island, raised but little above high-water mark, and very frequently drenched by the sea-spray, the endemic *Cotula lanata*, its thick stems creeping over the rock and rooting in places from the nodes, is very abundant. Growing in a similar position, and rooting into the chinks of the rock, are the large, green, hard cushions of *Colobanthus muscoides*. Close beside this latter, and frequently growing on its surface, is the reddish-coloured *Tillæa moschata*. Scattered about here and there are the soft green tufts of *Scirpus aucklandicus*, while flattened close to the rock are the green rosettes of a species of *Plantago*, probably endemic, and which was referred by Hooker first to *P. carnosa* and finally to *P. brownii*. Rising from the flat rocks of the shore are perpendicular basaltic cliffs, on the summit of which, growing in the ever-present peat of these islands, are large green bushes of *Veronica elliptica*, or in another part of Ewing Island the magnificent *Olearia lyallii* crowns the cliffs; but neither of these plants belong to the formation now under discussion, although perhaps the *Veronica* may grow on the coastal cliffs in some part or other of the group, since such are a very common station for this plant in the South Island of New Zealand. Where the rock is wettest—and these rocks often fairly drip with water—the curious indigenous grass *Poa ramosissima* is very abundant, the pale-green of its leaves

giving a distinct colour to the formation. On the peat-covered ledges of rock the halophytic grass *Festuca scoparia*, also common on coastal cliffs in the South Island of New Zealand, grows abundantly and luxuriantly. Here, too, the xerophytic ferns *Lomaria dura* and *Asplenium obtusatum* form dense and large masses, their rhizomes, roots, and decaying fronds being very efficient soil-producers. Finally, in many places *Cotula lanata* trails its stems down the rock-faces.

The cliffs of Rose Island, where we landed from the "Hinemoa's" oil-launch, are almost perpendicular, and are still wetter than those mentioned above. Here *Poa ramosissima* clothes them so densely as to make a close formation, a most uncommon event for the vegetation of rocks. The masses of this grass measured quite 20 cm. through to the wet peat in which it was rooted. Here, too, *Festuca scoparia* helps to make the close mass of vegetation, its leaves hanging downwards for more than 1·5m., their tips almost dipping into the sea at high-water. On the wet ledges not covered with grasses are *Callitriche antarctica* and tufts of *Scirpus aucklandicus*. My notes do not mention the customary maritime ferns, but it may be taken for granted that they are present, and also probably *Cotula lanata;* indeed, the cliffs here have the same vegetation as those treated of above, but owing to their greater moisture their vegetation is more luxuriant.

The stony beach of Adams Island, facing the Western Arm of Carnley Harbour, abuts on the *Pleurophyllum* meadow, no forest or scrub zone in many places separating the two formations. In consequence of this, and perhaps also because it is not much exposed to sea-spray, some of the characteristic meadow-plants, notably the very fine umbellifer *Ligusticum latifolium*, grows amongst the stones of the beach. Here also *Cotula lanata* and the closely related *Cotula plumosa* are abundant.

On the summit of the rocks at the western corner of Adams Island, at perhaps 50m. or so above sea-level, is *Plantago* sp. and the very common New Zealand halophyte *Samolus repens*. At times during heavy weather the plants of these rocks must be drenched with sea-spray. Mr. E. Lukins describes how he found "large pieces of kelp, seaweed, broken shells, and starfish" on these cliffs, "all thrown up by the force of the huge seas"(75). This must be the station where Kirk collected *S. repens*, and if it occurs nowhere else in the Auckland Group or in the Southern Islands it is a most interesting and instructive example of local distribution, similar in character to examples of other species of spermaphytes in Chatham Island, which I have pointed out may be considered relics of a former vegetation much richer in species (23, p. 316).

Besides the various species of plants enumerated above as belonging to the coastal-rock formation, the following are mentioned in the "Flora Antarctica": *Myosotis capitata*, growing "on gravelly banks near the margins of woods close to high-water mark"; *Gentiana cerina*, "near the sea on rocky islets in Rendezvous Harbour"; *Urtica australis*, "on the pebbly beach above high-water mark"; and *Urtica aucklandica*, "on the sea-beach." Of these plants, *Urtica australis* is a very common plant near the sea on the shores of the large lagoon in Chatham Island (23, p. 273), and also it occurs abundantly at certain spots on the gravelly shore of Dog Island and Centre Island, in Foveaux Strait; while *Gentiana cerina* is closely related ecologically to *G. saxosa*, a most abundant plant of the coastal turf in the neighbourhood of Foveaux Strait.

Regarding the life-forms of the plants of the formation under consideration, only those which are endemic need any detailed description here, while of these those belonging more strictly to the meadow, or to a zone between meadow and shore, will be treated of further on. To the first category belong *Cotula lanata (Compositæ)*, *Colobanthus muscoides (Caryophyllaceæ)*, *Plantago* sp. *(Plantaginaceæ)*, *Poa ramosissima (Graminaceæ)*, and *Urtica aucklandica (Urticaceæ)*.

Cotula lanata has pale-green or sometimes brown prostrate stems, which creep along the ground or hang down the face of vertical cliffs. They are ± 12 mm. in diameter, but are usually rather wider in the horizontal than in the vertical direction, thick, fleshy, and with a smooth surface. The extremities of the stems are ascending, bending upwards and bringing into the light the terminal leaf-rosettes, which consist of a few spreading pale-green pinnatifid leaves. The stems are marked at intervals of ± 6 cm. with old leaf-scars, and from some of the nodes roots pass downwards into the rock-crevices, thus firmly anchoring the plant to the substratum. Shorter or longer lateral branches are frequently given off from the main stem. The leaves are fleshy and vary somewhat in colour, those innermost and not fully developed being of a darker green than the larger and more external ones. In shape they are obovate, the blades deeply pinnatifid, ± 15 mm. long × ± 12 mm. broad, and the segments are toothed on the upper margin. Such teeth, ± 2 mm. long, are bent at an angle, frequently almost at a right angle, to the plane of the leaf, thus making one-third of the assimilating surface vertical or nearly so, while the remaining two-thirds is horizontal. The fleshy pale-coloured petiole is nearly twice as long as the lamina, and possesses a broad sheathing base ± 5 mm. long, furnished with a membranous margin. The petiole and midrib are covered, especially in young leaves,

with cottony hairs loosely interwoven. Thus, the sheathing petioles and the persistent remains of the leaf-sheath and leaves of the preceding year form an efficient protection for the delicate bud. Early in spring new shoots are put forth from near the apex of the branches at the same time that the flower makes its appearance, such shoots in three weeks in cultivation attaining a length of ± 3 cm. The leaves close to the end of the shoot are arranged spirally, but the remainder are brought into two ranks through twisting of the leaf-sheaf, the leaf-surface thus becoming horizontal This dorsi-ventral habit seems hereditary, a stem which had been planted so as to be vertical at a height of 5·4 cm. from the ground put forth in spring three dorsi-ventral shoots, which stretched out in the air parallel to the ground and at right angles to the vertical stem. The internodes of young shoots are densely covered with loose white cottony tomentum. The flower-heads are 7 mm. in diameter, the florets yellow in colour and densely packed together; the peduncles are ± 1·3 cm. long, and tomentose.

Colobanthus muscoides is an extremely dense cushion plant, more or less circular in outline, with a convex upper surface. The shoots are packed as closely together as those of the "vegetable sheep" (*Raoulia mammillaris*), so that the plant as a whole can be quite easily removed from the ground, and when dry makes an interesting museum object. These dense cushions are bright-green in colour, and vary considerably in size, a large one measuring 54 cm. in diameter. The leaves are linear in shape, quite glabrous, ± 6 mm. in length × 1 mm. in breadth, and fleshy. They form little rosettes of about six leaves each at the extremity of each shoot. Below—that is, within the cushion—the old leaves are all in a greater or less advanced stage of decay, and form a dense, yellow, sticky, peaty mass ± 10 cm. in depth, through which the shoot-axes penetrate, giving off at the under-surface of the cushion a large number of fine roots. The peaty mass absorbs water like a sponge, and in the wet climate must nearly always be saturated with moisture.

The endemic species of *Plantago* forms rather hard green round rosettes, often pressed closely together and flattened close to the surface of the rock. These rosettes measure ± 4 cm. in diameter. The leaves are fleshy, rather stiff, and bright-green in colour. Those of the periphery are the longest, those more internal being shorter, but broader in proportion to their length. The epidermis is strongly cuticularised on the upper surface. There is a dense palisade parenchyma, and a rather close, round-celled spongy parenchyma. Numerous resin-passages are present. The root-stock is short and thick, and gives off several long deeply

descending roots. Sometimes the rosettes are so close together as to be mixed up with one another, and in such cases the rosette-form is not evident.

Poa ramosissima is, as Hooker pointed out, "a grass of remarkable habit." The long wiry decumbent stems, 1 mm. or more in diameter, are often quite naked below, but above are covered with the membranous leaf-sheaths of the preceding year ± 4·5 cm. long. Above a great number of leafy branches are given off. The leaves are very numerous; the leaf-blade ± 5 mm. long, ± 2 mm. broad, pale-green, flat, soft, and flaccid.

Urtica aucklandica was not observed by me. According to Hooker it is a rare plant. It is described in the Handbook as "herbaceous, robust, softly downy all over, except the upper surface of the leaves, where there are a few stinging hairs. The leaves are broadly ovate-cordate, coarsely serrate or toothed, rather coriaceous or rigid. Petioles stout, ½ in. to 1 in. long."

3. *The Forest-formations.*

As in the case of the formations already described, I can make no definite statements as to the limits of the forest. It seems best here, then, to give some details regarding each of the pieces of forest visited by me There are two very distinct types of forest. The first, and by far the most common, is that in which *Metrosideros lucida* is the dominant tree. The second, which is extremely local, consists of *Olearia lyallii*. For the former formation I propose the name "rata forest," and for the latter "*Olearia lyallii* forest."

(a.) *The Rata Forest.*

This formation forms a belt of evergreen trees and shrubs extending round a considerable portion of the coast of the various islands, its distribution depending probably upon the nature of the soil, exposure to wind, and altitude of the land. Thus, the rata forest is most luxuriant at the heads of sheltered inlets, while in places exposed to the full violence of the frequent gales it is altogether wanting, and at a certain altitude, averaging possibly 120m., it gives place to formations of scrub or meadow. Where high cliffs form the coast-line the forest is absent, and where there is excessive moisture in the ground a tussock formation may occur side by side with the forest, as in certain parts of Enderby and Ewing Islands. Regarding the distribution of the forest, Chapman states (15, p. 501), "The north coast is almost without wood; this may be due to lack of shelter. The west coast is too steep for trees; so is the external part of the south coast."* I

* This evidently refers to Adams Island.

had an opportunity of examining the forest in the following places: Enderby Island, where I almost passed through the belt into the tussock beyond; Ewing Island; near the depot at Port Ross, in the north of Auckland Island; at the head of Musgrave Inlet; at Camp Cove, Carnley Harbour, where I ascended right through the forest-belt on to the subalpine meadow.

On Enderby Island there is a considerable quantity of rata forest and scrub, which forms a somewhat narrow belt on the east and south sides, the whole of the west side of the island, according to Captain J. Bollons, being a tussock formation. This forest-zone consists of *Metrosideros lucida* and *Dracophyllum longifolium*, with an undergrowth of *Suttonia divaricata*, *Coprosma fœtidissima*, and the semi-arborescent fern *Aspidium vestitum*. Proceeding through the forest to the north, the *Metrosideros* becomes less in quantity and more stunted, while *Cassinia vauvilliersii* makes its appearance, this shrub finally becoming dominant. It seems from this that we have here to do with two formations—viz., the true rata forest and a scrub in which *Cassinia vauvilliersii* is the leading plant—but I have not sufficient data to make any statement on this head. My notes say nothing about the height of the *Metrosideros* trees; probably they are some 5m. tall. The view within the forest is amazing in the extreme, and to give a lifelike and vivid word-picture of the appearance of the trees is quite beyond my powers of description. The trunks of the ratas are frequently prostrate from their bases for more than half their length. From such prostrate trunks are given off many naked branches much twisted and gnarled. The ultimate branchlets are erect, and form with the foliage a dense flattened head to the tree, whose spread is altogether out of proportion to its height. Such spreading branches may measure ± 60 cm. in diameter. In this forest *Dracophyllum longifolium* is common, and is frequently furnished below with many "reversion-shoots," having much broader leaves than those of the adult and similar to those of juvenile plants. Viewed from a slight eminence, the roof of the forest presents a dense green appearance, and one thus viewing it from above would think the whole formed a thick, low, shrubby growth such as the heaths of northern moorlands. Through the rata-foliage the *Dracophyllum* puts forth its erect, straight, needle-like leaves for a short distance. The undergrowth consists of shrubs of *Coprosma fœtidissima* and the very densely growing *Suttonia divaricata* (76), while the fern *Aspidium vestitum* spreads out abundantly its arching dark-green fronds of 1m. or more in length. The floor of the forest here, as in all parts of the Auckland Islands, consists of wettish peat. In many places it is bare, perhaps owing to the

sea-lions lying down upon it and wallowing in the mud, for the comparatively wide tracks of these animals are very numerous. Indeed, but for such tracks, in many places churned up into thick mud, progress through this dense forest would be far more difficult. Where the forest-floor is not bare numerous rounded patches of mosses and liverworts are present, also seedlings of the various trees and shrubs are very common, while *Nertera depressa*, its stems creeping on the ground, and the species of *Uncinia* formerly known as *U. hookeri*, but now referred by Kükenthal to *U. riparia* as var. *pseudorupestris*, are abundant. Here and there are a few plants of *Urtica australis* and stunted *Stilbocarpa polaris*. *Epilobium linnæoides* and *Stellaria decipiens* are also frequent. As one penetrates further into this forest towards the north the shrubs increase in number, *Cassinia vauvilliersii* appears, and progress through the dense shrubby growths becomes extremely difficult.

The rata forest on Ewing Island is very similar to that just described; but, if possible, the curious twisted branches of the rata in that portion of the forest visited by me were even more striking. Some of these branches extend for a long distance at right angles to the main stem, others are given off at all kinds of angles and twisted on their axes, the whole mass of branches making a most bewildering network. Here, too, the forest-floor is frequently quite bare, no doubt owing to the great numbers of sea-lions, which formidable-looking creatures were constantly encountered.

In Erebus Cove, Port Ross, stands the depot for castaways. It was in this neighbourhood that for three years Enderby had his headquarters, and during that period cut down several acres of the forest. In this same locality, so Captain J. Bollons informs me, the early whalers also cut down a considerable number of trees, filling their vessels with wood before proceeding to Campbell Island, where true forests are wanting. Where this extensive clearing was made there is now a dense growth of evergreen shrubs, forming a most beautiful shrubbery of various hues of green. An account of the constituents of this new formation is given further on, when dealing with the effect of introduced animals, &c., on the vegetation.

The most luxuriant forest that I had an opportunity to examine is that at the head of Norman's Inlet, but, unfortunately, only a few minutes were available, it being late in the afternoon when we landed. The position of this forest possibly affords the maximum amount of shelter to be found on Auckland Island, and in consequence the trees are taller than in the more exposed forests, and the interior hygrophytic vegetation richer both in quantity and species. A

stream of considerable size from the adjacent rugged mountain also adds its quota to the moisture of the atmosphere. The remarkable broad-leaved form of *Polypodium australe*—*P. rigidum*, Homb. and Jacq.—is here abundant. The plants collected by me seem to match those figured in "Voyage au Pole Sud" (45, pl. ii., Monocot. Vasc.). The fronds measure ± 14·5 cm. × ± 2 cm., are given off from a stout rhizome ± 4 mm. in diameter, and form tufts on the tree-trunks. This plant is very different in appearance from the typical species, also abundant in the same forest, nor did I notice any "intermediate forms." In this forest Mr. W. Joss made a most interesting discovery—viz., one plant of the common New Zealand tree-fern *Hemitelia smithii*, tree-ferns, if we except *Aspidium vestitum*, not having been previously observed in any of the Southern Islands. This important discovery extends the range of tree-ferns very much further to the south than was previously known.* Unfortunately, I had no time to pay the plant a visit, so only saw the specimens which Mr. Joss had just collected. The general character of this part of the rata forest is very similar to that next to be dealt with, so to avoid needless repetition no more need be said here.

Passing into Carnley Harbour at first a dense belt of forest clothes either shore, extending up the steep mountain-slopes for perhaps 150m.; but after the Western Arm is reached the upper meadow comes lower, until finally it descends to sea-level, alternate bands of forest and meadow clothing the slopes. Such grassy spurs offer a most excellent opportunity for reaching the higher ground of Adams Island, doing away with the laborious climb through the forest necessary in most parts of Auckland Island before the subalpine region can be reached. I had no opportunity to examine the Adams Island forest, but several hours in the neighbourhood of Camp Cove afforded me facilities to examine the forest in the south of Auckland Island.

At Camp Cove the trees come right down to the edge of the water, into which the leaves of *Dracophyllum longifolium* almost dip. Here *Metrosideros lucida*, as usual the dominant plant, grows with spreading gnarled branches, but hardly to the same degree as in the more wind-swept forest of Ewing Island. The accompanying photograph (Pl. XIII.) gives, however, only a poor idea of the interior of a rata forest, since in order to get near and distant objects into focus a rather open part of the forest had to be selected. Mixed with the rata is *Panax simplex* and *Dracophyllum*

* Mr. W. Botting Hemsley, F.R.S., has kindly informed me that the previously recorded limit of tree-ferns was that of *Alsophila prunata*, at about 47° S., in Port Otway, Patagonia.

longifolium The forest-roof, as before described, is of extreme density, and it is situated some 4·5m. above the surface of the ground. Such a dense covering, combined with the great amount of moisture in the atmosphere, affords very strong hygrophytic conditions within the forest, with the result that plants of the most marked hygrophytic structure abound, and grow with great luxuriance. The forest floor is extremely uneven. Large mounds, formed in part of decayed vegetation, consisting principally of mosses and liverworts, are very common. Such mounds, the forest-floor in general, and the many fallen and dead tree-trunks are densely covered with liverworts, mosses, and filmy ferns, the two former frequently forming great cushions. These same plants are also epiphytic on the tree-trunks and stout spreading branches of the rata, forming finally, in many cases, deep masses of soil, in which seedling trees and shrubs grow with vigour. *Hymenophyllum multifidum* and several other filmy ferns form sheets on the bark of the trees, while *Polypodium billardieri*, one of the most characteristic plants of this forest, climbs over their trunks, and also ramifies over large areas of the forest-floor. Frequently this latter is quite occupied by an extremely dense and deep undergrowth of *Aspidium vestitum*, or, nearer the shore, there is much *Asplenium obtusatum* and *Lomaria dura*. In other places the ferns may be replaced almost altogether by a still denser undergrowth of *Suttonia divaricata*, so close that the shrubs touch one another. In such places as this, but for the seals' tracks and what I took to be pigs' tracks higher up, but which may also be made by seals, progress through the forest would be much more difficult.

If we consider the climatic and edaphic conditions to which the rata formation is subjected we find them extremely diverse. There is on the one hand the almost constant wind, which very frequently assumes the character of a furious gale —a strongly marked xerophytic factor. There is also a very wet, badly drained, peaty soil—a soil, indeed, probably to some extent physiologically dry—a second xerophytic factor. But on the other hand is a climatic condition diametrically opposite to the above, one strongly hygrophytic indeed—namely, an extremely moist and equable climate, which favours forest-growth exceedingly, and would be an ideal rain-forest climate (92, p. 505) were the mean summer temperature not so low. The physiognomy and interior contents of the forest is the resultant of these opposing factors. Thus, there is every indication of the mechanical action of the wind on the trees causing the flat dense roof of foliage and gnarled trunks and branches; but the moist climate at the same time encourages the spread of the forest as a whole, and the luxuriant lateral growth of the branches, which is out of all

proportion to the height of the trees. Moreover, the dense roof of the forest assists in keeping its interior calm, and here the hygrophytic factors can exercise full sway, so that the vegetation within the forest is of the most extreme hygrophytic character, and its constituents the filmy ferns, liverworts, &c., such as can endure only for a very limited period dry air or exposure to direct sunlight. The light factor, indeed, is a very important one so far as many of these forest plants are concerned. Feeble light is of as much importance in the cultivation of certain liverworts and filmy ferns as is moist air, and the letting-in of more light into a New Zealand rain-forest when timber is being removed has perhaps the most to do with the death of a large percentage of the hygrophytes.

This rata forest of the Auckland Islands is by no means altogether an endemic plant-formation. Very similar forests are found in certain parts of the South Island of New Zealand and in Stewart Island, but they contain more arborescent components — notably, *Weinmannia racemosa* is a frequent member; nor is the general physiognomy the same. This interesting fact—the occurrence of a very similar formation in two regions so distant—is discussed when dealing with the history of the vegetation.

Since all the plants of this formation, if we except the fern *Polypodium rigidum*, occur in New Zealand proper but little need be said here as to the life-forms of most of them. The general aspect of *Metrosideros lucida* has been sufficiently described above; its lanceolate, thick, coriaceous, shining green leaves furnished with numerous oil-glands, their blades $\pm$ 3·6 cm. $\times$ $\pm$ 1·6 cm., growing closely together, are quite able to withstand the most violent winds so long as the atmosphere is charged with moisture. On the dry Canterbury Plain the hot north-west winds do not allow this tree to be brought into cultivation, whereas in Dunedin, where this wind is unknown or extremely modified, the rata flourishes in gardens, though not a member of the forest of that locality. The narrow semi-vertical needle-like leaf-blades of *Dracophyllum longifolium* have their transpiring surface still more reduced by the concavity of the upper (inner) surface, and are, moreover, confined to the extremities of the ultimate branchlets. Like *Dracophyllum arboreum* of Chatham Island (22, p. 294), *Drac. longifolium* has juvenile leaves broader than those of the adult, and it also frequently puts forth "reversion-shoots," as mentioned above. Such shoots have leaves much broader and longer than those of the adult, and they closely resemble the juvenile leaves. In the juvenile leaves the position with regard to light is different from that of the adult leaf, the surface of the former being almost horizontal, while the latter is semi-vertical. There are also differences

in size and colour, juvenile leaves being nearly twice as broad and 1·5 times as long as adult leaves; while, as to colour, the juvenile leaves are reddish-brown and the adult are green.

Panax simplex is a plant which exhibits a still more remarkable heterophylly, which, as I stated some years ago (21, p. 355), is not yet understood. Since that time I have been collecting material, and hope to publish my results shortly. As, however, I collected some special evidence on this matter on Auckland Island it may be briefly discussed here. According to Kirk *Panax simplex* has two quite distinct primary juvenile forms through one or other of which it must pass before it assumes its second later juvenile form and its final adult form. One of the primary juvenile forms has simple leaves and the other has compound leaves, these being, according to Kirk (66, p. 217), "five-foliate on slender peduncles; leaflets petiolulate, linear lobed or pinnatipartite." In his "Forest Flora" Kirk gives figures of the various forms (65, pl. cvi., cvii.). Now, the point which chiefly concerns us here is that Hooker stated that only the entire-leaved seedling form was found on Auckland Island, while Kirk affirms, "It [the entire-leaved form] is the prevalent form on Stewart Island, but the lobulate form occurs there also" (65, p. 211). Taking for granted that the fact of the occurrence of these forms as here stated was correct, I wrote some time ago (22, 355), "Different environment, as will be shown later on, has a most marked effect on the same forms in many plants; hence this case, granted that the facts are as stated, may be merely a case of different development under different conditions." In the accompanying plate may be seen figures of various forms, which certainly throw a new light on our knowledge of this important biological matter. Fig. 1, Pl. XI., shows that the form with deeply cut leaves also occurs in Auckland Island, the seedling in question being collected by me in the forest at Norman's Inlet. Fig. 3 shows a 5-foliate and rather deeply cut leaf, which occurs, moreover, on the same shoot with a ternate leaf (fig. 4). Turning to plants collected by me at Port Pegasus, Stewart Island, in the "rata-pine forest," fig. 5 shows the simple-leaved form and fig. 6 the cut-leaved compound-leaf form on the same plant. This latter, at any rate, shows that the entire-leaved seedling and the compound deeply cut-leaved seedling are not distinct from one another. The subject has now reached the stage when experimental treatment is demanded. Probably moist air has something to do with the stimulating an hereditary tendency to produce compound trifoliate deeply cut leaves; but, as I said above, I hope to have some definite statements to make shortly on this matter. The adult form of *P. simplex* has simplex, oblong-lanceolate, coriaceous leaves, the laminæ

measuring 6·5 cm. × 2·25 cm., or frequently they are of somewhat lesser dimensions.

Coprosma fœtidissima varies very considerably in the form and size of its leaves; so much so, in fact, that Hooker made two species out of the various forms of the Auckland Islands, the one *Cop. fœtidissima* and the other *Cop. affinis*. This latter is distinguished from the type by its larger and longer leaves, the apex of which is acuminate. Later on Hooker merged both forms into one species. Amongst my specimens are none which match the figure in the "Flora Antarctica," but, generally speaking, the leaves are larger than those of specimens collected in such a moist habitat as the forest near Preservation Inlet. Seedlings of forms which in the adult have leaves with their laminæ 5·9 cm. × 2·1 cm. have large leaves at quite an early age, a plant 8 cm. tall having the lowest leaves 2·5 cm. × 1·6 cm., and the uppermost 3·5 cm. × 2 cm.; indeed, such seedlings have larger leaves than the average adult leaves of plants at Preservation Inlet. Leaves from rapidly growing suckers are of still greater dimensions, measuring 7 cm. × 3 cm.

Suttonia divaricata belongs to that class of shrubs which I have elsewhere designated as xerophytic,* and which bear especially the impress of exposure to strong dry winds and a dry soil. Such shrubs are very frequent in New Zealand, and belong to very different genera, or even natural orders, yet so much resemble one another that some botanical knowledge is required to discriminate between them. Some lianes, too, assume a similar habit of growth in the open, and are frequently associated with the plants in question in such stations as stony *débris* on dry hillsides or on river-terraces. These plants are distinguished by the possession of thin, wiry, interlacing, frequently divaricating branches, the whole forming a dense mass so strong as to almost support the weight of a man, and which can be reclined on as on a wire-wove mattress. The leaves are of small size, more or less coriaceous, and in some cases few in number. Amongst the commonest plants of this class are several species of *Coprosma (Rubiaceæ)*, *Aristotelia fruticosa (Tiliaceæ)*, *Pittosporum rigidum (Pittosporaceæ)*, *Panax anomalum (Araliaceæ)*, species of *Hymenanthera (Violaceæ)*, *Corokia cotoneaster (Cornaceæ)*, the plant under discussion — *Suttonia divaricata (Myrsinaceæ)*, and amongst lianes species of *Rubus (Rosaceæ)*, *Muhlenbeckia complexa (Polygonaceæ)*, and *Clematis afoliata (Ranunculaceæ)*. *Suttonia divaricata* possesses in a marked degree the habit mentioned above. The ultimate branchlets at the outside of the plant are

* Trans. N.Z. Inst., vol. xxxiii., p. 279. 1901.

straight and stiff, ± 3 mm. in diameter, and given off from the more internal and thicker branches at right angles, and sometimes at a lesser angle. The main trunk, according to Hooker, is 10 in. or 12 in. in diameter (46). The leaves are numerous, somewhat coriaceous, and their laminæ measure about 11 mm. × 10 mm. The figures in the "Flora Antarctica" and "Das Pflanzenreich" (77, fig. 56, p. 334) furnish some idea of the appearance of a small branch of this shrub, but give little notion of the aspect of the plant as a whole. Contrary to the majority of the above-mentioned xerophytic shrubs, *S. divaricata* usually occurs in the rainy regions of the New Zealand biological area. Such a structure as that described above seems quite unsuited for moist forest regions, and its presence and that of other xerophytic plants can, it seems to me, be only explained on those historical grounds which Dr. L. Diels was the first to suggest. These were that during the great rise of the land, which according to Hutton led to the remarkable extension of the glaciers of New Zealand (53), a steppe or semi-desert climate would exist on the new tableland and plain in the east of New Zealand, and that the plants of that region would require to be modified in accordance with the changed conditions of their existence—from a rain-forest climate to a semi-desert climate—or perish. In accordance with this view, as the land receded to its former small area some of the plants would be left in outlying stations no longer connected with New Zealand proper, such as Chatham Islands and the Southern Islands; others would find a congenial habitat in the extreme xerophytic stations of limited area still remaining in the east and centre of the North and South Islands; finally, others would get mixed up with the western vegetation at a time of a further sinking of the land, when some of the passes over the Southern Alps would be about 305m. lower than at the present time. But this matter is too important to discuss in the limited space here available; I can only refer the reader to Diels's original paper (27) and to some further remarks on the subject published by me elsewhere (23). One matter of interest in this connection lies in the fact that *Suttonia divaricata* shows the rigid divaricating habit of growth in seedlings at quite an early age. Thus, a seedling 6·4 cm. tall has a rigid stem 2 mm. in diameter; near the first leaves one short, straight branch is put forth from the main stem at an angle and in a manner similar to that of the adult; also, the leaves are equal in size and similar to adult-leaves, except that some of them are more or less toothed or slightly lobed on the margin. So far as I have observed up to the present, it is exceptional for a New Zealand xerophytic shrub

to have leaves similar to the adult; on the contrary, these plants offer instructive examples of what Goebel calls heteroblastic development, thus giving a clue from the study of the development of seedlings to the phylogeny of the species.

As for the remainder of the forest-plants which have not yet been described, little can be said here. They are mainly such as occur in the rain-forests of New Zealand, and are mostly typical hygrophytes. Many of these, however, lead an epiphytic life, and are provided—amongst the liverworts more especially—with many remarkable adaptations towards that mode of existence.

(b.) *The* Olearia lyallii *Forest.*

This is a forest-formation of remarkably local distribution. It is not found at all in New Zealand proper, but occurs only on the Snares, on Ewing Island, and perhaps to a very limited extent in one or two places on Auckland Island itself And yet where it does occur it grows with great luxuriance; seedlings of all sizes are abundant. Nor does there seem any reason why it should not be the dominant forest of the Southern Islands. We have here possibly one of those cases where a very slight difference in adaptation to environment, not to be estimated in the present state of knowledge, has led to one formation becoming dominant and another remaining stationary in a limited area; or, what is perhaps likely here, a former primeval forest adapted to slightly different conditions has been ousted by a newer formation as the conditions changed.

"Viewed from the sea," to quote from my note-book, "Ewing Island has a decidedly attractive appearance." This is owing to the fine natural shrubbery of *Olearia lyalli* which fringes the shore, its huge leaves exposing their silvery undersurface as blown by the frequent wind, and contrasting finely with the green of the upper surface. Alternating with the *Olearia* are pale-green clumps of *Veronica elliptica*, while in front of it are in places dense tall tussocks of some species of grass, more than 1·5m. in height, with "trunks" similar to those of the "niggerhead." In front of the tussock again is a rather dense growth of the bright-green grass *Poa foliosa*. Near the depot the beach is stony, consisting in part of boulders strewn with seaweeds and in part of solid rock worn down to sea-level, backed up by low rocky faces dripping with water, and their summits crowned with *Veronica* or *Olearia*.

The individual trees of the formation are some 6·1m. to 9·1m. tall, some being erect, while others have the lower part of the trunk prostrate. Such trunks are $\pm$ 50 cm. in diameter. From very near the base the main trunk branches into three or four secondary trunks covered with a rough

bark. The ultimate branches divide into several short branches radiating upwards and outwards after the manner of *Olearia chathamica* of Chatham Island (23, p. 298), *O. operina* of the west coast sounds, or *Rhododendron ponticum*, so common in gardens, finally giving off from near their extremities numerous large leaves, which form a dense mass. These leaves are thick and coriaceous, their laminæ ± 20·5 cm. × ± 13·5 cm., and provided with a short stout petiole expanded and sheathing at the base. The upper surface is dark-green, varnished and quite glabrous except at the margins and on the broad midrib. The under-surface is densely clothed with flannelly tomentum quite white in colour. This tomentum is rather more than half the thickness of the leaf-substance proper. The midrib on the under-surface of the leaf is excessively stout, measuring at the base 9 mm. × 4 mm. The young leaf, just when it is unfolded from the bud, is white and soft like a piece of flannel, being extremely tomentose on both surfaces. The ultimate shoot-axes are 1·5 cm. in diameter, and densely covered with white tomentum similar to that of the leaf. Shade-leaves are rather larger than sun-leaves, and have the veins less prominent. A cross-section of the leaf shows a large-celled epidermis on the upper surface, having the outer wall but little thicker than the inner walls. There is a dense palisade parenchyma with water tissue extending in places into it from the epidermis. Round the vascular bundle is a stereome sheath which extends to the upper epidermis, while on its under-surface is a large-celled water tissue. On the under-surface are a number of glandular hairs.

In the forest of Ewing Island trees with prostrate trunks are very much more common than those whose trunks are erect. As a rule, indeed, more than half the trunk is prostrate upon the ground. Kirk thus describes *Olearia lyallii* as it grows on the Snares (56, p. 215), "When growing in level situations it is erect, with open spreading branches, but when growing on slopes exposed to the wind it is often inclined or with a prostrate trunk, the roots partly torn out of the soil; and the branches, rooting at the tips, give rise to new trunks, which in their turn are brought to the ground and repeat the process." As for the plants on Ewing Island, Kirk writes (56, p. 219), "Most of them are erect and well grown, but a few exhibit the inclined position so frequent on the Snares." Chapman thus describes the behaviour of *O. lyallii* on the Snares: "When this" [*O. lyallii*] "grows a certain height it falls down with the weight of the leaves and the pressure of the wind and takes root where it touches ground; then it grows upwards again, and after a while it falls again, tearing its oldest roots up and rooting itself a third time: thus the

trunk is almost gifted with the power of locomotion" (16, p. 494). I have given the above quotations partly because they differ somewhat from my account and partly because this prostrate habit seems to me a matter requiring further investigation as to its causes. That it may at the present time be frequently caused by the wind no one can deny, but there is no reason on that account why the prostrate habit should not be, in part at any rate, hereditary. The behaviour of seedlings may furnish a clue. In the interior of the forest beneath the dense leafy canopy the air is comparatively still, when without a gale is blowing. Of the quite young seedlings growing in the ground which I examined, and of which only a few leaves were developed, most had their stems prostrate on the ground for more than half their length. In one instance, in an older plant, 30 cm. was erect and 15 cm. was prostrate. On the other hand, a number of young seedlings growing closely together on the trunk of a tussock were orthotropous, but in this case density of growth or their relation to gravity may have caused the difference. At any rate, it is an interesting matter requiring further investigation, for it bears directly on the inheritance of acquired characters.

The floor of the *Olearia lyallii* forest consists of coarse peat covered with numerous fallen leaves in various stages of decay. For the most part it is quite bare, owing probably to the incursions of the numerous sea-lions. There is no undergrowth of shrubs, consequently the forest is much more open than is the rata forest. Growing on the forest-floor are many rather distant patches of young *Olearia* plants, while in other places are *Asplenium obtusatum* and *Lomaria dura*. The young plants of *O. lyallii* early on develop quite large leaves; *e.g.*, a plant 30 cm. tall had leaves measuring 13 cm. × 8 cm.

Ecologically and floristically the formation under consideration is related to the *O. chathamica* formation of Chatham Island, the *O. colensoi* formation of Stewart Island, and the *O. operina* + *Senecio rotundifolius* formation of the west coast sounds, though all three must be designated scrub, and not forest. Like the above formations, and situated like them in a rain-forest climate, the *O. lyallii* formation is distinctly xerophytic; but the mild moist atmosphere has caused production of excessive leaf-surface, just as in the rata forest there is great lateral growth of the *Metrosideros*. Occupying only a narrow zone on the sheltered side of the island, the *O. lyallii* gives place to the rata forest, which certainly seems on that account the better able of the two to withstand the wind, while in its turn on Enderby Island rata gives place on the windward side to *Cassinia* scrub, and this in its turn to tussock.

4. *Lowland Tussock.*

This formation I was only able to examine in two localities—namely, near the landing-place on Ewing Island and between the dunes and the rata forest on Enderby Island; of its distribution on Auckland and Adams Island I know nothing.

The surface of the ground is very wet peat, in many places being actual swamp. Where this occurs the formation varies as to its members, and *Carex* to a large extent takes the place of the grass tussock. The tussock which gives the distinguishing character to the formation as a whole is some species of grass which I had no means of identifying. Ecologically it is remarkable for having constructed large "trunks," on the top of which the grass-plant grows, while its long filiform leaves, which are at first erect, finally arch over and droop downwards on all sides of the "trunk" in great shock-headed masses. Such trunks are more than 1·5m. tall, frequently irregular in shape, and consist of decayed and decaying stems, roots, and leaf-bases; while beneath the green living leaves, which, arching, droop downwards on all sides of the "trunk" to the ground and quite surround it, is a thick layer consisting externally of recently dead leaves, but internally of quite decayed leaves, which surround the "trunk" proper as with a mantle. Such tussocks burn very readily when dry in the summer, according to Captain Bollons, for the most recently dead leaves are frequently quite dry, even when the outside of the tussock is in its normal wet condition. These trunks absorb water like a sponge, and in this manner the living grass above will get a direct water-supply of rain-water, and so be quite independent of the more or less acid water of the boggy ground or of the actual swamp. Similar "trunks" are a frequent feature of the New Zealand landscape, and are formed by *Carex secta*. As the ground becomes more swampy *Carex trifida* appears, taking the place of the tussock-grass.

Between the tussock and the actual sea-shore is a zone of *Poa foliosa*. Probably in this formation are included two quite distinct from one another, a grass-tussock and a *Carex* bog, but the time was too limited to do more than take the above brief notes. A very similar formation seems to be present on Enderby Island, but I have no details, except such as are shown in a photograph, from which it is evident that the tussocks there are of great size. All that part of Enderby Island fully exposed to the wind is occupied by a tussock formation.

5. Pleurophyllum *Meadow.*

Beyond learning that a certain number of most striking and beautiful herbaceous plants grow in company with one

another there, there is little to be found in the writings of those botanists who treat of the Southern Islands, as to the extent, limits, altitude, or edaphic conditions of the plant-formation which these plants constitute, or whether, indeed, such plants do form a distinct society. From the writings of Sir Joseph Hooker it seems clear that at the northern end of Auckland Island—that part alone of the group where his botanical explorations were made—a considerable altitude must be reached before the above-mentioned striking plants are encountered in any number, while he distinctly points out that on Campbell Island, owing to their occurrence at a lower altitude, they form a more striking feature of the landscape. Thus, Hooker writes, "Beyond the wooded region some of the same plants" [the forest trees] "in a dwarf state mingled with others compose a broad shrubby belt, which ascends the hills to an altitude of 800 ft. or 900 ft., gradually opening out into grassy slopes, and succeeded by the alpine vegetation. It is especially towards the summits of the hills that the most striking plants are found, vying in brightness of colour with the arctic flora, and unrivalled in beauty by those of any other antarctic country."

On Adams Island, as mentioned before, strips of treeless hillside reaching to the edge of the water alternate with strips of rata forest. Now, it is just on these treeless pieces of hillside that the formation under consideration appears in that part of the Auckland Group, and so rich in striking flowers is the piece of land at the western extremity of Carnley Harbour that it has received the name of "Fairchild's Garden," a tribute to the memory of the late John Fairchild, who, as captain of the "Hinemoa," did much to advance the knowledge of New Zealand natural history.

The following are the most important members of the *Pleurophyllum* formation: *Pleurophyllum speciosum, Pleur. criniferum, Celmisia vernicosa, Cotula plumosa, Cot. propinqua (Compositæ); Ligusticum (Aciphylla) latifolium, Lig. (Aciph.) antipodum (Umbelliferæ); Nertera depressa (Rubiaceæ); Epilobium confertifolium (Onagraceæ); Stilbocarpa polaris (Araliaceæ); Acæna sanguisorbæ* var. *antarctica (Rosaceæ); Myosotis capitata (Boraginaceæ); Gentiana concinna, Gent. cerina (Gentianaceæ); Bulbinella rossii (Liliaceæ); Scirpus aucklandicus (Cyperaceæ); Aspidium vestitum, Asplenium obtusatum (Filices);* various mosses, liverworts, and lichens. In the gullies is a good deal of *Veronica elliptica.*

Between the *Pleurophyllum* meadow and the stony beach comes a zone of *Poa foliosa,* the before-mentioned tussock-grass with great "trunks," *Carex trifida,* and alternating with these, or in close proximity to them, *Stilbocarpa polaris* and *Ligusticum latifolium.* Probably the *Pleurophyllum* forma-

tion contains some of the smaller grasses, but in midwinter identification of these was impossible.

The soil of this formation consists of a great depth of peat, which at the time of my visit was very wet and sticky, but certainly not so wet as I had expected. The ground, in fact, is neither bog nor even semi-bog, but merely a very moist peaty slope. The forming of peat, even while a plant is alive, is a common-enough occurrence amongst New Zealand cushion-plants. Kirk shows, for instance, how the dense lower leaves on *Raoulia goyeni* of Stewart Island become changed into peat while the upper leaves are performing their usual functions (62, p. 215). In Fuegia also the leaves of living plants are rapidly converted into peat. Darwin writes regarding *Astelia pumila* (23*a*, p. 286), "Fresh leaves are always succeeding one to the other round the central tap-root; the lower ones soon decay, and in tracing a root downwards in the peat the leaves yet holding their place can be observed passing through every stage of decomposition till the whole becomes blended in one confused mass." In the Southern Islands such peat-forming is very plainly to be seen, especially in winter, in certain of the plants, which die down to the ground. Then the leaves of the past year lie rotting upon the surface of the soil, while their bases form great decayed masses many centimeters in thickness round the leaf-bases of the young leaves of *Pleurophyllum criniferum* or *P. hookeri*. In these sheaths of decaying leaves considerable numbers of earthworms are found, and they appear also to be fairly numerous in the peat itself. This will lead to a greater amount of oxygen in the soil than is usually present in peat, and probably there is a considerably less percentage of humic acids; but I have no data on this head. All that can be said is that, notwithstanding the soil is altogether peat, it must be very much more favourable for plant-life than is the peat of an ordinary bog, or even a dry heath.

Since my visit took place in the depth of winter I myself can say nothing regarding the magnificent display of flowers which this spot and the formation in general, if it be indeed a true formation, exhibits during the summer season. However, Chapman gives a most vivid picture of Fairchild's Garden, which is here quoted almost in its entirety: "This place" (16, p. 505) "will now be known by the name we gave it—Fairchild's Garden. It extends from the strait at the north-west end of the island along the shore to the first piece of bush, and thence up to and over the summit of the hill—in all perhaps 400 acres—one of the most wonderful natural gardens the extratropical world can show. No doubt other parts of Adams Island and other places in the group are equally beautiful, but the day we spent here can never be for-

gotten. A peaked rock overhead is 700 ft. above the sea ; the summit rocks are 1,100 ft. by the aneroid. The whole of the ground up to these and beyond them is literally packed with beautiful flowering herbaceous plants. Near the shore the *Ligusticums*, *L. latifolium* and *L. antipodum*, grow in splendid profusion, their stout rhizomes and huge rigid leaves stopping the progress of pedestrians. Along the shore were masses of golden lily (*Anthericum rossii*) in seed. Here, too, grew sweet-scented *Cotula lanata* and its handsome congener *C. plumosa*, both of which are worth cultivating. Over the whole country *Pleurophyllum speciosum* sends up, among huge ribbed leaves 2 ft. long, its spikes of beautiful lilac or purple flowers. These spikes are usually four or five, sometimes eight or ten, in number. The regular imbricating of the large ribbed leaves, so strong as to push aside the rank grasses, renders these plants singularly beautiful. They form deep cups of crisp foliage, which gives way with a crash as you set foot on it." "The next species, *Pleurophyllum criniferum*, was also plentiful. Its leaves are even larger, and, although not so handsome, make it a fine plant, especially as its tall white flower-stalk, sometimes 3 ft. high, covered with button-like brown rayless flower-heads 1 in. across, is a very striking object." "Here, too, we met in immense quantities the most beautiful of all the *Celmisias*, *C. vernicosa*, a little plant with leaves here seldom more than 2 in. long, gleaming like polished nephrite new from the lapidaries' hands, arranged in the most perfect rosettes."

In the middle of winter the *Pleurophyllum* meadow presents a very different aspect, owing perhaps not so much to the absence of flowers as to the winter habit of some of the more important plants. Thus, the huge leaves of *Pleurophyllum criniferum* are altogether wanting, *P. speciosum* only forms comparatively small rosettes—one's feet do not then "crash through the horizontal leaves as though walking on thin ice" (56, p. 220)—while *Bulbinella* is hardly visible at all, the winter buds hidden by the brown bases of the old decayed leaves just protruding above the surface of the ground. To be sure, the great rounded leaves of *Stilbocarpa polaris* and the large dark-green leathery pinnate leaves of *Ligusticum latifolium* still form as dense masses of greenery as in summer, but here the absence of the inflorescence—as large as the head of a man, according to Hooker (46, p. 16)—must make a striking difference between the winter and the summer aspect; but as these plants appear frequently to form an association mixed with little other vegetation of a striking appearance they exercise much influence on the winter physiognomy of the meadow as a whole. Everywhere the ground is dotted with the bright-green winter rosettes of *Pleurophyllum speciosum*

pressed closely against the ground, or numbers of such occur in close proximity. Such rosettes seem to vary considerably in size according to their position with regard to wind and light, those of shady gullies being much larger than those on the hillside. A rosette in the open may be ± 25 cm. in diameter, made up of quite a few leaves, hugging the soil, pressed closely above one another and arching downwards so that their upper surface is convex, a kind of cup being thus formed, with the highest part of its arching leaves as its brim. During rain this cup quickly fills with water, which soaks rapidly through the leaf-bases, bringing fresh rain-water to the roots. The leaves also become thoroughly wetted, their numerous hairs helping to hold the moisture, and it is probable that these also assist in the supply of pure water through their power of absorbing such, as suggested by Diels (27, p. 291). Very frequent all over the formation are large colonies of *Bulbinella rossii*, the green tips of the winter buds just visible above the dark-coloured peat, or the buds are completely hidden by the brown leaf-bases of the previous year's leaves. Such colonies may be several square metres in extent. Trailing over the surface of the ground very abundantly are the long shoots of *Acæna sanguisorbæ antarctica*, with its characteristic pale-green leaves almost or quite glabrous on the upper surface. The small-leaved bright-green *Nertera depressa*, another creeping-plant, is also very abundant. Here and there are grass-like tufts of *Scirpus aucklandicus* and the silvery-leaved *Helichrysum prostratum*, and very frequently associated with these are the shining green winter rosettes of *Gentiana cerina*. The feathery leaves of *Cotula plumosa* are especially noticeable, its thick green stems straggling over large patches of ground. Near the sea *Lomaria dura* is a frequent member of the formation.

Turning now to the life-forms of the endemic members of the *Pleurophyllum* meadow, the most striking feature, and that which distinguishes it especially from the subalpine and alpine meadows of the New Zealand Alps, is the very large leaf-surface possessed by some of the most characteristic plants. Similar leaf-development is seen, however, in some other parts of the New Zealand biological area. In Stewart Island and some of the adjacent islands is *Aralia lyallii*, and in the Chatham Islands the magnificent *Myosotidium nobile*, now almost extinct in the wild state (23, p. 302). In Kerguelen Island also *Pringlea antiscorbutica* may be instanced as a parallel development under similar conditions.

Pleurophyllum speciosum has large leaves pressed close to the ground, and forming, according to Kirk, "a flat rosette 3 ft. to 4 ft. in diameter" (56, p. 220). This position of the leaves must be of great advantage in enabling the plant to

resist the wind, and at the same time it prevents the encroachment of other plants. The winter rosettes, as shown above, are much smaller—25 cm., or about 10 in., in diameter. The leaves have white sheathing bases, which in the largest—*i.e.*, the outermost—measure ± 6 cm. long × ± 7 cm. in breadth, and are densely clothed with long silky hairs pressed closely against the surface. The lamina of such a leaf measures 14 cm. × 14 cm. On its under-surface are about twenty-five very prominent, stout, firm ribs forming the boundaries of channels ± 3 mm. in breadth, filled with a loose tomentum These channels gradually narrow towards the leaf-base, and are widest above, measuring in one leaf measured 9 mm. The upper surface of the leaf is much channelled with parallel channels, triangular in cross-section and ± 9 mm. wide from ridge to ridge. On the ridges are many transparent moniliform hairs which stretch over the channels. The general aspect of the leaf, so far as its ridges and channels are concerned, is that of the corrugated iron so much used in roofing in New Zealand, and this corrugated appearance must be still more striking in adult leaves. Within the excellent protection afforded by the leaf-sheaths are the bright pale-yellow leaves of the young bud. A cross-section of the leaf shows a thin-walled epidermis, with the outer wall hardly thicker than the inner ones. Beneath this is a one- or, in places, a two-layered large-celled water tissue. The palisade parenchyma consists of rather short, oblong cells, and the spongy parenchyma is extremely loose, the intercellular spaces being of very large size. The roots are large and fleshy, but my notes say nothing as to their direction in the soil.

As for *Pleurophyllum criniferum*, I did not note it at all on either Auckland or Campbell Island, owing to its habit of dying completely to the ground in winter, the tips of the buds alone just projecting above the surface; nor was it until digging in the bogs of Antipodes Island that I met with this, to all accounts, very common plant. The young bud is closely surrounded by a very thick covering of old leaf-bases in various stages of decay. Kirk describes the adult plant as of a very different habit from *P. speciosum*: "The leaves are usually petioled, and from 1½ ft. to 3 ft. in length, suberect and spreading, forming a ring round the erect scapes" (56, p. 220). In texture they are "membranous, but firm, white with thin tomentum beneath" (58, p. 434). Hooker speaks of this plant "as so bulky that an ordinary specimen weighs many pounds" (46, p. 33), and from this latter it may be seen how great a peat-maker this species must be.

Bulbinella rossii, which in summer has numerous thick, spreading, broad leaves 40 cm. long × 3·5 cm. broad, in winter,

as before stated, exhibits merely the tips of the buds, which reach above the surface of the ground to a height of ± 3·5 cm. Such buds, from certain examples measured, are about 11 cm. in length × 2·26 cm. in diameter. They are somewhat conical in shape, and quite sharp at the apex, thus easily piercing the soil. Above they are pale-green, but gradually toning down to yellowish-green or very pale-yellow at the base. The leaves of the bud are fleshy and imbricate closely, thus protecting the interior of the bud, while the bud itself is protected by a thick covering of the dead bases of the old leaves, consisting mainly of the vascular bundles. The rhizome measures probably 2 cm. or so in thickness, and is concealed by the dense masses of thick and fleshy yellow roots, which usually radiate outwards and downwards from the base of the bud.

Stilbocarpa polaris is a noble plant, somewhat after the manner of the Chilian *Gunnera chilensis*. The large rhizome, measuring ± 8 cm. × ± 7 cm., creeps on the surface of the ground. Usually about six fully developed leaves are given off from an ascending portion of the stem. These leaves are ± 6 cm. broad at the sheathing base, which is furnished with a very large stipule ± 18 cm. long × 10 cm. wide at the apex—its widest part. Such stipules in part enclose the interior bud, against which they are pressed tightly by their concave inner surface, and play a most important part in its protection. The petiole, ± 54 cm. long, is thick, but hollow. The leaf-blade is orbicular reniform. It is ± 19 cm. in length, measuring from sinus to apex, and ± 29 cm. broad. These leaf-blades are more or less in the form of a funnel, through the lobes of the reniform base being bent inwards, and so convey any water which falls on them to the roots of the plant. The leaves on both surfaces and the petioles are furnished with many pale hairs 10 mm. in length, which seem to vary considerably in number in various individuals. Drops of water frequently accumulate on these hairs, but whether they can absorb such, as seems to me likely, can only be ascertained by experiment. These hairs remain unchanged in number in plants cultivated under conditions quite different to those of their natural habitat, judging from a plant I have had in cultivation several years in the neighbourhood of New Brighton, on a sandhill at the back of a wall, sheltered from the north-west, and about 1m. from a small stream of water. The leaf-anatomy of *Stilbocarpa* is of some interest. The epidermis on the under-surface of the leaf is attached only to the veins, thus leading to numerous spaces full of air between epidermis and spongy parenchyma. At first there seems to be an almost colourless tissue of rounded cells between the epidermis and palisade, but evidently these become ruptured and the above-

mentioned air-spaces are formed. The lower epidermis contains large numbers of stomata. The upper epidermis consists of a single row of large rectangular cells which are slightly cuticularised. The assimilating portion of the leaf consists of about six rows of palisade parenchyma, each cell about twice as long as broad, succeeded by the smaller and rounder cells of the spongy parenchyma, the lowermost of which project into the above-mentioned air-spaces somewhat after the manner of the assimilating tissue in the air-cavities of *Marchantia*.

Ligusticum latifolium has leaves ± 60 cm. in length, with a very thick stalk ± 2·5 cm. in diameter. The blade is dark-green in colour, very coriaceous, ovate in outline, and bi-pinnately divided into rather broad segments, which are 3- to 5-lobed, each lobe terminating in a needle-like sharp point. These lateral segments are not flat, but bent inwards, thus bringing the two surfaces into proximity, and the upper half into a vertical position with regard to the light. There are fine *Ligusticums* in both the subalpine region of New Zealand and the moist coastal regions of the South Island, but, as is the case with these Southern Island plants, they nearly always exceed their largest New Zealand representatives in luxuriance of growth. The leaf-anatomy much resembles that of *L. antipodum*, described below, but the stereome of the under-surface is replaced by water tissue, and the spongy parenchyma in the middle of the leaf does not seem quite so open as in the allied species. A specimen which I have had in cultivation for some years side by side with *Stilbocarpa polaris*, as mentioned above, has decidedly thinner leaves than those of plants recently collected on Auckland Island.

Liqusticum antipodum is a rather smaller plant than *Lig. latifolium*, and the leaf-blade is cut into a great number of narrow linear needle-like segments, the ultimate ones being ± 2 cm. long. The leaves of this plant are in part dealt with when treating of the subalpine rocks of Campbell Island There is a thick cuticle on both surfaces. Next to the epidermis is a ring of stereome, which stretches into the interior of the leaf, alternating with broad layers of palisade parenchyma. The arrangement on the under-surface is much the same, but the green tissue is composed of rounded cells. In the centre of the leaf is spongy parenchyma with large intercellular spaces. There are a number of resin-passages Stomata occur on both surfaces, and they are sunken.

Myosotis capitata, although not endemic in the Southern Islands, is by no means a common plant in New Zealand. In winter it presents semi-rosettes of rather thick, soft, dark-green leaves ± 5·3 cm. × ± 6 mm., covered on the upper

surface with bristly white hairs. The stems, ± 6 mm. in diameter, are prostrate, but with the extremities ascending and forming roundish tufts ± 16 cm. in diameter and 6 cm. from the surface of the ground. The leaves are semi-patent, and frequently recurved at their extremities, and dense enough for one rosette to touch the next. A cross-section of a leaf shows that it is dorsi-ventral, with a non-cuticularised epidermis and large intercellular spaces in the spongy parenchyma.

Gentiana cerina has in winter rather dense rosettes, crowded together, of dark-green imbricating leaves, the four or five outer leaves much larger than those crowded internally. Each rosette is about 3·7 cm. in diameter. Such a plant may measure 10 cm. × 8 cm. In spring the rosettes open out and the new branches spread out radially, with their tips ascending.

Cotula plumosa, which is also found in Kerguelen Land, has stout creeping stems 9 mm. in diameter, by which it spreads over the surface of the ground. They are green on the upper but paler on the under surface, and strongly marked with old leaf-scars, the internodes being ± 1·5 cm. long. Rather stout, cord-like roots, furnished with filiform lateral rootlets, are given off from the nodes. Such creeping stems may be quite without leaves for long distances, and serve both as storage and assimilating organs; in a collected plant 25 cm. were quite bare, but no measurements were taken from growing plants. The leaves in winter are in rosettes at the ends of the creeping stems. The very young leaves in the centre of each rosette are protected by a covering of long silky hairs. The leaves have broad sheathing bases, fleshy in the centre and membranous at the margin, tightly overlapping one another, and this further protects the bud. In each winter rosette there are only a few fully developed leaves. These are pinnate, with the pinnæ much divided, the whole leaf having a feathery appearance, as the specific name implies. The upper side of the leaflet-axis is furnished with about 7 segments—there are, in fact, segments from base to apex; but the lower side has segments only near the apex. The segments also are only divided on their outer side. By this arrangement the various portions of the lamina hardly overlap at all. There is also a gradual transition from pinnæ without any lower segments to those with 2–3 segments on the lower side, the two nearest the base having no lower segments. Such a leaf as the above measures 14·2 cm.; the lamina 7·5 cm. × 4·3 cm.; the pinnæ 1·8 cm. × 10 mm. The sheath is 3·5 cm. long × 5·5 cm. wide (when spread out). The remainder of the petiole is stout, almost flat on the upper and rounded on the under surface,

tapering slightly from below upwards, and 2·5 mm. thick × 5 cm. broad towards its centre. The leaves are pale-green in colour. On the blade and sheath are a few straggling hairs. Numerous roots are given off from the leafy portion of the plant, but only a few from the naked creeping stems, and these roots will function especially as holdfasts. *Cotula propinqua* is intermediate between the above and *Cot. lanata*, so need not be further dealt with here.

Celmisia vernicosa has the leaves in densely crowded rosettes 3·1 cm. in diameter in one case measured; but they must very frequently be much larger than this, for the leaves, according to Hooker (47, p. 136), may reach the length of 4 in. (10·1 cm.). Below are the remains of many dead leaves. The leaves are bright-green, highly polished and shining, extremely coriaceous, and with margins recurved. The rosettes frequently form large patches. *Veronica benthami* is described in the part relating to Campbell Island. The remaining plants (spermaphytes and pteridophytes) of this formation are more or less common in New Zealand, and need not be dealt with here.

Perhaps that which is most noticeable about the *Pleurophyllum* meadow when comparing it with related ecological formations in New Zealand—as, for instance, a western subalpine meadow in the South Island—is the very different colouring of the flowers. In the subalpine meadow is the dazzling white of *Ranunculus lyallii* or the various species of *Celmisia*, the yellow-throated but otherwise white *Ourisia macrocarpa*, white gentians, white *Luzula*, the yellow-, white-, or cream-coloured *Senecio scorzonerioides*, and amongst the shrubs are white-flowered *Olearias* and *Veronicas* (these sometimes with a shade of lilac) and yellow *Senecios;* in short, with hardly an exception, all amongst flowers in any way conspicuous are white or yellow.* In the *Pleurophyllum* meadow, on the contrary, are: *P. speciosum*, with disc-florets purple and ray-florets purplish-white; *P. criniferum*, with flower-heads deep-brown; *Lig. latifolium*, with large umbels of reddish flowers; *Lig. antipodum* of similar colour to its ally; *Celmisia vernicosa*, with rays white and disc-florets deep-purple; *Bulbinella rossii*, orange-coloured; *Veronica benthami*, deep-blue; *Gentiana cerina*, white with stripes of bright-red; *Myosotis capitata*, violet-blue fading to purple; *Epilobium confertifolium*, pink Moreover—and this is a very significant fact—with the exception of the *Myosotis*, a rare plant in New Zealand, the whole of the above are endemic, and they are also the dominant plants

* The alpine flora of Australia, as evidenced by the plants of Mount Kosciusco, have, according to Mr. J. H. Maiden, "an enormous preponderance of white flowers," while yellow flowers come next in number (75A, p. 29).

of the formation. Certainly there are some yellow flowers; *e.g.*, *Cotula plumosa* and perhaps *Bulbinella rossii* should be here included. The gentian is described by Kirk as occasionally white. *Helichrysum prostratum* is also found in New Zealand, and it has white flower-heads. The flowers of *Stilbocarpa polaris* I have not seen in the living state; they are described by Kirk as "one-quarter of an inch in diameter, yellow, waxy, shining, with purple centres" (66, p. 215). The remaining plants have all small and inconspicuous flowers.

Thus, the difference so far as colour is concerned between a *Pleurophyllum* meadow and an allied formation in New Zealand proper is most marked. As to how such differences have come about is discussed under another head.

7. *Subalpine Meadow.*

The portion of subalpine meadow visited by me was that just above the forest-line at Camp Cove, in the south of Auckland Island. Here the ground is at a gentle slope, and much cut up by gullies, which are full of scrub. The soil, as elsewhere in the Southern Islands, consists of peat, always more or less saturated with water, and in places so wet that such might be designated semi-bog. This differs considerably in its plant-members from the drier part of the meadow. The dominant meadow-plant is the large coarse-leaved tussock-grass *Danthonia bromoides*, which gives a feature to the landscape, as pointed out by Kirk (56, p. 221), similar to that afforded by its relative, *Danthonia raoulii*, of the Canterbury mountains. The meadow-scenery, in fact, to quote a very familiar instance, much resembles that on either side of the West Coast Road, in Canterbury, between Parapet Rock and the road-crossing at Cave Creek. Dotted about all over the meadow are bushes of *Dracophyllum longifolium* of about the height of an average man, the xerophytic structure, stiff needle-like leaves arranged semi-vertically and confined to the ends of the shoots, enabling this forest-plant to hold its own in the open in the full blast of the subalpine wind. *Cassinia vauvilliersii* is also plentiful, in its case the small tomentose leaves and strong stiff branches being in harmony with its environment. *Coprosma cuneata* is also plentiful, and it, in addition to small leaves of xerophytic form, creeps close to the ground, and in consequence receives much shelter from the tussocks and erect shrubs. On the surface of the ground large patches of various species of moss are abundant, and on the stems of the shrubs are various lichens.

The semi-bog, which forms a distinct plant-association, can at once be distinguished from the rest of the meadow by the presence of the large, round, bright-green, dense cushions of *Phyllachne clavigera*, a bog xerophyte of the typical form

of many other antarctic cushion-plants. *Coprosma repens* covers the wet ground with its rather succulent prostrate stems and small green leaves, and the needle-leaved *Cyathodes empetrifolia* is very common. Growing associated with the above are patches of *Astelia linearis subulata*, the short, stiff, vertical, green portion of the leaf rising above the ground for about 11 mm. This plant spreads into large colonies by means of its long wiry stems, which creep just beneath the surface of the ground. These stems are covered thickly with old decayed leaf-sheaths, and with these and the roots form extremely dense mats 3 cm. or more in depth. The stem proper is marked with old leaf-scars, and measures only 1·5 cm. or less in diameter. Just before issuing from the ground the stem branches into two or three leafy shoots, each furnished with 2–3 green leaves. Such leafy shoots, being quite close, form a rather dense turf. The leaves are $\pm$ 2·1 cm. long, and consist of a pale-coloured sheathing base, which is rather longer than the vertical or semi-vertical shining green subulate lamina. There are a few hairs on the sheath and occasionally at the base of the lamina, otherwise the green portion of the leaf is quite glabrous. The assimilating tissue consists of round cells close together, except on the upper surface, where this tissue is broken into by a rather broad layer of large-celled water tissue reaching to the centre of the leaf. The epidermis is moderately cuticularised, and the stomata are just below the cuticle. This plant differs very considerably from the type, which is altogether larger in all its parts and has leaf laminæ, linear, 5·4 cm. long $\times$ 5 mm. broad, coriaceous, so bent upwards as to make a channel on the upper surface of the leaf, and the midrib and edge of leaf covered with adpressed brown chaffy hairs. The rhizome is also much stouter and more densely clothed with decayed leaves. Mixed up with the above-mentioned plants are various mosses, liverworts, and lichens, which find a suitable habitat on the wet soil, very conspicuous being the beautiful white masses of *Cladonia retipora* or an allied species. Growing through the carpet of *Cop repens* or forming large patches to itself is the filmy fern *Hymenophyllum multifidum*, a striking testimony to the constant moisture of the atmosphere. Growing in this situation it has altogether a different habit to that which it bears as a forest plant. From the slender wiry rhizome creeping amongst the mosses or turf pass upwards numerous erect very dark-brown wiry stipes from 2·9 cm. to 5 mm. in length. The dark-green leaves, which look almost black from the dark colour of the midribs, arch downwards parallel with the erect stipes, and may bury their apical portion or even more amongst the accompanying mosses. The pinnæ likewise are curved vertically downwards,

and the segments, crowded together and with their edges more or less recurved, reduce the leaf-surface into a very small compass indeed compared with the normal form, which has its pinnæ expanded horizontally. Plants of this form cultivated in the moist chamber of the Canterbury College Biological School have their new fronds not in the least degree curled up and of a bright-green, contrasting strongly with the almost black curled fronds. Such young fronds are at first erect, with their pinnæ plagiotropous, but finally the stipes bend so as to bring the whole surface of the frond into a horizontal position * There are other plants belonging both to the wet and dry parts of the subalpine meadow, but my notes only mention the above, for they were taken most hastily. Amongst some of the important plants omitted are *Drosera stenopetala*, *Astelia linearis* (the type), *Juncus scheuzerioides*, *Gaimardia ciliata*, *Oreobolus pumilio*, *Lycopodium fastigiatum*, *L. varium polaris*, and *Schizæa australis*.

8. *Subalpine Scrub.*

The difference in species between the formation of the open meadow and that of the more sheltered gullies and depressions is very instructive, for in the latter position occur those constituents of the forest which have a less marked xerophytic structure than those which can exist as plants of the meadow, and which in the latter situations certainly become more stunted, but otherwise are of perfect vigour. Thus, in the gullies are found some of the arborescent forest-plants, small trees no longer, but now dense shrubs, forming, so far as form goes, a typical "subalpine scrub," such as might occur above the forest-line of a New Zealand mountain. *Metrosideros lucida* and *Panax simplex* are both present, but now no taller than the accompanying *Suttonia divaricata*. Here, too, is the prostrate *Coprosma cuneata*, and most likely *Cop. ciliata* and *Cop. parviflora*. Scrub such as this is even more difficult to penetrate than is the western subalpine scrub of a South Island mountain, and in consequence, as it was late in the afternoon when I reached the subalpine meadow, and as these gullies full of scrub had constantly to be crossed, I had no time to see the vegetation of a mountain-summit in the Auckland Islands, the place *par excellence* where any novelties might be expected to occur.

II. CAMPBELL ISLAND.

GENERAL REMARKS.

Campbell Island lies in latitude 52° 33′ S. and longitude 169° 09′ E., and is distant 145 miles south-east of Auckland

* By March, 1904, the new fronds of the curly leaved form were identical with those of the type.

Island and 330 miles south by east from the South Cape of Stewart Island. It was discovered in 1810 by Frederick Hazelburgh, master of the brig "Perseverance," who described the island as being thirty miles in circumference, and the country mountainous (90, p. 417).

The general configuration of the island can be seen from the accompanying map. Although the mountains are not quite so high as those of the Auckland Islands, they are somewhat steeper and more rocky. The coast-line for the most part consists of abrupt cliffs not unlike those near the entrance of Akaroa Harbour, and it is described by Hooker as, "Iron-bound as that of St. Helena, the rocks assuming even a wilder and more fantastic form." Buchanan's drawings (9, pl. xxxviii.) give some idea of the island as seen from the sea.

The "Hinemoa" stayed the whole of two days, so I was enabled to see a good deal of certain parts of the island, ascending the first day to the summit of Mount Honey, 568m., the highest point on the island, and on the second day crossing over Lyall's Pyramid from Perseverance Harbour to North-east Harbour. My notes are therefore confined to the country in the east of Campbell Island, much of which, as may be seen further on, is no longer in its primitive condition, owing to fires and the grazing of sheep for some seven years past.

CLIMATE.

From Mr. Gordon, manager of the sheep-run on Campbell Island, I have received very many valuable details respecting the climate. This, on the whole, seems very similar to that of Auckland Island. There is the same lack of sunshine and similar frequent gales accompanied by driving rain and sleet, especially in spring and autumn. The driest period, if we can speak at all of such in these Southern Islands, is from November to May. Sunshine is most frequent during the summer months, but even when bright at sea-level there is generally more or less fog on the higher peaks. The snowfall at sea-level is very slight, Mr. Gordon having noted 76 mm. as the heaviest fall during a period of seven years. Such snow comes in blasts from the south-west, while these gales are frequently accompanied by hail. During five winters the thermometer at sea-level only registered 2° Fahr. of frost. In what I designate the "subalpine region" the frost is certainly much stronger than the above. Although on the day when I climbed Mount Honey there was no frost at sea-level, above a certain altitude the ground was frozen so hard that I could not dig up the plants in order to examine their subterranean organs; but there was no general covering of snow, only a few patches here and there. Such frost without a pro-

tective covering of snow subjects these plants to comparatively severe conditions—much more severe, in fact, than any to which the plants of lower levels are exposed. As for rain, really heavy rain—according to Mr. Gordon—is not very frequent; usually it is a fine drizzle. In short, there must be a great number of rainy days, but no excessive annual rainfall.

GEOLOGY.

According to Hector (40, p. 737), Campbell Island is a volcanic mass, but has the peculiar feature of having, slightly above sea-level, the original rock-formation on which it is founded. On the north and south it presents fantastic peaks and precipices carved out of rocks of the same character as those which form Otago Peninsula. Towards the southern end it is traversed by Perseverance Harbour east and west, which is by a moderately high saddle connected with West Harbour. On the north and south of this rift are frowning cliffs and peaks of basaltic lava-sheets; but at the sea-level there is an exposure, both on the east and west coasts of the island, of the Upper Cretaceous rocks, with chalk flints and fossil wood, such as is found in New Zealand in the Upper Amuri series. These have been brought to the surface-level together with the volcanic outburst, as they are injected and interstratified with dykes and tufa rocks of the same kind. The wonderful mystery of the occurrence of fossilised dicotyledonous wood in the far south latitude of Campbell Island is therefore thrown entirely out of the distribution of plant-life in Tertiary times, and must be referred to the Cretaceous epoch. At an altitude of 800 ft. clear evidence of the existence of a true corrie and moraine of the first order was obtained, but it is purely local, and is the only evidence of former glacier-action observed.

According to Filhol (35*a*, p. 261), Campbell Island is formed of a band of limestone and lavas. "The limestone band is jammed between two coral dykes, the overflow from which has partly covered it. This layer, the thickness of which is about 70 metres, has evidently been formed in a very deep sea. Fossils are absolutely wanting in it, and micrographic sections have only enabled me to note the presence of *Globigerina*. This limestone, which is of a yellowish colour, is not met with again in any part of New Zealand. Its upper surface at those parts where it is not covered by the lava is not overlaid by any terrestrial deposit." "It is perfectly certain that the geological age of the island, constituted as we now see it, corresponds to the epoch of the appearance of the volcanic eruptions." "The limestone which the eruptions of Campbell Island have brought up, or which perhaps by its fracture has formed a passage for the lava, must have been

formed during Post-pliocene periods—that is to say, in the epoch during which New Zealand possessed its last great geographical extension. It was not, therefore, before the very end of the Pliocene that Campbell Island as it now exists appeared above the surface of the sea." This account of Filhol's differs very materially from that of Hector; as to which is the more correct I can offer no opinion.

THE PLANT-FORMATIONS.

The plant-formations consist, so far as I was able to ascertain, of the following: (1) Stony shore; (2) scrub; (3) lower tussock meadow; (4) subalpine tussock meadow; (5) *Rostkovia* formation; (6) subalpine rocks. There are doubtless also lowland swamps, maritime-cliff vegetation, running-water vegetation, while possibly certain combinations of plants which I did not meet with may constitute formations or associations. Indeed, here as elsewhere for these Southern Islands my account and classification of the plant-formations is but provisional. Most of the life-forms of the endemic members of the formations have been dealt with in the part of this paper referring to Auckland Island, but one or two more common in Campbell Island than in the Auckland Group, as well as those endemic to the island under consideration, are dealt with when describing the formations of which they form a part.

1. *Stony Shore.*

An extremely rapid examination was made of the stony shore along the south of North-east Harbour. Here *Ligusticum latifolium* comes right on to the stones of the beach, accompanied by *Stilbocarpa polaris*, which does not approach so near to the water's edge. Creeping over the stones is *Cotula lanata*, and growing here and there amongst them is a small grass, in general appearance not unlike *Danthonia australis* (11, pl. xxxi.), but which I cannot identify until a specimen in cultivation flowers. Wherever rocks are present are the cushions of *Colobanthus muscoides*. Altogether, this formation is very similar to that of the stony sea-shore of Auckland Island.

2. Dracophyllum *Scrub.*

There is no arborescent growth to which one can with truth apply the term "forest" on Campbell Island. The scrub may vary considerably in height according to the degree of shelter it receives, but everywhere there are only shrubs, and not low trees with bare trunk and spreading crown beneath which one can walk, as in the forests of Auckland Island. Most probably the absence of forest depends upon the slightly stronger winds and much less shelter

to be found than in Auckland Island, dependent upon the configuration of the ground and to some degree upon the smaller size of the island. On Antipodes Island, as will be seen further on, the scrub attains still smaller dimensions, and has almost reached the vanishing-point, while on Macquarie Island there is no scrub at all (39). These islands, then, as a whole, afford an instructive example of how arborescent plant-formations even in a rain-forest climate may be inhibited by frequent and violent winds and their place taken by meadow growths, which, notwithstanding the wind, are so stimulated by the moisture as to be of very great luxuriance.

The arborescent constituents of the scrub are the following: *Dracophyllum longifolium*, *Dracophyllum* sp. (not identified) *(Ericaceæ)*; *Coprosma cuneata*, *Cop. ciliata*, *Cop. parviflora (Rubiaceæ)*; *Suttonia divaricata (Myrsinaceæ)*. From this it appears that this formation is closely allied to the subalpine scrub of the Auckland Islands.

Seen at a distance, as from the deck of a ship in either of the harbours, the *Dracophyllum* scrub of Campbell Island presents an even surface, and puts one in mind of the *Leptospermum* scrub so common on poor soil in many parts of New Zealand. It occurs on both sides of Perseverance Harbour, especially near the entrance and on the north side, where, however, it has been much burned. The long comparatively flat valley leading inland from the head of North-east Harbour is filled in many places with scrub, which ascends thence to a considerable height up the slopes on both sides of this valley. Generally speaking, the shrubs grow closely together, and are of the most extremely dense habit of growth. There is nothing in my experience of quite a number of dense forest and scrub growths in New Zealand more difficult for one to penetrate than this *Dracophyllum* scrub of Campbell Island. In many places one has to crawl beneath the stiff masses of branches, but in other cases this is quite impossible, and one has to scramble over the tops of the shrubs. Happily, here and there open spaces occur, especially in the neighbourhood of watercourses, where there are dense masses of herbaceous plants, and such spots afford breathing-places.

The dominant constituent of the scrub is the unidentified species of *Dracophyllum* mentioned above.* It varies considerably in height, averaging perhaps 1·5m., but is frequently of lower growth. It possesses numerous densely growing, strong, erect, rather brittle branches covered with almost black bark. These branches are again much branched, and furnished near their extremities with a close mass of short leaves. The secondary branches pass from the main stem at an acute angle, curving slightly inwards. The ulti-

* Perhaps a form of *Dracophyllum scoparium*, Hook. f.

mate branchlets pass upwards from the stem at a very acute angle, thus bringing the leaves into an almost vertical position. The leaves are short and narrow, ± 14 cm. in length × 1 mm. in breadth, concave and pubescent on the upper surface and convex on the under-surface. They are so densely crowded together as frequently to touch one another. Where this scrub was tallest a stem measured 8 cm. or 9 cm. in diameter at 90 cm. from the ground. Mixed with the *Dracophyllum* is *Suttonia divaricata*, but the amount present of this dense shrub varies in different places. Where the scrub is tallest there is mixed with it a small proportion of *Dracophyllum longifolium*. Where the scrub becomes more open *Coprosma cuneata* is a constituent, knee-deep, and so, much more luxuriant than on the wind-swept hillside; also, there are large patches of *Lomaria procera*. The leaves of *Dracophyllum longifolium* are much more spreading than those of its vertical-leaved ally, and the two species can easily be distinguished from one another at some distance away. The scrub frequently merges into the *Danthonia* meadow, and the two formations thus become intermingled, or occasionally the large grass may be a constituent of the scrub proper. In the former case we have probably a line of tension between scrub and tussock meadow. Such mixture of tussock and scrub was especially noticeable on the north side of Lyall's Pyramid, and is described at some length further on.

The floor of the scrub varies both in the density and character of its plant-covering according to the openness of the scrub and the moisture-content of the soil. Where the scrub is extremely dense there is little on the ground beyond a carpet of dead *Dracophyllum* leaves, sometimes 15 cm. in depth. If the bushes are a little further apart *Aspidium vestitum* makes its appearance, in company with *Lomaria procera*, and seedlings of the different shrubs are common. With still greater openness of the scrub *Lomaria procera* becomes taller and more abundant, growing in company with stunted *Coprosmas* and small plants of *Dracophyllum* sp. Here, too, rather tall clumps of *Lycopodium varium* are a conspicuous feature, while where the ground is unoccupied by other vegetation is a carpet of mosses, liverworts, and lichens. Very frequently some of these mosses or liverworts form mounds, on which grows abundantly the filmy fern *Hymenophyllum multifidum;* or mosses, liverworts, and ferns may be mixed up with the prostrate branches of *Coprosma cuneata*. In this part of the formation *Epilobium linnæoides* is always present to a greater or lesser extent.

Sometimes the various *Coprosmas* and *Suttonia divaricata* are more abundant than the *Dracophyllum*, and in sheltered places attain a height of 1·7m.

The conditions of life for the plants of the floor of this formation are quite different from those to which the scrub as a whole is exposed, and which regulate its distribution and define its components. Where one sits down within the shelter of the scrub the air is quite still, while the wind can be heard plainly whistling overhead.

That comparatively open spaces exist within the domains of the scrub was pointed out above when speaking of its density. Such are occasionally met with on the southern slopes of Lyall's Pyramid, and increase in number as North-east Harbour is neared. Here are associated together many of those fine herbaceous plants which were described when treating of the *Pleurophyllum* meadow of the Auckland Islands, and probably this association of plants is a formation distinct from the scrub, owing its existence to greater moisture in the ground and protection from the scrub. In such situations the great leaves of *Ligusticum latifolium*, with their stout petioles, are more than knee-deep. Where the ground becomes a little wetter still is *Pleurophyllum speciosum*, its leaves larger and less decayed than in the meadow formation. These same plants, and, most of all, *Stilbocarpa polaris*, follow the many watercourses which cut into the hillside, and grow luxuriantly in the running water. On the banks of such streams the small buttercup, *Ranunculus subscaposus*, is abundant. This plant so far has only been found in Campbell Island. According to Hooker it is quite rare (46, p. 5), for during the Ross expedition only one specimen was discovered. Hooker subsequently referred an allied New Zealand buttercup to this species (48, p. 7), but Kirk very rightly separated this latter from *R. subscaposus* in the "Students' Flora," giving it the name of *R. foliosus* (66, p. 14). I collected a number of living plants of *R. subscaposus*, and two are now growing well on the Canterbury College rockery, one of which bloomed on the 25th October. The leaves of *R. subscaposus* are somewhat cordate in outline, trifoliate, with leaflets cuneate at the base and three-lobed above. Both petiole and lamina on both surfaces are densely covered with appressed whitish* hairs. The petiole is stout, and 2·2 cm. to 3·8 cm. long in the plants examined; the lamina is 2 cm. × 1·8 cm. The petals are yellow, with a broad band of brown, which is most noticeable at the back of the petal.

The transition between tussock meadow and scrub, mentioned above, and which may be designated "tussock scrub," consists of tussocks of *Danthonia bromoides* ± 1·6m. tall and

* In the "Flora Antarctica" the hairs are described as of a tawny-yellow colour.

large bushes of *Coprosmas* mixed with *Aspidium vestitum;* but these two latter are not so tall as the tussock. At distances of about every 12m. the ground is cut by deep gullies having running streams in their bottoms, their sides covered with scrub and their bottoms filled with a dense mass of *Ligusticum latifolium*, *L. antipodum*, and *Stilbocarpa polaris*. The *Danthonia* tussock has been already described. As for the *Coprosmas*, they consist within of dense masses of bare interlacing twiggy branches. On the periphery alone of such bushes is the actual green part of the plant, and this leafy zone only penetrates into the plant for perhaps 7 cm. at most. Looking from the north side of Lyall's Pyramid at the slopes bounding the opposite side of the flat valley filled with tussock and tussock scrub, they are seen to be curiously marked below by brown tussock meadow on the ridges, while very irregular-shaped masses of scrub or tussock scrub define the main and tributary gullies. Above all this is an even formation of sub-alpine tussock meadow. Passing through the tussock scrub, and keeping at a uniform height on the hillside, crossing in the meanwhile gully after gully full of vegetation as described above, wetter ground than the average is here and there encountered. Such contains a different assemblage of plants to the tussock scrub proper, and should really be described under another head, but for convenience' sake it is dealt with here. It is especially instructive in showing how a change in the water-content, even in a region where all the normal soil is fairly saturated with water, will at once bring about a marked change in the vegetation. On such a spot, which was specially examined, the *Danthonia* tussock, although still present, was much reduced in size; *Pleurophyllum speciosum* and *Pleur. hookeri* were very plentiful; *Lomaria procera* carpeted the ground in many places and gave a character to the whole. The common *Dracophyllum* was dotted about, but here again a characteristic plant of another formation was much reduced in size, the plants being less than 30 cm. in height, in other places the carpet consisted of a small *Juncus* (*J. scheuzerioides ?*), liverworts, mosses, *Coprosma repens*, *Helichrysum prostratum*, *Ligusticum antipodum*, tufts of *Lycopodium varium* or *Lycopodium fastigiatum* rising up here and there; while everywhere *Coprosma* bushes, these much stunted, were scattered about. Large breadths of *Hymenophyllum multifidum* and hummocks of mosses and liverworts about 30 cm. in height were abundant, while the ever-present lichens, both foliaceous and fruticose, gave colour, their whites, yellows, and browns contrasting finely with the many hues of green. In some places water trickled over and in others stones cropped out of the wet peaty ground. Finally, there were many large clumps of *Bulbinella rossii*.

3. *Lower Tussock Meadow.*

Buchanan writes (9, p. 398), "The whole coast-line is rugged in the extreme, although inland large flat areas may be seen apparently covered by grasses and indicating rich pasture. This appearance, however, on closer examination, is found to be deceptive, as but few grasses exist, and a coarse wet cyperaceous pasture prevails, which would prove worthless for feed except for cattle of a hardy breed that would stand the rigours of the climate. There is no doubt, however, that on the lower levels, where soil can accumulate, a rich though coarse vegetation exists; but the land is so spongy and wet that the finer grasses cannot thrive. The extreme wetness of the soil is shown by the fact that wherever a plant is dug out with a knife the hole immediately fills with water, and an indication is thus obtained of the treatment such plants should receive when it is attempted to grow them in a drier climate."

However true the above may be as regards certain portions of the island, it certainly does not in the least apply to the parts visited by me, and extending from sea-level to the tops of two of the hills, one the highest on the island. It may be that there are low-lying tracts occupied chiefly by *Carex*, but so far as my investigations went, except where there was scrub, grasses and not cyperaceous plants abound, and the tussocks which densely clothe the mountains from summit to base are of grass and not of sedge, while small grasses of various kinds are by no means uncommon. Moreover, such tussocks are at the present time feeding 4,500 sheep, and this on at most only one-half of the island. As for the wet nature of the ground, it certainly does contain a great deal of moisture, but even in the middle of winter water cannot be generally wrung out of the peat; nor did any hole made by me in digging for plants fill with water, as, *e.g.*, in the bogs of Chatham Island.

The lower tussock meadow forms a more or less distinct zone on the hillsides from the sea-level to a height perhaps of 150m., where it is succeeded by a second zone of meadow, to which I have given the name "subalpine tussock meadow," above which comes a third but narrow zone where *Rostkovia gracilis* is the characteristic plant, while above and through this latter is the final zone, that of the rock-plants.

In no place where I was able to examine the lower tussock meadow was it in its virgin condition. Everywhere on Mount Honey, where at one time this formation must have been typical, have sheep grazed for some years, and their effect has been so marked that it is dealt with under another heading. But even now it is not hard to form a very fair

idea of what the virgin formation was like, for although many plants are destroyed their remnants remain. Some few places still approximate to the primeval condition, and—most important of all—introduced plants have not as yet appeared in any quantity, and so increased enormously the difficulty of determining the character of the virgin formation.

The dominant plant is a tussock-grass with long narrow filiform leaves, probably a species of *Poa*—perhaps, indeed, identical with the meadow tussock of Antipodes Island, referred by Kirk to *Poa anceps*. My specimens, collected in midwinter, were too poor for identification; even Mr. D. Petrie, whose knowledge of the New Zealand grasses is so thorough, could make no definite statement as to the species.* By Mr. Gordon, of Campbell Island, it is called "silver-tussock," and that name will serve admirably for the present.

With the silver-tussock is mixed occasionally a little *Danthonia bromoides*, and everywhere in the open spaces between the tussocks are the great colonies of *Bulbinella rossii* which attracted the attention of Hooker so that he wrote (46, p. 73), "It" [*Bulbinella*] "covered the swampy sides of the hills in such profusion as to be distinctly visible at a full mile from shore." Similarly, the allied but smaller *B. hookeri* clothes many hillsides in the lower mountain region of the South Island with sheets of yellow. In these same open places *Pleurophyllum speciosum* was very frequent, while the dark-green *Aspidium vestitum*, the brown-coloured *Lomaria procera*, and prostrate bushes of *Coprosma ciliata* were common. These bushes are in some places flattened close to the ground; in other places, where the shelter is greater, they may be about 1·9m. long × 90 cm wide × 90 cm. tall. Their surface is sometimes flat, as if cut by shears, or at other times marked by long longitudinal ridges. They form extremely dense, large, flattened, pale-green hummocks, with bare, much-interlacing, rather thick, twisted branches beneath, looking not unlike stems of lianes; but the dense green surface, composed of quite small leaves, is at most 9 cm. or 10 cm. in depth. In some cases reversion-shoots are given off from the base of the plant, in the shelter and dim light of its interior, having very much larger leaves than those of the adult, and being almost identical with those of seedlings. In one seedling examined the stem was densely pilose; leaves ovate-oblong with rounded or cuneate base, pale-green, ciliated, a few hairs sometimes on the upper surface of the lamina, but always on the midrib. Petiole densely hairy,

* Since writing this Mr. Petrie informs me that the Antipodes Island tussock was the one he had referred to *Poa chathamica*, but that he, and probably Mr. Cheeseman also, now considers it to be a new and unnamed species.

3 mm. long; lamina 1·6 cm. × 1·1 cm., veins distinct. No pits, so common in *Coprosma*,* were noticed on the back of the leaf.

With the bushes of *Coprosma ciliata*, *Aspidium vestitum* is frequently mixed. Here and there, growing through the bushes or mixed with the tussock, were the rather shaggy naked stems of *Veronica benthami*, a shrub confined to the Campbell and Auckland Islands. These stems are marked with many old leaf-scars, but above are quite green. The leaves are crowded together at the extremities of the branches; they are thick, rather soft, narrow obovate-oblong in shape, dark-green, and their margins are edged with a pale-coloured tomentum. In size they are about 3 5 cm. × 1·4 cm. With regard to the light, the surfaces of the lower and larger leaves are horizontal or frequently arch downwards somewhat. The structure is that of a typical dorsi-ventral leaf. Nearer the apex of the shoot the leaves are smaller than those below, broader in proportion to their length, and loosely imbricating. The flowers are in racemes, which lengthen considerably during flowering, each flower subtended by a very large green leaf-like bract. The petals are a most clear violet-blue marked by very narrow lines of a still deeper blue.

Where the ground becomes wetter the character of the formation changes. There the surface is carpeted with the brown fronds of *Lomaria procera*, amongst and over which trailed the silvery-leaved *Helichrysum prostratum*. Through the *Lomaria* grow tussocks of *Carex appressa*.

The following extract from my notebook affords some idea of a general view of a piece of lowland meadow: "Large breadths of *Lomaria procera* mixed with stunted *Carex appressa*, low bushes 16 cm. tall of *Coprosma parviflora*, little conical cypress-like shrubs of *Dracophyllum scoparium* 30 cm. to 60 cm. tall dotted here and there, yellow tussock waving in the breeze everywhere except where *Lomaria procera* is abundant." These little *Dracophyllum* shrubs have naked dark-coloured stems for half or less than half their height.

From the above it may be seen that there are two distinct associations of plants included under my term "lowland tussock meadow," more or less sharply separated from one another by the amount of moisture in the ground: on the drier ground silver-tussock is dominant, and on the wetter a fern—*Carex* association. All the same, many of the meadow plants are common to both associations, and appear to thrive equally well either in the drier or moister ground. It must

* Greensill, N. A. R.: "Structure of Leaf of certain Species of *Coprosma*." Trans. N.Z. Inst., vol. xxxv., pp. 342, 355. 1903.

be borne in mind that the term "dry" is here merely comparative.

The soil of the formation as a whole consists of spongy peat, which is elastic underfoot. The surface is at first gently sloping, but becomes steeper as one proceeds up the mountain-side. Except within the gullies, and these in consequence filled with scrub, all the hillsides of Campbell Island must be much wind-swept; indeed, it seems evident that wind is here, as on the uplands of Auckland Island, the determining factor as to whether arborescent or grassy growth shall predominate.

4. *Subalpine Tussock Meadow.*

The presence of this formation, and also those next to be considered, probably depends upon the greater severity of the climate, arising from frosts being much more severe and of very much longer duration than at a lower level, the frequency of such frost unaccompanied by snow, the greater exposure to winds—these at times must be of the most extreme severity—and, finally, the smaller amount of sunshine and the almost constant presence of mist. The soil of this formation is similar to that of the lower tussock meadow.

The dominant plant, as in the subalpine meadow of Auckland Island, is *Danthonia bromoides*, in many places growing very thickly. Between the tussocks are large quantities of *Pleurophyllum hookeri*, in winter its leaves projecting above the ground to a height of ± 7 cm., and the leaf-blades of the previous year, 17 cm. × 7 cm., forming a decaying mass spread out radially round the plant. Creeping over the surface of the ground are in many places considerable breadths of *Coprosma repens*, while *Helichrysum prostratum*, *Nertera depressa*, *Stellaria decipiens*, *Epilobium linnæoides*, *Epilobium confertifolium*, and *Lycopodium fastigiatum* are common. As in the lowland tussock, *Aspidium vestitum* and bushes of *Coprosmas* give an additional character to the physiognomy of the formation. Where the ground is wettest *Sphagnum* appears, and in conjunction with this bog-moss are a number of other plants, some of which are truly bog-plants, while others are prominent members of very different formations. Of the above plants the most striking are the large, bright-green, hard cushions of *Phyllachne clavigera*, patches of *Hymenophyllum multifidum* with curled-up fronds, as previously described for the subalpine meadow of Auckland Island, *Coprosma repens*, much-stunted *Coprosma* bushes, *Pleurophyllum hookeri*, *Pleurop. speciosum*, *Epilobium confertifolium*, large patches of *Bulbinella rossii*, and very many lichens.

Of these plants the only one which needs detailed treatment here is *Pleurophyllum hookeri*, which is by far the most

common representative of that genus in the subalpine region of Campbell Island. This species was originally described, and also figured, by Buchanan in 1884 (10, p. 395); later on Kirk gave it the MS. name of *P. gilliesianum*, and still later described it under the name of *P. hookerianum*, J. Buch. (58), a slip which he corrected in the "Students' Flora," where the plant is described as *P. hookeri*. According to Kirk (58, p. 435) the adult-leaves are 6 in. to 10 in. long by 3 in. to 4 in broad, white on both surfaces with silky, lax, or close tomentum, and, appressed to the ground, form a rosette. From each plant from one to three scapes are given off, 15 in. to 24 in. tall, which bear—from Kirk's plate of this species—some 20 hemispherical or almost globose heads $\frac{3}{4}$ in. in diameter. The ray-florets are few or wanting, and are of a deep lurid-red or reddish-purple.

In winter a clump of *Pleurop. hookeri* may occupy a space of $\pm$ 46 cm. $\times$ $\pm$ 30 cm., and consists of a number of short rosettes (buds) surrounded by the dead leaf-blades of the previous year, as stated further back. The leaves of the largest rosettes are semi-erect, or those with very short leaf-apices quite erect, and densely imbricate, especially at the base, the plant in this condition reminding one rather of the habit of *Celmisia verbascifolia* than of a *Pleurophyllum*. Surrounding these living leaves is a dense mass of old decayed leaf-bases sopping with water. Stripping off these dead leaves, in one particular instance the column of living leaf-bases measured 2·26 cm. in diameter, but with the sheath of dead leaves the diameter of the whole was 6 cm. In another case measured the dead and living leaf-bases taken together were 23 cm. in circumference. The winter leaves are broadest at the base—3·5 cm.; but the margins remain almost parallel for most of the length of the leaf, finally converging into an acute point 3·3 cm. long at 5·5 cm. from the apex. The sheathing bases are extremely silky, with long hairs pressed upwards against the surface of the sheath. Such hairs are $\pm$ 2·3 cm. long, very silvery and glistening, especially those which cover with a thick loose mass the back of the sheath. The leaf as a whole is rather flaccid, and coloured pale-green where exposed to the light. The margin and adjoining portion of the sheath is membranous, but elsewhere, and especially towards the centre, it is fleshy. The rootstock is $\pm$ 2·4 cm. in diameter. The roots are numerous, thick, and fleshy. Seen from a distance the rosettes are of a whitish-green colour.

5. *The* Rostkovia *Formation.*

At a certain altitude on a Campbell Island mountain the formation now to be described forms a very distinct zone, which is especially noticeable since its physiognomy differs

altogether from that of the tussock meadow, owing its characteristic stamp to the numerous yellowish-brown (in winter) tufts of *Rostkovia gracilis*, 28 cm. in height, which form considerable patches, but not appearing as tall as they really are owing to their waving in the wind. Growing side by side with the *Rostkovia* in large quantities is *Pleurophyllum hookeri*, and this, when in flower during the summer, will doubtless be the most striking feature of the formation. Large green cushions of *Phyllachne clavigera* are everywhere abundant, some of them of great size—*e.g.*, 66 cm. × 40 cm. and 20 cm. high—the extremities of the shoots rooting in the decayed leaves now turned into peat, and which make up the chief bulk of the cushions. Each main shoot of this interesting plant branches near its extremity, giving off several short shoots 1 5 cm. in length, the upper 6 cm. of which are densely clothed with very small imbricating green leaves. These final shoots are all pressed tightly together, and make apparently a solid convex mass. The leaves are very thick and coriaceous, expanded at the base, convex on the under (outer) surface, but slightly concave on the lower half of the upper (inner) surface, but flat on its upper half. They are not quite erect, but the globose tips point slightly outwards. This plant, then, is of that typical bog xerophytic form, as pointed out before, common to many New Zealand, Fuegian, and Andean plants, and which reaches its climax in the vegetable sheep of New Zealand, which, however, are not bog-plants, but denizens of sunny alpine rocks.

Other common members of the *Rostkovia* formation are *Luzula crinita*, *Helichrysum prostratum*, a species of *Cardamine* spoken of further on, one or two small grasses, *Polypodium australe pumila*, *Ranunculus subscaposus*, *Abrotanella rosularis*, *Hymenophyllum multifidum* (the mountain form), while everywhere are mosses, lichens, and, most of all, liverworts.

The *Rostkovia* formation usually occurs among the stony *débris* at the bases of the cliffs near the summits of the hills. This *débris*, the result of that weathering which has formed the steep faces of the cliffs, is for the most part mixed to no small extent with the peat which has accumulated from the decay of many generations of plants Here and there large rocks are lying on the ground covered with crustaceous lichens, white and yellow. In other places are patches of *Sphagnum*, and water oozes frequently out of the ground and trickles over its surface.

Where the stony *débris* has little or no peat mixed with it spermaphytes are almost absent, but there are numerous lichens and mosses. In such situations, however, here and there are the bright-green rosettes of a species of *Cardamine*

6·5 cm in diameter. The leaves are dark-green, pinnate, with three leaflets on each side, thick and fleshy, the petiole deeply channelled and broadening gradually to the base. The largest leaflets measure 5 mm. × 6 mm. The outermost leaves are flattened against the stones, the remainder spreading upwards and outwards at about an angle of 45° from the vertical. The buds appearing on cultivated plants at the end of October are sheltered by the innermost leaves. A transverse section of a leaf shows a thin-walled epidermis on both surfaces, having also equally abundant stomata both on the upper and under surface, a two-layered palisade, and an open spongy parenchyma. This structure is remarkably hygrophytic for a plant whose characteristic station is stony *débris*, and it eloquently testifies to the abundant moisture of the atmosphere. The closeness, also, with which the plant hugs the soil will protect it much from the action of the wind, and the water of the stony substratum will be quite different in its humus-acid content from that of the wet peat.

6. *Subalpine Rocks.*

The summits of the hills of Campbell Island are very rocky. The final peak of Mount Honey is composed entirely of rocks, much weathered, as may be well imagined in a situation so exposed. The summit of the ridge of Lyall's Pyramid consists for a large part of steep rocky faces; in fact, in many places such may be called cliffs. In these rocks are frequently hollows, small gullies, ledges, irregularities, and crevices, in or on which are often considerable quantities of peat; in fact, peat is always present wherever it is possible for such to lodge. In many cases the rocks drip with water, or sometimes they are dry; but even where this is the case the rock, owing to the excessive moisture of the climate, offers by no means an unfavourable station for certain forms of plant-life. In a dry climate rock-vegetation may be scanty or perhaps altogether wanting in places, but there are hardly any spots entirely unsuitable for plants.

The rock-plants proper are few in number. Leaving out of the question certain mosses, liverworts, and lichens, they are: *Ligusticum antipodum (Umbelliferæ); Colobanthus subulatus (Caryophyllaceæ); Abrotanella rosularis, Abrotanella spathulata (Compositæ); Hymenophyllum multifidum* (subalpine form); *Polypodium austr pumila (Filices);* one or two small unidentified species of grass (*Gramineæ*). This is a very small list, while the whole of the species, moreover, occur in other formations, and in the case of the *Ligusticum* and *Hymenophyllum* in great profusion

An exact account of the distribution of the vegetation o

the subalpine rocks of Campbell Island with regard to the physical conditions afforded would be an interesting study, but here only a few details can be given regarding certain specified spots.

On the face of a precipitous rock facing north-west, not far from the summit of Mount Honey, at an altitude of about 538m., the vegetation consists of lichens, mosses, small cushions of *Colobanthus subulatus*, and stiff rosettes of *Abrotanella rosularis*. In the chinks of the rock grows the curious little fern *Polypodium australe pumila* and *Ligusticum antipodum*, here very much smaller and with stiffer and more coriaceous leaves than when occurring at a lower level as a meadow-plant.

On the dry wind-swept rocks of the actual summit of Mount Honey, at an altitude of 568m., are various species of lichens, some mosses, *Polypodium australe pumila*, *Ligusticum antipodum*, *Phyllachne clavigera*—here a rock-plant, just as the closely related bog-plant *Phyllachne colensoi* frequently is in the Southern Alps—a small unidentified grass, and *Luzula crinita*.

On Lyall's Pyramid, at an altitude of about 153m., facing south, a rock dripping with water is covered densely with mosses, liverworts, *Hymenophyllum multifidum* (or perhaps here it was *H. villosum*) to a depth of 9·3 cm., and through this grows the small *Polypodium* and *Ligusticum antipodum*. This has the bases of the leaves densely sheathed with old leaf-bases. The leaves arch upwards and outwards radially, with the result that many of the stiff needle-like pinnæ are almost vertical and others horizontal. Each primary leaflet finally arches downwards. In a position such as this the conditions, although on a rock, are not very different from those of a bog, except that the water will be distinctly more pure.

A rich vegetation occurs in the hollows between the rocks where there is plenty of soil and moisture. Here, as described above, is a dense carpet of mosses, &c., through which are growing *Rostkovia gracilis*, prostrate *Coprosma cuneata*, *Ligusticum antipodum*, *Helichrysum prostratum*, *Ranunculus subscaposus*, *Celmisia verricosa*, *Celmisia chapmanni*.

In wet sheltered hollows of the cliffs on the north side of Lyall's Pyramid *Ligusticum antipodum* is very abundant, its leaves usually pressed closely against the rock.

Steep rock-faces are covered for large breadths by the subalpine form of *Hymenop. multifidum* and a species of *Cladonia*, but where the rock offers a flat surface and peat can form in which moisture can lodge *Ligusticum antipodum* forms an almost close formation, mixed with *Phyllachne clavigera*, stunted *Coprosma cuneata*, *Coprosma repens*, and a small grass,

the whole growing through a most dense and thick carpet of mosses, &c.

But the richest rock-vegetation of all is found in those sheltered hollows large enough for peat to have accumulated in abundance. In such spots is a rich vegetation of the large herbaceous plants common to the Southern Islands. *Pleurophyllum speciosum* and *Pleur. hookeri* are abundant; *Veronica benthami* and *Celmisia chapmanni* both grow most luxuriantly; *Ranunculus pinguis* and *Azorella reniformis* are more or less plentiful. But I had no time to take a list of all the plants of such a station, which, so far as I can recollect, contained representatives of most of the herbaceous plants of the island. And it is easy to see how such a station as this is very favourable for plants, since the very conditions are here present which experience has found essential for the cultivation of difficult alpine plants—viz., shelter, a porous soil, abundance of pure water, perfect drainage—conditions which are more acceptable possibly to *Pleurophyllum*, &c., than those offered in some of its usual habitats.

Before leaving this formation something must be said regarding the life-forms of the rock-plants endemic to Campbell Island, or those which have not yet been dealt with.

Abrotanella rosularis has wiry stems, creeping at first, but finally erect, covered more or less with old dead leaves. The terminal leafy portion of the shoots measures 1·3 cm., and consists of spreading imbricating leaves, the uppermost of which form a stiff dark-green rosette about 1·3 cm. in diameter, the individual leaves so spreading outwards as to have their upper surface horizontal. The individual leaves are linear or linear-lanceolate, sheathing at the base, which is frequently purplish-rose-coloured, coriaceous, concave on the upper surface. Hooker describes the plant as "a small, densely tufted, moss-like plant." The leaf-anatomy presents certain xerophytic features. There is a thick cuticle on the upper surface provided with slightly sunken stomata, a dense palisade parenchyma, frequent resin-passages, and a certain number of mucilage-cells. On the other hand, the stomata of the under-surface are not sunken, and there is an abundant spongy parenchyma.

Polypodium australe pumila is a most abundant plant on the subalpine rocks. The very small fronds are given off at close intervals from the rhizome, which is densely covered with brown scales. These fronds are very thick and coriaceous, small but somewhat variable in size; the blade measured in certain specimens 7 mm. × 4 mm., 7 mm. × 2 mm., 5 mm. × 1·5 mm., and is frequently more or less buried in mosses or liverworts, which accentuates its small size; the stipes measured from 5 mm. to 1·5 mm. Grown in

moist air the plant is rapidly developing rather larger leaves, which are narrower in proportion to their length. Such measure 11 mm. × 3 mm., and stipes 4 mm. long, but probably such fronds have not attained their full size. However, judging from the experiment as it proceeds, it seems unlikely that fronds will be developed to match the typical form of *P. australe.*

Celmisia chapmanni forms large rosettes of glossy dark-green leaves, reaching a size of 14 cm. in diameter and 12 cm. in height. The more external leaves radiate outwards, at the same time arching downwards, while the short not fully developed internal leaves are vertical. The leaves are not nearly so varnished as those of *Cel. vernicosa;* they are thick and coriaceous, ± 8·8 cm. × ± 9 mm.; and have a short, thick, fleshy base. The dead leaves remain attached to the plant, rapidly rotting and turning into peat. The epidermis of both surfaces is strongly cuticularised; extremely strong bands of stereome surround the vascular bundles; the spongy parenchyma consists of large cells containing a great number of oil-globules. The stomata on the under-surface are sunken.

Colobanthus subulatus forms small, convex, round, dense, soft cushions ± 5 cm. in diameter. At the ends of each shoot are 6–8 stout green leaves ± 7 mm. in length, the base membranous and sheathing and the apex acicular. The upper surface is channelled. Below the terminal green leaves the shoot-axis is clothed with the old leaves of previous years.

III. The Antipodes Islands.

General remarks.

The Antipodes Islands are situated in latitude 49° 41′ south and longitude 178° 43′ east (90), and consist of one island much larger than the remainder, named Antipodes Island, and some seven much smaller islands and rocks, of which Bollons Island is the only one of any importance. The group is 490 miles east-south-east from the South Cape of Stewart Island, and 400 miles east-north-east from Campbell Island.

Antipodes Island, according to Captain Fairchild, is about two miles and one-third in length from east to west, and one mile and one-third in breadth from north to south. The highest point is Mount Galloway, 402m., but a large part of the island is at a considerable height above sea-level. From the base of Mount Galloway in an easterly direction lies a considerable tract of flat land sloping very gently towards the sea. The "Hinemoa" sailed right round the island, and so its aspect as viewed from the sea could be noted. The coast-line is precipitous and rocky, the rocks black in colour or marked with many broad patches of a white crustaceous

lichen, which at a close view gives the steep rock-faces the appearance of having been painted white. Above the cliffs, when they are not very high, or where the coast is not rocky, stretch upwards steep slopes densely covered with brownish-yellow tussock. These slopes are shallowly seamed by very steep gullies filled with patches of *Aspidium vestitum* and *Coprosma* scrub, which at a distance look like black bands stretching through the tussock.

Bollons Island is an extremely precipitous island rising out of the sea to a height of 140m. A landing can only be effected in the very finest weather. Captain Bollons, who has once landed on the island, tells me that it is clothed in places with tussock and small scrub similar in appearance to that on Antipodes Island. There are many petrel-burrows and sea-hawk rookeries.

Regarding the geology of the group, Hector writes (40, p. 737), "Antipodes Island is the result of four distinct centres pouring out scoria and basaltic lavas with enormous deposits of volcanic breccia, which proves the great local violence of the eruptions. The erosion of the coast-line has been very slight considering the friable nature of the rock, so that the eruptions must have occurred in a very late geological time, coincident probably with that of the Auckland peninsula." Kirk (56, p. 228) describes the main island as being "somewhat the shape of a ham." "The eastern extremity, corresponding to the shank of the ham, appears to have been formed by a narrow lava-stream." "The island is simply the crater of an extinct volcano, and would be roughly circular in shape were it not for the lava-stream which has been already mentioned." "The crateriform portion of the island is surrounded by low rounded hills on three sides. It is not quite certain whether the whole island is volcanic. Some distance from the landing-place I noticed what appeared to be a mass of finely bedded sandstone, but could not get near enough to determine its precise nature. Most of the rocks observed were basaltic." Captain F. W. Hutton, who visited Antipodes Island in January, 1891, informs me that he considers it the remains of a submarine volcano, and that probably the island has never formed a part of the mainland of New Zealand at the time when the problematical island-continent included what is now the Kermadec Group in the north, and perhaps New Norfolk, the Chatham Islands in the east, and the remainder of the Southern Islands in the south—Macquarie Island perhaps excepted.

With regard to the climate of Antipodes Island, I should imagine that it is very similar to that of the other Southern Islands—cloudy skies, frequent showers, a mild temperature in winter but a cool summer, and, finally, furious gales and

squalls with hail or sleet, of which winds the nature of the arborescent plants bears abundant evidence. During my all-too-short visit it drizzled at intervals, with the wind blowing in squalls, between which occasionally the sun would peep out for a few minutes.

Although sealers and whaling-ships had frequently visited the Antipodes Islands, and H.M.S. "Victoria" had called there in November, 1865, it was not until Kirk published an account of their plants that anything definite was known regarding the botany of the group. But prior to this important publication some general facts were known about the vegetation, for Captain J. Fairchild had reported, as a result of his visit in 1886, that the whole island was covered with a coarse grass, and that no bushes or wood of any kind was found (90), meaning by this latter that there were no trees or large shrubs.

Reischek, the ornithologist (89, p. 386), who visited Antipodes Island in January, 1888, states regarding the vegetation that it "consists of tussock-grass with some cotton-plants, aniseed, and veronicas intermixed with it, and that there is no bush whatever. The tussock-grass all grows in humps, except on the tops of the hills, where there is shorter." The "cotton-plants and aniseed" would be *Pleurophyllum* and *Ligusticum*, while probably the "veronica" would be *Coprosma*, though there is no reason why *V. benthami* might not be eventually found on the island.

Kirk's account is quite short, occupying only four pages octavo, and includes a list of the plants which he had collected or noted—viz., forty-one species of spermaphytes, of which two are introduced plants, and twelve species of pteridophytes Two endemic species new to science were discovered—*Senecio antipoda*, a quite remarkable plant, and *Gentiana antipoda*, which is related to the other gentians of the Southern Islands It is impossible to say how much of the island Kirk examined, but, judging from his remarks and bearing in mind the difficult nature of the ground owing to the closeness of the large tussocks, he could hardly have penetrated to any great distance from the landing-place.

Chapman, however, who visited the island on the same day as Kirk, reached the summit of Mount Galloway, and describes it as "clear ground, matted with *Pleurophyllum* and low-growing *Ligusticum*. Owing to fog we failed to see a clear lake* said to exist there. There was a good deal of flat ground up there, which was literally alive with albatroses."

Owing to the short time at my disposal, I was only able to

* This lake was reported by Mr. W. Dougall as covering an area of 13 or 14 acres (14, p. 200).

examine the vegetation of the flat ground extending from the base of Mount Galloway northwards, the ridge forming the south-eastern boundary of this flat ground, the slopes on both sides of this ridge, the gully through which the northern stream flows, and the tussock slopes and rocks on the northern side of the island near the landing-place. It will be seen from this that the whole western side of the island and the greater part of the southern side is still botanically unexplored, and this comprises somewhat about one-half of the island, small as it is. All the same, I think there will hardly be any other plant-formations of any importance than those described below, unless it be a swamp formation in the west, at that point marked "Swampy" in Fairchild's map (33); and perhaps the actual summit of Mount Galloway may have a different combination of plants to the meadow formation described below. During a long summer's day, if the weather kept fine, it would be easy for an active man to travel over the greater part of the island, especially if he had an assistant to carry some of the impedimenta. The lake on the summit of Mount Galloway requires a careful examination for water-plants.

THE PLANT-FORMATIONS.

Speaking generally, the vegetation of Antipodes Island, when viewed from an eminence, seems to consist of dense masses of tussock-grasses, so that one might at first glance be apt to consider the whole plant covering as but one formation, which might be designated "tussock meadow," or some such name But on a closer examination it is clearly to be seen that the plant covering is by no means a uniform one, and that different conditions of water-content in the soil, of shelter from the constant fierce winds, of proximity to the sea or to "bird-rookeries" have led to the differentiation of sufficiently well-marked plant formations and associations, some of which are separated from one another by sharp boundaries and do not mingle to any extent, although they have many species in common; that is to say, such formations present themselves as distinct groups of the vegetation rather from the manner in which their members are combined than from these being different species. Thus we have here an instructive example of how from the same materials several distinct combinations can be made by slightly different surroundings, the poverty of the flora emphasizing the selective power of the habitat

The plant-formations which I noted as forming more or less distinct societies are the following: (1) Maritime rocks; (2) tussock meadow, divided into three sub-formations—(*a*) maritime tussock slopes, (*b*) flat tussock meadow, (*c*) inland tussock slopes; (3) scrub; (4) bog; (5) inland rocks; (6 and 7) stream and swamp.

1. *Maritime Rocks.*

The surface of the rock may be quite flat or more or less vertical. On the flat rocks, in the crevices, or on the ledges are frequently considerable accumulations of peat. As to moisture, although the surface of the rock must vary considerably in this respect, it seems probable, considering the wet climate, that even the vertical faces of the rocks will usually be covered with moisture. Ecologically this formation is the same as that already described for the Auckland Islands under the heading "Coastal Rocks," but floristically, so far as is at present known, there are some considerable differences, for here the well-known New Zealand *Apium australe* occurs, while the grass which gives such a character to the Auckland Island cliffs—*Poa ramosissima*—and also the rosettes of the *Plantago*, are absent.

The closeness of the formation depends upon the steepness of the rocks. Where they are quite vertical their vegetation — lichens and mosses excepted — occupies only the crevices or ledges; but where they are flat or the ledges large a more or less dense covering occurs, which, if present in sufficient quantity, might quite well be considered a distinct formation, closely related ecologically to what I may designate "coastal turf," and which is a frequent formation in certain parts of the south coast of the South Island of New Zealand and of the small islands in Foveaux Strait.

The following, copied almost verbatim from notes taken on the spot, gives some specific examples of the maritime-rock plant-formation: "Growing just above high-water mark on the flat rocks is *Tillæa moschata*, mixed with small tufts of *Festuca scoparia*. Over steep faces large green masses of *Tillæa* hang downwards, mixed with a small form of *Apium australe*. In crevices of the bare rock are round cushions of *Colobanthus muscoides* of a vivid green. In a sheltered nook on a flat rock, with a high perpendicular rock behind, is a dense mass of *Scirpus aucklandicus* 1·35m. × 60 cm. in area, and growing through it *Tillæa*, *Apium*, and *Festuca*; while just at the junction of this combination of plants and the bare rock are several small cushions of *Colobanthus*. Such masses of *Scirpus*, *Tillæa*, and *Apium* are about 15 cm. deep." The driest of the perpendicular rocks or cliffs are covered densely with a white crustaceous lichen. Where the cliffs are quite glistening with moisture a dark-green shining moss grows upon their steep faces, forming cushions after the manner of and in company with *Colobanthus muscoides*. Such moss-cushions are wringing wet. On the flat summit of a low cliff creep the stout green stems of *Cotula plumosa*, with a carpet of *Tillæa moschata* on the seaward side. Behind this first zone of coastal-turf or rock plants, which clothe the rocks

and cliffs or fill their hollows, comes a second zone, consisting for the most part of *Poa foliosa*, mixed with a variable amount of *Carex trifida*. This same zone, which merges into the maritime tussock slope, occupies the flat summit of the cliffs, down the precipitous faces of which the long, green, flat leaves of the grass hang in thick masses.

2. *Tussock Meadow.*

The tussock meadow is by no means a uniform formation, but varies so much in composition and physiognomy according to the position in which it grows that it is here subdivided into three sub-formations; indeed, I am not sure but that these latter should be considered as distinct plant-formations.

(a.) *Maritime Tussock Slopes.*

From the steeply sloping bank of soft, wet, and spongy peat rises up a dense mass of tussocks about 1·5m. in height growing upon thick trunks so very closely together that it is not easy to walk between them. These tussocks consist chiefly of a species of grass which I could not identify, and is possibly the same as the "silver-tussock" of Campbell Island. Kirk mentions *Poa anceps* as occurring on Antipodes Island, and it may be that this is the grass referred to. At any rate, it is by far the commonest grass on the island, and it is the characteristic plant of the tussock meadow as a whole. Mixed with this tussock are others, but occurring to a much smaller extent, of *Poa foliosa* and *Carex trifida*. Where these tussocks grow closely there is room for no other spermaphytes, unless they grow on the summit of the tussocks' "trunks"; but where they are a little further apart, so that spaces clear from tussock occur, there is a varying amount—in some places, indeed, a great abundance—of *Ligusticum antipodum*.

(b.) *Flat Tussock Meadow.*

Perhaps this should rather be classed as a heath, for ecologically it seems much more to resemble this latter than it does a meadow. The badly drained soil, poor in nourishment, the abundance of lichens and lycopods, the stunted bushes of *Coprosma*, and the semi-xerophytic ferns certainly point to its classification as a heath; but, on the other hand, the presence of a grass as the dominant plant seems to mark the society as a meadow.

Taking a general view of the meadow, and casting the eye for some distance over its flat expanse, yellow tussocks 50 cm. or so apart are seen waving in the breeze, and alternating with the very dark, almost black, spreading fronds of *Aspidium vestitum*, so that it appears at first glance as if only these two species were present, as it is, indeed, they alone

which stamp the physiognomy of the meadow. Where the tussock and fern are not so dense *Ligusticum antipodum* occurs in such quantity as to add bright-green patches of colour in an equal proportion with the yellow grass or dark fern. But if the eye be cast not so far afield, then the pale-green of the *Acæna*, climbing amongst the tussock or fern, and the withered brown fronds of *Pteris incisa* add other features to the general picture.

The soil of the meadow consists on the surface of rather loose brown peat, so soft that a stout stick can be thrust deeply into it. Water cannot be wrung out of the surface-soil, but this can be quickly kneaded into the consistency of porridge. The surface is very uneven, the dead trunks of grass or fern forming mounds on which many plants grow, while between the living tussocks are numerous slight depressions and deeper hollows. Everywhere the ground is occupied by vegetation, which, although not rich in species, consists of many individuals.

Amongst the most frequent plants are the following: Foliaceous and fruticose lichens, mosses of several species, liverworts, *Lomaria alpina*, *Pratia arenaria*, *Acæna sanguisorbæ antarctica*, *Luzula crinita*, *Gentiana antipoda*, *Epilobium linnæoides*, *Hypolepis millefolium*, *Epilobium* sp.—the *E. alsinoides* of Kirk's list (56, p. 230)—*Stellaria decipiens angustata* (66, p. 57), *Lycopodium fastigiatum*, *Lycopodium varium*, *Asplenium bulbiferum*—a form with thick leaves—*Hymenophyllum multifidum*, *Helichrysum prostratum*, *Coprosma repens*, and *Coprosma cuneata*.

The carpet of small plants clothing the peaty ground is not a uniform one. Notes taken in various parts of the meadow show that sometimes one plant and sometimes another is the leading one for the particular station; for instance, in some places the thick-leaved form of *Asplenium bulbiferum* is abundant, in others is much *Hymenophyllum multifidum*, with its fronds curled up and arching downwards until partly buried amongst the mosses or liverworts which grow in its company.

In the shelter of a grass-tussock *Lycopodium varium* ± 25 cm. tall is frequent; below it is erect and furnished with many yellowish-green imbricating leaves, while above its brownish spikes arch downwards. *Ligusticum antipodum*, as well as the tussock and *Aspidium*, also plays its part as a shelter-plant, its leaves spreading out radially, with their surface more or less horizontal, such plants averaging about 78 cm. in diameter and 22 cm. in height.

One or two quotations from my notebook may assist in giving a picture of the floor of the meadow: "Here on ground where the tussocks and fern are more distant, growing in the

hollows, are large quantities of *Gentiana antipoda*, numerous fruticose lichens of various species, *Coprosma repens*, *Acæna*, *Luzula crinita*, many fine foliaceous lichens, and large patches of the filmy fern, this latter sometimes 8 cm. tall." "Here is tussock growing, mixed with *Aspidium vestitum* and *Luzula crinita*. In the hollow near by are mosses, lichens, hepaticas, *Acæna*, *Pratia arenaria*, and *Lomaria alpina*." "Here is a large plant of *Ligusticum antipodum* not nearly so tall as the tussock, and so in partial shelter. On one side of this two tussocks, on the other side one half-dead tussock with lichens and *Luzula* and *Hymenophyllum* growing on its trunk and *Aspidium* growing through it, while the neighbouring hollow is filled with *Hymenophyllum* and lichens growing together. In parts of the meadow the tussock and *Aspidium* become much smaller or are almost altogether absent, and here *Lomaria procera* takes its place, its arching fronds almost parallel to the ground, raised but a few inches above its surface, their pinnæ bent a little upwards, the surface of the frond thus becoming semi-horizontal.

The summer aspect of the meadow must be very different from that described above. The tender green of the two abundant ferns, *Pteris incisa* and *Hypolepis millefolium*, will then add a feature quite wanting in winter, while the difference will be still more marked when the great umbels of *Ligusticum antipodum* are in full bloom.

The only endemic plant to be dealt with here is *Gentiana antipoda*. This has a short root-stock $\pm$ 5 mm. in diameter, which is usually at first decumbent, but finally erect for $\pm$ 7 mm.; from this pass decumbent branches, except at apex, $\pm$ 2·7 cm. $\times$ 2·5 mm. in diameter, closely covered with leaves, except near base. The leaves are vertical in their lower but spreading somewhat in their apical half. The vertical part and back of leaf is pale yellowish-green, but the more spreading part is bright-green. They are $\pm$ 5·4 cm. $\times$ $\pm$ 8·5 mm., slightly fleshy, and linear-spathulate or ligulate in shape. The margins are slightly recurved; the upper green part of the leaf is flat and the lower pale part is channelled. The root is of considerable length, and runs more or less horizontally in the soil. A seedling plant 1·35 cm. tall had a root 4·9 cm. long.

A cross-section of a leaf shows a strong cuticle furnished with conical protruberances equalling the thickness of the cuticle. There is a palisade 5 or 6 cells deep of rather short, broad, rounded, oblong cells about 1½ times as long as broad. The spongy parenchyma is loose, having many intercellular spaces. Kirk (69, p. 341) describes two forms of this species under the names *pallida* and *rubra*. The former is stated to have yellow stems and white flowers, and the latter red stems

with white flowers vertically streaked with red. He also describes the plant as perennial, but I think that most probably it is a biennial. Mr. H. J. Matthews, who cultivated this plant, agrees with me in this conclusion.

(c.) *Inland Tussock Slopes.*

In many respects this sub-formation is similar to that last described, but it contains very much more *Stilbocarpa polaris;* and, in addition, the following plants, which, if they occur at all on the flat meadow, are very rare: *Urtica australis, Poa foliosa, Senecio antipoda, Carex appressa,* and rather large bushes of a species of *Coprosma*—perhaps *C. ciliata.* Unfortunately, I neglected to bring away specimens of this latter plant, but it did not seem the same to me as *C. ciliata* of Auckland and Campbell Islands. The ordinary grass-tussock and *Aspidium vestitum* are much larger than are the same species in the flat meadow, owing probably to the better drainage of the slope. The soil is, generally speaking, drier than that of sub-formation (*b*), and shallow gullies change the conditions with regard to wind, in consequence of which a transition between "scrub" and "tussock slope" is there present. In certain places the ground is more or less bare, where the giant petrel has its "rookeries," and in consequence the soil must be much enriched with its manure.

As one painfully toils up the hillside huge plants of *Aspidium vestitum* 1·5m. tall, with stout trunks and spreading fronds, are encountered growing in company with tussocks equally large of *Poa foliosa* and *Carex appressa,* amongst which are dotted large flat-topped bushes of the *Coprosma* mentioned above or small colonies of the large-leaved nettle *Urtica australis.* The "trunks" of these tussocks are of great size, and when the plant dies large mounds of peat remain. Seen at a distance the *Aspidium* makes large black-coloured blotches on the hillside. Frequently fern, tussock, and scrub give place to great masses of *Stilbocarpa polaris,* its large rhizome creeping on the surface of the ground, and the large leaves, quite close together, raised aloft on their exceedingly stout petioles, the whole mass of leaves and leaf-stalks forming dense thickets. One colony of this remarkable plant measured 11m. × 3m., but those met with further on, of which no measurements were taken, were of much larger size. With the *Stilbocarpa* are mixed few other plants, the rhizomes occupying the ground and the leaves excluding the light. The *Coprosma* bushes are of equal height to the fern and tussock of grass or sedge. The leafy top is about 1·8m. in diameter and almost semi-globular in shape, its ultimate twigs extremely dense and leafy for a depth of 16 cm. The leaves are very numerous, but quite small and narrow—about 7 mm.

long × 1·9 mm. broad. This combination of *Poa foliosa*, *Aspidium vestitum*, *Coprosma ciliata*, *Urtica australis*, and *Stilbocarpa polaris* appears to form a distinct association, its presence depending upon the greater amount of shelter that it receives. This protection from wind is also much increased for its internal members when such an association becomes established, the tussocks themselves affording much shelter. Right on the summit and most exposed part of a ridge, seated on the ground under the lee of a tussock, the storm could be heard raging overhead, but where I sat was quite calm.

Where the hillside is less sheltered the vegetation consists of the common meadow-tussock, *Aspidium vestitum*, and *Pteris incisa*, with the ever-present *Acæna* climbing in thick masses over the grass and fern. Here both fern and tussock, although still of considerable size, are of much smaller dimensions than in the association described above, and this part of the sub-formation is but a continuation of the flat meadow.

The bare ground manured by the giant petrel (*Ossifraga gigantea*) is occupied by another association of which the endemic *Senecio antipoda* is the dominant plant. Growing in its company are very thick masses of *Acæna*, which is frequently mixed with *Pteris incisa*. *Stellaria decipiens angustata* is also common. *Senecio antipoda* much more resembles the common European groundsel in outward appearance than do any others of the herbaceous section of this genus in New Zealand. It is a very curious fact that, both here and in Chatham Island (23, p. 268), in situations frequented by certain sea-birds there should be an endemic species peculiar to such stations. So far as *Cotula featherstonii* of Chatham Island is concerned, its growing in ground near the holes of mutton-birds is recognised by the settlers who live in its vicinity, and from them it has received the name of the "mutton-bird plant." I do not see why rich heavily manured soil should not be just as much a factor in determining the life-form of a plant as illumination, moisture in the air, wind, or any other ecological factor, and to find two plants each of distinctly luxuriant growth growing under very similar conditions is suggestive, to say the least.

Senecio antipoda is a stout herbaceous plant of upright growth. It has a rather thick main stem, hollow in old plants, which gives off numerous lateral branches from its upper portion, and these are furnished above with many usually large, spreading, membranous, green leaves. These when fully grown are broadly spathulate in outline, the upper and expanded half of the leaf being deeply pinnatifid, while the segments are again deeply cut, especially on their lower margin. Such expanded portions of the leaves measure 9·5 cm. × 7·7 cm. The lower half of the leaf is entire or

toothed—this might be called a winged petiole—and has the margins almost parallel; in the leaf in question it measured 6 cm. × 1·9 cm. The leaves vary much in size according to the size of the plant, as also somewhat in shape. The upper surface of the leaf is green and almost glabrous in adult-leaves, but the under-surface is more or less tomentose with loose cobwebby hairs, the tomentum being much more abundant in young than in old leaves. The margins are recurved, and on the under-surface of the leaf is a prominent midrib, which gradually broadens towards the base, and which may attain to a thickness of 5·5 mm. The tomentum plays an important part in protecting the bud during winter. The leaves round the growing point are tightly pressed together, and remain quite vertical until of a considerable size—6·8 cm. × 4·6 cm. in one case measured. These young leaves are tomentose on the upper surface of the broad midrib, and especially towards their base, which tomentum, becoming entangled with that of the under-surface of the contiguous leaf, binds all the leaves round the growing point into a firm weather-resisting mass not easily penetrated by moisture.

3. *Scrub.*

On the sheltered sides of the hills the scrub becomes somewhat higher and more abundant than that mixed with the herbaceous plants of the tussock slopes. Such scrub occurs, so far as I could see, in every sheltered gully on all the hills of the island, and not merely, as stated by Kirk, on Mount Galloway (56, p. 228). Seen from the summit of the ridge on the east side of the island, the scrub is of a dark-green colour, and descends in long broad lines down the hillside. Only a few minutes were available for examination of this formation, but where I entered it, it consisted of *Coprosma* plants, 1·5m. tall, growing very closely together and possessing long thin trunks about 3 cm. in diameter at most, so far as I can recollect, and dividing into two or three vertical branches, which give off numerous dense twigs, these forming a flat leafy crown about 16 cm. or less in breadth and perhaps 8 cm. in depth. Certain lichens and mosses grow on the stems, which are otherwise bare, and where the shrubs are not close together there is some *Epilobium linnæoides* and *Lagenophora forsteri* on the ground. This is a most incomplete account of this interesting formation, the only representative on Antipodes Island of the forests of the Auckland Group or the extensive scrub of Campbell Island.

4. *Bog.*

Towards the centre of the flat meadow occur many almost circular patches where the soil is much wetter than that of

the meadow, and where genuine bog-conditions prevail. Such patches can be recognised at a glance (see Pl. XX.) by the difference of their vegetation, which has a physiognomy of its own, quite distinct from that of the meadow which surrounds them, and from which the bogs are divided by quite a sharp line. If a number of such bogs be examined it will be found that, though they do not all contain their members in exactly the same proportion, there is a most striking similarity between them all, separated though they are by large patches of meadow.

That which at first glance most distinguishes the bog from the meadow is the large amount of *Carex ternaria* in the bog, the almost complete absence of tussock-grass, and the presence of *Pleurophyllum criniferum*, which, with its very large leaves and striking flowers, must in summer much more emphasize the distinct character of this formation. Certain of the other plants also are much more abundant in the bog than in the meadow, although frequent enough in this latter. These are *Ligusticum antipodum, Coprosma repens, Coprosma cuneata, Stilbocarpa polaris, Hymenophyllum multifidum.*

The soil of the bog is peat quite saturated with water, so that water can be readily wrung out of it, and if a small hole be made in the ground it quickly fills with water. Sometimes the centre of the bog may be occupied by a pool of dark peaty water.

Perhaps the most characteristic plant is *Carex ternaria.* At the time of my visit its brown leaves lay prostrate upon the ground, green only at their bases. Here and there *Marchantia* sp. covers the wettest ground, in company with a small moss and a leafy liverwort. Many plants of *Ligusticum antipodum*, either dotted about or in clumps, grow amongst the *Carex*. Such isolated plants have their leaves spreading out radially, and are 40 cm. tall. The surface of the bog consists of little elevations and hollows. In the hollows grow *Luzula crinita* of robust growth, *Marchantia* sp., many lichens, tufts of *Gentiana antipoda.* Considerable patches of ground are frequently occupied by *Hymenophyllum multifidum,* the fronds curled up and of a reddish-brown colour. In other places a dense green carpet of *Coprosma repens* covers the ground, or mixed with it may be lichens and the filmy fern. In most of the bogs *Aspidium vestitum* is present, and occasionally in the driest parts are a few plants of the tussock. Here and there the apices of the leaves of *Pleurophyllum criniferum* just protrude from the ground. *Coprosma cuneata* of very dwarf stature is quite plentiful in some places. It creeps close to the ground, and its small leaves are in winter quite brown. *Uncinia riparia pseudorupestris* is common in some places.

5. *Inland Rocks.*

These I had only an opportunity of examining in two places, so can say little on this head. A sloping rock near the summit of the ridge on its eastern side was covered with a beautiful white-coloured species of *Cladonia*. Through this grew a few small plants of *Coprosma ciliata*(?) about 30 cm. tall, *Lycopodium fastigiatum*, and *Lycopod. varium*, *Hymenophyllum multifidum*, *Helichrysum prostratum*, *Lomaria alpina*, a little stunted *Ligusticum antipodum*, and *Aspidium vestitum*, the whole of these, including the lichen, being also plants of the meadow.

On the face of a dry vertical cliff were white crustaceous lichens, some fruticose lichens, a few mosses, a plant or two of *Colobanthus muscoides*, while on ledges where peat had been formed a tuft or two of the common tussock-grass.

6 *and* 7. *Stream and Swamp.*

For convenience' sake, these two formations are taken together, since I had only an opportunity to examine very rapidly the stream flowing down a gully from the meadow and the swampy ground in its vicinity. The only plant noted in the stream was *Callitriche antarctica*. *Carex appressa* tussock comes to the edge of the water, even extending into it, and filling up the hollow of the gully with great tussocks. Where the ground is a little drier very large grass-tussocks are mixed with the sedge. The ground, so far as I can remember, was very wet, and the tussocks grew much too densely to permit more lowly plants to grow. But my examination was of the very briefest, the allotted time on shore having almost expired. On the map an extensive swamp is marked as existing in the south of the island. Captain J. Bollons tells me he has crossed over this, and that the vegetation consists of large tussocks and of *Aspidium vestitum*, on the top of which you must walk to make any progress and to escape the knee-deep water.

IV. The Bounty Islands.

The Bounty Islands, according to Fairchild, are situated in 47° 43′ south latitude and 179° 05′ east longitude. "The group consists of about twenty islets and rocks ranging from 10 ft. to 290 ft. in height, and occupying a space about three miles east and west and two miles north and south" (90). They lie 490 miles east of the South-west Cape of Stewart Island.

Landing on the main island, where the depot is situated, is a matter of some difficulty; nor is walking on the smooth surface of the granite, of which rock all this group is composed,

by any means easy. This glass-like smoothness is occasioned by the polishing action of the millions of penguins which at present occupy the rocks during the breeding season, and of the fur-seals, which formerly were extremely abundant. These animals, happily, although at one time nearly extinct, are distinctly on the increase, more than sixty being observed during the "Hinemoa's" visit. In summer I understand the rocks are thickly covered everywhere with the excrement of the birds, but at the time of my visit this was nearly all washed away by the abundant rain and sea-spray, which passes at times over the highest island. But in the hollows and under the stones guano was still present, and here Mr. Jennings, of the Otago Museum, and myself had the great pleasure of discovering a peculiar fauna rich in individuals; indeed, in some places the guano beneath the stones was fairly alive with amphipods, beetles, spiders, and small flies, while larger flies were in great numbers on the bare warm rocks.

As for plant-life, the rocks between the ebb and flow are densely covered with the indiarubber-like masses of a species of *Durvillæa* of a much yellower colour than that so frequent in the other islands or on the coast of New Zealand proper. The zone of *Macrocystis*, which so frequently occurs beyond the zone of *Durvillæa* where the plant is not exposed to the danger of buffeting on the rocks, is here absent. On the granite of the island is no permanent soil of any kind except the before-mentioned guano, nor are there any land-plants at all, excepting an alga clothing the rocks and giving them a greenish hue in places. The specimens of this plant which I collected were unfortunately lost, so I cannot state to what genus it may be referred.

Probably these islands are a remnant of a much larger land-area, and the alga not the forerunner of a more extensive future vegetation, but the last survivor of one long passed away. With regard to the spiders, some remarks are made further on when dealing with the history of the vegetation of the Southern Islands.

V. Effect of Animals upon the Vegetation of the Southern Islands.

1. *Indigenous Animals.*

Before the advent of the white man, and even now in many places, vast numbers of sea-birds and seals lived on the Southern Islands for longer or shorter periods every year. The time of my visit was unfavourable for observing the birds, since these for the most part come on land only during the breeding season. I therefore can say little as to how they

affect the plant covering. From the writings of Kirk and Chapman, especially from the latter, something may be learned as to their effect on the vegetation of the Snares. Thus, Kirk writes (56, p. 214), "The island is the abode of numberless penguins, petrels, and other sea-birds, and exhibits numerous indications of their influence on the vegetation." "Two or three swamp-plants exist under difficulties, being constantly flattened under the broad feet of these birds" [penguins], "which abound everywhere." Chapman writes (16, p. 495), "Wherever a rookery is formed the timber or scrub dies, and we often found places where the penguins had taken up new ground, killing a piece of scrub alongside a rookery." The above quotation shows very plainly how great an effect the penguins can have on the plant covering. On the Bounty Islands, where the penguins stand close together in millions, there is no vegetation of any kind, excepting a fresh-water alga which grows upon the rocks. Captain Bollons tells me that they also occupy the cliffs of Antipodes Island in countless numbers, and that small rookeries, where the birds are much scattered, are found at the edge of the forest of the Auckland Group or near the scrub on Campbell Island. The mutton-bird makes holes in the ground, where it rears its young, and such holes must assist very materially in draining the land, while at the same time there will be a good deal of manure on both its surface and in the holes. Chapman describes the whole of the ground of the chief island of the Snares Group as being honeycombed with mutton-bird holes: "The traveller constantly breaks the surface and drops into these tunnels, but the depth is not great." Where the giant petrels (*Ossifraga gigantea*) congregate on Antipodes Island the ground becomes more or less bare, and a quite different association of plants occurs there to what occupies the unmanured slope. As was mentioned in dealing with Antipodes Island, it is here alone that the endemic *Senecio antipoda*, a species differing much from any other New Zealand one, occurs, and I suggested that the rich soil caused by the birds' manure had played an important part in its evolution.*

Various species of albatros breed on the different Southern Islands, and in some parts are extremely numerous. I had an opportunity on both Campbell and Antipodes Islands of seeing the young birds on the nest, and on the latter island was enabled to take some notes as to what plants take possession of the ground which gets laid bare round the nests.

* Moseley shows (79) how a sort of mutual-benefit alliance has sprung up between the penguins and the tussock on Tristan d'Acunha—how the manure benefits the grass and the shelter of the grass the birds. I suspect something of the same with the *Poa foliosa* zone of the Southern Islands.

The nests are built out of peat mixed with short pieces of grass. On Bounty Island, where there is neither soil nor grass, guano and the old quill-feathers of the penguin are made use of. They are quite hard and solid, about 60 cm. in diameter, 25 cm tall, and the upper surface is very slightly hollowed. On this the albatros lays her one large egg, hatches it out, and the young bird remains on the nest for many months, finally, when fully fledged, walking about just in the neighbourhood of the nest until the following season, when the old bird returns to lay another egg. Then the young bird makes its way to the sea, and first of all takes to the water in this manner. I saw young albatroses both on Antipodes and Campbell Island in July; they were still covered with lovely white down, through which the quill-feathers of the wing were plainly visible when the wind ruffled the down. Round about such nests all the vegetation is finally destroyed for some distance, and it is a most common sight to see old nests surrounded by a ring of quite bare ground, while in other cases a new vegetation has arisen. I took a few notes in order to see what plants under these natural conditions repopulated the ground—as opposed to vegetation being destroyed by introduced animals.

Such old nests may be 39 cm. in diameter and 23 cm. tall, the upper surface. where the young bird has been for many months seated, slightly hollowed. Growing in the centre of the nest is *Stellaria decipiens minor*, with small plants of *Luzula crinita* growing through it. Climbing over the nest and extending into the hollow portion is *Acæna*, which also occupies the formerly bare space round the nest where the old bird has alighted and the young one takes exercise before leaving the nest for the ocean. Large tufts of *Luzula* grow on the ground through the *Acæna*, together with two small plants of *Senecio antipoda*. On the ground, otherwise quite bare, are *Marchantia* sp. and another liverwort. Surrounding the ring of ground laid bare by the albatros are grass-tussock, *Aspidium*, and *Ligusticum*. Another nest examined was bare in its centre, but elsewhere were similar plants to those enumerated and one small plant of tussock-grass. A third bare spot showed rather more tussock. So far as I remember, in all the nests and bare spaces examined *Acæna* and *Stellaria* were the first plants to make their appearance.

The young albatroses also must play a notable part in the distribution of *Acæna*, and may be accountable for the great abundance of this plant all over Antipodes Island. For this idea I am indebted to Chapman's paper, in which, writing of the summit of Mount Galloway, it states, "There was a good deal of flat ground up there which was literally alive with albatroses. Young black birds were very common;

often their breasts were covered with down, and this was matted with piripiri seeds (*Acæna*). The albatroses were building nests everywhere." Such young albatroses, on their way to the water (for they do not fly from the neighbourhood of their nest, but walk to the sea), would certainly assist very materially in spreading the fruits of *Acæna*, or the down coming off with the attached fruit could easily be blown for considerable distances by the furious gales.

The fur-seals will have but little effect on the vegetation although they originally existed in very great numbers, hundreds of thousands having been killed for the sake of their skins. At the present time they are all but extinct in many places, though on the Bounty Islands they are again becoming more numerous, thanks to their being strictly protected by the New Zealand Government. Their rookeries are situated on the more inaccessible rocks at the bases of precipitous cliffs, where they are exposed to the full fury of sea and storm.

The sea-lions play a more important part with regard to the vegetation. These animals frequent the more sheltered stony or sandy beaches. Especially are they fond of the sandy shore of Enderby Island, from which they move on to the sandhills and into the neighbouring meadow or forest. On the sandhills and also on the floor of the forest they roll and wallow about, and as at one time they were present in very great numbers they must have exercised considerable influence in keeping the forest-floor bare, as I have stated when treating above of the *Olearia lyallii* forest. On the sandhills also they would to some small extent loosen the sand, and may have caused sand-drifting, but probably only to a very limited extent.

2. *Introduced Animals.*

In contradistinction to the effect produced by the indigenous animals of any region upon its vegetation, which is, of course, strictly a natural one, to which the vegetation as a whole must have become accustomed, and in response to which the plants in certain cases may have developed special adaptations, the effect of certain introduced animals, including man himself, on the vegetation of a region where such have previously been unknown leads to an artificial state of affairs for a time, which has a most profound bearing on the distribution of the various species making up the vegetation. Excepting man himself, of all animals, where previously none have existed, herbivorous mammals work the greatest change. When in addition to animals foreign plants appear and come into competition with those proper to the region, and, most of all, when man, by the aid of fire in the first place, and afterwards by agriculture and other means, seeks to "reclaim" a virgin waste, then the equilibrium between the plant-forma-

tions is upset altogether, and a new flora and new plant-formations arise. This must have taken place to a greater or lesser extent in all civilised and semi-civilised lands, and their floras and formations must be very different indeed to what they were in the dim past before man appeared upon the scene. At the present time it seems to me that remote regions, especially isolated islands such as those of the New Zealand biological area, are almost the only places where the general laws that govern such vegetation-modifications can be found out, for the gradual changes from purely virgin formations to final "reclamation" can be observed and the factors bringing this about noted. But, so far as the New Zealand biological area is concerned, such investigations must be conducted at once, since year by year the actual virgin formations decrease rapidly in area. Of all places, Campbell Island offers the most favourable conditions for such studies, since all the facts with regard to animals and settlement by man are available, a settlement which has existed for only seven years. In what follows some notes dealing with the matter in hand, kindly furnished by Captain Bollons at my request, have been freely made use of.

(a.) *The Snares.*

These islands have been frequently visited by parties of sealers, who lived there for some months at a time. Beyond cutting down some of the trees and making a few tracks here and there they have had little effect on the vegetation. Where the *Olearia lyallii* trees were felled there is now, according to Kirk (56, p. 215), a dense growth of *Veronica elliptica* mixed with tussock. According to Captain Bollons, goats—perhaps the most destructive of all quadrupeds—were introduced in 1890; but these have most likely died, none having been seen since 1900. The following plants, according to Kirk, are naturalised, but nothing is said as to their frequency or their stations: *Dactylis glomerata*, *Holcus lanatus*, *Poa annua*, *Lolium perenne*. The above and the following New Zealand plants Kirk considers to have been introduced by the sealers: *Sonchus asper*, *Juncus bufonius*, *Hierochloe redolens*, *Deyeuxia forsteri*.

(b.) *The Auckland Islands.*

Captain A. Bristow, in 1807, landed pigs on Auckland Island. Both Hooker and Enderby reported them as very numerous, and Captain Bollons considers that there are still great numbers of them.

During the Ross expedition a ram and two ewes, pigs, poultry, and rabbits were landed on Auckland Island, and seeds of cabbage, turnip, mustard, cress, and other seeds were sown. Gooseberry, currant, raspberry and strawberry plants

were distributed over various parts of the island by Hooker. Rabbits were also landed on Enderby Island. Near the Observatory the forest was set on fire, with the result that the whole country "appeared in a blaze of fire at night" (91, p. 151, *et seq.*).

Enderby introduced cattle and sheep in 1850, but the whole of these were killed by the early sealers. Captain Norman, in 1865, landed four goats, three females and one male, on the south side of Terror Cove, but none of these have been seen since that date.

On Enderby Island cattle, sheep, pigs, and goats were landed by C. Enderby in 1850. In 1865 Captain Norman placed a few goats and rabbits on the island, "which at once took to the English grass" (90). In 1894 cattle and sheep were brought by the "Hinemoa." Probably there are about ten head of cattle at the present time.

Rabbits were put on Rose Island by Enderby, who writes, "I had rabbits in the first instance on a small piece of detached land between Auckland and Rose Island, but they multiplied so rapidly that there was not sufficient food for them," so he removed some of them to Rose Island, where, as on Enderby Island also, there are considerable numbers at the present time. There are also about fifteen head of cattle on Rose Island; some have been placed there in 1894.

Two or three goats were landed on Ewing Island in 1895, but none have been seen recently. On Ocean Island, a very small island in the Auckland Group, goats are numerous at the present time, but I have no details as to how they got there.

On Adams Island Captain Norman landed six Muscovy ducks. Here, also, sheep were landed in 1891, but none have been seen since 1896.

As to the effect of the above-mentioned animals on the vegetation of the Auckland Islands, that of the pigs might be expected to have made its mark. Hooker writes (46, p. 32) of *Pleurophyllum criniferum* "forming the larger proportion of the food of the hogs which now run wild upon the islands of Lord Auckland's Group. It is, indeed, so abundant in the marshy spots on these latter islands that these animals frequently live entirely amongst it, especially when it grows near the margins of woods, where they form broad tracks or runs through the patches, grubbing up the roots to a great extent, and by trampling down the soft stems and leaves use them as warm and soft forms to litter in." According to Mr. McCormick, who was surgeon on the "Erebus," the pigs fed on *Stilbocarpa polaris*. The rabbits also, confined to two small islands, must have destroyed a considerable amount of vegetation, and have changed to some extent the percentage of the smaller grasses and other herbaceous plants on which

they may feed. As for the cattle, Captain Bollons considers that they have already brought about considerable changes in the swampy ground of Enderby Island by consolidating it; and in dealing with the sand-dunes I have shown how these animals have already changed stable into unstable dunes, in which work the rabbits also may play some part.

At the time of the Enderby Settlement, as before pointed out, a considerable piece of the forest in the north of Auckland Island was cleared. This cleared ground is now completely reoccupied by a new formation differing in some important characters from the original rata forest. This new formation consists of a dense growth of evergreen shrubs, and with these is mixed a considerable percentage of *Phormium tenax*. This latter plant is not indigenous to the group,* it having been introduced by the sealers, who made use of the leaves for making sandals in which to chase the fur-seals over the extremely slippery rocks. That *Phormium tenax*, a most characteristic New Zealand plant, should be on the increase, and more than holding its own with the secondary arborescent growth, is a matter of interest distinctly bearing on the question of former land-connection with New Zealand proper; but it must be borne in mind that such secondary growth as that under consideration is the result of changes brought about by man, and the spread of *Phormium* under such circumstances is no proof that it would increase if introduced into a primitive formation. The new formation consists of *Metrosideros lucida*, *Panax simplex*, *Coprosma fœtidissima*, *Dracophyllum longifolium*, and *Phormium tenax*, the whole forming a most beautiful natural shrubbery of various hues of green. Unfortunately, there was no time to examine the undergrowth, or to take notes as to the relative quantity of the various components.

Regarding the introduced plants of the Auckland Group I can say but little. So far as I could judge at a season most unfavourable for such investigations, the vegetation of the flat ground between the sand-dunes and the forest on Enderby Island is largely modified, and contains a number of introduced grasses and other plants growing mixed with some of the more lowly indigenous herbs. It would be in this locality that the goats and rabbits which took so kindly to the English grass were landed in 1865 by Captain Norman. During this last-named expedition certain exotic plants were planted in various localities. Thus, oak, ash, and pine trees

* Mr. W. Joss tells me that he remembers when there were only three plants of *P. tenax* in this locality. On the occasion of our visit he landed at this spot purposely to gather some *Phormium* leaves, remembering well that the plants were there, although he had not been to the group for many years.

were planted, and seeds of lettuce, turnip, carrot, parsnip, pumpkin, and other vegetables were sown, on the south side of Terror Cove, while on Adams Island several young trees were planted and seed sown at the head of Carnley Harbour (90). *Phormium tenax*, as I have pointed out above, is an introduced plant, and it is distinctly on the increase; if it finally spreads on to the wet open ground it may considerably modify the *Pleurophyllum* formation. It should also be able to thrive on the sand-dunes, and everywhere, indeed, except in the subalpine region. Finally, I may add that the question of the effect of introduced animals, &c., on the vegetation of the Auckland Group, owing to the many animals that have roamed there for some time, and the length of time that introduced plants have had a footing in some part or other of the group, is a matter of considerable complexity, and cannot be grappled with except by a long residence in the group. Generally speaking, however, I think it safe to conclude that almost all the forest and scrub formations and by far the largest part of the remainder are, to all intents and purposes, in their virgin condition.

(c.) *Antipodes Island.*

Here the conditions are very much more simple than in the Auckland Islands, for it was not until the year 1887 that any exotic animals were introduced. Since then, and up to the last visit of the "Hinemoa," in July, 1903, cattle, sheep, and goats have been landed on several occasions, but such invariably died after three or four years. At the present time there are on the island only the three heifers which were landed in July last. It is very easy to see how such tussock slopes and swamps as those I have described are most unfavourable for the well-being of domestic animals. Sheep, thickly clothed with wool through not being shorn, if they once fall down in such tussock meadows can never rise again, and must perish. Cattle certainly may get on better, and might make tracks through the tussocks; but whether they could thrive exposed to the furious gales in the more open lands of the interior is questionable. It seems highly probable that the peculiar vegetation, aided by the climate, might quite well prove the victor in the struggle with any introduced domestic animals left uncared-for on the island. Were the place to be turned into a sheep-run, where the sheep were annually shorn and the tussock burnt off, then, indeed, the face of nature might be changed, and one of the most wonderful natural museums in the world be destroyed, which would, indeed, be a scientific calamity in no wise to be compensated by the trivial and problematical gain that could be acquired by sheep-farming on Antipodes Island.

(d.) *Campbell Island.*

Here sheep-farming is an accomplished fact. My notes, in consequence, afford some clue as to the effect that sheep and fires have on an absolutely virgin vegetation, which has existed for ages without having been exposed to either of these factors. Unfortunately, I was unable to make any list of the introduced plants; but the presence of these hardly affects my results, since there are few, if any, introduced plants at the higher levels where my notes were taken. At the time of the visit of Captain Norman six oaks, six elms, and one ash-tree were planted. Three pigs, some game and guinea fowls were at the same time landed at the head of Perseverance Harbour. The pigs and, I presume, none of the other animals have been seen there for the past twenty years. In 1890, according to Captain Bollons, sheep and goats were landed; the sheep died off, but probably two or three goats remain. In 1896 the sheep-farming was commenced. Only a few sheep were brought at first, but these have been frequently added to; they have also increased by natural means, and now there are about 4,500 on the island. Burning has also been largely resorted to in order to get rid of the scrub and make travelling more easy both for the sheep and the shepherds

Now, it is obvious that at first the sheep would be confined to comparatively small areas, and that a small number would affect the vegetation to an equal degree as quite a large number would if these latter were equally distributed over the whole island. Even now the 4,500 sheep do not roam over more than half the surface of the island, and still less than that if we take into account the scrub, gullies filled with scrub, patches without new vegetation where burning or overstocking has taken place, *débris*-slopes, and rocks. Consequently the sheep exert almost a maximum influence upon the plant-formations. There are certain plants of which the sheep are especially fond. These are *Danthonia bromoides*, *Pleurophyllum speciosum*, *Ligusticum latifolium*, and *Stilbocarpa polaris*. *Pleurophyllum hookeri* is eaten to some extent; and so, of course, are the various small grasses and the "silver-tussock." *Celmisia verricosa*, *Cel. chapmanni*, and *Bulbinella rossii* are not touched.*

The lower tussock meadow formerly contained vast quantities of *Pleurophyllum speciosum*. This the sheep devour most greedily, eating right down into the plant almost to the root-stock. On the slopes of Mount Honey were hundreds of plants, the leaf-rosettes eaten quite away, the remains of the dead plant looking not unlike the nest of a bird. In some

* From information supplied by Mr. J. Gordon.

instances, perhaps, such plants are not killed outright, and may recover. In course of time in all the formations where sheep can feed this magnificent plant will be destroyed, and, so far as Campbell Island is concerned, it will only be found in rocky hollows of the cliffs where a sufficient amount of peat can accumulate.

It is the subalpine tussock meadow and the tussock scrub that are undergoing the greatest changes In the former, as pointed out before, the noble grass *Danthonia bromoides* forms great tussocks as large as the largest snow-grass tussocks of the Canterbury mountains. These are eaten right down to their base in one year, if the meadow is heavily stocked, and nothing remains but great roundish decayed mounds, the bases of the leaves projecting upwards, the whole 30 cm. or more in height. Such heaps, at a distance of 90 cm. or so apart, meet the eye all over the hillside. Between these dead tussocks on the south side of Lyall's Pyramid occur the following plants: *Phyllachne clavigera*, various species of lichens, *Luzula crinita*, *Coprosma repens*, a few young grasses belonging to species I could not identify at the time, *Hymenophyllum multifidum*, *Pleurophyllum speciosum* (this mostly quite killed), *Pleurophyllum hookeri* (a good deal eaten), *Epilobium confertifolium*, *Bulbinella rossii* (in large quantity). On the dead rotten hummocks of *Danthonia*, *Phyllachne*, some mosses, and *Coprosma repens* were growing, and on the ground near by *Stellaria decipiens* had become very abundant. *Here, then, a distinctly changed formation is in process of evolution in which the two most striking plants, which stamp the physiognomy of the original formation, will be altogether absent, while some of the smaller plants, kept in check by these dominant larger ones, will increase considerably in numbers.* The next phase in the history of the changed formation will be when introduced plants put in an appearance and contend with the present survivors for possession of the ground, and it is certain from New Zealand experience that many of these will be equally or better in harmony with their new surroundings than are the endemic species.

In some parts of the subalpine region the new formation is somewhat different from that just described, in so much that very large quantities of a small indigenous grass are occupying the ground. According to Mr. Gordon, the manager of the Campbell Island sheep-run, this grass is not destroyed by the sheep, although they feed upon it. If this is so, another meadow formation is in process of evolution, depending probably upon the amount of moisture in the soil. This grass was especially noticeable on the ground below the cliffs on the north side of Lyall's Pyramid.

In certain places the "tussock scrub" has been burned,

and, of course, sheep also can range, and have most probably ranged, over it. Such spots are specially instructive, because these burnt and unburnt portions of the formation can be observed side by side. An account has been given, when dealing with Campbell Island, of this virgin formation, so no more need be said on this head. The burning would, in the first instance, destroy all the plants and parts of plants which were above the surface of the ground. Some would be killed outright, and others spring up again from their underground parts. At the time of my visit the former tussocks were indicated by rotten dead masses of leaves, &c. The *Coprosma* bushes were a mass of dead interlacing branches, which showed most admirably the manner of growth of those shrubs. The floor of the formation beneath such dense bushes had formerly been quite bare, there being neither space nor light enough for plant-life. Now the floor beneath such *Coprosma* skeletons is most densely covered with the pale bluish-green *Acæna;* but frequently this is mixed with *Epilobium linnæoides* and *Stellaria decipiens*. Such new growth is usually of extreme closeness. In the new formation *Aspidium vestitum* is abundant, having come up again from its rootstock after being burnt to the ground. On the ground between the *Coprosma* skeletons and the *Aspidium* is much *Acæna*, while *Epilobium linnæoides* and *Stellaria decipiens* are exceedingly abundant. *In this case, again, the plants which give the stamp to the physiognomy of the original formation are no longer present, while certain plants present in no great abundance before, and which have come up from seed, are now dominant,* the *Acæna* especially being on the point of becoming a "weed" in the eyes of the farmer. This changing of indigenous plants into weeds by disturbing the balance of nature is well shown in Chatham Island, where, even in ground constantly grazed by sheep, *Acæna novæ-zealandiæ* is extremely abundant (23, p. 306), while the frequent burning of bog-vegetation has finally led to the common bracken—*Pteris esculenta*—occupying large areas where formerly it hardly existed, and hindering the growth of grasses available for stock (23, p. 307).

Where the *Dracophyllum* scrub of the lower levels has been burned *Acæna* also is making great headway, though here also *Aspidium vestitum* remains. Most probably such burning of scrub will in time transform the whole scrub formation of the island, except in deep gullies, into meadow of some kind or other.

From the above it is very easy to see that Campbell Island will be a very different place in a few years' time, so far as its plant-formations and plant inhabitants are concerned, if the island continues to be a sheep-run. Possibly none of these latter will be altogether destroyed, unless it be *Danthonia*

bromoides, but some of the most common meadow-plants will be found only on rocky crevices or in the bottoms of unburnt gullies, while other plants formerly kept in check by the vegetation-conditions of the island will have increased to a remarkable extent, some actually becoming "weeds," unless their spread is again checked by some foreign species which may get into the flora. At any rate, after a time equilibrium will be once more restored, and formations apparently natural come into being in harmony with the new biotic surroundings *Under such a condition of affairs some of the then rarest plants will have formerly been the most common, and some of the commonest have been comparatively rare, and have been confined originally to quite different stations.* Thus, originally common meadow-plants may be only rare and local on rocks, and small rare and local rock-grasses may be the chief meadow-grasses. Such facts as these seem to me to have a distinct bearing on plant-distribution in the civilised countries of the Old World.

VI. History of the Flora of the Southern Islands.

To deal at all exhaustively with the history of the flora of the Southern Islands would necessitate going into the origin of the whole New Zealand flora, an undertaking altogether too great for a paper such as this. All that can be attempted here is to give some details regarding the elements of which the flora is composed, and to make some remarks as to its possible origin, specially referring to any matter contained in what has gone before that sheds light on this subject

The elements of the flora are three—an endemic, a Fuegian, and a New Zealand, this latter itself a complex, but here treated as a single element. Only the spermaphytes are here considered. The presence of pteridophytes easily spread by wind is of no very great importance in any discussion regarding the presence of identical forms on land-areas separated by wide stretches of ocean.

The total number of spermaphytes, counting both species and well-marked varieties, is 138, of which 54, or 39 per cent., are endemic; 26, or 18·8 per cent., Fuegian; 7, or 5 per cent., Fuegian which do not extend to New Zealand; and 58, or 43·1 per cent., New Zealand, excluding the New Zealand – Fuegian element, consisting of 19 species. After some hesitation I have included two species which extend to the Chatham Islands amongst the endemic plants.

If we now consider the endemic element, it may be divided into two classes—viz., those species found in only one island of the group and those occurring on more than one. Of the former there are 25 species, which are thus distributed: Auckland Islands, 10; Campbell Island, 7; Antipodes Is-

lands, 3; Macquarie Island, 3; Snares Islands, 2. Regarding the 29 species found on more than one island, 1 (*Colobanthus muscoides*) is found on all the islands; 2 (*Luzula crinita* and *Stilbocarpa polaris*) occur on Auckland, Campbell, Antipodes, and Macquarie; 2 on Auckland, Campbell, and Macquarie (*Pleurophyllum hookeri* and *Stellaria decipiens*); 1 on Auckland and Antipodes (*Pratia arenaria*—also very common in Chatham Island) (23, p. 305); 1 on Snares and Auckland (*Olearia lyallii*); 1 on Auckland and Chatham (*Poa chathamica**); 6 on Auckland, Campbell, and Antipodes (*Acæna sanguisorbæ antarctica, Epilobium confertifolium, Ligusticum antipodum, Pleurophyllum criniferum, Coprosma ciliata, Poa* sp.—the common tussock-grass forming large "trunks"); and 15 on Auckland and Campbell Islands. This distribution of the endemic species shows Auckland and Campbell Islands to be the headquarters of the flora, which, on account of the size of the former and of the number of plant-stations provided by the configuration of the latter, might be expected.

The endemic species are in many cases very closely related to New Zealand ones; indeed, regarding some of them it is a question whether they are not either identical with or at best forms of existing New Zealand species, as, *e.g.*, *Epilobium confertifolium, Pratia arenaria, Azorella reniformis, Coprosma ciliata, Plantago* sp. (the *P. brownii*(?) of the Aucklands), *Ranunculus subscaposus, Aralia lyallii robusta, Acæna sanguisorbæ antarctica, Astelia linearis subulata, Cardamine depressa stellata*, &c. But, notwithstanding this, the endemic element is very clearly defined through the presence of two endemic genera—*Pleurophyllum* and *Stilbocarpa*—and such species as *Ligusticum latifolium, Lig. antipodum, Celmisia vernicosa, Cel. chapmanni, Senecio antipoda, Veronica benthami, Colobanthus muscoides, Cotula lanata*, and *Bulbinella rossii*.

If we turn now to the 58 New Zealand species, 51 are endemic and the remaining 7 Australian. A summary of the stations in which they and the New Zealand–Fuegian species are found in New Zealand proper is not without interest. For this purpose I have roughly classed these stations under three heads—coastal, forest, alpine and subalpine. Under the term "forest" is included not only the plants of the forest proper, but those which are found in

* It is doubtful whether this grass occurs in Auckland or Antipodes. Moreover, Petrie, who recorded its occurrence in the Southern Islands, shows that it differs from the Chatham Island plant in certain particulars; but he adds (85, p. 395), "It is clearly a form of the present species" [*P. chathamica*], "and presents only such subvarietal differences as might be expected from the difference of habitat combined with long isolation."

the forest region, even if meadow-plants. This classification is quite a rough one, for many plants are found in all kinds of stations and at all kinds of altitudes. Placing the New Zealand species after (*a*) and the New Zealand - Fuegian after (*b*), the figures are: Coastal — (*a*) 12, (*b*) 8 = 20; forest — (*a*) 18, (*b*) 2 = 20; alpine and subalpine — (*a*) 28, (*b*) 9 = 37. Thus, the mountain-plants are considerably in excess of either of the other classes; and this is more accentuated when it is pointed out that the forest-plants are in large measure plants of a forest which ascends to the lower subalpine region, or is found usually, when at a lower altitude, under such conditions as will permit the growth of alpine plants at a low level—*e.g.*, Stewart Island, west coast of South Island, &c. Generally speaking, these alpine plants are not amongst those most characteristic of subalpine and alpine plant-formations. Certain genera, such as *Raoulia*, *Gaultheria*, *Euphrasia*, *Ourisia*, *Pimelea*, *Forstera*, *Gunnera*, *Wahlenbergia*, and *Coriaria*, are altogether wanting; and of the numerous species of *Celmisia*, *Olearia*, *Veronica*, and *Senecio* none of the mountain forms extend to the Southern Islands, where, however, they are represented by one or two Southern Islands' endemic or New Zealand coastal species. Of the more common mountain-plants common to New Zealand and the Southern Islands, it is an interesting fact that they are frequently plants of New Zealand alpine bogs, in certain places, however, in the south of the South Island and in Stewart Island occurring also in bogs at sea-level. Amongst these are *Gaimardia ciliata* and *Gaim. pallida*, *Drosera stenopetala*, *Oreobolus pumilio*, *Scirpus aucklandicus*, *Cyathodes empetrifolia*, *Ehrharta thomsoni*, *Carex ternaria* (also frequent in lowland stations), and *Juncus scheuzerioides* (see also Diels, 27, pp. 254, 257) Some of the alpine plants belong to the subalpine scrub—*e.g.*, *Coprosma cuneata*, *Dracophyllum longifolium*, *Drac urvilleanum*,* *Myrsine divaricata*, *Cassinia vauvilliersii*. *Coprosma repens* is a very common subalpine meadow-plant, while *Helichrysum prostratum* is by no means widespread, but its close ally *H. bellidioides* is everywhere on the mountains.

Having now briefly considered the elements of the flora, we are led to inquire how did they reach a number of very small islands not merely far away from any centre of distribution, but distant from one another some hundreds of miles; and, above all, how comes it that this group of islands has nearly 19 per cent. of its flora composed of species—twenty-six in number—which occur in the southern part of

* This is if we accept Kirk's identification of the species of *Dracophyllum* most common in the scrub of Campbell Island.

South America, distant about half the circumference of the globe? Two explanations have been suggested: one that seeds of these Fuegian plants were brought by winds, by birds, by ocean currents, on icebergs, &c.; the other that changes more or less great in the configuration of the lands of the Southern Hemisphere have taken place, bringing different points either into direct land-communication or very much nearer than they are at present. Correlated with this latter view is the belief that a milder climate may have existed in the Southern Hemisphere than is now the case.*

As to the first hypothesis, I may point out that introduced land-birds have been blown from New Zealand to Auckland Island and to Chatham Island, and that in consequence certain European birds are now naturalised on these two islands. The smoke of bush-fires reaches Chatham Island during certain winds from New Zealand. Dr. P. Marshall has recently shown (76) how a storm of dust has reached New Zealand from Australia, and how during such an occurrence small seeds could reach New Zealand from Australia. Certain islands are supposed to have been colonised with plants entirely by such methods as the above, the Azores and Bermudas being cases in point. As for the latter group, Trelease considers(101*a*) that most of the existing species have been introduced largely by human agency since the discovery of the islands.

As for the currents, Captain Bollons writes to me: "The current, generally speaking, is a set to the eastward, sometimes at the rate of one and a half knots per hour. Have not noticed anything in the shape of driftwood or flotsam of any kind which could be taken as coming from other lands." So far as Chatham Island is concerned, logs from New Zealand have been frequently cast up on its shores.

Sea-birds, as shown previously, are enormously abundant on these islands. Some of these make their nests in the ground, and so, as Moseley has shown, may get their feathers covered with vegetable mould, which in some cases will contain seeds. The fruits of *Acæna*, as shown above, adhere in large numbers to the feathers of the albatros. Whether such sea-birds visit any other islands than the one on which they breed I do not think is known; nor are any facts available as to how much exposure to salt-water the seeds of the plants under consideration could tolerate. As to whether sea-birds will eat the fruits of berry-bearing plants, for instance, there is, so far as I know, only the testimony of Dr. Guppy (37), which refers merely to one case.

* This is now confirmed by Mr. Ferrar's splendid discovery of fossil plants on the Antarctic Continent during the recent British Antarctic Expedition.

Generally speaking, the consensus of opinion amongst botanists is against seeds being brought in appreciable quantities over wide stretches of ocean, and I do not think that any one at the present time claims that all the ancestors of the New Zealand flora arrived in this manner.

As to whether the Southern Islands got their New Zealand element by wind-carriage, water-carriage, bird-carriage, &c., I will only make one or two remarks. The seeds of New Zealand plants as a whole do not germinate very readily; nor will the majority germinate at all unless the conditions be very favourable Seeds of introduced plants in New Zealand, even those of most aggressive species, rarely produce plants that come to maturity in undisturbed ground in mountain regions where introduced animals, including man, have never been. Even on the lowlands it is the ground that has been disturbed that they seize upon, and it is under artificial conditions that they exterminate indigenous plants. Plants from a flower-garden, even when they seed freely and produce young plants in the garden itself, rarely invade the surrounding country by means of seedlings. So far as I have observed, it is only plants with certain special adaptations which become naturalised in special positions and there become dominant

The presence in the Auckland Islands of a New Zealand rata forest—*i.e.*, not of a number of separated species, but of a distinct plant-formation such as one might encounter in many parts of the South Island—is a matter bearing directly upon the question of former land-connection between the southern parts of the New Zealand biological area. This rata forest, wanting some few of its usual constituents, indeed, but otherwise, excepting for its peculiar physiognomy, which is in harmony with the climatic conditions, is a true New Zealand rata forest, a combination of *Metrosideros lucida*, *Panax simplex*, *Dracophyllum longifolium*, *Coprosma fœtidissima*, *Suttonia divaricata*, beneath the shade of which are the ferns, mosses, liverworts, and lichens which one would expect to be there. Were the tree *Weinmannia racemosa* present nothing would be wanting. The presence of such a forest some hundreds of miles from New Zealand is to me a most striking fact. It is quite conceivable how seeds or fruits of many plants might be brought by wind, by birds, or other agencies, but that such should consist in large measure of the plants of some special formation, and that they should arrange themselves in almost exactly the same manner as they did in the land of their nativity, is a matter much more difficult to believe than that New Zealand has extended to the south far beyond its present limits, and that on such land a previously existing forest has slowly moved southwards. This brings us at once to the question of what evidence there

is regarding former extension of New Zealand, and while on this topic the question of former antarctic land-areas occupied by plants may be briefly discussed. To approach this difficult question we must turn to the geological history of New Zealand. Captain Hutton's most recent utterance on the subject may be taken as summing up what is believed to be known on this head Here there is no need to go into Hutton's arguments; only some of his conclusions need be stated: "In the middle of the Jurassic period came a violent upheaval." "The new land, which we may now call New Zealand, for it has never since been entirely covered by the sea, extended in a westerly direction to at least twice its present breadth, and to the north it joined New Caledonia and New Guinea, which at that time probably formed part of a South Pacific continent.* Plants and animals—including snails, worms, and insects, but no birds—came trooping down from the north to form the basis of our flora and fauna." "In the Upper Cretaceous the land subsided, and New Zealand was reduced to comparatively small limits." "A little before the commencement of the Tertiary era the rocks were folded once more, the land rose again, and again it stretched far away to the north, but was not again united to New Guinea or to northern Australia. A second invasion from the north followed, and quantities of plants of all descriptions, accompanied by animals—among which were many land-birds—migrated to New Zealand, and it is the descendants of this Eocene invasion which form the greater part of the present fauna and flora." "In the older Pliocene came the last great upheaval. All the islands were joined together, and the land stretched away to the east and south so as to include the Chatham and Auckland Islands, as well, perhaps, as Campbell and Macquarie Islands, while to the north it certainly extended to the Kermadecs and much further. Probably at this time more land existed in the Antarctic Ocean, for New Zealand added to its flora and fauna many antarctic plants and marine animals. But this land could not have connected New Zealand with either Patagonia or South Africa, for if it had done so we should certainly have had more immigrants, including land-birds and probably mammals" (52, pp. 181, 182).

Wallace, although far from agreeing with Hutton in all his conclusions. also believes in a much greater extension of New Zealand, and seeks to show how the basis of its flora came from Australia (102, p. 506) during a period—probably

* The recent discovery of species of *Corynocarpus*, supposed to be endemic in New Zealand, in New Caledonia and New Hebrides is of great interest in this connection (43*a*).

the early Tertiary—when that continent, although connected with New Zealand, was itself divided into an eastern and a western half by a wide strait (102, p. 496), New Zealand having previously possessed "a scanty vegetation of mixed antarctic and Polynesian origin" (*l.c.*, p. 499) By the above means New Zealand would get the thirty-two tropical genera common to it and Australia, and probably "thirty-two more genera, which, though chiefly developed in temperate Australia, extend into the tropical or subtropical portions of it, and may well have reached New Zealand by the same route" (*l.c.*, p. 501). The ninety-six species common to New Zealand and Australia at a much more recent period in some manner or other crossed the sea, at least six hundred miles broad, between New Zealand and Australia. The Fuegian plants, many of which belong to northern genera, the New Zealand genera *Pachycladon* and *Notothlaspi*, "said to have affinities with arctic plants," and *Stilbocarpa*, with its "nearest allies in the Himalayan and Chinese *Aralias*" (*l c.*, p. 519), came from South America (the arctic and northern elements by way of the Andes during the glacial periods), some settling down in Tierra del Fuego and Southern Chile; others passed over the five hundred miles to the South Shetlands, and thence by way of the antarctic continent or group of large islands to Adélie Land, and thence to Young Island. From here they travelled across the sea 750 miles to Macquarie Island, and thence across another expanse of sea to New Zealand or Tasmania, these lands at this time having a considerable extension to the south

Dr. H. O. Forbes advocates actual land-connection between the New Zealand biological area, the antarctic continent, South America, South Africa, &c, but unfortunately only the short notice of his views in *Nature* and certain letters he wrote in that journal are available here (36)

With regard to direct land-connection between New Zealand and South America, the presence of genera of animals which could not tolerate sea travel is of the highest importance Such, for instance, are earthworms. Regarding the genus *Microscolex*, of which a species, *M. huttoni*, occurring in Chatham Island, was recently described by Dr. W. B. Benham, that author writes (6, p. 143), "The existence of this genus here in New Zealand, with four distinct species, goes very far towards supporting a land-connection with South America, and points perhaps rather to a connection with the northern part of the southern continent than with the extreme south." Another worm is *Acanthodrilus macquariensis*, Benham, of Macquarie Island, which "has closer affinities with the species occurring in Patagonia, the Island of South Georgia, and the Falkland Isles than with those of New Zealand" (*l.c.*, p. 132);

while as for *Notiodrilus aucklandicus*, Benham, of the Auckland Islands (7) the same may be said, it in addition having affinities with South African species.*

Spiders, again, are animals which could not travel by means of the sea or be blown for long distances by wind. On the Bounty Islands, which consist entirely of granite, and therefore are of great age, as pointed out before, are many spiders. Specimens of these, collected by me in July last, were sent to Mr. H. R. Hogg, who thus writes regarding them to Professor C. Chilton, to whom I gave the specimens, "The spiders you sent from Bounty Island are most interesting. Their nearest congeners are from the south of South America, and although they are typical of a well-defined family, the *Cybocinæ*, I have had to make a new genus for them." "They would seem to add another link to the connection of South America with Australia."

Dr. H. Woodward, in a recent paper, sums up the evidence, geological, zoological, and botanical, in favour of a former antarctic continent containing an abundant fauna and flora, and concludes that "a summary of the flora characteristic of the Southern Hemisphere fully confirms the conclusions derived from a study of the fauna, and establishes beyond a doubt the former existence of extensive land-connections between the southern continents and islands in Tertiary times which have since disappeared beneath the ocean" (105, p. 429).

Now, all the above does not put us much beyond Hooker's classical theory of a much greater extent of land in the Southern Hemisphere to account for that most wonderful fact, the exact similarity of the flora of all the antarctic islands from Cape Horn to Kerguelen Land, a similarity so great that Alboff includes in his term "Fuegian flora" the plants of all the land on the western side of the Andes from and including the Chronos Archipelago and the numerous isles along the coast, the greater part of the north side of the Strait of Magellan, Tierra del Fuego (excepting its northern flat portion), the Falklands, and the other islands at about the same latitude up to and including Kerguelen Land (1).

I have pointed out above how the presence of the rata forest in the Auckland Islands supports Hutton's theory of a great southern extension of land during the Pliocene period. On the other hand, the *Pleurophyllum* meadow may be the last remnant of a former much more extensive southern meadow formation. *Pleurophyllum*, an endemic genus in the

* During my excursion I collected a number of earthworms, of which probably one from Antipodes and two species from Campbell Island may be of some interest. These are now in Professor W. B. Benham's hands for identification

Southern Islands, and occurring in the whole of them except the Snares, is, according to Bentham (4*a*, p. 407), closely related to the Andine section *Orithropium* of Erigeron, as is also *Celmisia*. If, with Bentham and the "Pflanzen-Familien," we consider all the southern species of *Ligusticum* to belong to *Aciphylla*, then this may also be, perhaps, called an "antarctic genus," although most closely related to the northern *Ligusticum*. *Acæna*, *Epilobium*, *Uncinia*, and *Veronica* may also well have belonged to this problematical ancient plant-formation. The presence of *Stilbocarpa* and *Bulbinella* present more difficulties. The former, as stated above, is allied to the Chinese araliads, so it either did not belong to the above suggested ancient antarctic plant-formation, or its ancestors in other parts of the Fuegian region have long since died out, these coming, as Wallace suggests, from the north during the glacial period. As for the presence of the South African genus *Bulbinella*, it is one of those remarkable South African relationships such as *Peripatus* amongst animals.

The bright colours of the flowers of this formation—blue, red, purple—have already been alluded to. Captain Hutton has shown that such in this case is hardly correlated with the visits of insects (53*b*). It seems to me most probable that these colours originated through the greater amount of sunlight to which the plants would be exposed during the long summer days of a higher latitude.* On this head Schimper writes (92, p. 716), "Die in den meisten Reiseberichte erwähnte Farben-intensität der arctischen Blüthen wird gewohnlich und wohl mit Recht, als ein Wirkung der andauernden Beleuchtung aufgefasst."

On the Snares, Ewing Island, and in one or two places on Auckland Island is an *Olearia lyallii* forest. This is apparently just as much in harmony with its surroundings as is the dominant rata forest; but I think there can be little doubt, from what has been said in treating of the forest-formations of the Auckland Islands, that this *Olearia* forest was once more extensive, but has been gradually driven into smaller and smaller compass by the encroaching rata forest. In my opinion, the *O. lyallii* † forest is the ancient forest of the Southern Islands, perhaps, indeed, that of a part of the problematical antarctic continent; but it could not withstand the more vigorous Pliocene invader. The genus *Olearia* is exceedingly common in New Zealand, there being at least thirty-four species According to Bentham (4*a*, p. 405),

* On the other hand, their luxuriant growth does not point to evolution in a rigorous climate.

† According to this view *O. lyallii* and many of the endemic plants are examples of "relict endemism," and not of "initial endemism," to use the term suggested by Shull (94).

Olearia is closely allied to "the antarctic or subantarctic genus *Chilotrichium*, a genus of three species, one of the numerous connecting-links between the Australian and extra-tropical or Andine South American floras. This genus is closely allied as well to *Olearia* of the former as to *Diplostephium* of the latter region." *Olearia lyallii* belongs to a distinct division of the genus confined to the New Zealand area, distinguished by their large solitary heads, usually solitary on terminal peduncles, but in one species with simple 3–8-flowered racemes. Kirk has called this section of the genus the macrocephalous *Olearias*. Besides the flower-heads, the foliage is very distinct. With one exception, the xerophytic *O. insignis*, they all occur in the very wettest regions of the South Island or on the Chatham Islands, Stewart Island, and the Southern Islands. *O. lyallii* is very closely allied to *O. colensoi* of Stewart Island and the western subalpine scrub in the South Island.

The extraordinary plasticity of many New Zealand plants, shown by the great changes in leaf-form which can be quickly brought about by culture under conditions different to what they experience in nature, and the striking heterophylly exhibited in a state of nature by a great number of plants, points distinctly to the species being by no means in harmony with their present surroundings. *Discaria toumatou* cultivated in moist air no longer produces spines, but in their place are drooping leafy shoots. Many species belonging to the genera *Raoulia*, *Veronica*, and *Carmichaelia*, all most characteristic New Zealand genera, will revert to the seedling form by cultivation in moist air or feeble light (see Pl. XXII.), or under the same conditions the seedlings in some cases will never assume the adult form. The case of New Zealand xerophytic shrubs as affording evidence of the Pliocene land-extension has already been cited.

As for further evidence regarding land-connection with South America, no more need be said except to point out the great resemblance between the flora of Kerguelen Land and that of Macquarie Island In this latter island no fewer than nine out of twenty-seven species are Fuegian, and if we omit the endemic species of Kerguelen Land, including *Poa cookii* as such, six out of the remaining fifteen species occur on Macquarie Island, amongst which is the wonderful *Azorella selago*, which does not extend to any of the other islands.

Whether all the Southern Islands have formed a part of New Zealand during its one, or it may be more, southern extensions is a debatable point. Filhol (35*a*), from geological evidence collected on the island during a stay of a considerable period, claims that Campbell Island has always remained isolated. Hector, on the contrary, considers that

some part has been above sea-level since before the volcanic outburst to which almost all the present island is due. So far as the botanical evidence is concerned, the many species these islands have in common points distinctly to connection.

As for Antipodes Island, Hutton suggests that this has never been united to the other Southern Islands. Here, again, I think the botanical evidence is in favour of land-connection, for the prevailing north-west wind would be just as likely to colonise it with plants from New Zealand as the south-west with plants from others of the Southern Islands.

The Bounty Islands are perhaps the last remnant of a portion of greater New Zealand, and its scanty algal flora not the commencement of a land flora on a new-born land just issuing from the waters, but the last survivors of such a vegetation as that which has been described for these Southern Islands.

VII. List of the Indigenous Spermaphytes and Pteridophytes of the Southern Islands.

In the following the various elements which make up the flora of the Southern Islands are thus indicated: A = endemic in the Southern Islands; B = occurring also in New Zealand; C = Fuegian, using this term in the wide sense proposed by Alboff (1).

—	Snares.	Auckland	Campbell.	Antipodes.	Macquarie.
Ranunculaceæ.					
Ranunculus pinguis, Hook. f. A	..	1	1	..	..
R. acaulis, Banks and Sol. B	..	1	..	..	..
R. subscaposus, Hook. f. A	..	..	1	..	..
R. aucklandicus, A. Gray. A	..	1	1?	..	..
For the Campbell Island habitat see Kirk (57, p. 387). Probably he confused *R. subscaposus* with this species, for he only gives Auckland Island as habitat in "Students' Flora."					
R. hectori, Kirk. A	..	1	..	..	..
I am by no means sure that this is distinct from *R. aucklandicus*.					
R. crassipes, Hook. f. C	..	..	..	..	1
Cruciferæ.					
Cardamine hirsuta, L., var. *subcarnosa*. B	..	1	1	..	1
C. corymbosa, Hook. f. B	..	1	1	..	1
C. depressa, Hook. f. B	..	1	1	..	..
C. depressa var. *stellata*. A	..	1	1	..	..
Lepidium oleraceum, Forst. B	1	1	..	..	..
For Auckland Island habitat see Kirk (59, p. 379)					

—	Snares.	Auckland.	Campbell.	Antipodes.	Macquarie
CARYOPHYLLACEÆ.					
Stellaria decipiens, Hook. f. A	..	1	1	..	1
S. decipiens var. *angustata*, T. Kirk. A	..	..	..	1	..
Colobanthus billardieri, Fenzl. B, C	.	1	1	1	1
C. subulatus, Hook. f. B, C	..	..	1	..	..
C. muscoides, Hook. f. A..	1	1	1	1	1
PORTULACEÆ.					
Montia fontana, L. B, C..	.	1	1	..	1
Occurs in north and south temperate regions.					
GERANIACEÆ.					
Geranium microphyllum, Hook. f. B	..	1	1	..	..
Subalpine region, Campbell Island, L. C.					
ROSACEÆ.					
Geum sericeum, Kirk. A	..	1	..	..	..
Allied to a Fuegian species					
Acæna sanguisorbæ, Vahl. B	..	1	1	1	1
A. sanguisorbæ var. *antarctica*, var. nov.	..	1	1	1	..
This is the common *Acæna* of the Southern Islands, and seems to me quite distinct from any form found in New Zealand. It was most likely referred to var. *pilosa* by Kirk, to which form, or, as I consider it, species, it bears some resemblance. The leaves are pale-green, but not whitish-green as those of *A. sanguisorbæ* var. *pilosa*, glabrous on upper surface, but with many adpressed hairs on under-surface. Scape almost glabrous, short and hardly raised above the foliage, ± 2·3 cm. long (In the var. *pilosa* the scapes are raised high above the foliage.) Head ± 8·5 mm. in diameter; calyx-lobes bright-green (in the var. *pilosa* they are more or less reddish), calyx-tube not densely pilose; stamens not exserted, but it may be that this variety is in part dioecious.					
A. sanguisorbæ antarctica can be distinguished at a glance from *A. sanguisorbæ pilosa* by the general aspect, which is chiefly brought about by the colour of the leaves, the length of the scapes, the colour of the calyx-lobes, and the length of the stamens.					
A. adscendens, Vahl. C	..	..	..	..	1
This is stated to occur in New Zealand, but Macquarie Island specimens which I have examined seem to me very different to the New Zealand plant, with which I am well acquainted.					
CRASSULACEÆ.					
Tillæa moschata, D.C. B, C	1	1	1	1	1

—	Snares.	Auckland.	Campbell.	Antipodes.	Macquarie.
DROSERACEÆ.					
Drosera stenopetala, Hook. f. B	..	1	..	..	..
HALORAGIDACEÆ.					
Callitriche antarctica, Eugelm. C	1	1	1	1	1
MYRTACEÆ.					
Metrosideros lucida, A. Rich. B	..	1	1?	..	..
Mr. Gordon, who knows this plant quite well, states that he has not seen it in Campbell Island.					
ONAGRACEÆ.					
Epilobium linnæoides, Hook. f. B	..	1	1	1	1
E. confertifolium, Hook. f. A	..	1	1	1?	..
Kirk refers certain New Zealand forms to this species, but Mr. D. Petrie, with whom I fully agree, considers that *E. confertifolium* does not occur in New Zealand proper. The flowers are bright-pink.					
E. nerterioides, A. Cunn. B	..	1	..	..	1
E. alsinoides, A. Cunn. B	..	..	..	1	..
I am not sure that Kirk's identification is correct.					
E. nummularifolium, R. Cunn. B	..	..	..	..	1
Probably this is *E. nerterioides*.					
UMBELLIFERÆ.					
Azorella selago, Hook. f. C	..	..	..	.	1
A. reniformis, Benth and Hook. A	..	1	1	..	..
Ligusticum latifolium, Hook. f. A	..	1	1	..	.
L. antipodum, Hook. f. A		1	1	1	..
L. acutifolium, Kirk. A	1	..	..	..	..
Apium australe, Thouars. B, C	1	..	..	1	..
ARALIACEÆ.					
Panax simplex, Forst. f. B	..	1	..	..	..
Stilbocarpa polaris, A. Gray. A	..	1	1	1	1
Aralia lyallii, Kirk (Armstg.), var. *robusta*, Kirk. A	1	..	..	..	..
I consider this a distinct species, so far as I can judge from the description and my knowledge of *A. lyallii*.					
RUBIACEÆ.					
Coprosma fœtidissima, Forst. B	..	1	1?	..	..
According to Mr. Campbell this does not occur in Campbell Island.					
C. cuneata, Hook. f. B	..	1	1	1	..
C. ciliata, Hook. f. A	..	1	1	1?	..
I am not sure but that a ciliate-leaved *Coprosma* from Westland should be referred to this species. I am not at all certain as to what species the Antipodes Island *Coprosma* should be referred.					
C. repens, Hook. f. B	..	1	1	1	1
Nertera depressa, Banks and Sol. B, C	..	1	1	..	..

—	Snares.	Auckland.	Campbell.	Antipodes.	Macquarie.
COMPOSITÆ.					
Lagenophora forsteri, D.C. B	..	1	1	1	..
Olearia lyallii, Hook. f. A	1	1	..	..	..
Celmisia vernicosa, Hook. f. A	..	1	1	..	..
C. chapmanni, Kirk. A	..	..	1	..	..
C. verbascifolia, Hook. f. (Campbell Island, Rathouis)	..	..	1?	..	..
The occurrence of this on Campbell Island seems most unlikely. Mr. Gordon has never seen it.					
Gnaphalium luteo-album, L. (cosmopolitan). B ..	..	1	..	1	..
Abrotanella spathulata, Hook. f. A	..	1	1	..	..
A. rosulata, Hook. f. A	..	..	1	..	..
Helichrysum prostratum, Hook. f. B	..	1	1	1	..
Cotula plumosa, Hook. f. C	..	1	1	1	1
C. propinqua, Hook. f. A	..	1	1	..	..
C. lanata, Hook. f. A	..	1	1	..	..
C. australis, Hook. f. B	..	..	1	..	..
For occurrence of this on Campbell Island see Buchanan (9, p. 399).					
Pleurophyllum speciosum, Hook. f. A	..	1	1	..	..
P. criniferum, Hook. f. A	..	1	1	1	..
P. hookeri, Buchanan. A	..	1	1	..	1
Senecio stewartiæ, J. B. Armstg. B	1	..	..	..	..
This does not occur either on the actual mainland of New Zealand or on Stewart Island, but on some small islands in close vicinity to this latter.					
S. antipoda, Kirk. A	..	..	..	1	..
Cassinia vauvilliersii, Hook. f. B	..	1	1?	..	..
Mr. Gordon says he has not observed this on Campbell Island, and I certainly did not meet with it.					
Erechtites sp. B	..	1	..	..	..
Enderby Island, L. C.					
Sonchus asper,* Hill (cosmopolitan). B	1	.	..	1	..
If *S. asper littoralis*, Kirk, is the plant which grows on the Snares, then it is the form, or perhaps species, which is confined to New Zealand.					
STYLIDIACEÆ.					
Phyllachne clavigera (F. Muell.), Hook. f. A ..	..	1	1	..	..
CAMPANULACEÆ.					
Pratia arenaria, Hook. f. A	..	1	..	1	..
Also common in Chatham Island.					

* This and *Cotula dioica* have been collected on the shore of Auckland Island by Dr. R. Koettlitz during the recent visit of the "Discovery." *Cotula dioica* is an addition to the flora of the Southern Islands, but it is not included in my percentages, &c.

—	Snares.	Auckland.	Campbell.	Antipodes.	Macquarie.
ERICACEÆ.					
Dracophyllum longifolium, R. Br. B .. .. A var. "*retortum*" is figured in (45). Possibly *D. arboreum*, Cockayne, of Chatham Island, is a form of this species.	..	1	1	..	..
D. scoparium, Hook. f. A	..	..	1	..	..
D. [*urvilleanum*, A. Rich.(?)]. B(?)	..	..	1	..	..
Cyathodes empetrifolia, Hook. f. B	..	1	1	.	..
MYRSINACEÆ.					
Suttonia divaricata, Hook. f. B	..	1	1	..	..
PRIMULACEÆ.					
Samolus repens, Pers. B, C	..	1	..	..	..
GENTIANACEÆ.					
The species are here given as in Kirk (69).					
Gentiana cerina, Hook. f., form *α*, *suberecta*, Kirk. A	..	1	..	..	..
G. cerina, form *β*, *cerina*, Kirk. A	..	1	..	..	..
G. cerina, form *γ*, *concinna*, Kirk. A	..	1	..	..	..
G. antarctica, Kirk. A	..	..	1	..	..
G. antarctica var. *imbricata*, Kirk. A	..	..	1	..	..
G. antipoda, Kirk. A	..	..	..	1	..
Kirk makes some interesting ecological remarks regarding the variation of *G. cerina* according to station, and the above three forms are dependent on their station. Experimental work is required on this head, a not too easy matter, since these gentians are difficult to cultivate.					
BORAGINACEÆ.					
Myosotis capitata, Hook, f. B	..	1	1?	..	..
M. capitata albiflora. B	1	..	..	..	..
M. antarctica, Hook. f. B(?)	..	..	1	..	..
The flowers are coloured blue in "Flora Antarctica." The series of forms referred to this species in New Zealand have white flowers. Perhaps the Southern Islands plant is a distinct variety or species.					
SCROPHULARIACEÆ.					
Veronica elliptica, Forst. B, C	1	1	1	..	..
[*V. odora*, Hook. f.]	..	1	..	..	..
This, I think, is at most a form of *V. elliptica*.					
V. benthami, Hook. f. A	..	1	1	..	..

—	Snares.	Auckland.	Campbell.	Antipodes.	Macquarie.
PLANTAGINACEÆ.					
Plantago aucklandica, Hook. f. A	..	1	..	..	..
P. [*brownii*, Rafin.(?)]. A	..	1	..	..	..
This is the *P. carnosa* figured in the "Flora Antarctica." When growing it bears no resemblance whatever to the plant known as *P. brownii* in the Southern Alps. It much more resembles a species of *Plantago* very common in coastal situations in the neighbourhood of Foveaux Strait, which is probably *P. hamiltonii*, Kirk. The Auckland Island species certainly seems to me distinct from any New Zealand species.					
POLYGONACEÆ.					
Rumex neglectus, Kirk. B	..	1	..	..	..
URTICACEÆ.					
Urtica aucklandica, Hook. f. A	..	1	..	..	..
U. australis, Hook. f. B	..	1	..	1	..
This species is not found on the New Zealand mainland. It occurs, however, on Dog Island and Centre Island, in Foveaux Strait, and it very probably occurs on some one or other of the beaches of Stewart Island. It is common in Chatham Island.					
ORCHIDACEÆ.					
The time of the year being quite unfavourable for obtaining these plants, none were seen by me. This list is merely compiled from Hooker, Kirk, &c.					
Corysanthes rotundifolia, Hook. f. B	..	1	1	1?	..
C. macrantha, Hook. f. B	..	1	..	..	..
Caladenia lyallii, Hook. f. B	..	1	..	..	..
C. bifolia, Hook. f. B	..	1	1	..	..
Chiloglottis cornuta, Hook. f. B	..	1	1	1	..
Lyperanthus antarcticus, Hook. f. B	..	1	..	..	..
Thelymitra longifolia, Forst. B	..	1	..	..	..
T. uniflora, Hook. f. B	..	1	..	..	..
Prasophyllum colensoi, Hook. f. B	..	..	..	1	..
LILIACEÆ.					
Bulbinella rossii, Benth. and Hook. (Hook. f.). A ..	..	1	1	..	..
Astelia linearis, Hook. f. B	..	1	1	..	..
A. linearis subulata, Hook. f. A	..	1	1	..	..
Probably a species.					

—	Snares.	Auckland.	Campbell	Antipodes.	Macquarie.
JUNCACEÆ.					
Juncus antarcticus, Hook. f. B	..	1	1	..	..
J. scheuzerioides, Gaud. B, C	..	1	1	1	..
J. bufonius, L. (cosmopolitan). B, C	1	1	..	..	..
J. planifolius, R. Br. B	1	..	.	..	..
Rostkovia gracilis, Phil. C	..	1	1	..	..
R. sphænocarpa, Desv. B, C	..	..	1	..	..
Luzula crinita, Hook. f. A	..	1	1	1	1
RESTIACEÆ.					
Gaimardia ciliata, Hook. f. B.	..	1	..	..	..
G. pallida, Hook. f. B	..	..	1	..	..
CYPERACEÆ.					
Scirpus aucklandicus (Hook. f.), Bœck. B, C ..	1?	1	1	1	..
S. cernuus, Vahl. (cosmopolitan). B, C	1	..	..	1	..
S. antarcticus, L. B, C	1	..	..	..	..
Oreobolus pumilio, R. Br. B, C	..	1	1	..	..
Carex ternaria, Forst. f. B	..	1	..	1	..
C. trifida, Cav. B, C	1	1	1	1	..
C. appressa, R. Br. B	..	1	1	1	..
Uncinia riparia, R. Br., var. *pseudorupestris*, Kuken. B	..	1	1	1	1
According to a communication from Pastor G. Kukenthal, who is investigating the genus *Carex* for "Das Pflanzenreich," the synonyms of this variety are "*U. rupestris*, Boott., non Raoul, and *U. hookeri*, Boott. Kukenthal also writes, "The true *U. rupestris*, Raoul, is not in the Kew Herbarium. I think that it is identical with *U. nervosa*, Boott.					
GRAMINACEÆ.					
Ehrharta thomsoni, Petrie. B	..	1	..	..	..
Hierochloe redolens, R. Br. B, C	1	..	1	..	..
H. brunonis, Hook. f. A	..	1	1	..	..
Deyeuxia forsteri, Kunth. B	1	..	1	..	..
Agrostis antarctica, Hook. f. C	..	..	1	1	1
A. subulata, Hook. f. A	..	..	1	..	..
Deschampsia cæspitosa, Beauv. (cosmopolitan). B, C	..	1	..	..	..
D. chapmanni, Petrie. A	..	1	..	..	..
D. hookeri, Kirk. B	..	1	1	1	1
D. gracillima, Kirk. A	..	1	..	..	..
D. penicillata, Kirk. A	..	..	..	..	1
Trisetum subspicatum, Beauv. B, C	..	..	1	..	..
Northern arctic regions.					
Danthonia bromoides, Hook. f. B	..	1	1	..	..
D. australis, Buch. B	..	..	1	..	..
Festuca scoparia, Hook. f. B	1	1	1	1	..
F. contracta, Kirk. A	..	..	..	..	1

—	Snares.	Auckland.	Campbell.	Antipodes	Macquarie.
Poa foliosa, Hook. f. B	1	1	1	1	1
Not found on the actual mainland, the so-called var. β having been made by Hackel into a species under the name *Poa novæ-zelandiæ* (38).					
P. ramosissima, Hook. f. A	..	1	1	..	..
P. hamiltonii, Kirk. A	..	..	..	..	1
P. breviglumis, Hook. f. A	..	..	1	1	..
P. crassata, Petrie. A	..	1	..	..	..
P. chathamica, Petrie. A	..	1?	..	..	..
P. [anceps, Forst.(?)] A(?)	..	1?	1?	1	..
PTERIDOPHYTA. B.					
Hemitelia smithii, Hook. B	..	1	..	..	..
Hymenophyllum tunbridgense, Sm. B	..	1	..	..	..
H. minimum, A. Rich. B	..	1	..	..	..
H. bivalve, Swartz. B	..	1	..	..	..
H. multifidum, Sw. B	..	1	1	1	..
H. polyanthos, Sw. B	..	1	..	..	..
H. villosum, Col. B	..	1	1	1?	..
H. dilatatum, Sw. B	..	1	..	..	..
H demissum, Sw. B	..	1	..	..	..
H. flabellatum, Labill. B	..	1	..	..	..
H. javanicum, Spgr. B	..	1	..	..	..
Pteris esculenta, Forst. B, C	..	1?	1	..	..
I did not observe this species.					
P. incisa, Thunb. B, C	..	1	..	1	..
Lomaria procera, Spgl. B, C	..	1	1	1	..
L. discolor, Willd. B	..	1	1	..	..
L. dura, Moore. B	..	1	1	1	..
L. alpina, Spgl. C	..	..	.	1	1
L. fluviatilis. B	..	1	..	..	..
Forest south of Auckland Island, L. C.					
Asplenium mohrioides. C	..	1	..	..	..
A. obtusatum, Forst. B, C	1	1	1	1	..
A. scleroprium, Homb. and Jacq. A	..	1	..	..	..
A. bulbiferum, Forst., var. B(?)	..	..	..	1	..
A. flaccidum, Forst. B	..	1	..	..	..
Aspidium vestitum. B, C	..	1	1	1	1
A. cystotegia, Hook. B	..	1	..	..	..
Polypodium (Grammitis) australe, Mett. B, C ..	..	1	1	1	..
P. australe rigida, Homb. and Jacq. A	..	1	..	..	..
P. australe pumila, Armstg. B	..	..	1	..	1
P. grammitidis, R. Br. B, C	..	1	1	..	..
P. rugulosum, Labill. B	..	1	1	..	..
P. (Phymotodes) billardieri, R. Br. B	..	1	1	..	..
Schizæa australis, Gaud. B, C	..	1	..	..	..
Hypolepis millefolium. B	..	..	..	1	..
Todæa superba, Col. B	..	1	..	..	..
Lycopodium varium, R. Br., var. *polaris*, Kirk. B ..	..	1	1	1	1
L. fastigiatum, R. Br. B, C	..	1	1	1	..
L. scariosum, Forst. B, C	..	1	..	..	..
Tmesypteris forsteri, Endlich. B	..	1	..	..	..

VIII. Table showing Percentage of the Different Floral Elements for each of the Southern Islands.

Explanation of Abbreviations used.—End. = found only in one island; End. S.I. = found in more than one island; Fueg. = Fuegian, including those species found also in New Zealand; Fueg. S.I. = Fuegian which do not extend to New Zealand; N.Z. = New Zealand, but excluding the New Zealand-Fuegian species.

Islands.	End.		End S.I.		Fueg.		Fueg. S I.		N Z.		Total
	Species.	Percentage.	Species.	Percentage.	Species.	Percentage.	Species.	Percentage	Species.	Percentage.	Species.
Auckland	10	10	29	29	15	15	3	3	46	46	100
Campbell	7	8·6	27	33·3	16	19·9	4	4·9	31	38·2	81
Antipodes	3	7	10	23·2	11	25·6	3	7	19	44	43
Macquarie	3	11	5	18·5	9	33·3	6	22 2	10	37	27
Snares ..	2	9·5	2	9·5	10	47 6	1	4·7	7	33·5	21

IX. Bibliography.

[The numbers correspond with the references in the paper.]

1. Alboff, N.: "Essai de Flore raisonnée de la Terre de Feu." Ann. d. Museo de la Plata, sec. bot. i., xxiii. (Review in Bot. Centralb. by A. Gallardo. 17th March, 1903.)
2. Armstrong, H.: "Cruise of the Brig 'Amherst.'" N.Z. Govt. Gaz., Prov. of Southland, 1868.
3. Armstrong, J. B.: "Descriptions of New and Rare New Zealand Plants." Trans. N.Z. Inst., vol. xiii., p. 335; 1881.
4. Baker, J. H.: N.Z. Govt. Gaz., Prov. of Southland, p. 117; 1865.

4*a*. Bentham, G.: "Notes on the Classification, History, and Geographical Distribution of *Compositæ*." Journ. Linn. Soc., vol. xiii., p. 335; 1873.

5. Baker, J. G.: "A Summary of the New Ferns which have been discovered or described since 1874." Ann. of Bot., vol. v., 1891.
6. Benham, W. B.: "On some Earthworms from the Islands around New Zealand." Trans. N.Z. Inst., vol. xxxiii., p. 129: 1901.
7. —— "On an Earthworm from the Auckland Islands." Trans. N.Z. Inst., vol. xxxv., p. 275; 1903.
8. Blanchard, E.: "Proofs of the Subsidence of a Southern

Continent during Recent Geological Epochs." Abstract by author in "Comptes Rendues." Translation, N.Z. Journ. of Sc., vol. i., p. 251; 1882–83.

8*a*. Bray, W. L.: "Plant-geography of North America: The Relations of the North American Flora to that of South America." Repr. Science, n.s., vol. xii., No. 306, p. 709; 1900.

9. Buchanan, J.: "Campbell Island and its Flora." Trans. N.Z. Inst., vol. xvi., p. 398; 1884.

10. —— "Notes on New Species of Plants." Trans. N.Z. Inst., vol. xvi., p. 394; 1884.

11. —— "Manual of the Indigenous Grasses of New Zealand." 1880.

12. —— "Sketches of Headlands and Harbours of the Auckland Islands: to accompany a Chart by Officers of H.M.S. 'Blanche.'" 1870.

13. Bull, H. J.: "The Cruise of the 'Antarctic' to the South Polar Regions." 1896.

14. Buller, Sir W. L.: "A History of the Birds of New Zealand," 2nd ed., 1888.

15. Carrick, R.: "New Zealand's Lone Lands." 1892.

16. Chapman, F. R.: "The Outlying Islands south of New Zealand." Trans. N.Z. Inst., vol. xxxiii., p. 491; 1891.

17. —— "On a New Species of *Celmisia*." Trans. N.Z. Inst., vol. xxxiii., p. 407; 1891.

18. Cheeseman, T. F.: "On the Flora of the Kermadec Islands; with Notes on the Fauna." Trans. N.Z. Inst., vol. xx., p. 151; 1888.

19. —— "The Naturalised Plants of the Auckland Provincial District." Trans. N.Z. Inst., vol. xv., p. 268; 1883.

20. —— "On the New Zealand Species of *Coprosma*." Trans. N.Z. Inst., vol. xix., p. 218; 1887.

21. —— "A Revision of the New Zealand Species of *Carex*." Trans. N.Z. Inst., vol. xvi., p. 414; 1884.

22. Cockayne, L.: "An Inquiry into the Seedling Forms of New Zealand Phanerogams and their Development. Part I." Trans. N.Z. Inst., vol. xxxi., p. 354; 1899.

23. —— "A Short Account of the Plant Covering of Chatham Island." Trans. N.Z. Inst., vol. xxxiv., p. 243; 1902.

24. Darwin, C.: "The Origin of Species," 6th ed., 1899.

24*a*. —— "A Naturalist's Voyage: Journal of Researches into the Natural History and Geology of the Countries visited during the Voyage of H.M.S. 'Beagle' round the World." 1889.

25. Dean, W.: "Asa Gray." Bull. Tor. Bot. Club, vol. xv., p. 59; 1888.

26. Decaisne, J.: "Voyage au Pol Sud, Botanique," tom. ii., "Plantes vasculaires."

27. Diels, L.: "Vegetations-Biologie von Neu-Seeland." Engler's Bot. Jahrb. bd. xxii., 1896.
28. Drude, O.: "Manuel de Geographie Botanique." Traduit par G. Poirault. 1897.
29. D'Urville, Dumont: "Voyage au Pol Sud: Histoire du Voyage," tom. ix., 1846, p. 202.
30. Dendy, A.: "The Chatham Islands: a Study in Biology," Mem. and Proc. Manchester Lit. and Phil. Soc., vol. xlvi., pt. v.; 1902.
31. Enderby, C.: "Proposal for Re-establishing the British Southern Whale-fishery through the medium of a Chartered Company and in Combination with the Colonisation of the Auckland Islands." 1847.
32. —— "The Auckland Islands: a Short Account of their Climate, Soil, and Productions." 1849.
33. Fairchild, J.: "Sketch-map of the Antipodes Islands." 1886.
34. Field, H. C.: "The Ferns of New Zealand and its Immediate Dependencies." 1890.
35. Filhol, H.: "Mission de l'Ile Campbell: Recueil de Mémoires, &c., rel. à l'observation du Passage de Vénus sur le Soleil," tom. iii., 2e. Partie; 1885.
35*a*. —— "Geological and Zoological Relations of Campbell Island and the Neighbouring Southern Lands." N.Z. Journ. of Sc., vol. i., p. 259; 1882–83.
36. Forbes, H. O.: "The Chatham Islands and an Antarctic Continent." *Nature*, vol. xlvii., p. 474; 1893.
37. Guppy, H. B.: "Flora of the Antarctic Islands." *Nature*, 1888.
38. Hackel, E.: "On New Species of Grasses from New Zealand." Trans. N.Z. Inst., vol. xxxv., p. 377; 1903.
39. Hamilton, A.: "Notes on a Visit to Macquarie Island." Trans. N.Z. Inst., vol. xxvii., p. 559; 1895.
40. Hector, Sir J.: "Notes on the Geology of the Outlying Islands of New Zealand; with Extracts from Official Reports." Trans. N.Z. Inst., vol. ii., p. 176; 1870.
41. —— "Note on the Geology of the Outlying Islands of New Zealand." Trans. N.Z. Inst., vol. xxviii., p. 736; 1896.
42. Hemsley, W. B.: "Vegetation of South Georgia." *Nature*, 1886.
43. —— "Report on the Scientific Results of the Voyage of H.M.S. 'Challenger'": Botany."
43*a*. —— "On the Genus *Corynocarpus*." Ann. Bot., vol. xvii.; 1903.
44. Hombron and Jacquinot: "Voyage au Pole Sud, Botanique." Paris, 1852.

45. Hooker, Sir J. D.: "Flora Novæ-Zelandiæ," pt. i., "Botany of Antarctic Voyage." London, 1853–55.
46. —— "Flora Antarctica," pt. i., "Botany of Antarctic Voyage," vol. i. London, 1847.
47. —— The same, vol. ii. London, 1847.
48. —— "Handbook of the New Zealand Flora," vols. i. and ii. London, 1864–66.
49. —— and Jackson, B. D.: "Index Kewensis." 1893–95.
50. Hutton, F. W.: "The Beetles of the Auckland Islands." Trans. N.Z. Inst., vol. xxxiv., p. 175; 1902.
51. —— "On a Small Collection of *Diptera* from the Southern Islands of New Zealand." Trans. N.Z. Inst., vol. xxxiv., p. 169; 1902.
52. —— "The Geological History of New Zealand." Trans. N.Z. Inst., vol. xxxii., p. 159; 1900.
53. —— "Origin of the Flora and Fauna of New Zealand." Ann. and Mag. of Nat. Hist., ser. v., vol. xv., p. 77.
53*a*. —— "On the Cause of the former Great Extension of the Glaciers in New Zealand." Trans. N.Z. Inst., vol. viii., p. 383; 1876.
53*b*. —— *Nature*, vol. lxviii.; 9th July, 1903.
54. Jhering, H. von: "On the Ancient Relations between New Zealand and South America." Trans. N.Z. Inst., vol. xxiv., p. 431; 1892.
55. Kidder, J. H.: "Contributions to the Natural History of Kerguelen Land." Bull. U.S. Nat. Museum. 1876.
56. Kirk, T.: "On the Botany of the Antarctic Islands." Rep. Third Meeting Austral. Assoc. for Adv. of Science, p. 213; 1891.
57. —— "Notes on Plants from Campbell Island." Trans. N.Z. Inst., vol. xiv., p. 387; 1882.
58. —— "On *Pleurophyllum*," Hook. f. Trans. N.Z. Inst., vol. xxiii., p. 431; 1891.
59. —— "A Revision of the New Zealand *Lepidia*, with Descriptions of New Species." Trans. N.Z. Inst., vol. xiv., p. 379; 1882.
60. —— "Notes on Recent Additions to the New Zealand Flora." Trans. N.Z. Inst., vol. xiv., p. 382; 1882.
61. —— "Remarks on the Genus *Abrotanella*, Cassini, with Descriptions of New Species." Trans. N.Z. Inst., vol. xxiv., p. 418; 1892.
62. —— "On the Ferns and Fern Allies of Stewart Island." Trans. N.Z. Inst., vol. xvii., p. 228; 1885.
63. —— "On the Flowering Plants of Stewart Island." Trans. N.Z. Inst., vol. xvii., p. 213; 1885.
64. —— "The Botany of the Snares" (Reprint from Journal of Botany). N.Z. Journ. of Sc., new issue, p. 161; July, 1891.

65. Kirk, T.: "The Forest Flora of New Zealand." Wellington, 1889.
66. —— "The Students' Flora of New Zealand and the Outlying Islands." Wellington, 1899.
67. —— "On *Hymenophyllum villosum*, Colenso." Trans. N.Z. Inst., vol. x., p. 395; 1878.
68 —— "On *Lycopodium varium*, R. Br., and *L. billardieri*, Spreng.; with Description of a New Form." Trans. N.Z. Inst., vol. xvi., p. 376; 1884.
69. —— "A Revision of the New Zealand Gentians." Trans N.Z. Inst., vol. xxvii., p. 330; 1895.
70 —— "Description of New Grasses from Macquarie Island." Trans. N.Z. Inst., vol. xxvii., p. 353; 1894.
71. —— "On the Botany of the Snares." Trans. N.Z. Inst., vol. xxiii., p. 426; 1891.
72 —— "On the Botany of Antipodes Island." Trans. N.Z. Inst., vol. xxiii., p. 436; 1891.
73. —— "On the Macrocephalous *Olearias* of New Zealand, with Description of a New Species." Trans. N.Z. Inst., vol. xxiii., p. 443; 1891.
73*a*. Lang, R. M.: "Revised List of New Zealand Seaweeds," pt. 1. Trans. N.Z. Inst., vol. xxxii., p. 57; 1900.
74. —— As above, pt. 2. Trans. N.Z. Inst., vol. xxxiv., p. 327; 1902.
75. Lukins, E.: "Round Southern Isles." Nelson, 1896.
75*a*. Maiden, J. H.: "A Second Contribution towards a Flora of Mount Kosciusco." Miscel. Pub. 331. Dept. of Agric., N.S.W., 1899.
76. Marshall, P.: "Dust-storms in New Zealand." *Nature*, vol. lxviii., p. 223; 1903.
77. Mez, C.: "*Myrsinaceæ*." Das Pflanzenreich, 9 heft. (iv. 236). Leipzig, 1902.
78. Montagne, M. C.: "Voyage au Pol Sud: Plantes Cellulaires—Botanique." 1845.
79. Moseley, H. N.: "Notes by a Naturalist on the 'Challenger.'" London, 1879.
80 —— "On the Botany of Marion Island, Kerguelen's Land, and Yong Island, of the Heard Group." Journ. Linn. Soc., vol. xiv., p. 387; 1875.
81 —— "Notes on the Flora of Marion Island." Journ. Linn. Soc. Botany, vol. xv., p. 481; 1877.
82. —— "Further Notes on the Plants of Kerguelen, with some Remarks on the Insects." Journ. Linn. Soc. Botany, vol. xv., p. 53; 1877.
83. Musgrave, T.: "Cast away on the Auckland Isles: a Narrative of the Wreck of the 'Grafton' and of the Escape of the Crew after Twenty Months' Suffering." London, 1866.

84. Petrie, D.: "Descriptions of New Native Plants, with Notes on some known Species." Trans. N.Z. Inst., vol. xxiii., p. 398; 1891.
85. —— "Descriptions of New Native Plants, and Notes." Trans. N.Z. Inst., vol. xxxiv., p. 390; 1901.
86. —— "A Visit to Stewart Island, with Notes on its Flora." Trans. N.Z. Inst., vol. xiii., p. 323; 1881.
87 Raynal, F. E.: "Les Naufragés; ou, Vingt Mois sur un Récif des Iles Auckland," 3me ed. Paris, 1873.
88. —— "Wrecked on a Reef, or Twenty Months in the Auckland Isles." London, 1885.
89. Reischek, A.: "Notes on the Islands to the south of New Zealand." Trans. N.Z. Inst., vol. xxi., p. 378; 1889.
90 Richards, G. H., and Evans, F. J.: "The New Zealand Pilot," 6th ed. London, 1891.
91. Ross, Sir J. C.: "Voyage of Discovery and Research in the Southern and Antarctic Regions." London, 1847.
92. Schimper, A. F. W.: "Pflanzen-Geographie auf Physiologischer Grundlage." Jena, 1898.
93. Scott, J. H.: "Macquarie Island." Trans. N.Z. Inst., vol. xv., p. 484; 1883.
94. Shull, G. H.: "Geographic Distribution of *Isoetes saccharata*." Bot. Gaz., vol. xxxvi., p. 187; 1903.
95. Thomson, G. M.: "The Ferns and Fern Allies of New Zealand." Dunedin, 1882.
96 —— "On the Fertilisation, &c., of New Zealand Flowering Plants." Trans. N.Z. Inst., vol. xiii., p. 241; 1881.
97. —— "On the Origin of the New Zealand Flora," being a Presidential Address to the Otago Institute. Trans. N.Z. Inst., vol. xiv., p. 485; 1882.
98. —— "On some Aspects of Acclimatisation in New Zealand." Rep. of Third Meeting of Austral. Assoc. for Adv. of Science, p. 194; 1891.
99. —— "Plant-acclimatisation in New Zealand." Trans. N.Z. Inst., vol. xxxiii., p. 313; 1901.
100. —— "The Stability of the Native Flora." Conference of N.Z. Fruit-growers and Horticulturists, p. 103. Wellington, 1901.
101. Thun, C.: "Aus den Tiefen des Weltmeeres." Jena, 1900.
101*a*. Trelease, W.: "Botanical Observations on the Azores." Reprint from 8th Ann. Rep. of Missouri Bot. Garden. 9th Sept., 1897.
102. Wallace, A. R.: "Island Life," 2nd ed. London, 1892.
103. Warming, E.: "Lehrbuch der ökologischen Pflanzengeographie." Zweite Auflage der Deutschen Ausgabe. Bearbeitet von P. Graebuer. Berlin, 1902.

104. Wilkes, C.: "Narrative of the United States Exploring Expedition during the Years 1838–39–40–41–42." Philadelphia, 1845. Account of Auckland Island, pp. 351–53; and Macquarie Island, p. 354.
105. Woodward, H.: "The Distribution of Life in Antarctic Lands." Presidential address to the Norfolk and Norwich Naturalists' Society. Geolog. Mag., vol. x., No. IX.; 1903.

EXPLANATION OF PLATES XI.–XXIV.

[All the photographs were taken by the author.]

PLATE XI.

1. Juvenile leaf of *Panax simplex*, from plant collected at Norman's Inlet, Auckland Island.
3. Five-foliate leaf of *Panax simplex*, from juvenile plant collected at Norman's Inlet, Auckland Island.
4. Ternate leaf of *Panax simplex*, from same shoot as No. 3.
5. Simple leaf from same shoot as 6—Stewart Island juvenile plant of *P. simplex*, collected at Port Pegasus.
6. Cut-leaved juvenile form of *P. simplex*, larger but similar to 1, Port Pegasus, Stewart Island.

[The above figures merely show the outlines of the leaves.]

PLATE XII.

Sand-dunes and sandy shore of Enderby Island. The dark patches on the dunes show the close vegetation. Portion of rata forest in left-hand top corner.

PLATE XIII.

Interior of rata forest, Auckland Island. The fern is *Aspidium vestitum*.

PLATE XIV.

Olearia lyallii forest above cliffs of Ewing Island.

PLATE XV.

Olearia lyallii forest coming to near high-water mark, Ewing Island. *D'Urvillæa utilis* washed up on to the shore. Grass-tussock in left-hand bottom corner.

PLATE XVI.

Exterior of low rata forest—almost scrub—on Enderby Island. *Suttonia divaricata* in right-hand bottom corner.

PLATE XVII.

General view of forest as in Plate XVI., in front of which is grass-tussock 1m. or more tall. North end of Auckland Island in background.

PLATE XVIII.

Aristotelia fruticosa, a New Zealand xerophytic shrub, growing at outskirts of a beech forest, Canterbury, South Island.

PLATE XIX.

Cliffs of Antipodes Island near the boat-landing. Maritime tussock slope on left.

PLATE XX.

Flat tussock meadow of Antipodes Island. Bog in centre. Inland tussock slope on right.

PLATE XXI.

Aralia lyallii growing near shore, Ruapuke Island, Foveaux Strait.

PLATE XXII.

Veronica lycopodioides after culture for some months in moist air and feeble light. To illustrate "plasticity" of certain New Zealand plants.

PLATE XXIII.

Map of Auckland Islands, Antipodes Islands, and Bounty Islands. (In the map of the Auckland Islands "Musgrave Inlet" should read "Norman Inlet," and *vice versâ*.)

PLATE XXIV.

Map of Campbell Island.

ART. XXVII.—*Abnormal Growth of a Plant of* Phormium colensoi.

By the Right Rev. W. L. WILLIAMS, D.D., Bishop of Waiapu.

Plate XXV.

[*Read before the Auckland Institute, 6th July, 1903.*]

IN the month of February, 1896, having occasion to walk round the rocks at Blackhead, my attention was attracted by a plant of *Phormium colensoi*, growing a little above high-water mark, which was then in seed, the seed-capsules being accompanied with numerous persistent bracts, which were then quite dry. A specimen of this was brought away and sent to the late Professor Kirk. A few seeds which dropped from this specimen were sown, and one of the plants raised from that seed is the subject of this paper.

On this plant in the spring of 1900 one scape appeared, which did not grow to a height of more than about 3 ft. One or two abortive flowers were produced, but instead of more flowers a cluster of buds appeared, each of which produced a number of leaves from 12 in. to 15 in. long. These buds were afterwards cut off and planted, but none of them took root. In 1901 four scapes shot up, the growth of each of which was arrested at the height of about 3½ ft., no flowers being produced, but each scape being crowned with a large cluster of leafy buds, like the scape of the previous year, the leaves being now from 18 in. to 2 ft. long. In 1902 four scapes again appeared, three of which are about 7 ft. high. These all produced flowers and seeds in the normal way, though the flowers