1908.

NEW ZEALAND.

DEPARTMENT OF LANDS:

REPORT ON A BOTANICAL SURVEY OF THE TONGARIRO NATIONAL PARK.

By L. COCKAYNE, Ph.D.

Presented to both Houses of the General Assembly by Command of His Excellency

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Sir,— Department of Lands, Wellington, 22nd June, 1908.

I have the honour to submit herewith the report on a botanical survey of the Tongariro National Park which has been carried out by Dr. Cockayne under your instructions.

Although the park was created by Act of Parliament in 1894, it is only recently that much interest has been manifested therein; and in consequence of your directions to have the scenic, botanic, and other features of the region thoroughly inspected and reported on, so that it might be known how far they were suitable for protection and development, Mr. E. Phillips Turner (Inspector of Scenic Reserves) has executed a complete topographical survey showing the natural features of the park, whilst Dr. Cockayne has furnished an elaborate report on its flora. A joint report has also been handed in by these gentlemen containing their recommendations for the extension and development of the park.

The accompanying report on the botanical survey is of worldwide interest, as it is the first that has been made on this particular tract of country, which embraces so many varied classes of soil and vegetation, and forms a valuable adjunct to Dr. Cockayne's former reports on Kapiti Island and the Waipoua Kauri Forest, which were also made under your instructions. Taken together, these reports give a very clear idea of some of the most characteristic botanical features of New Zealand, and will be of considerable value to the scientific world as affording careful and precise particulars of an original investigation into conditions of plant-life that in many cases do not exist outside of this Dominion.

The enclosed map illustrating the report is the work of Mr. Phillips Turner, and shows the topographical features of the park in a very comprehensive manner.

I have, &c.,
Wm. C. Kensington, Under-Secretary.

The Hon. Robert McNab, Minister of Lands.

REPORT ON A BOTANICAL SURVEY OF THE TONGARIRO NATIONAL PARK.

By L. Cockayne, Ph.D.

I. INTRODUCTION.

The Tongariro National Park was in the first instance created a special reserve because of the presence of certain more or less active volcanoes, such being not only a most valuable scenic possession, but forming the climax, as it were, of the celebrated thermal region of the North Island. Correlated, too, with the height and extent of these volcanic ranges is much fine scenery—in fact, it is hardly going too far to declare that such is of a more varied character than that of any other equal area of land in the Dominion. Ruapehu, 9,200 ft. in altitude, has glaciers on its east, south, and west slopes, which, although they cannot vie with their southern sisters in magnitude or beauty, are the only ice-rivers of the North Island, and thus a source of special interest to travellers on the Waiouru–Tokaanu Road or the Main Trunk line. Also, to those unable to visit the South Island, a close acquaintance with these ice-masses must be a matter of great interest. Furthermore, on the summit of Ruapehu, occupying its ancient crater, is a glacier as remarkable in its way as any in the world. This contains in its bosom a small lake of water, boiling at times and emitting volumes of steam (15), at others almost cold, while on its surface frequently float small icebergs broken off from the 200 ft. of perpendicular cliff bounding part of its margin (see Photo. No. 1). From this lake probably comes the celebrated Wangaehu River, the water of which issues from a rock-bound gorge, and which even at its mouth is still highly charged with sulphurous acid and certain sulphates.

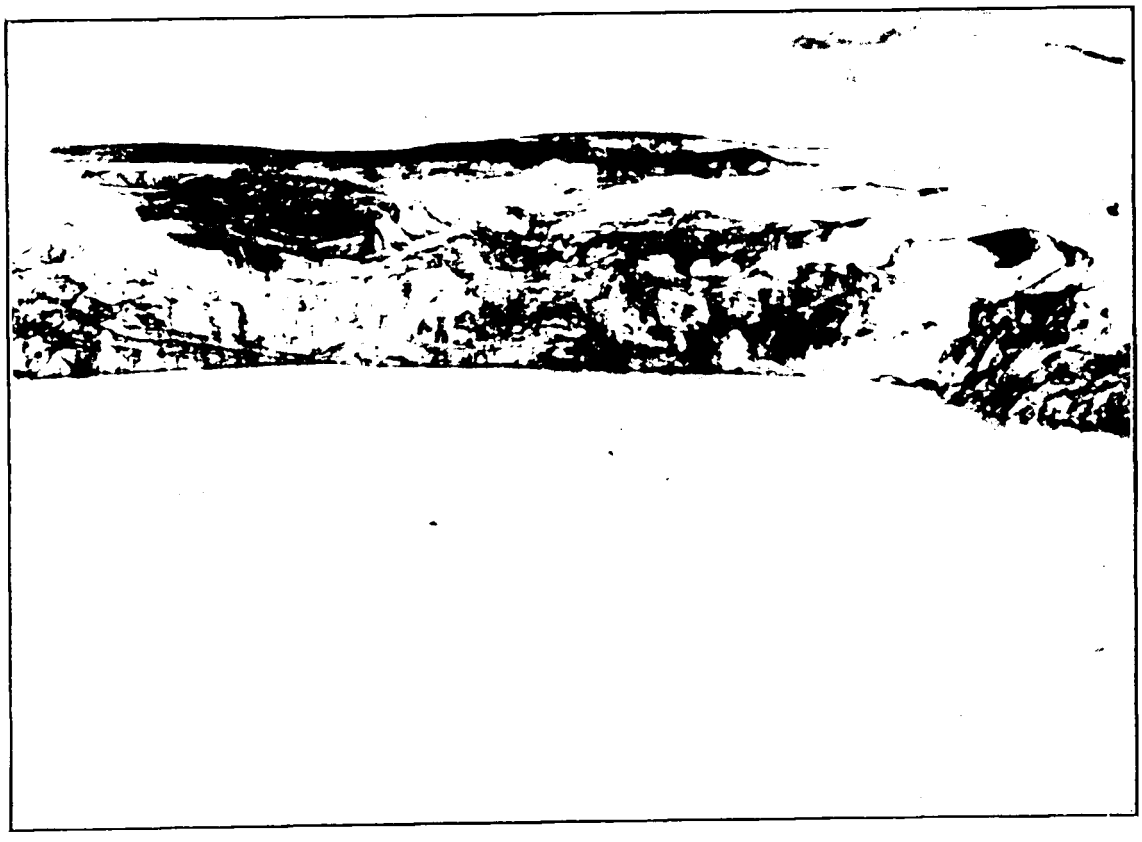
Ngauruhoe is an easy excursion from the Ruapehu hut, and the climber is not merely rewarded with a most extensive view, but stands on the rim of the crater, a mud volcano in its centre and a strong jet of steam blowing with loud noise from its hidden recesses.

Between Ngauruhoe and Ruapehu is a saddle some 4,000 ft. in altitude leading to the west, and here are two interesting crater-lakes, called Nga Puna a Tama. Tongariro itself contains two active craters—the Red Crater, so named from the colour of its walls, and Te Mari, which is the more active of the two, and was in eruption some ten years ago. Also there are the very powerful "blowholes" of Ketetahi, which constantly emit vast volumes of steam. Here, too, are several hot springs containing various kinds of water, and probably of much importance from their curative properties. Nor are the signs of present volcanic activity the sole interest. The ancient craters, and especially the lava-flows, are truly impressive sights, particularly that recent one from Te Mari which not so many years ago cut a fiery path through the totara forest, or the more ancient flow still in the great Oturere Crater, now weathered into most fantastic forms.

Leaving aside the actual volcanoes, there are the forests and collections of shrubs, the vast deserts, sublime and weird, the river-gorges of great depth—true cañons, indeed. There are rivers, too, such as the Ohinepango and Waihohonu, which all on a sudden issue from the solid rock, widening out into quiet pools, haunts of wild duck (Photo. No. 2), or dash at once foaming over their stony beds as true alpine torrents. The tooth-leaved-beech forest of the west and south, with its open undergrowth and bright-green foliage looking like delicate lacework, is equal in beauty to the same association as found in the Cold Lakes region. On the north of Tongariro is a forest of quite a different type, with the thin-barked totara (*Podocarpus Hallii*) as the leading tree, while the beeches (*Nothofagus*) are absent.

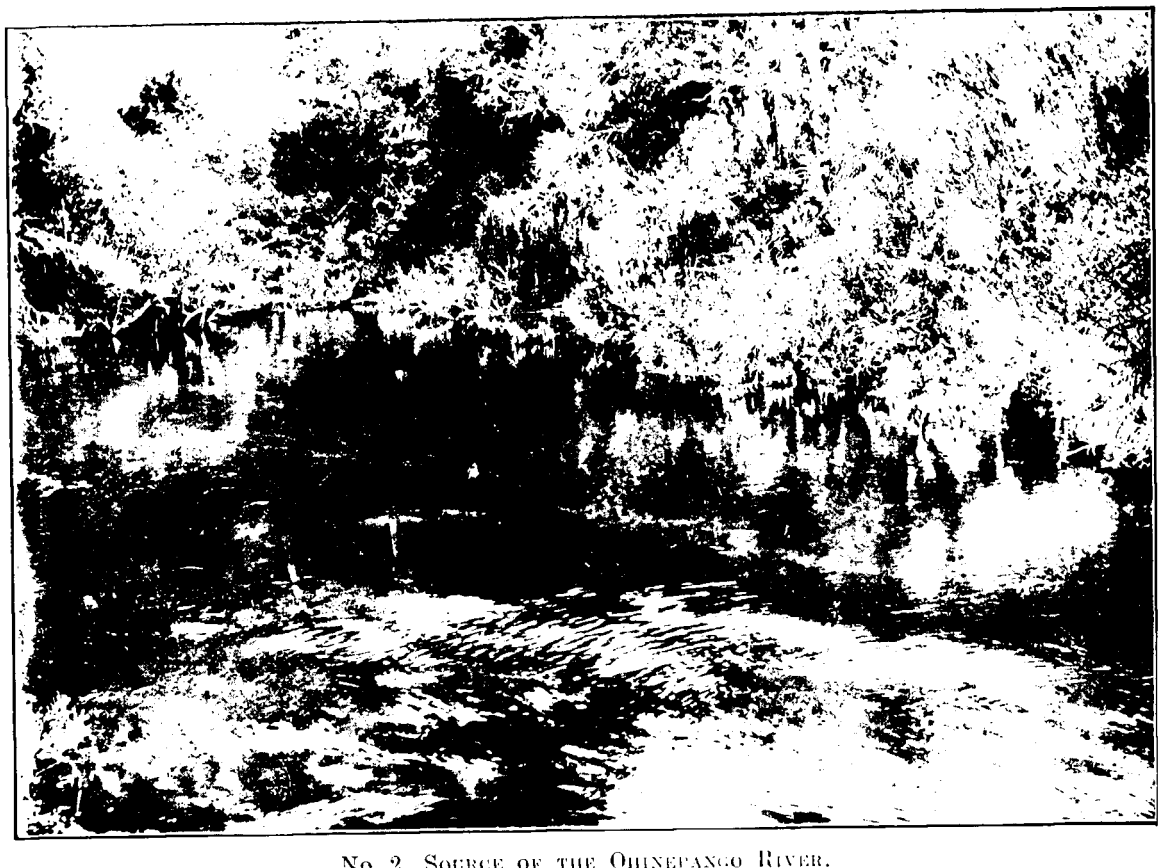
But it must not be forgotten that mountain, river, lake, glacier, and even hot spring, are much the same the world over, and that the special features of any landscape depend upon the combinations of plants which form its garment, otherwise a monotonous uniformity would mark the whole earth. Therefore the more special the vegetation, the more distinctive the scenery. And nowhere does this dictum carry weight more than in New Zealand, where the vegetation is unique.

Moreover, these plants, not the least by any means of our possessions, are day by day vanishing from the land, and thus our national parks become havens of refuge where the vegeta-



No. 1. The Hot and sometimes Boiling Lake in Old Crater of Ruapehu, with the Ice-cliffs of the Crateral Glacier at about 8,500 ft. altitude.

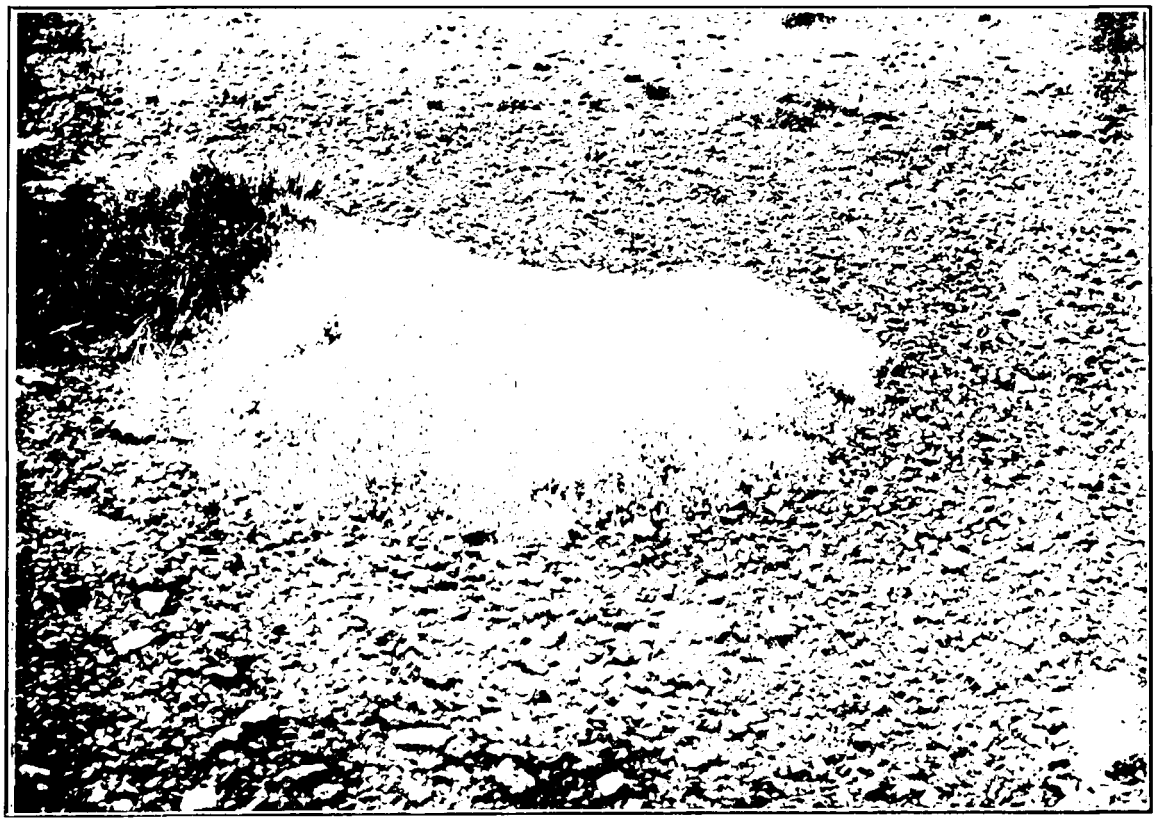
[*Photo, R. Speight.*



No. 2. Source of the Ohinepango River.

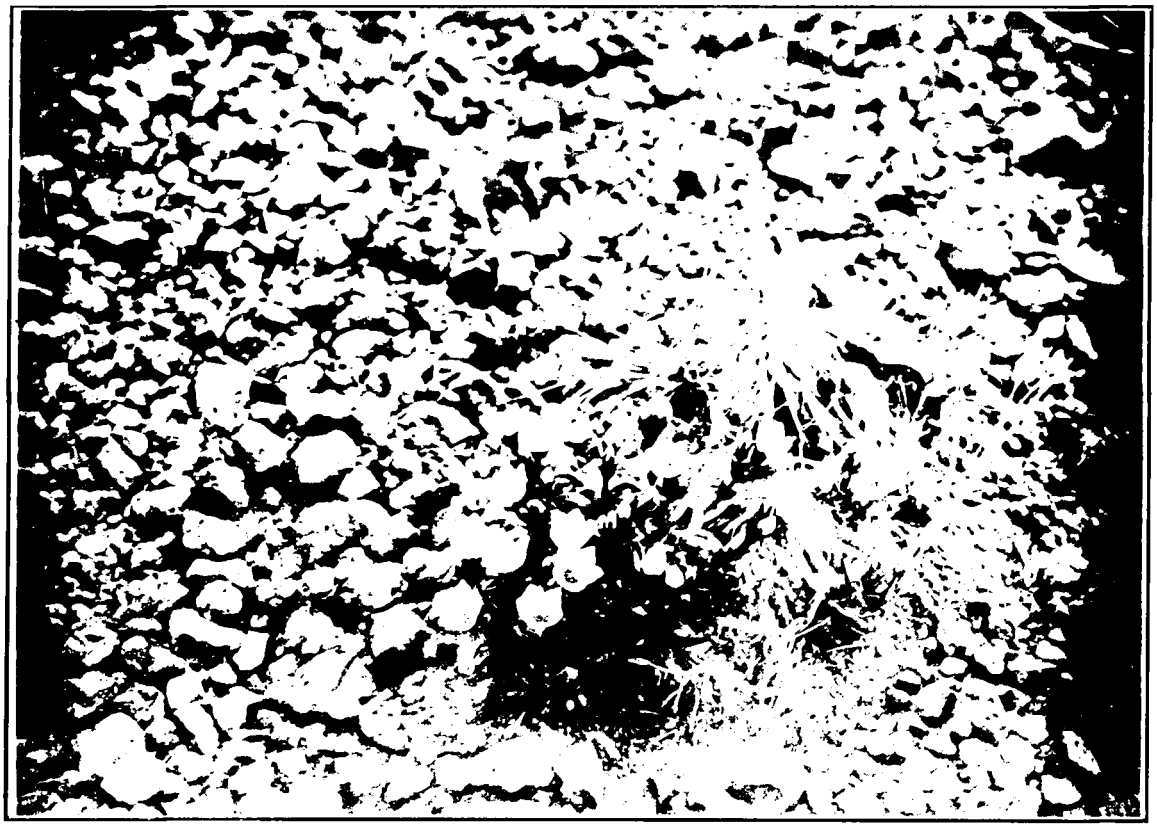
[*Photo, L. Cockayne.*

To face p. 2.]



No. 3. *Raoulia australis*, a Mat or Low Cushion Plant, growing on Scoria Desert, Tongariro, at altitude of 4,300 ft.

[*Photo, L. Cockayne.*



No. 4. *Gentiana bellidifolia* in Bloom on Scoria Desert, Tongariro. Blooms $\frac{3}{4}$ in. in diameter.

To face p. 3.]

[*Photo, L. Cockayne.*

tion, and also those indigenous animals whose presence depends upon forest or meadow, may exist unmolested and remain intact, year by year increasing in interest for us and for our descendants. Nor is it merely the individual species which are interesting, but equally important and of greater moment to the scenery is the manner in which they are associated together. Thus, the brown steppe of waving tussock is a special feature of the landscape, the dull-coloured and reddish carpet of shrubs which clothes the barren slopes is another, while even the gloomy scoria deserts are enlivened by the silvery cushions of a moss-like seed-plant or the delicate snow-white blossoms of a gentian (Photos. 3, 4).

The national parks are five in number, each offering special and peculiar attractions. In the North Island are two of these domains—one, Mount Egmont, which includes a considerable area of fine mixed forest round its base, then a subalpine forest of cedar and totara, and above this meadows of alpine flowers reaching far on to its scoria slopes; and the other, the region of dying but still active volcanoes described in this report.

In the South Island is the Arthur's Pass or Waimakariri Park, which includes the far-famed Otira Gorge, the glacier scenery at the source of the Waimakariri, Lake Minchin, a spot of extreme loveliness hidden in the recesses of the Snowcup Range, many noble virgin forests of the mountain-beech, ancient glacial lakes, and beautiful alpine and subalpine meadows containing a rich and varied flora. Then, further to the south lies the Mount Cook Park, with an abundant vegetation differing considerably from the above and equal in interest, but the region is specially marked out by its extensive glaciation and the presence of the loftiest peaks of the Southern Alps. Finally, there are the world-famed Sounds of Otago, where again another vegetation flourishes, imperfectly known as yet, but which, clothing even the wall-like cliffs or dipping almost into the calm waters, marks these majestic fiords as distinct from like ice-carved depths elsewhere.

The vegetation of these various national parks, then, is a priceless possession of the people, but one which to the majority is at best but a name. The plants, it is true, have in some measure been collected and classified, though even this work is far from complete. But here botanical knowledge for the most part ends. Little as yet has been written either as to the combinations of species which form the covering of the land, or regarding their life-forms and the contrivances by which they, in more or less harmony with soil and climate, exist. Nor have even catalogues been published of these great open-air museums—collections which surely rival those stored up in our cities. This report, then, seeks in some measure to supply what is distinctly a national want. That it is complete is not to be expected. A thorough examination of a district so extensive as the Tongariro Park would occupy much more time than I was able to devote, and would also need investigations at all seasons of the year. All that is attempted is to give a general idea of the plant-covering, with some details as to the most important plant formations and life-forms of the species. In time to come, as the population of the Dominion increases, the scientific workers will also increase in numbers, and reports such as this should be of use to these future investigators for comparative purposes. At the present time, too, it is hoped that they may be of assistance to present students, and perhaps help to arouse an interest in our unique plant-life, and assist also in building up a popular sentiment towards its protection.

Before concluding this introductory section I must express to the following my indebtedness for much valuable assistance: Messrs. William C. Kensington, Under-Secretary for Lands; A. Hamilton, Director of the Dominion Museum; E. Phillips Turner, Inspector of Scenic Reserves; Dr. P. Marshall, Lecturer on Geology, Otago University; and Dr. Setchell, Professor of Botany, University of California. Finally, I must specially thank Mr. R. Speight, M.A., B.Sc., Lecturer on Geology at Canterbury College, who has so kindly contributed the valuable section dealing with the geology of the region, without which the report would be most incomplete.

II. HISTORY OF SCIENTIFIC INVESTIGATION.

Until comparatively recently the chain of active volcanoes and the adjacent plateau were forbidden ground for the white man. Notwithstanding this, during the first half of the last century, before the "King" movement shut up so much of the centre of the North Island from the colonist, more than one traveller of a scientific bent had managed to evade the Native guardians of the place, and had penetrated into the tabooed region. Mr. J. C. Bidwill, so well known in connection with the alpine flora of New Zealand, was the first white man to ascend Ngauruhoe, and gives a most graphic account of what was then both a difficult and daring feat. The account of the ascent he published in 1841 in his very interesting little book, "Rambles in New Zealand" (2). Bidwill had with him finally two lads he had brought from Tauranga and several people from Roto-iti. "As usual, the men carried the children, and the women the potatoes, &c. The procession was closed by one or two pigs, which, from the opposition they made to the efforts of the drivers, seemed to have as great a dread of Tongadido as the Mowries themselves" (2, p. 47). "We were on Tongadido all day, but the peak was never visible in consequence of the mist which covered the upper regions." The Natives, who were in a state of terror, maintained the ascent of the mountain was impossible, although close to the cone (2, p. 47). Not far from its base the explorer passed the night with a fire made probably from two of the shrubs now bearing his name. Next morning he started for the summit with two Natives, who, especially as they declared the mountain had been making a noise in the night, could not be persuaded to go within a mile of the base of the cone. "As I was toiling up a very steep hill I heard a noise which caused me to look up, and saw that the mountain was in a state of eruption. A thick column of black smoke rose up for some distance and then spread out like a mushroom. As I was directly to windward I could see nothing more, and could not tell whether anything dropped from the cloud as it passed away. The noise, which was very loud and not unlike that of the safety-valve of a steam-engine, lasted about half an hour and then ceased, after two or three sudden interruptions; the smoke continued to ascend for some time afterwards, but was less dense. I could see no fire, nor do

I believe there was any, or that the eruption was anything more than hot water and steam; although from the great density of the latter it looked like black smoke." Bidwill continued the ascent, and found he had not been climbing the main mountain, but merely a cliff, over which he dropped on to a lava-stream below, of which he says, "I had no idea of the meaning of a sea of rocks until I crossed them. The edges of the stony billows were so sharp that it was very difficult to pass among them without cutting one's clothes into shreds." Arriving finally at the true base of the cone, he had, as is now also the case, great difficulty on account of the loose volcanic cinders. "Had it not been for the idea of standing where no man ever stood before, I should certainly have given up the undertaking." "A few patches of a most beautiful snow-white veronica* (Photo. No. 5), which I at first took for snow, were growing among the stones, but they ceased before I had ascended a third part of the way. A small grass reached a little higher, but both were so scarce that I do not think I saw a dozen plants of each in the whole ascent." Bidwill then got on to that lava-flow which comes from the summit of the mountain, thus escaping the loose dust and ashes. He continues, "It was lucky for me another eruption did not take place while I was on it, or I should have been infallibly boiled to death, as I afterwards found it led to the lowest part of the crater, and, from indubitable proofs, that a stream of hot mud and water had been running there during the time I saw the smoke from the top. The crater was the most terrific abyss I ever looked into or imagined. The rocks overhung it on all sides, and it was not possible to see above ten yards into it from the quantity of steam which it was continually discharging. . . . As I did not wish to see an eruption near enough to be either boiled or steamed to death, I made the best of my way down. I got back to the tent about seven in the evening. The Natives said they had heard the eruption which took place as I was returning, and that the ground shook very much at the time; but I did not feel it, perhaps because I was too much occupied with the difficulties of my path." Bidwill paid particular attention to the plants of the region, which he afterwards sent to Sir W. J. Hooker, they forming the first collection made in the interior mountains of the North Island.

The Rev. W. Colenso visited the volcanic plateau in 1847, adding much to our knowledge of the botany of that region. His detailed account was not published till 1884 (7), long after the description of his plants had appeared in the Flora Novæ Zealandiæ. His collection was made chiefly on the Rangipo Plain and the Onetapu Desert, where he was delayed for two days by a fierce storm from the south-west. "Not really knowing how far we were from help, I could only allow two teacups of rice for all my Natives (six in number) for breakfast, and two for their dinner, and for supper one cup of rice was all that could be spared, which, with a few scraps of bacon-fat and a little salt, made a mess of pottage." It was somewhere between this camp and the banks of the River Moawhango that he found on the next day the species of *Logania* which has not since been rediscovered.

In 1841 Dieffenbach was unable to get permission from the Maoris to ascend Tongariro, and in 1850 the same thing occurred to Sir George Grey.

In 1851 Mr. Dyson made an ascent of Ngauruhoe, and, like Bidwill, describes how the large clouds of steam hid completely the bottom of the crater from his view. Dyson saw no plant-life of any kind upon the cone.

In 1883 Mr. J. H. Kerry-Nicholls made a journey through the King-country, and ascended both Ngauruhoe and Ruapehu. He collected a few plants in the region, and some of them are noted in the appendix to his work, published in 1884 (36). He describes the crater as sending forth "enormous jets of steam with a roaring, screeching noise," while hot springs "sent up streams of boiling water," and miniature "cones of dark smoking mud rose up in every direction, while around all was a seething fused mass of almost molten matter, which appeared to require just one or two degrees more of heat to transform it into a lake of liquid lava." "No fire was visible in the crater, nor was there any indication of a very recent volcanic eruption." This account seems fairly contradictory, since, judging from the first part of the description, one would think an eruption was almost in progress. Kerry-Nicholls also describes his ascent of Ruapehu to the summit of Te Heuheu peak, but nothing is said regarding the glacier-lake, excepting that on page 249 a note states that such occurs.

Hochstetter also was forbidden to make the ascent; nevertheless he gives an interesting and important account of the volcanoes (29, pp. 371, 379).

In 1873 Kirk published a paper (38) dealing with the flora of the thermal region. The account ends at the country north of Lake Taupo. He gives some valuable ecological details *re* plants growing near boiling pools, also a number of facts as to plant-habitats, and some especially valuable observations concerning the occurrence of maritime plants at high levels inland, he firmly believing such to be strong evidence in favour of former sea-extension.

In 1888 Messrs. D. Petrie, A. Hamilton, and H. Hill spent two days on the Rangipo Plain, ascending on to the lower spurs of Ruapehu, and making extensive collections of the plants. No botanical account of this excursion was published, but the plants in Petrie's Herbarium have since been noted by Cheeseman in the Manual of the New Zealand Flora.

Mr. L. Cussen in 1887 published an important paper (9A, p. 375) showing that Ruapehu was not extinct, as had been supposed, and that clouds of steam rose at times from a hot lake on its summit. The same observer in 1891 published in the Report for the Department of Lands and Survey a most valuable report on Tongariro, accompanied by an excellent map.

Professor J. Park ascended Ruapehu at about the same time as Cussen, but by a southern spur. His account appeared in 1887 (40). He saw neither the crater-lake nor any steam.

Mr. Dunnage, who in 1904 and 1905 ascended Ruapehu, published two interesting photographs of the crater-lake (15) and took the temperature of the water. He also noted steam rising from the west of the mountain.

The most active investigator of the volcanic region of late years has been Mr. H. Hill, who has visited the district many times, publishing details *re* its geology and topography, and collect-

* *Veronica spathulata.*

ing plants. In several important papers (25, 26, 27) he gives an account of the region and of an ascent of Ruapehu, describing its topography, and noting the experiences of Mr. Birch, who ascended the mountain in 1881, and was probably the first white man to note the lake.

Mr. T. F. Cheeseman visited the volcanic plateau on three occasions. In January, 1907, he examined the western part of the plateau, ascending Hauhungahi, Tongariro, and the slopes of Ngauruhoe and Ruapehu; but his work was much hindered by bad weather. He had previously, in 1905, and also at an earlier date, examined the country on the eastern side of the plateau from Lake Taupo to the Rangipo Plain. Some of his findings are recorded in his Flora, and others are noted in a paper in the forthcoming volume of the Transactions of the New Zealand Institute, but he published no detailed account of his explorations.

Dr. P. Marshall has visited the volcanoes on many occasions, and has ascended Ruapehu no fewer than eight times. His publications on the subject are only just appearing. He informs me that the various accounts *re* the crater-lake are correct, and that it varies much in temperature and colour. He also had the good fortune to be at Ngauruhoe during an actual eruption. I am indebted to him for the interesting photo. of Ngauruhoe on the title page, and he very kindly sent me a detailed account of the changes which have taken place in the crater of that volcano, but which unfortunately reached me too late for insertion in this report.

Dr. Friedlander, of Berlin, visited the volcanoes a few years ago, and published the very important paper cited in the Bibliography.

The Rev. F. H. Spencer has collected the plants of the volcanic plateau assiduously during recent years, and his results are embodied in Cheeseman's Flora.

As for my own investigations, I was employed by the Department of Lands and Survey to make a botanical survey of the Tongariro National Park in association with Mr. E. Phillips Turner, Inspector of Scenic Reserves, whose duties were to survey the boundaries of the Domain, and, along with myself, report on the park as a national reserve and offer such suggestions as seemed advisable *re* extending its boundaries. Our work was commenced on the 11th January, and the field-work was concluded on the 19th March. Unfortunately, a slight accident to my knee made me waste a considerable amount of valuable time, otherwise I could have made my investigations more complete. A good deal of time was spent in photographing the plants as they grew and the plant formations, and besides the purely scientific work some attention was paid towards investigating the scenic attractions of the park.

III. LEGENDS OF THE PARK.

The volcanoes and volcanic plateau, with their steaming mountains, dread sounds issuing from the earth itself, fearsome lakes in crater-hollows, moving deserts of sand, and strange stone figures rising from the black and glistening lava-flows, could not fail to be invested with many curious stories, and be, to the Maori, places which should be approached with the utmost caution or altogether shunned. Thus on Tongariro is one dire spot, to cross which is to meet face to face the unspeakable and indefinable horror. The Onetapu Desert is still known to every Taupo Maori as the death-bed of that mythical Taka, who, lured by a false friend with stories of much food to be there found, went forth joyously with his companions, only to die of starvation in the biting cold. As for the great volcanoes themselves, with them was originally a third, Taranaki by name. But he, seized with an evil passion, attempted to abduct Pihanga, the wife of his friend Tongariro. A fierce conflict took place between the two giants. Taranaki, badly beaten, fled, and in his hasty flight tore up the ground, making the deep channel where now flows the Wanganui, and, finally coming to rest near the sea, he, as snow-capped Egmont, still remains to prove the story. Also it is told how a certain Maori chieftain, accompanied by his slave Ngauruhoe, set forth on a voyage of discovery to explore the country on which he had just landed after the perilous voyage in the great canoe the Arawa, and how on his way southwards, performing meanwhile many marvellous feats, he saw in the distance a great cone-like hill. This he, like any true explorer, decided to ascend and so better view out the land. Its snows, however, were too much for the traveller fresh from the sultry north, so he cried aloud in his distress to his sisters at Whakari, the steaming island in the Bay of Plenty, to send him fire. This, two taniwhas, Pupa and Te Haeata, brought by a subterranean passage, but too late to save the life of his devoted slave, who, smitten by the bitter cold, had perished. But the sacred fire, which had burst forth from the summit of the mountain, which he named Ngauruhoe after his slave, still burns on—not there alone, but throughout the whole of the underground passage, from which at various places it bursts forth even yet, as at Rotorua, Oraikeikorako, Taupo, and elsewhere.

IV. CLIMATE.

So far as the climate of the volcanic plateau goes, few statistics are available, and these refer only to the rainfall, the very important matters of temperature and the direction and force of the wind being wanting. Judging by the distribution of the vegetation alone, one comes at once to the conclusion that a much more abundant rainfall occurs on the tree-clad west and south of the volcanic chain than is to be met with on its eastern side, which, it may be seen, lies between the volcanic mountains on the west and the Kaimanawas on the east. This position, it could well be expected, would lead to a comparatively dry climate on the flat eastern table-land, such as we find from similar causes at the present time in certain parts of the South Island—*e.g.*, the Awatere Valley in Marlborough, the Trelissick Basin in Canterbury, Central Otago, and the Canterbury Plains. The rainfall statistics bear out the above supposition. At Makatote, on the west, the total rainfall for 1907 was 99·26 in., on 231 days; whereas for the same period at Taupo it was only 60·05 in., on 112 days. Not only is the rainfall much greater at the above western than eastern station, but the number of days on which rain falls—that most important factor—are more than double. A comparison also of the appended tables will show how much greater the rainfall is on the west than on the east.

TAUPO.

RAINFALL.

Year.	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.		Total.	
	Rainfall.	Number of Days.	Rainfall.	Number of Days.	Rainfall.	Number of Days.	Rainfall.	Number of Days.	Rainfall.	Number of Days.	Rainfall.	Number of Days.	Rainfall.	Number of Days.	Rainfall.	Number of Days.	Rainfall.	Number of Days.	Rainfall.	Number of Days.	Rainfall.	Number of Days.	Rainfall.	Number of Days.	Rainfall.	Number of Days.
Taupo.																										
	In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.	
1901 ...	...	...	...	...	...	...	...	...	...	...	...	...	5·91	20	5·23	9	2·84	12	1·82	7	0·57	5	4·70	14	21·07	67
1902 ...	2·43	13	3·04	5	5·81	7	10·68	13	3·26	9	8·69	12	0·65	2	4·35	7	4·78	13	4·07	9	1·00	6	2·15	9	50·91	105
1903 ...	9·19	11	1·22	4	0·83	4	5·03	10	6·61	15	2·67	7	4·95	8	3·22	7	2·64	5	3·37	10	7·13	11	4·96	12	51·82	104
1904 ...	3·57	6	7·20	14	11·12	10	3·57	6	3·95	8	...	...	3·73	6	5·07	7	4·88	7	7·14	15	2·25	8	6·04	14	58·52	107
1905 ...	1·95	3	1·80	6	0·89	4	3·27	6	4·20	10	6·76	11	3·18	8	2·72	8	5·06	15	7·37	17	3·42	7	3·39	12	44·02	107
1906 ...	2·45	7	2·20	9	2·97	7	3·42	8	3·94	9	1·80	2	6·93	12	3·17	7	8·96	12	0·97	6	3·78	11	4·15	8	44·74	98
1907 ...	13·28	11	6·01	8	4·84	9	4·26	11	3·75	8	2·44	3	2·80	5	5·68	12	3·90	14	5·94	14	2·53	8	4·62	9	60·05	112
1908 ...	0·06	1	0·27	3	8·48	16	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Monthly means	4·70	7·5	3·11	7	4·99	8	5·04	9	4·29	10	4·47	7	4·02	9	4·21	8	4·72	11	4·38	11	2·95	8	4·29	11	51·5	106
Makatoke.																										
1906 ...	...	...	...	...	...	...	11·97	24	9·28	23	7·25	17	10·06	26	5·52	15	7·52	17	8·00	18	6·37	14	9·28	14	...	...
1907 ...	8·15	11	7·93	18	8·94	17	5·43	19	8·75	23	7·82	15	6·02	19	7·09	23	15·05	28	13·10	22	5·33	16	5·67	17	99·26	231
1908 ...	0·32	2	0·92	4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	..	...	...	...

The snowfall, and especially the length of time that it lies on the ground, is a matter of much moment to plant-life and its distribution. From conversations with those who live in the neighbourhood, it appears that at an elevation of between 3,000 ft. and 4,000 ft. snow does not lie, usually, for above a few days, except where it has drifted. At above this elevation it is probable that snow lies for the whole of the winter months, while in the gullies and shaded places it does not entirely disappear before the beginning of March, a few small patches remaining all the year round even on Tongariro and Ngauruhoe, whereas, of course, in the deeper highest gullies and near the glaciers of Ruapehu there are perpetual snowfields. It is the melting of this snow, as shown further on, which leads to the occurrence of semi-bogs on the steppes, and on it depends to a considerable extent the underground water-supply which here and there oozes from the road-cuttings and from the surface of the ground.

As for the temperature of the district under consideration, I can give no exact particulars. The clear sky and the high elevation lead to a powerful direct action of the sun's rays, which is easily manifest by placing the hand upon the bare scoria-covered ground. Probably during the summer, notwithstanding the elevation, the heat of the sun will be as great as at any place in New Zealand. On the west and south of the mountains cloud and mist will be more frequent and the power of the sun generally less manifest than on the east.

Frost is extremely common all over the volcanic plateau, and is strongly felt even during the month of January, when shallow water frequently becomes covered during the night with a fairly thick coating of ice. At the same time, here as elsewhere in New Zealand it is probable that we are apt to overestimate the intensity of the cold, and it is reasonable to suppose that the thermometer will rarely sink below about 16° Fahr.

With regard to wind, the factor of all others of importance in relation to the special distribution of vegetation in New Zealand, and which also has a strong bearing on the life-forms of the plants, I can say very little. Judging from my own experiences, on the east at any rate, during the summer the wind factor is much less than is general in the New Zealand biological region. At the same time, the appearance of the plants and their distribution leads one to believe that high winds are not infrequent, and that in many parts of the district they exercise a very powerful influence.

V. GEOLOGY.

[By R. Speight, M.A., B.Sc., F.G.S.]

(A.) GEOLOGICAL HISTORY OF THE DISTRICT.

In order to understand the procession of events with regard to the evolution of the plant formations and the history of the vegetation generally it is necessary to discuss rather fully certain geological matters concerned with land beyond the confines of the park, and here the Kaimanawa Range comes especially into consideration.

The oldest rocks in the neighbourhood of the Tongariro National Park are the slates and sandstones of the Kaimanawa Mountains. These are probably of Carboniferous age, and form a portion of the structural axis of older rocks which extends through the North Island from near Wellington towards the eastern side of the Bay of Plenty. The Kaimanawas can hardly be called a mountain-range. Their southern portion, at any rate, is part of a plain of marine denudation formed in Tertiary times, and the tolerably level surface then acquired was subsequently raised above sea-level and thoroughly dissected by stream-action, so that now it is composed of a number of more or less isolated elevations. At the time of the submergence a great bay or strait must have occupied the middle of the North Island, extending north-east from Wanganui and probably cutting off the unsubmerged parts of the Kaimanawas and Ruahines from islands lying to the north-west. An archipelago then occupied the area now covered by the North Island. Thick and extensive deposits of marine clays and limestones, stretching in a broad band from the Ruahines across the middle courses of the Rangitikei, Wangaehu, and Wanganui Rivers towards the Tasman Sea in the west, prove that in Miocene times the sea transgressed over a great area in the south-western part of the Island. The limestone beds of this deposit now rise to a height of 3,700 ft. on the southern flank of the Kaimanawas, proving an elevation of at least that amount. Account must also be taken of the depth of the sea in which the beds were laid down, as this must be added in order to give a true measure of the elevation. However, it could not have been very great, as the presence of limestone, associated with detrital deposits, indicates somewhat shallow water conditions. It is highly likely the levelling of the surface of a part of the Kaimanawa country, mentioned previously, took place during this time of submergence of the land. In these beds no direct evidence of volcanic action is known. After their deposition elevation seems to have commenced, probably attended by volcanic outbursts further north. Possibly the elevation of the land, and also the volcanic action, as is known in other parts of the world, were due to a crustal movement but little understood. One result was to raise the centre of the Island into the form of a low flat dome, over the surface of which rivers run north, and west, and south. The drainage which has thus been recently established is called "consequent"—*i.e.*, following the general slope of the land-surface as it emerged from the sea. The rivers run usually in the direction of the dip, in deep, narrow channels. Their tributaries are slightly inclined to the main river, and they do not show yet any marked signs of the development of subsequent drainage. This is a very decided proof of the recency of the land-surface. The beds show on their northern side a very decided scarp-slope. Through this the rivers have cut their way.

The earliest undoubted proof of volcanic activity occurs in beds of Pliocene age overlying the limestones, and containing fragments of water-worn pumice. Occasionally whole beds are found of pumice sands. They are very strongly developed on the Pohangina River and in the beach near Kai Iwi. Where the pumice came from is uncertain. In any case, it did not come

from Ruapehu or Tongariro, as their lavas are exclusively andesitic. It probably came from the vicinity of Lake Taupo, possibly from the site of the lake itself, as near it there are extensive flows of rhyolite identical in chemical and mineral composition with the pumice.

Since that period pumice has been discharged from time to time, so that it forms an important constituent of recent deposits, especially of surface soils, both in the middle of the Island and in the coastal districts. The possibility of its wide distribution by paroxysmal eruptions is made manifest by the great area over which recently the ash from Tarawera was scattered. The transporting power of water acting on such a light material accounts for its rapid movement along river-valleys, in the lower part of which it is particularly abundant, and for its association with marine deposits. The pumice may have been formed either, like the Tarawera ash, from comminuted and partially fused fragments of former consolidated lava-flows, which have been reduced to powder by the rending force of steam, or it may have been a primary product of the original volcanoes. Doubtless some of the earlier deposits are due to the latter cause. Its present distribution as a surface deposit on the top of the recent andesitic lavas of Ruapehu and Tongariro, as well as on the slates of the Kaimanawas, lying, regardless of the form of the landscape, sometimes as a thin coating and close by in thick drifts, shows that quite recently it has fallen in heavy showers.

All over the central plateau the pumice is full of the charred remains of forest-trees, sometimes 2 ft. in diameter and from 10 ft. to 12 ft. in length. These have probably been destroyed where they lie by a hail of hot pumice, but were covered so quickly that they were prevented from actually burning away. The occurrence of such wood shows that much of the treeless district round Ruapehu was covered at one time with heavy forest.

As these pumice soils are so widely distributed, a complete investigation of their possibilities is urgently needed. They cover a wide area in the North Island, and, with the possible exception of the loess of the South Island, are the most widely distributed type of soil in the whole Dominion. In the interior of the North Island they are associated with scanty vegetation, but this is largely due to the fact that they have not sufficiently weathered. In time, however, they will form a very fair soil. No doubt the richness of the soil of certain parts of the Hawke's Bay district is partly due to the admixture of decayed pumice.

It is possible that both Ruapehu and Tongariro were originally submarine volcanoes, but this cannot be stated for certain, as their base is in no place exposed to view. Where contact with the older rocks no doubt exists, a surface accumulation of drift prevents satisfactory examination. The fact that no trace of volcanic rocks has been found in the Miocene clays and limestones of the Upper Rangitikei, which lie within a few miles of the great volcanoes, makes it probable that such action had not begun in the locality at the end of the Miocene period. The occurrence of pumice in Pliocene beds does not help us as regards Ruapehu and Tongariro, except as showing that volcanic action had begun further north in Pliocene times. The succession of volcanic rocks in New Zealand does not help us much either, since the evidence furnished by the sequence in the Coromandel Peninsula, at Mount Somers, and at Gebbie's Valley is contradictory. It is hardly safe to conclude that the andesites forming the base of Ruapehu and Tongariro are subsequent to the rhyolites of Taupo, although it is probable that such is the case.

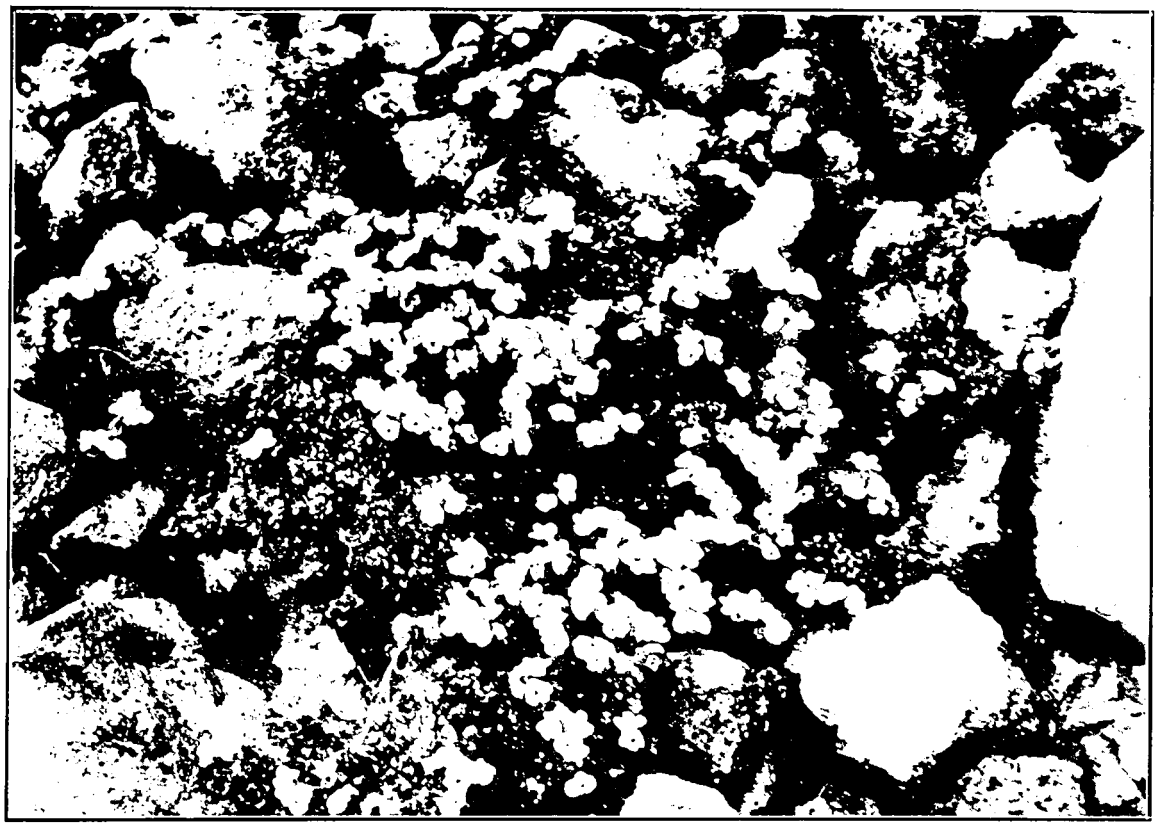
Inclusions of what is apparently a partially fused rhyolite frequently occur in the lava-flows of Ngauruhoe and Ruapehu. If this diagnosis is correct, it points to the existence of rhyolite rocks under the main mass of the great volcanoes, and this would fix their age with tolerable certainty.

After a general consideration of all the circumstances it seems reasonable to say that the foundations of Ruapehu and Tongariro were laid in late Pliocene times — *i.e.*, they are geologically very young—and that activity has persisted since then right up to the present day.

During all this time lavas and scoriaceous matter have been erupted, and, accumulating round the volcanic vents, have built up the cones. The chemical composition of the lava varies somewhat, and the later flows show a close relationship to basalts. The lavas all contain the mineral hypersthene or its near relative enstatite as a characteristic constituent, though hornblende and augite also occur, the former being of somewhat rare occurrence, while the latter is extremely common. The hornblende crystals are further of interest as they are often corroded by the solvent action of the liquid magma in which they floated before it finally solidified. The reported existence of trachyte and phonolite seems to me to be based on an incorrect identification. The whitish and light-grey rocks which might reasonably be mistaken for trachytes appear under the microscope to be hypersthene-andesites. After a careful examination of the slopes of Ruapehu I have not been able to discover any true phonolites, as the rocks which have split into thin slabs, and ring when struck with the hammer, which were originally identified as phonolites are also undoubtedly andesites. Even the later flows, which are basaltic in appearance and sometimes contain a little olivine, also contain a small amount of hypersthene, and thus must be classified as hypersthene-andesites.

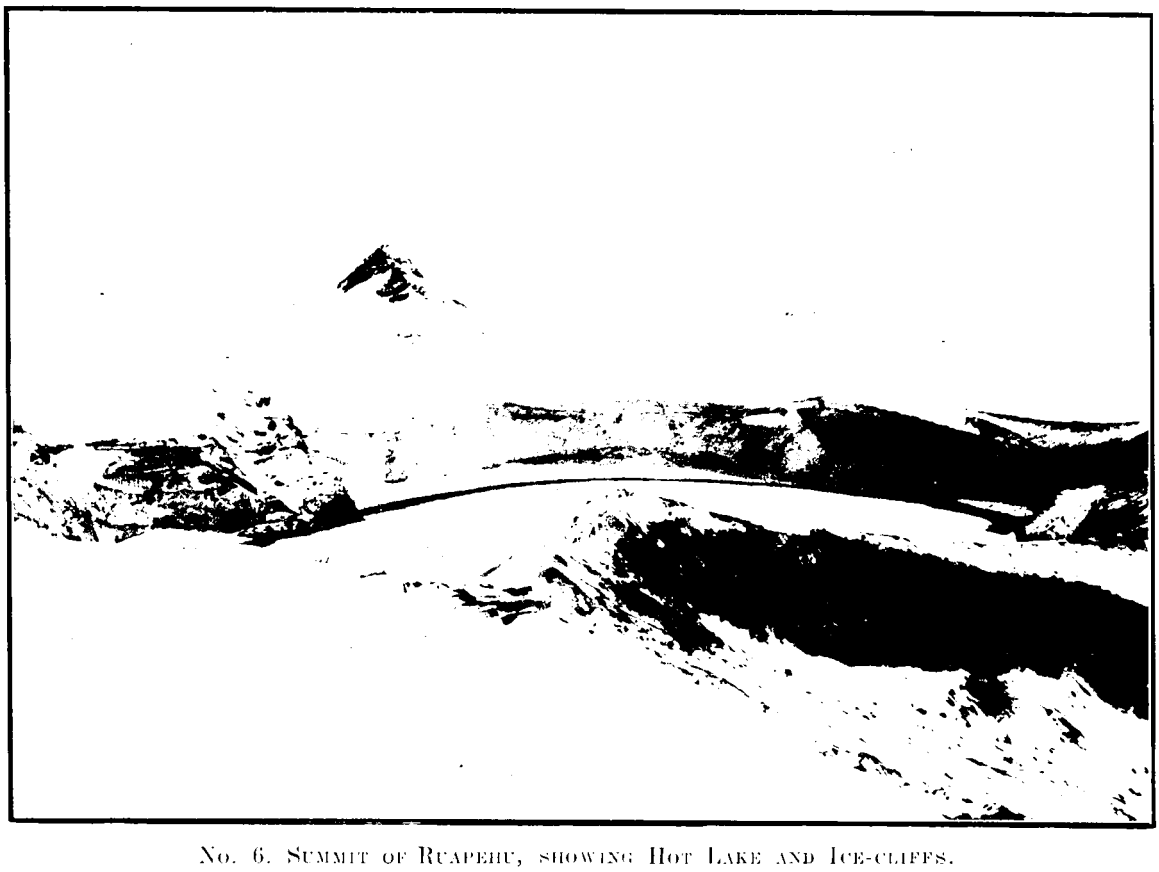
The pouring-out of this variety of andesite has more than mere local interest. It is found with remarkable persistence along a line of volcanic vents stretching from Ruapehu in a northeasterly direction far out into the Pacific. Hypersthene-andesites are found at Mount Horohoro, near Rotorua, and at White Island, in the Bay of Plenty. Dr. Marshall informs me that he has found hypersthene in some of the bombs thrown out from Tarawera. It occurs also in the Kermadec rocks.

The similarity in the mineral composition of the lavas and the linear arrangement of the centres of activity point to some deep-seated cause affecting the whole area. No doubt a line of weakness in the earth's crust extends in an approximately straight line from Ruapehu through Tonga and Samoa towards distant Hawaii. This line may perhaps be called the "Maori line" of volcanoes, as no doubt the first Maori immigrants to the country followed its direction more



No. 5. *Veronica spathulata* growing on the Scoria Desert near Base of Ngauruhoe. The Plant is 12 in. across.

[*Photo, L. Cockayne.*



No. 6. Summit of Ruapehu, showing Hot Lake and Ice-cliffs.

To face p. 9.]

[*Lands Dept., photo.*

or less closely, and the legends of the Native race contain references which show clearly that they recognised the linear arrangement of the vents and their common origin. Activity is more pronounced now at the northern end of this line, perhaps owing to the fact that another earth-fissure crosses it, running west-north-west and east-south-east—*i.e.*, approximately at right angles to the Maori line. The great volcano of Savaii, in Samoa, is placed at their intersection, and hence its continuous activity for the past few years.

The Hawaiian line is parallel to the Samoan line, and the Maori line when prolonged intersects it at the centre of its greatest activity. There are thus two intersecting sets of telluric cracks crossing the Pacific Ocean.

Returning to the Maori line, we find that submarine eruptions have been reported south-west of Tonga, and probably the marked deep-sea shoalings which lie in the same direction are further manifestations of volcanic activity. Great movements of elevation and depression also occur in the neighbourhood of Tonga, caused by either great faults or earth-folds—probably by both, as explained by Jensen (34)—and these volcanoes are probably connected with this disturbance. The faulting which has gone on near Tonga develops gradually into the gentle arching-up of the crest which has taken place in the New Zealand area in recent times. Volcanic activity is a frequent attendant of a folding of this kind. Its centre of maximum disturbance will doubtless shift backwards and forwards along this line, but the periods will be of long duration.

Thus it is likely that Ruapehu will be active again — perhaps not in the near future, but almost certainly after a long space of time. Its general form, the character of its lavas, though not in themselves absolutely sufficient to warrant the prediction as certain, yet suggest that Ruapehu has not passed through all the phases of its life-history.

(B.) GENERAL DETAILS AS TO THE VOLCANOES.

(1.) Ruapehu. (Photo. No. 31.)

Ruapehu is a great cone rising from the central plateau to a height of over 9,000 ft. It has been built up by successive flows of andesitic lava and showers of scoria, and shows the beautiful mathematical profile that characterizes such mountains. The sides have been deeply scored by mountain-torrents rising in its glaciers and snowfields. These torrents have had a marked effect on the country surrounding the mountain. They have swept from this latter the loose scoriaceous materials, and also the products of rock-disintegration, till now these have accumulated in the form of great alluvial fans around the base of the cone and prolong its slope in conformity with that which is dependent on the regular succession of lava-flows and beds of scoria. This has the effect of extending the base of the mountain.

The summit of the cone is occupied by a large crater, nearly a mile across, and filled with ice. It was no doubt formed originally by a powerful explosion which tore away the top of the mountain. The only present signs of activity exist in a small subsidiary crater occupied by the hot lake. The southern portion of the mountain seems to have been formed from another vent or pipe, the lavas from the two overlapping. It is therefore a twin cone, like Etna, produced by the coalescence of the peaks formed from two adjacent and more or less connected vents. The southern peak belongs to one which has been long extinct.

The most remarkable feature of the summit of Ruapehu is the hot lake (Photo. No. 6) which lies near the eastern side of the great crater. It is about two hundred yards across, nearly circular in shape, and depressed beneath the level of the ice about 150 ft. Its walls are partly of volcanic rock, and partly of glacier ice, which is rapidly melted by the heat of the water as the ice moves down to it. Small icebergs continually break away, but they are, of course, soon destroyed. There is evidence that the lake boils frequently (11, 15, 16, 39), and on the 22nd March, 1906, it ejected quantities of mud over the surrounding snow. It is usually quiet, however, but it emits a strong sulphurous smell, and is of a dirty colour. No doubt it is largely formed from the melting of the ice by steam issuing from a crack or fissure in the mountain. It is highly likely that the water percolates through the porous walls of scoriaceous rock on the eastern side, and perhaps forms the true source of the Wangaehu River.

The lower slopes of the mountain are distinguished by the immense amount of disintegrated matter. Through it rises at times the solid rock, usually of a dark colour, in most weird and fantastic forms. As you ascend the cone the solid rock becomes more and more pronounced. The colour of the lava varies greatly. Sometimes it is almost black, with a resinous surface, frequently fissured by cracks produced by shrinkage on cooling; sometimes it is red, and contains prominent hornblendes; but usually it is of varying shades of grey.

Small glaciers hang in the hollows on the flanks near the summit, and stretch down sometimes over 2,000 ft. before they melt. As a rule, the amphitheatre at the head of a valley is the place where snow accumulates before it turns into glacier ice, but here the crater itself is the collecting-ground. This crater glacier is nearly circular in shape, about a mile across, and some three hundred acres in area. Its depth probably does not average more than 200 ft. The pressure of continual falls has consolidated the snow into ice, and the excess of what falls over that which is evaporated flows over the lower portions of the lip of the crater and down the sides of the mountain. The middle of the field is solid and not crevassed, but as it approaches the top of the outward slope it breaks into regular crescentic crevasses. When the outflow of the ice is impeded by the rocks of the crater-ring, it is broken up by the irregular crevasses that one sees in a valley glacier when its regular flow is obstructed. This type of collecting-ground is worthy of special notice. On the ice there are occasionally blocks of stone that have fallen from the surrounding cliffs, forming at times true glacier tables, and at one place near the lake there is a ridge which somewhat resembles a moraine in structure. I think that this must have been formed of stones thrown out by an explosion from the lake, though it is just possible that it may be the remains of a ridge which once divided the crater.

These Ruapehu glaciers and the quite small ones on Mount Egmont are the only signs of glaciation that the North Island shows. It may be that the remains of very small glaciers may still be found in the Ruahines or Kaimanawas (see Hill, 28), but there is no probability that conditions ever existed resembling those which obtained over the South Island in Pleistocene and more recent times. This can be explained by supposing that the elevation of the land which took place in the South Island during the glacier epoch, and which explains the extension of the glaciers in that region, did not affect the North Island, or did not raise it sufficiently to allow glaciers to form. In the case of the South Island the recent major movements of the land have been downward (of course, there have been minor upward movements), whereas the great movement in the North Island has been upward. It is possible, therefore, that the mountains in the North Island were not high enough during the South Island glacial epoch to allow of great accumulations of snow. They are perhaps at the present time slowly approaching that height when glaciers can form.

If the country had been elevated as a whole 2,000 ft. above its present level during the glacial epoch, glaciers should have appeared in several parts of the North Island. Perhaps the crater of Ruapehu is such an excellent collecting-ground that these glaciers on its sides are formed under eminently favourable conditions. On the other hand, some of the Ruapehu glaciers have no connection with the hollow on the summit.

In connection with Ruapehu attention must be called to Hauhungatahi, the curious mountain which is such a feature from the Waimarino Plain. It is a parasitic cone belonging to Ruapehu and built up of scoria and lava flows somewhat similar in composition to those of the great volcano.*

(2.) Tongariro.

The geological history of Tongariro in its earlier stages is somewhat similar to that of Ruapehu: a great cone was built up by a succession of lava-flows and scoria-beds till it rivalled Ruapehu in height and size. The age of both mountains and the mineralogical composition of their ejectamenta are almost identical. The lavas are principally augite-hypersthene-andesites, although hornblende-bearing hypersthene-andesites also occur sparingly among the earlier flows. They vary in colour, but in the original Tongariro they are mostly grey, varying from a pale whitish shade to nearly black. After the cone had been formed, a catastrophe overtook it similar to that which befell its contemporary, but on a much larger scale. While an explosion reduced Ruapehu by several hundred feet, Tongariro was docked by two or three thousand, if not by more: the whole summit was destroyed, and an irregular crater-ring left. The general effect has been to leave Tongariro with no distinct peak or prominence marking its highest point, but with a rough mountainous area from which certain remnants rise to a higher level than their surroundings. If Ngauruhoe be left out of consideration, as it is a much more recent structure, these remnants attain a fairly uniform height of a little over 6,000 ft. The highest point is that known as Tongariro on the Survey maps, but others are nearly as high. The peak of Tama, south-west of Ngauruhoe, is also a part of the original Tongariro, and shows the structure of the irregular crater-ring perhaps better than any other locality.

After the catastrophe, lavas appear to have been poured out so that the flows abut against and overlie the edges of those of which the original mountain was built. Their light-grey appearance and microscopical characters show that they belong to the earlier phases of the history of the volcano. Soon after the great explosion, or perhaps partly contemporaneously with it, several minor explosion craters were formed.† The most important are the Central Crater, the South Crater, and the Oturere Crater. Above all there is the explosion crater of which the ridge of Tama forms the southern wall, and within which the cone of Ngauruhoe (the most recent of the volcanoes) has been more recently built up. The Central Crater has been much modified by subsequent volcanic action, and it is possible that the North Crater, and also the hollows occupied by the picturesque lakes called Nga Puna a Tama, between Ruapehu and Tongariro, also date from this time. Although these craters are probably not quite simultaneous, they are approximately all of the same age, and were formed under similar conditions. They may be due to the last paroxysmal efforts of the great volcano. They all have flat floors surrounded by cliffs which show clearly the edges of the lava-flows of the old mountain. They do not seem to have poured out molten rock, but a considerable amount of semi-fused scoriaceous material found everywhere may have been thrown out of them. Their formation marks the second stage in the volcanic activity of the region.

A long time seems to have elapsed before the third and last stage was entered on. During this interval the explosion craters were readily broken into and enlarged by the vigorous streams fed by the winter snows. Some of the valleys are comparatively wide in their upper portions and narrow considerably, so that the streams run in deep gorges on the outskirts of the mountain. During the third phase activity seems to have been localised along a great fissure whose direction passes through Ruapehu and Ngauruhoe, and forms a small section of the great Maori line of volcanoes. The only exception is the vent known as the North Crater, which apparently belongs to a fissure that runs more to the north, and intersects the other somewhere near the centre of the cone. The Ketetahi boiling springs (Photo. No. 7) above Lake Rotoaira are perhaps connected with this line of weakness. On the main fissures are situated the present active vents, Ngauruhoe, the Red Crater (Photo. No. 8), Te Mari, and a number of points where activity has ceased—*e.g.*, the Blue Lake (Photo. No. 9) and the hollows where the two lakes Nga Puna a Tama lie. But Ngauruhoe, the most active centre in the New Zealand area, is the most important, both from its geological and scenic interest.

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* For specimens of rock from Hauhungatahi I am indebted to Mr. Louch, Chief Engineer on the Auckland section of the Main Trunk line.

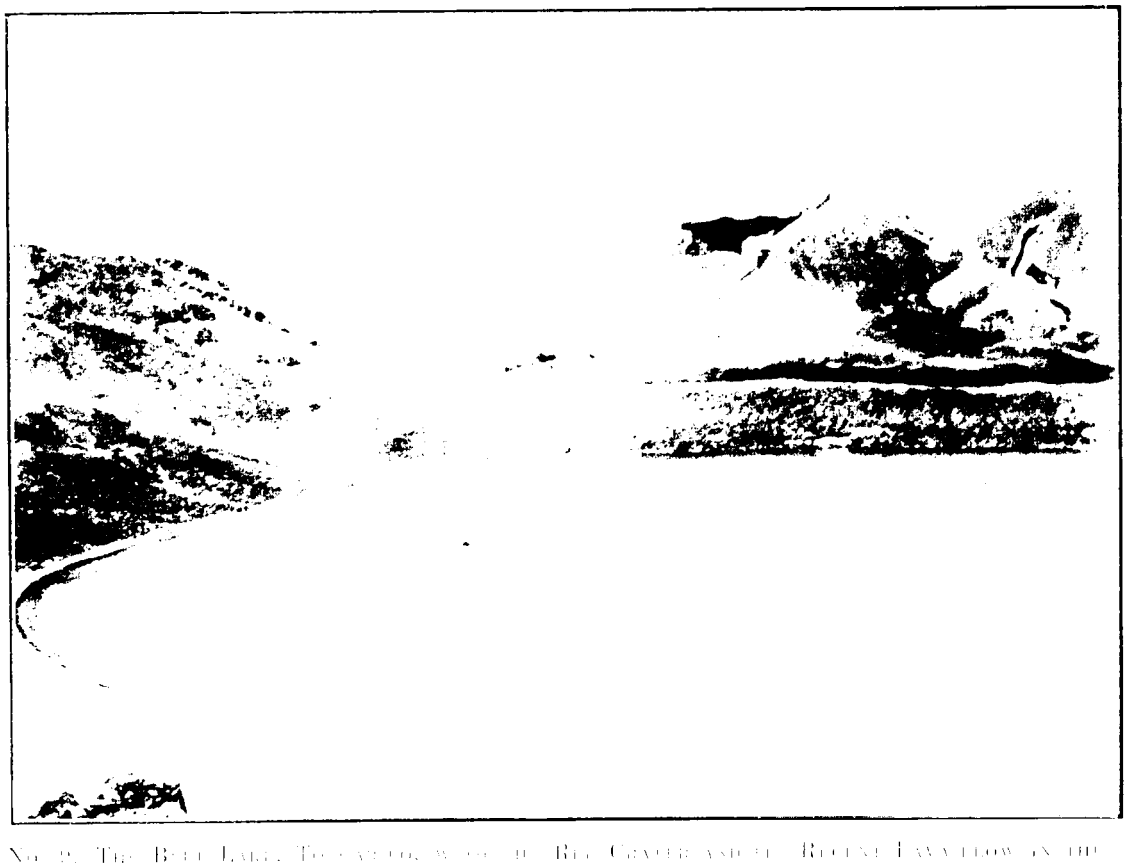
† Some of the crateriform basins on Tongariro are perhaps "pseudo-craters" caused by the collapse and the sinking of more or less circular areas after the great explosion.

No. 7. The K[illegible] Boiling Hot Springs on Tongariro.

[illegible]

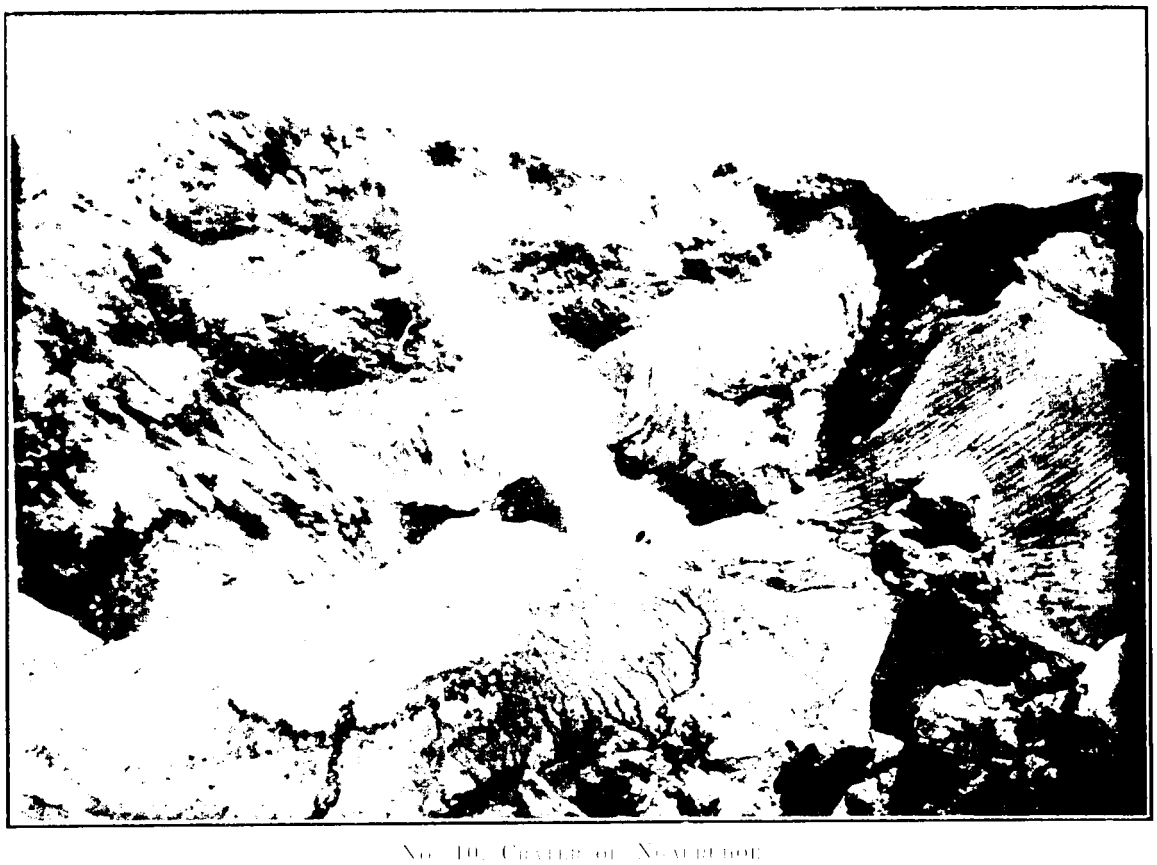
No. 8. Steam issuing from side of the Red Crater of Tongariro.

[illegible] [illegible]



No. 9. The Red Lake, Tongariro, with the Red Crater and the Recent Lava flow in the centre. Ngauruhoe in the background, and Ruapehu in the distance.

W. A. R. Speight



No. 10. Crater of Ngauruhoe

To face page 7.

L. Cockayne, photo.

(3.) Ngauruhoe. (Photo. No. 17.)

Ngauruhoe is a cone of 7,500 ft. in height which has been built up inside an explosion crater formed on the south side of Tongariro. It is constructed of flows of augite-hypersthene-andesite of a dark colour, and of scoriaceous material of the same mineralogical composition. The lava-flows are very extensive, especially on the western and southern side, where they cover large areas in the upper valleys of the rivers running into the Wanganui and in the valley of the Waihohonu, a tributary of the Waikato. They have flooded these valleys like a viscid stream, spreading out over their floors, and where confined by the crater-ring near Tama have piled up against it in thick masses, or have broken through where the ring has been destroyed. Most of the later flows are very dark in colour and resemble basalts in appearance, but they are all augite-hypersthene-andesites.

On the north-west side of the peak is in all probability the most recent lava-flow in New Zealand, which, report says, issued from the crater as late as 1869, an extremely likely supposition considering its fresh appearance.

Some of the flows extend only a part of the way down the steep cone, and this is covered over wide areas with vast quantities of loose scoriaceous material lying at a very steep angle and set in motion at a touch.

The crater of Ngauruhoe is an irregular hollow (Photo. No. 10), about 150 yards across, at the top of the mountain. On the east, south, and west it has steep unscalable walls over 100 ft. high, while on the north side the wall has gone so that it is possible to enter the floor of the crater. Two large apparently extinct mud volcanoes occupy the principal part of the floor of the crater, and only at one point is activity shown, where from a fissure near the western wall steam issues with roaring sound and explosive violence. Also, different parts of the crater-edge emit steam and give out small puffs of sulphur-laden vapour. The recent activity of the mud volcanoes is evidenced by the great amount of mud which covers the upper slopes of the mountain, and which, according to Dr. Marshall, was ejected less than two years ago. This is channelled as if it had been subjected to the action of streams of hot water, which was no doubt thrown out when the volcano was more active. This crater has evidently reached the solfatara stage of activity. But rumblings and detonations from the interior of the mountain show that it has still a store of energy left, which may make its presence known by showers of ashes and scoria, or even by streams of molten rock.

(4.) The Red Crater.

This interesting spot, in the very centre of Tongariro, owes its name to the colour of the scoriaceous matter present in large quantities near its mouth. The colour-effects are very striking, for, besides the red, there are other materials, orange and yellow, brown and black, which are set off by the two little green ponds. This crater has thrown out quite recently considerable quantities of black scoria, and lava-flows have issued from it. One very large one has covered the floor of the Oturere basin and flowed out at the lower end; another recent one has flowed down alongside this for some distance; yet another has breached the crater and covered the southern half of the floor of the Central Crater (Photo. No. 11). A very small one indeed has congealed on the side facing the South Crater. These flows are of the same character as the latest from Ngauruhoe, and probably are of the same approximate age. The crater itself now emits jets of steam and sulphurous gases with considerable noise (Photo. No. 8).

(5.) Te Mari.

The third active vent on Tongariro is called Te Mari, and is situated on a small parasitic cone on the north-eastern corner of the mountain. The crater is some distance below the summit of the mountain, its elevation being 4,700 ft. The cone is composed of lavas and scoria thrown out from the crater. Within tolerably recent times a great flow of black andesite has run down the north-side of the mountain, cutting a path through the dense forest. Te Mari is very active at times, and throws out quantities of ashes and occasionally stones. It emits a great quantity of sulphurous gases, and incrustations of sulphur colour the rocks in its vicinity a vivid yellow. There is a line of small steam-holes and sulphur-vents above the crater in a line with the Red Crater and Ngauruhoe, and an almost extinct crater on the other side of the ridge running up to the Te Mari trig.-pole. Below Te Mari itself there is another disused crater, which is sometimes filled with water. The linear arrangement of the volcanic vents is well seen from Te Mari Trig. Station. Looking south-west, the Blue Lake, the Red Crater, Ngauruhoe, and Ruapehu are in a direct straight line; while, looking north-east, beyond the borders of the park are Pihanga and Tauhara, extinct volcanoes, lying directly towards Tarawera and White Island.

(6.) Other Features of Tongariro.

Immediately inside the old ruined crater-ring of Tongariro from Te Mari is the somewhat picturesque though rather shallow Blue Lake (Photo. No. 9). This occupies an old crater, and is separated from the Central Crater by a wall of blocks of black and grey andesite and scoriaceous material. It lies at an elevation of 5,570 ft. above sea-level, is almost circular in shape, and is quite half a mile across.

The North Crater (6,100 ft. altitude) is also interesting. This is situated at the north-west corner of the mountain. It is about 600 yards across and is very shallow, with the exception of a pit near its western side. The crater is nearly full of black lava with scoriaceous surface. It seems probable that a fairly large explosion crater once occupied this position, and that it was subsequently nearly filled from a vent where the pit is now situated. Great quantities of black scoria lie around the large crater, especially on its south side, and flows of black andesite extend down the mountain, particularly in a northerly direction past the Ketetahi Hot Springs.

These springs are perhaps the most remarkable signs of thermal activity on Tongariro (Photo. No. 7). They lie on the north side of the mountain at an elevation of 4,700 ft. Great quantities of steam from the boiling water hang about the place, but there is rarely, if ever, any true geyser action. Considered as boiling springs, however, they are perhaps the most remarkable in the whole thermal region. From them issue several streams of boiling water. These are all impregnated with sulphurous gases, which cause incrustations on the neighbouring rocks, and which cause them to weather and decay with extreme rapidity.

Another interesting physical feature of the area are the lakes Nga Puna a Tama. Two of these are of considerable size, being about half a mile across. They occupy the floors of two explosion craters, and there are two other small craters near them which contain a little water. The larger lakes are depressed nearly 200 ft. below the encirling ridge of rocks. The walls are partly of solid flows and partly of scoriaceous material thrown out when they were active. These craters are evidently connected with a rent which has split through the old crater-ring south-west of Ngauruhoe. Cussen called this very appropriately the "Rift" (10), and he also noted the white rocks near it with their wonderful columnar structure.

(7.) Future of the Volcanoes.

It will no doubt be asked whether paroxysmal eruptions such as described above are likely to occur again. It is difficult to answer this question satisfactorily. We know so little about the causes of volcanic action, and of the time taken by that action to build up huge cones, that we can form no idea how long these periods of dormancy are. Ordinary volcanoes show long periods of rest, when their sides must have been covered with soil between periods of activity. Ruapehu may be passing through one of these periods, which may last for millions of years, but it seems probable that eventually this volcano will break out once more. Tongariro, on the other hand, is in a moribund condition, and after spasmodic fits of activity, more or less intense, will finally become absolutely extinct.

(C.) SURFACE-FEATURES.

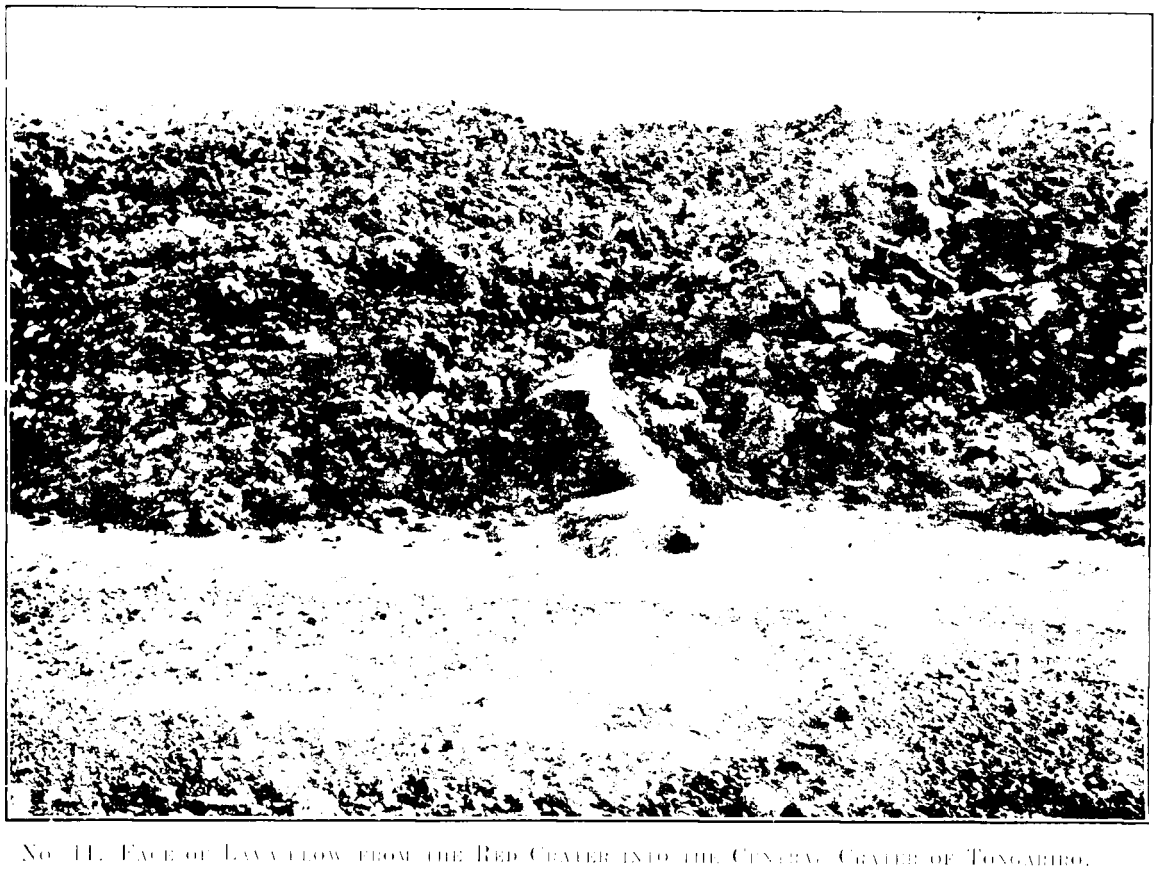
[By R. Speight and the Author.]

The Tongariro National Park and the adjacent country consist of a central chain of mountains running about 27° east of north, and arising out of a plateau some 3,000 ft. in altitude and which slopes gradually to the north, south, east, and west. The range shows towards its centre a comparatively low opening, some 4,000 ft. in altitude. On the east this high plain averages about six miles in width, and is bounded by the Kaimanawa Mountains. To the west and south it merges into the broken and forest-clad country watered by the Wanganui and its tributaries.

The general surface-features of the park are those produced by frost and by steam erosion on the structures due to volcanic action. The higher levels of the mountains, being covered by snow in winter and exposed to a strong sun in summer, show in consequence marked signs of disintegration through frost. The rocks are traversed by the natural joints due to contraction on cooling from the molten condition, and so water penetrates far into their interior, and in winter subjects them to enormous disruptive force. The surface of the mountains is therefore covered with very great quantities of disintegrated matter which shows little sign of weathering. This amount is increased by the fragments of scoria and lapilli thrown out by the volcanoes, which lie loose on the surface or which are only partially consolidated by the pressure of overlying solid lava-flows. A great deal of this has been produced by the latest eruptions, so that nearly the whole of the top and sides of Tongariro is covered by scoriaceous matter.

The loose covering thus due to combined volcanic action and frost is moved continually to lower levels by snow-slips and the streams which flow down the mountain-sides. On the lower parts of the slopes there are wide areas covered with small fragments which have not yet weathered down into soil. The streams all transport great quantities of the loose material and deposit it on the lower levels. On the east especially the action of the high westerly winds sweeping the lighter material from the river-beds and from the slopes leads to areas, more or less extensive, of shifting sands. The most important of these is the Onetapu Desert, which lies to the south of the Mangatoetoenui, and is traversed by the Wangaehu and the Waikato. This is dealt with at some length further on. True sand-dunes appear in these desert tracts, and their fixing by plant-life is an interesting matter. The slopes of Tongariro are not nearly so barren as those of Ruapehu, a fact possibly to be referred to difference in composition of the later lava-flows. These are more basic in character, and therefore have weathered to a richer soil.

The rivers running from the mountains have cut deep gorges in many places. A strange feature of some is that after flowing in fairly open valleys they suddenly take their course through narrow ravines—*e.g.*, the Waihohonu. This suggests that recent elevation of the land near the mountains, or a rapid lowering of a part of a country, especially near Lake Taupo, has given these streams increased power to cut down their beds. Earth-movements have undoubtedly exerted a marked effect on the course of the rivers, and, it seems probable, have caused the transfer of some of the streams running from the Kaimanawas from the Rangitikei basin to that of the Waikato. The Wangaehu may in course of time turn north to Lake Taupo, just at is seems very likely the most southerly branch of the Waikato has done. This is rendered all the more probable by the drift matter brought down by the Wangaehu and deposited between Ruapehu and the Kaimanawas. The steep fall of the streams towards the lake also tends to produce the same result. For the most part the watercourses are quite dry, though during the melting of the winter's snow, water will be abundant enough and floods common. Such have led to many channels, both shallow and deep (arising abruptly for the most part), being cut in the loose material of the plateau, with the result that there is frequently quite a maze of dry and deep watercourses, which have usually very steep sides. Occasionally these watercourses — called locally "wash-outs" — have wide, flat beds, occupied by a scanty desert vegetation.



No. 11. Face of Lava flow from the Red Crater into the Central Crater of Tongariro.

Photo, L. Cockayne.

No. 12. Interior of *Nothofagus fusca* Forest (Red beech) on south of Ruapehu. Undergrowth of Young Beeches.

To face p. 5a.

Photo, L. Cockayne.

Although the surface of the ground is everywhere composed of most permeable material, the drainage-conditions lead in certain places to the gushing-forth of water in very varying quantities. Thus it may be so great that torrents may emerge all at once from the apparently solid rock, or quite small trickles spread over the scoria, these latter giving rise to small oases, or, when more extensive, to bogs, the latter being especially abundant in the neighbourhood of the central saddle.

So far as soil is concerned, it may clearly be seen from what has gone before that there is frequently none in the popular acceptance of the term, the substratum being merely scoria, ashes, pumice, sand, and weathered lava. But in many places, thanks to lapse of time and a plant covering, the above materials have amalgamated, and with the addition of a certain amount of humus a light sandy soil exists for a varying depth, which in certain places is underlain by a sandy clay. Usually there is an outer thin layer of scoria and lapilli; then a deeper layer of sand and humus (frequently very little); then comes the clayey sand mixed with rock-fragments. That such a soil is by no means so "poor" as might be expected is shown by its plant covering when sufficiently watered.

VI. THE PLANT FORMATIONS.

(A.) GENERAL REMARKS.

It was pointed out in the botanical survey of Kapiti Island how the plants of any locality are not arranged by chance, but are found in definite combinations, called technically plant formations, which have come into existence in consequence of the geological history of the region, the climate, the nature of the soil, and other causes, some physical, others biological. Also it was shown that the mapping-out and describing of such formations was one of the first objects of a botanical survey, and that it had important bearings on agriculture and horticulture. In the case of a domain such as the one under consideration these biological entities are also the main factors in determining the scenery, and so their study becomes a further matter of moment when dealing with a scenic reserve.

Taking about 3,000 ft. as the lowest altitudinal limit of the park, the vegetation even at this point may be considered subalpine. This perhaps hardly applies either to the large forest-mass on the south and west of Ruapehu, or to those smaller collections of trees occupying the deep gullies on the east of the volcanic plateau, where such mild conditions prevail—especially absence of wind—as to render the formations at this point more of a montane character. The formations in their typical parts are well-enough marked, but between most of them transitions occur. There are really two main classes of vegetation—"forest" and "steppe"—and these, indeed, are connected by the subalpine scrub. All the same, large areas of an easily recognised and uniform vegetation occur, each with its peculiar features.

Scientifically the formations may be most correctly arranged according to their evolution. Thus the molten lavas, hot ashes, and scoria, burying or destroying all previous plant-life with which they came in contact, would offer an entirely new and virgin soil for invasion by the plant inhabitants of the unharmed region. Such destruction would be a gradual one, and the new country would, through weathering, transportation of material by rivers, and so on, be subject to a series of transmutations which could only be ascertained in part by long and careful research.

The general sequence would be—lava and ash-fields; disintegration of lava, and colonisation of ash-fields first and lava at a later date; hollowing-out or reconstructing river-valleys; building-up of flood-plains; cutting of ravines and gullies into these; gradual and frequently quite rapid weathering of these latter through water-action, wind, &c.; while finally would come the changes occasioned by introduced animals. Thus in such an evolutionary series we should have the solid lava occupied by lichens and small mosses, such as species of *Andreæa*, followed, as soil crept into the crevices, by an occasional chasmophyte or two. But simultaneously with the lava-flows would the sides of the volcanoes and the lava-flows themselves be covered deeply with scoria and ashes, as has been noted for Tongariro, Ngauruhoe, and Ruapehu at the present time. Thus a soil would be at-once provided without weathering, but which from its extremely porous and unstable nature would be but slowly occupied by those special xerophytes which alone can exist under conditions of excessive drought, fierce insolation, and an unstable substratum. Colonisation of this kind may be seen at the present time in the case of the new ground formed by the eruption of Tarawera, where, on the mountain-slopes in the very centre of the new ash-fields, within quite a few years, *Raoulia australis* has built up its conspicuous silvery cushions, thanks to its wind-blown seeds.

Further developments would occur at a much later date, many incipient plant-associations going to the wall with the changes in the topography, as the rivers formed themselves beds, built up terraces, and flattened out the *débris* of the lava and the scoria, pumice, ashes, and sand into plains; finally, melting of the winter snow, gushing-forth of springs, wind, and other causes would seam the apparently even surface with gullies, narrow or wide, deep or shallow, with or without streams on their floors. On these water-built plains the grasses and their accompanying plants could settle down, and within the gullies shrubs and trees, secure from the wind, could form thickets in the first place and finally forest.

But all the above account is of necessity very general. Various features of colonisation must have gone on synchronously. The extreme limits of the ash or pumice deluge would at once receive their covering of steppe-grasses, &c., long before the cooling lavas were in a position to foster the more lowly plants. But, all the same, there would be a procession of vegetation such as this: Rock-plants, desert, steppe, shrubby steppe, scrub, and finally forest; though, from what has gone before, the rock stage would frequently be absent. At the same time, a spring of water would at once offer special conditions in its neighbourhood, and pools with aquatic plants, or bogs varying in their water-content, would be formed without reference to the above-detailed procession of events.

Although the above evolutionary treatment will not be neglected, it is simpler to deal primarily with the plant covering as it at present exists, dividing it into the antagonistic classes (41) of forest and steppe, and referring our formations, the bog vegetation excepted, to the one category or the other.

(B.) FOREST FORMATIONS.

(*a.*) General Remarks.

Forest is undoubtedly the climax of vegetation up to a certain altitude, since the climate not only of the volcanic plateau but of the whole New Zealand region is of the rain-forest type; it is merely the edaphic conditions which inhibit its presence. These, as has been shown in the geological section, are of a truly desert character, and it is only when the grass and shrub formations can have prepared something of a soil, or the changed topographical conditions have provided shelter, that forest can replace the steppe or scrub. Shade is the greatest friend to forest-growth, and a south exposure, or a gully, will be first afforested. This fact an examination of any gully shows, where all stages in the life-history of a forest may be traced. So, too, a specially abundant rainfall may counteract desert conditions; and thus we find on the western side of Ruapehu a garment of forest continuous with that of the lower altitude, and reaching a fairly uniform height on the mountain. On the east there is nothing of the kind, but only isolated patches in places where special climatic conditions prevail. On the Kaimanawas, however, is a rich clothing of trees, though the rainfall there must be the same as that of eastern Ruapehu and Tongariro. This forest clothing of the Kaimanawas is no doubt due to the different nature of the rock and immunity from the more recent volcanic ashes, &c. It is then merely a question of time, and nature, if not interfered with, will afforest the eastern side of the volcanoes, though the process of changing the present deserts into associations of trees will of necessity be a very lengthy affair.

With the exception of the forest at the north of Tongariro, the remainder consists of various species of *Nothofagus* as the dominant trees. Where unbroken, there is a distinct zonal arrangement, each zone, however, gradually merging into the next. *N. fusca* forms the lowest zone (Photo. No. 12), then *N. Menziesii*, and finally *N. cliffortioides*. Even on the east, where the forests are separated by wide intervals of steppe or desert, and often concealed in river-gorges, the zonal arrangement holds good, altitude or exposure determining the class of forest.

A considerable number of species are common to the different forests, and their presence or absence is most likely rather their individual relation to altitude than a preference for growing in company with any particular species of *Nothofagus*. Other species, again, require the maximum rainfall—*e.g.*, *Luzuriaga parviflora*, *Libertia pulchella*, *Coprosma Colensoi*, *Gahnia pauciflora*—and these occur only on the west and south of Ruapehu, except the latter, which is in the north Tongariro forest.

Generally speaking, there is an abundance of young forest trees and seedlings, and many examples occur where the old trees are dying and being naturally replaced. Thus, if undisturbed, the forests will exist for long periods. But this natural rejuvenation under present forest-conditions is a quite different matter to what would happen should they be destroyed by fire. Then undoubtedly the soil-conditions would overbalance the climatic, retrogression would ensue, and steppe or desert once more appear.

The beech forests have all a strong relationship, yet accordingly as one or other species is the dominant tree, so is the general physiognomy distinct. Thus the close dark-coloured foliage, arranged in layers, of the mountain-beech (*Nothofagus cliffortioides*) is very distinct in appearance from the bright-green and much more open foliage of *N. fusca*, while there is no comparison between the size of the respective species. *N. Menziesii* comes midway between the two in its physiognomy.

(*b.*) The Leading Physiognomic Plants and their Life-forms.

There are no plants recorded up to the present time as peculiar to the forests of the volcanic plateau.* All are such as are found in other parts of New Zealand. The following are the species which most affect the physiognomy of the formations: (Fagaceæ) *Nothofagus cliffortioides*, *N. fusca*; *N. Menziesii*; (Rubiaceæ) *Coprosma fœtidissima*, *C. tenuifolia*; (Myrsinaceæ) *Suttonia divaricata*; (Araliaceæ) *Nothopanax simplex*, *N. Colensoi*; (Taxaceæ) *Phyllocladus alpinus*; (Compositæ) *Lagenophora petiolata*; (Filices) *Hymenophyllum multifidum*, *Polystichum vestitum*, *Blechnum penna marina*.

(1.) *Trees.*

Nothofagus cliffortioides (mountain-beech) is, on the volcanic plateau and its environs, a fair-sized evergreen tree, frequently 50 ft. tall, and with a straight trunk 2 ft. or more in diameter, covered with a dark-coloured moderately smooth bark. The branches when the trees are not crowded are spreading, but in the forest are much contracted but branch freely in a more or less distichous manner, bearing numerous short twigs, which have on their flanks many close, hard, stiff, and coriaceous small, dark, glossy, green leaves of an ovate type, which are clothed beneath with white adpressed hairs. The whole of the leafy branch-system is more or less flattened, presenting the appearance of close layers of foliage one above the other. The flowers are monœcious, the male being very numerous and red and showy when the tree is in full bloom. The seeds germinate freely, and seedlings are extremely numerous. These have rounded membraneous leaves without the adpressed hairs.

Nothofagus fusca (tooth-leaved beech) is a very large evergreen forest-tree attaining a height of 70 ft. and frequently much more, and having a straight trunk often 6 ft. in diameter, covered with deeply furrowed bark, which comes off in flakes. The base of the trunk is very frequently expanded into large, moderately thin plank buttresses (Photo. No. 13). The head of foliage is slender, but almost equals the bare trunk: the branches short, and more or less horizontal. The

* This statement is not true if the forests near Lake Taupo are considered as belonging to the plateau, since they contain the recent remarkable find by Mr. Hill, a species of Bagnisia which belongs to an order, Burmanniaceæ, not previously known in New Zealand.

No. 12. Base of *Nothofagus fusca* Tree, showing the Plank Buttresses. Forest south of Reapehu.

Photo, L. Cockayne.

No. 13. *Nothofagus fusca* (Red Beech) and Silver Beech with *Pittosporum Colensoi* and *Pharmacium breve* in front. South of Reapehu on Natural Opening in Forest.

Photo, L. Cockayne.

leaves are of the ovate type, deeply serrate, 1 in. or more long, bright-green, glabrous, and rather thin. The flowers are monœcious.

Nothofagus Menziesii (silver-beech) (Photo. No. 14) is a tall evergreen forest-tree with a straight trunk, not so thick usually as that of *N. fusca*, covered with smooth silvery bark when young, but, when old, furrowed and flaking. The branches are spreading when growing in the open, but in the forest the habit is more fastigate. Quite short branches are frequently given off from the trunk close to the ground. The final branchlets are stiff and slender, and bear on their flanks numerous shorter leafy twigs, which again branch, the whole forming a flat fan-shaped closely-leafy mass. The leaves are small, bright-green, and shining, but rather yellowish in the mass and not vivid green as those of *N. fusca*, coriaceous, and of broadly ovate type. The ultimate branches are clothed with brown pubescence. On the under-surface of the leaf, especially near the base, are fringed domatia.

(2.) *Shrubs.*

Coprosma fœtidissima (stinkwood) is a rather moderate-sized evergreen shrub, made up of a few slender arching stems, leafless and unbranched below, sparingly branched above, and bearing rather pale green, subcoriaceous leaves of the oblong type, one or two inches in length, and emitting a fœtid odour when bruised. The flowers are dicœcious. The drupes are produced in abundance, and are conspicuous through their orange colour.

Coprosma tenuifolia has very much the same habit as *C. fœtidissima*. There is a slender arching main stem or stems covered with smooth grey bark, and furnished with a few long branches which give off from their flanks rather distant, opposite, slender, brittle twigs, which branch in similar manner once or twice into very short twigs provided with moderate-sized, shining, rather thin, ovate, acute leaves of a dark or yellowish-green colour, their veins marked with dark-green and the under-surface quite pale.

Suttonia divaricata (weeping matipo) is a moderate-sized shrub with an extremely dense habit of growth after the manner of certain species of *Coprosma*. Its branches are slender, stiff, wiry, divaricating, and much interlaced. The leaves are small, of obcordate type, rather pale-coloured, coriaceous, and glabrous. The flowers are minute, and the drupe purple and fleshy.

Nothopanax simplex is a tall shrub or small tree with a short trunk or trunks, which give off numerous semi-erect slender branches, so that a tree of considerable diameter and thicket-like growth results. The leaves show a remarkable heterophylly, which is dealt with further on, and the adult leaves are simple, of lanceolate type, three or four inches long, glossy, coriaceous, and dark-green. The umbels are small, and the flowers are inconspicuous and greenish-white in colour.

Nothopanax Colensoi (ivy-tree) is an evergreen shrub, with unbranched naked stems of bamboo-like form, marked at irregular intervals of 2 in. or less with pale-coloured leaf-scars, which contrast with the brownish-green smooth bark. Short branches are given off near the ends of these stems, bearing the thick, dark-green, shining, glossy, coriaceous, large, digitate leaves on long stout petioles. The flowers are dicœcious, arranged in large umbels, and rather conspicuous through their number.

Phyllocladus alpinus (mountain-toatoa) is dealt with further on in the section on the subalpine scrub.

(3.) *Herbs.*

Lagenophora petiolata, although an insignificant plant, occurs in such considerable quantities on the floor of the mountain-beech forest that it demands mention here. It is a small creeping herb, spreading by means of rooting, and branching slender pale-coloured stolons into wide mats. The leaves are of orbicular type, coarsely toothed, dull-green, frequently purple on under-surface, thin, and with long slender petioles. The flower-heads are small, daisy-like, white, and raised high above the foliage on straight slender stalks 5 in. and more in length. Very frequently the ray florets are curled up.

(4.) *Ferns.*

Hymenophyllum multifidum is a filmy fern which forms extensive mats upon the ground or the tree-trunks, spreading far by means of its wiry, creeping rhizome. The fronds are 4 in. or 5 in. tall, or sometimes more, very thin and translucent, and vary from a dark to a light green.

Blechnum penna marina forms large colonies, spreading by means of the long, branching, creeping rhizome, which gives off the fronds in tufts. These are dimorphic, the sterile are narrow, lanceolate, almost pinnate, dark-green, coriaceous, and semi-erect, and the fertile are longer and narrower, of a brown colour, and with the segments much narrower than those of the sterile fronds.

Polystichum vestitum does not usually on the volcanic plateau show a trunk-development to any marked extent, as in many subalpine forests and in the subantarctic islands of New Zealand. It is a tall fern, with numerous spreading and arching fronds, which are 3 ft. to 5 ft. long, with a stout stalk densely clothed with dark-coloured scales, and lanceolate, dark-green, subcoriaceous, rather stiff blades.

(*c.*) Ecology.

The subalpine forest of the mountain-beech (*Nothofagus cliffortioides*) may perhaps be designated subxerophytic. It is true that Schimper (39) classified it as tropophytic, but this was probably to place it in the same category as the closely related deciduous beech forests of Fuegia rather than from any special character of the leading tree. This has small though numerous coriaceous leaves, hairy beneath, which are in part cast off yearly, young bright-green leaves appearing in the spring and giving a distinct and pleasing appearance to the landscape at that season. Also, a prolonged period of drought will bring about the leaf-fall. Thus, while camped in the forest near the Ruapehu Mountain House, the leaves during late February and early March

fell continuously in such numbers as to make a sound like the patter of raindrops on the roof of my tent. *Nothofagus Menziesii* is slightly less xerophytic than *N. cliffortioides*, while *N. fusca*, with its thin leaves, is distinctly hygrophytic. Thus, according to increasing altitude the forest zones become more xerophytic, the strongly hygrophytic mixed taxad forest at 2,000 ft. altitude, with its tree-ferns, woody lianes, and epiphytic asteliads, offering a great contrast to the mountain-beech forest 1,500 ft. above, with its undergrowth of shrubs, many identical with those of the wind-swept subalpine scrub.

Leaving the zone of *N. fusca* out of the question for the present, the under-shrubs of the upper forest have frequently coriaceous leaves, and in addition certain of them are of the markedly xerophytic divaricating type already described in the case of the very typical *Suttonia divaricata*. Xerophily is likewise shown in the filmy fern *Hymenophyllum multifidum* having its leaves so frequently curled up, a condition I have already proved by experiment to be brought about directly by excessive transpiration. The elegant fern *Hypolepis millefolium* is truly herbaceous, the bright-green fronds dying to the ground in winter; and *Polystichum vestitum* and *Blechnum penna marina* have each coriaceous leaves. Also, it must be pointed out that where the same species appear as both forest and subalpine scrub or shrub-steppe plants, so different are they at times that they might be considered by one unversed in the flora as different species. How much shade-conditions can alter form I have shown elsewhere with regard to the South Island form of *Pittosporum rigidum* (5). This plant is, out in the open, of the most dense and divaricating habit conceivable, but in the forest its leaves are pinnatifid and not entire, thin and not coriaceous, and its habit is twiggy and open. Still more interesting is the behaviour of *Aristotelia fruticosa*. This, in its juvenile form, exhibits a most remarkable leaf-variation, but in the open usually it finally becomes a divaricating shrub with small leaves and leafless branch-apices which are semi-spiny. But almost invariably in the forests of the volcanic plateau the plant in question is found with comparatively broad leaves, and remains of a hygrophytic rather than a xerophytic form. So, too, with *Corokia Cotoneaster*, a very rare plant for this locality.

In contradistinction to the xerophytic form is the hygrophytic, which is exhibited by several of the commonest plants. Thus there is nothing xerophytic about *Coprosma fœtidissima* and *C. tenuifolia*. *In fact, the composition of the forests depends far more upon the history of the vegetation*—i.e., *upon the plants which by chance came to settle down on the new ground—than upon any special adaptations these may have possessed.* Probably, the main requisite was the physiological one of their frost-enduring limit. Any xerophily would, however, stand them in good stead on first settling down on the new and excessively porous ground, while when coming finally into moist forest-conditions they assumed at once, according to their plasticity, more or less hygrophytic forms.

The light-relation regulates the density of the undergrowth. This is well shown by the powerful crop of saplings wherever a few of the old trees have died. Where more light still can penetrate, the undergrowth at once becomes abnormally thick, and certain plants enter in which are usually uncommon in the formation, especially the liane *Rubus australis* (bush-lawyer) and the aggressive herb *Acæna Sanguisorbæ* (piripiri). Increase of moisture also changes the forest-character, a shady bank or the bottom of a gully having a richer vegetation, and there certain species may appear which are absent elsewhere.

The soil factor of course is of great importance regarding the undergrowth. Within the forest it consists of a surface layer 2 in. or more deep of fallen beech-leaves, partially or altogether decayed, mixed with rotted moss-cushions, decaying twigs, and so on. Beneath this is a sandy soil with little or no humus, in which the various elements pumice, scoria, and lava are mixed together, and beneath this again at a varying distance a certain amount of sandy clay and stones. Such a soil becomes excessively dry in summer. Even digging in a gully will usually fail to reach water. It is the capacity of the top layer of decayed and decaying vegetable matter to hold water on which the plants must in considerable measure rely, and this moisture, which is renewed even by the slightest shower, encourages the growth of low moss cushions or mats, these playing a notable part as soil-makers and water-conservers. One especially, dying and decaying as it grows, builds up broad low cushions of a yellowish-green colour, only the peripheral portion being alive for a trifling depth. Through such moss stoloniferous plants penetrate; young seedlings find there the moisture they require, and finally, acquiring sufficient vigour, can penetrate into the sandy ground, sending down long roots and growing eventually into thickets.

Regarding the flowers of the forest-plants, more than 70 per cent. have insignificant flowers, mostly of a dull colour, while about 66 per cent. have unisexual flowers. *Alseuosima macrophylla*, *Myrtus pedunculata*, *Nothofagus cliffortioides*, *Lagenophora petiola*, and *Styphelia acerosa* are the only members which can lay claim to any degree of showiness, and of these only the *Alseuosmia* and beech are highly coloured, the remainder being white and small. In many cases wind will play the chief part in cross-fertilisation, but in some instances—*Astelia montana*, *e.g.*,—flies will be the fertilising agent.

Heterophylly, so common a phenomenon amongst New Zealand plants, has been already discussed in the case of certain divaricatingly branched shrubs. *Nothopanax simplex* is another important example. This small tree is especially distinguished by its having two quite distinct juvenile forms. The more common of the two has a compound deeply cut leaf, which, to be sure, varies a good deal in form, depth of cutting, &c. The second form is a ternate or simple leaf with merely toothed leaflets. At one time I felt assured that the two forms were related, and that each would appear at a definite stage in the life-history of the plant. But this does not altogether appear to be the case, the two forms growing side by side and thus under the same environment.*

* Certain specimens which I collected, however, have simple-toothed, ternate-toothed, and ternate-pinnatified leaves on the same plant, these latter in some cases showing transitions towards a toothed margin. The toothed and cut leaves therefore are far from being fixed and constant structures.

No. 15. General View of Piece of Shrub-steppe, with Forest of Mountain-beech in background to right. The Grass is *Danthonia Raoulii*.

Photo. L. Cockayne.

No. 16. *Cardyline indivisa* (Broad-leaved Cabbage-tree) growing on Outskirts of Forest on Hauhungatahi.

To face p. 7.

Photo. L. Cockayne.

Leaving out of the question the so-called variety *parvum*, there is only one form of adult, so there can be no question of two very similar species with a different life-history. Also, the toothed-leaved form is almost the exclusive one of the Auckland Islands, and was considered the only one of that region until my finding a cut-leaved example there in 1903. The adult tree has finally simple leaves, but with these are mixed both forms of the juvenile, the cut-leaved more sparingly than the other. Occasionally plants occur where cut-leaved shoots bloom. Also, these juvenile reversion-shoots are not confined to the base of the tree, as is so often the case of this class of phenomena, but occur also on the ultimate branches. Even with moist-air culture the toothed-leaved seedling, so far as my experiments of some years' duration go, will not grow into the cut-leaved form. That there was originally some connection between a hygrophytic station and the cut leaves there seems little doubt, the above experiments notwithstanding, especially when it is remembered that the more hygrophytic the forest the more luxuriant is the cut-leaved stage. But at the present time environment appears to have no influence, and *the dual forms must be considered no longer as adaptations, but merely as survivals from previous climatic conditions*, whereas in *Aristotelia fruticosa* cited above the various stages are still dependent to some extent on external influences, and the characters are not thoroughly fixed.

With the exception of the scrambler *Rubus australis*, woody lianes are absent. Nor, with the exception of some *Polypodium diversifolium* and *P. novæ-zealandiæ* in the west and south, are there climbing ferns. In the same region a few plants of *Astelia Cunninghamii* ascend to the upper forest, otherwise spermaphytic epiphytes are absent.

Parasites are represented by *Elytranthe tetrapetala*, which forms bushes on *Nothofagus; E. flavida*, which is confined, so far as I know, to *N. cliffortioides*; and the curious orchidaceous so-called root-parasite *Gastrodia Cunninghamii*, which is quite abundant in the forests of the east. The loranthads have plenty of chlorophyll in their leaves, and are therefore hemi-parasites. *Gastrodia* has a thick, fleshy, easily broken root a foot or more in length, full of starch, from which issues a brown-coloured, leafless stem, 1 ft. to 2 ft. tall, marked with darker spots, and which produces a raceme of brownish flowers in January. Personally, I have never traced the root to its attachment with the host, so can say nothing on this head, and consider the plant is probably a saprophyte.

(*d.*) Subalpine Beech Forest of Nothofagus cliffortioides.

(1.) *Distribution.*

This is the forest of the highest altitude and of the most exposed position. On the southern and western sides of Ruapehu it forms a continuous belt from about an altitude of 3,700 ft. to 4,000 ft., while on the eastern side of the volcanic mountains there is no such continuous zone, but merely a number of isolated patches, the largest, some hundreds of acres in extent, near the junction of the north and south branches of the Waihohonu River. On the east side of Tama is a fairly large piece of this formation, and there are one or two extremely small patches on the north-eastern spurs of Ruapehu, these and that of Tama marking the tree-limit on the east of the volcanic chain at about an altitude of 4,100 ft. Also, further to the south, beyond the gorge of the Wangaehu, are two pieces of this formation, one bearing the name of the "Round Bush."

(2.) *Physiognomy.*

The general appearance from without of the formation under consideration is that of a dense, and black, gloomy-looking, uniform mass of trees (Photo. No. 15). A nearer view yields a more pleasing sight. The trees, fairly close together, are well branched, the foliage verdant and healthy, while on their outskirts or just beneath their shade are certain invaders from the shrub-steppe —*e.g.*, numerous rounded bushes of the bright-green *Veronica lævis*, rather showy when, in early February, covered with close masses of white or lilac blossoms; taller and many-branched dark-green shrubs of *Dacrydium Bidwillii*, of a cypress-like habit; and the pale-"leafed" toatoa (*Phyllocladus alpinus*). Within the forest there is often not much undergrowth. Where the trees are young they are quite close, and little is seen but their slender, bare, straight, greyish stems, the rather dense foliage above, and, on the floor, many brown dead leaves and branches; while here and there are a few seedlings of the ordinary forest-shrubs enumerated further on. Such saplings may be from 2 in. to 4 in. in diameter, and from a foot to a yard apart. In other places the old trees are the most abundant, and tree-trunks, their bases hidden by shrubby undergrowth, catch the eye everywhere, but from the sapling forest to the adult are transitions of all kinds. In a fully matured portion the trees may be as much as 60 ft. tall and 2 ft. in diameter, but usually the dimensions are less. The trees are often a considerable distance apart. Their branches are much less spreading than those of the forest-outskirts; the trunks are straight and covered with moderately smooth bark, on which a few species of mosses form mats or cushions. Foliaceous lichens of the genus *Sticta* are also common, while a white, thin, crustaceous lichen pressed closely to the bark very frequently gives a characteristic colour to the trunk. The roof of the forest is not a continuous close covering; light penetrates everywhere, but its intensity is least where the saplings are especially dense

Beneath the trees the undergrowth is in two layers, though this arrangement is not present everywhere—a layer of shrubs, low trees, and young beech-trees, and the actual close covering of the forest-floor.

The shrubby layer is rarely sufficiently dense to offer many obstacles to the intruder. It consists of the sparsely branched pale-green *Coprosma fœtidissima*, its height reduced through its drooping habit; the large, taller, and much more bushy *Nothopanax simplex*, which is frequently the dominant shrub; *N. Colensoi*, with its dark-green, leathery, digitate leaves growing near the extremities of the naked bamboo-like branches; and moderate-sized shrubs or small trees of

Phyllocladus alpinus, its leaf-like shoots of a somewhat glaucous colour. This latter may assume a pyramidal form, 8 ft. or so tall, or be merely of a straggling habit and sparingly branched. There are also fairly dense bushes of *Suttonia divaricata*, *Coprosma cuneata*, *Aristotelia fruticosa*, *C. parviflora*, and *C. microcarpa*. These shrubs may grow so closely and be themselves so dense as to exclude the floor-vegetation.

The second layer or tier of plants is made up of those more lowly ones which carpet the ground, and of the seedlings, ferns, and herbaceous plants—these frequently of considerable size—which grow through this covering or are dotted here and there. The most conspicuous of the mat-forming plants is the bright-green or occasionally dark-green filmy fern *Hymenophyllum multifidum*, whose fronds are sometimes so much curled up that the plant looks dead. Both stoloniferous and mat-forming is *Lagenophora petiolata*, the small roundish leaves close to the ground, and the little, white, daisy-like flower-heads raised on straight slender stalks. A moss builds up low cushion-like masses of yellowish green, through which grow in abundance the beech seedlings; also the green, grass-like, narrow leaves and slender culms of *Uncinia cæspitosa* covering considerable areas, thanks to its creeping stems, which also benefit by the mossy covering. The broader-leaved and taller *Uncinia australis* is less common, and likes the more shady gullies and recesses. The small fern *Blechnum penna marina* is often quite common, and the club-moss *Lycopodium fastigiatum*, here erect and green, and not depressed and orange-coloured as on the steppe, may form spreading colonies. Seedlings of all the forest-plants are present, but the most common, next to those of the beech, are the cut-leaved form of *Nothopanax simplex* and *Aristotelia fruticosa*. Where the forest is more open the piripiri (*Acæna Sanguisorbæ*) is abundant. Near the outer rim of the formation is quite frequently a prostrate form of *Styphelia acerosa*, very different from the typical erect, dense-growing shrub, its wiry stems creeping through the loose layer of humus, and finally rising up for a few inches or even a foot. Other constituents of the forest, though not common, are *Erechtites glabrescens*, *Nertera dichondræfolia*, *Pittosporum rigidum*, *Gastrodia Cunninghamii*, and *Myosotis Forsteri*.

The gullies have a richer undergrowth than the slopes, and in such the dark-green, rather tall fern *Polystichum vestitum* and the delicate bright-green fronds of *Hypolepis millefolium* are abundant, while *Hymenophyllum multifidum* is everywhere. Here, too, is a good deal of *Astelia montana*, with its arching, coriaceous, hairy, sword-like leaves, while in many places are fine colonies of the enormous moss, a foot or more tall, *Polytrichum dendroides*.

The forest-floor is fairly level. There are no roots spreading over the ground, nor the unevennesses these occasion in the hygrophytic forests. The ground, mossy or covered with a thick layer of brown leaves, is springy to the tread. The higher epiphytes and lianes are quite wanting. *Hymenophyllum multifidum* is common on the tree-trunks, and so are mosses and lichens, as before mentioned.

Dead trees still standing (Photo. No. 15) or lying prone, are a frequent feature, while, as stated previously, seedlings and saplings are in abundance. So, if there are no fires, or interference from those animals which feed on the trees and especially destroy the bark and the undergrowth, these subalpine forests will long remain in their pristine vigour. Seedlings of most of the trees and shrubs are plentiful, even in forests where but few of the adults are present in the locality. The most abundant of all are the cut-leaved *Nothopanax simplex*, *Aristotelia fruticosa*, the beech itself, *Nothopanax Colensoi*, and finally the various species of *Coprosma*.

(3.) *Affinities of the Formation.*

Pure *Nothofagus cliffortioides* forest is very common in certain parts of the South Island, especially the central Southern Adps on their east side, but rarer in the North, where *N. Menziesii* is a more abundant subalpine tree. The presence of the formation usually bespeaks a dry and poor soil and a small rainfall—*i.e.*, for a mountain region and a high altitude. Probably powerful or frequent winds are a factor, too, which helps in determining its presence. Generally speaking, the forest we are considering has a richer undergrowth than the same formation in the eastern Southern Alps, but it is poorer in species as a whole, though this is a matter dependent on the history of the vegetation, and not on any special ecological factors.

(*e.*) Subalpine Beech Forest of Nothofagus Menziesii (Silver-beech).

This formation occurs at approximately an altitude of between 3,200 ft. and 3,700 ft. on the south and west of Ruapehu. It is also found in the higher parts of some of the river-gorges to the east of Tongariro. *N. Menziesii* is altogether a larger tree than *N. cliffortioides*, and is frequently more than 70 ft. in height, with a trunk 3 ft. in diameter. The tree itself is by no means confined to the subalpine zone, but occurs in abundance mixed with *N. fusca* at as low as 2,000 ft. altitude, even descending still lower into the mixed taxad forest.

The forest zones, as already noted, are only well defined in their central parts; elsewhere there is a combination of the two most adjacent. At about 3,400 ft. the trees are 40 ft. or 50 ft. tall, and consist almost entirely of *N. Menziesii*, though at a higher altitude than this a good deal of *N. fusca* is still present in places. The *N. Menziesii* forest of this district owes its physiognomy in part to the short leafy boughs or twigs which are given off from the trunks almost to their bases, while the abundance of *Coprosma fœtidissima*, which here replaces *C. tenuifolia* of the *N. fusca* forest, gives the stamp to the straggling and rather open undergrowth. Some of the trees are 2 ft. in diameter, but many are much less, and the thick ones are distant, being merely dotted here and there. The smaller trees and the thicker-stemmed shrubs are covered much more abundantly with mosses than are those in the mountain-beech forest. All the plants of this latter forest are also present here, but in addition are the following: *Luzuriaga parviflora*, *Libertia pulchella*, *Alseuosmia macrophylla*, *Coprosma tenuifolia*, *Uncinia leptostachya*, *Gahnia pauci-*

flora, Podocarpus Hallii, Libocedrus, Dacrydium Bidwillii, Blechnum discolor, Coprosma Colensoi, C. Banksii, Nothopanax anomalum, Elæocarpus Hookerianus, Polypodium novæ-zealandiæ. Where most luxuriant the undergrowth is about 8 ft. tall, *C. fœtidissima, C. tenuifolia, Nothopanax Colensoi, N. simplex,* and beech saplings being the tallest growth, but these latter are most abundant where the illumination is strongest, when they easily become dominant and are taller. The trees themselves vary in distance from one another by from a yard or two to as much as 20 yards, but this latter is exceptional. Their crowns mostly meet, but light comes through in fair abundance. The ground is usually covered with mosses and liverworts, into which the feet sink, making walking rather laborious. There are many fallen trees, some much decayed, and on them in the lower part of the formation plenty of the creeping fern *Polypodium novæ-zealandiæ,* its dark-green deeply-cut fronds a foot or more in length given off here and there from its long, thick, scale-covered rhizome. On the forest-floor are colonies of the broad-leaved grass *Microlæna avenacea;* a great abundance of *Astelia montana;* large breadths of *Hymenophyllum multifidum;* the shrub *Styphelia fasciculata,* not erect as usual, but closely hugging the ground; *Myrtus pedunculata,* of similar habit; *Luzuriaga,* its wiry stems creeping through the mosses; the grass-like leaves of *Libertia pulchella,* 4 in. or 5 in. tall; tussocks occasionally of the sedge *Gahnia pauciflora,* the leaves 3 ft. long; large colonies at times of the umbrella fern (*Gleichenia Cunninghamii*). As the altidude increases, *Nothofagus cliffortioides* seedlings put in an appearance, *Coprosma cuneata* becomes abundant, and an occasional young plant of *Libocedrus Bidwillii* and *Podocarpus Hallii* appear. Finally *N. cliffortioides* becomes dominant, and a new zone begins.

The following from my notebook describes a piece of *N. Menziesii* forest which occupies a deep gully on the east of Tongariro between the Waihohonu and the Oturere, and which is rather a conspicuous object in the landscape. The quotation shows how the above-described and this latter piece of forest resemble one another, the one owing its presence to its southerly position on Ruapehu, and the other to the shelter of a gully enclosed on all sides by steppe.

"The forest stands in part upon the hilly slope, and descends in part into the rather deep gully. The tall trees, 60 ft. or so tall and sometimes 3 ft. in diameter, are altogether *Nothofagus Menziesii.* There is a much closer and richer undergrowth than in the mountain subalpine forests of *N. cliffortioides.* This, together with the short branching of the trees and their numerous and still shorter lateral branches on the trunks, which are more or less moss-clad, gives a distinct stamp to the formation. The forest-floor is rarely bare, but covered frequently with a strong growth of *Hymenophyllum multifidum* and especially large quantities of *Polytrichum dendroides.* Besides the usual shrubs, certain subalpine-scrub shrubs enter into the formation—*e.g., Aristotelia fruticosa, Phyllocladus alpinus,* and *Olearia nitida* (which in this region is rather a forest-plant than one of the scrub.

"The undergrowth may be man-high, but generally it reaches to about one's middle. The sparsely branched *Coprosma fœtidissima* is dominant. Young plants of *Nothofagus Menziesii* are almost equally abundant. *Suttonia divaricata* and *Nothopanax simplex* are quite common. *Myrtus pedunculata,* not found in the *Nothofagus cliffortiodes* forest, is fairly abundant. *Coprosma parviflora, C. microcarpa,* and *C. cuneata* are frequent, especially the first-named. There is some *Drimys colorata. Rubus australis* is present where strong sunlight can penetrate, and occasionally has thick, rope-like stems. There is a good deal of *Nothopanax Colensoi,* some *Aristotelia fruticosa, Griselinia littoralis,* and *Pittosporum Colensoi,* and an occasional young plant of *Veronica salicifolia.* As for ferns, they are especially abundant in the gullies, where *Polystichum vestitum,* with short trunks, and *Hypolepis millefolium* are plentiful. There is also a small amount of the crape fern (*Ixeptopteris superba*).

"The trees are not very close, except where they are saplings. The old trees are tall and of considerable diameter. The bark of these is furrowed, as opposed to the smooth bark of younger trees. The leaves are bright-green, shining, small, and inserted closely together on the flanks of the final twigs, which are arranged in a somewhat flabellate manner. Besides mosses and lichens, there are frequently *Hymenophyllum* mats on the trunks, and *Asplenium flaccidum* depends in close, drooping masses from the lower boughs. Many of the old trees are in a state of decay, and there is much fallen *débris* on the ground. In short, the forest is at the present time undergoing a natural process of rejuvenation."

(*f.*) The Toothed-leaved-beech (Nothofagus fusca) Forest (Photo. No. 12).

At an altitude of 2,100 ft. or rather more, to the south and west of Ruapehu, the magnificent taxad forest of the Waimarino gives place to a zone in which the toothed-leaved beech (*Nothofagus fusca*) is the dominant tree, though a great deal of *N. Menziesii* is mixed with it. At first a large percentage of the shrubs and small trees of the taxad forest are present, but with increase of altitude certain species vanish or become scarce—*e.g., Melicytus lanceolatus, Rapanea salicina, Olea lanceolata, Melicytus ramiflorus, Hoheria sexstylosa, Coprosma grandifolia, Beilschmiedia tawa, Podocarpus ferrugineus, Dacrydium cupressinum, Aristotelia racemosa, Fuchsia excorticata, Nothopanax arboreum, Parsonsia heterophylla, Astelia nervosa, Blechnum lanceolatum, Hypolepis tenuifolia, Dicksonia squarrosa, D. fibrosa, D. lanata.* The *Nothofagus fusca* trees, at first frequently exceeding 80 ft. in height and 6 ft. in diameter, become gradually smaller in size, though it is remarkable how at 3,000 ft. and more altitude many still are of large dimensions.

The tender green of the leaves and the open character of the foliage, giving it a lacelike appearance, mark the physiogomy of this formation as quite different from that of those already described, while the thick and buttressed trunks (Photo. No. 13), with their flaking and furrowed bark, still more accentuate the difference.

There is a distinct second tier of shrubs or small trees with slender stems, frequently moss-clad, and short rather scanty lateral branches, and whose general direction is out of the perpen-

dicular. The most common is *Coprosma tenuifolia*, 6 ft. or so in height. *Myrtus pedunculata*, sometimes more or less prostrate, plays a most important part amongst the lowest shrubs, but it also occurs as a small tree with a slender trunk. Lianes and epiphytes are scarce. Young plants of *Nothofagus Menziesii* are abundant in the undergrowth, which, generally speaking, is of an open character (Photo. No. 12). The floor is copiously furnished with dead beech-leaves, and in places there are quite bare patches. The ferns, even at 2,000 ft. altitude, play no very important part, nor are ferns in general much in evidence. *Polypodium novæ-zealandiæ* is, however, frequent in many places, both as an epiphyte and creeping over fallen trees, and *Leptopteris superba* is common, but still not nearly so abundant as in the upper taxad forest. The beautiful flowering shrub *Alseuosmia macrophylla* is common, especially on the dry mounds beneath the beech-trees. Altitude, of course, changes the relative abundance of the species, but no further details are necessary, as the formation is not one of much moment in the National Park, and the description of the *N. Menziesii* zone will serve for that of its upper part.

Besides the southern and western Ruapehu forest, there are considerable areas of the same formation in the lower parts of the deep river-gorges of the eastern portion of the plateau, as, for instance, that of the Oturere.

(*g.*) The Totara Forest of Tongariro.

Quite a small belt of forest, a portion of a much larger area, occurs within the precincts of the park. This is especially noteworthy because the beeches (*Nothofagus*) are altogether absent, the formation having the thin-leaved totara (*Podocarpus Hallii*) as its leading tree. Notwithstanding the altitude of this piece of forest, many of the trees are 50 ft. or more tall, and such may have trunks, usually short, and averaging perhaps 3 ft. in diameter. The trees grow either in moderately close clumps or are distant half a chain or more. The forest is fairly open, this being due in part to the incursions of the horses and cattle of the Natives. The second tier of plants consists of small trees—*e.g.*, *Drimys colorata*, *Melicope simplex* (not noted elsewhere in the park), *Pseudopanax crassifolium*, *Nothopanax simplex*, *N. arboreum*, *N. Colensoi*, and an occasional *Dacrydium Colensoi*. Beneath these is a fairly close undergrowth in which *Drimys colorata* is easily the dominant plant, while on the forest-floor its seedlings, large and small, are excessively abundant. *Coprosma tenuifolia*, *C. fœtidissima*, and *Myrtus pedunculata* are also present. From the above it may be seen that this formation is rather of a montane than subalpine character.

This forest has been in part destroyed by a lava-stream from Te Mari, and portions quite separated now from the main body extend high up the mountain in sheltered places, merging finally into subalpine scrub. Such a piece of forest, at about 4,000 ft. altitude, is made up of low trees of *Podocarpus Hallii*, *Phyllocladus alpinus*, and broadleaf (*Griselinia littoralis*), and is related to the *Phyllocladus* scrub or low forest described under another head.

The low trees may be 20 ft. or so tall. They frequently lean a good deal out of the perpendicular. Such a formation may have either the *Podocarpus* or the *Phyllocladus* dominant. The undergrowth consists of *Drimys colorata*, *Nothopanax Colensoi*, *Coprosma tenuifolia*, *C. microcarpa*, *C. fœtidissima*, *Suttonia divaricata*, *Aristotelia fruticosa*, *C. parviflora*, *C. cuneata*, *Pittosporum Colensoi*, and abundance of *Myrtus pedunculata*. On the ground are large breadths of *Hymenophyllum multifidum* and the great moss *Polytrichum dendroides* (not intermingled), plenty of *Uncinia cæspitosa*, and an abundance of *Astelia montana*. *Viola filicaulis* is also a characteristic feature.

(*h.*) The Forest of Hauhungatahi (Photo. No. 30).

This I examined in only one part of the mountain—namely, on its northern side—nor am I sure that this particular part comes in the suggested new boundaries of the park. But it seems interesting to include here some account of this forest, as nothing has previously been published regarding it.

On its exterior, where bounded by the Waimarino Plain, is a narrow belt of low trees and shrubs, consisting of *Pittosporum Colensoi*, *Nothopanax Colensoi*, *Veronica salicifolia*, *Cordyline indivisa* (see Photo. No. 16), *Drimys colorata*, *Melicytus lanceolatus*, *Suttonia divaricata*, *Dacrydium Colensoi*, small *Libocedrus Bidwillii*, small *Podocarpus Hallii*, *Coprosma lucida*, and an abundance of the woolly tree-fern, *Dicksonia lanata*.

Between the steep face of the mountain and the grassy plain (steppe) is a flat piece of forest with numerous moderate-sized trees (3 ft., but more frequently less, in diameter) of rimu (*Dacrydium cupressinum*) much scattered, miro (*Podocarpus ferrugineus*), totara (*P. Hallii*), and some cedar (*Libocedrus Bidwillii*).

The undergrowth is dense, and consists of the following: The tree-fern *Dicksonia lanata*, in extreme abundance, and forming an almost continuous mass through the forest—indeed, it is the striking feature of the formation; *Nothopanax arboreum; Coprosma Colensoi; C. tenuifolia; Myrtus pedunculata; Drimys colorata; C. fœtidissima; C. grandifolia; Elœocarpus Hookerianus* (its juvenile form); *Rapanea salicina; Carpodetus serratus; Phyllocladus alpinus; Griselinia littoralis; Aristotelia racemosa; Brachyglottis repanda; Weinmannia racemosa; Alseuosmia macrophylla; Schefflera digitata; C. parviflora; Pseudopanax crassifolium.* The ferns are *Hymenophyllum pulcherrimum*, abundant on tree-trunks; *Blechnum Pattersoni*, extremely abundant on the floor; *Asplenium bulbiferum; Polystichum vestitum; Hymenophyllum multifidum; H. flabellatum; H. dilatatum; Leptopteris hymenophylloides; L. superba; Asplenium flaccidum; Blechnum capense.*

As one ascends the rimu-trees get much fewer in number, and the *Libocedrus*, on the other hand, increase greatly, while a few tooth-leaved beech (*Nothofagus fusca*) enter in, the forest-trees at 3,400 ft. being *Libocedrus Bidwillii*, *N. fusca*, and *Podocarpus Hallii*. Regarding the forest at an altitude of 3,600 ft., my notebook says, "Here is a sort of combination of subalpine scrub and

forest, and as far as one can see in an upward direction *Libocedrus Bidwillii* dominates. *Dicksonia lanata* still continues in abundance. The other shrubs as from the flat forest are present. *Coprosma parviflora* and *C. cuneata* are especially plentiful. There is some *Nothofagus Solandri*. One has to creep under the projecting shrubs, and their heads intermingle and interlace. Where trees have died (this being a frequent occurrence) and the light enters in, the confusion gets worse, and the density also increases with the steepness."

On the dead *Libocedrus* trees was growing the remarkable filmy fern *Hymenophyllum Mallingii*. This plant, as Giesenhagen (20) has shown, through its reddish-brown stellate hairs, can keep the leaf-cells surrounded by an envelope of water, a matter of importance to a hygrophyte, whose special structure renders it especially susceptible to even a very short period of drought. I have myself never seen it growing otherwise than on dead *Libocedrus* trees,* usually on the standing trunk, where it forms very extensive mats of a silvery or reddish-silvery colour. Even here on Hauhungatahi the portion of the living tree on which I noted the plant was dead and quite decayed.

Seen from without, the Hauhungatahi forest is a dark mass marked here and there with the grey colour of dead trees (Photo. No. 30). The yellowish rimus show distinctly as a basal zone, and extend in a straggling manner up the mountain for some distance, but, above, *Libocedrus Bidwillii*, recognisable at a distance, easily dominates.

(C.) DESERTS, STEPPES, AND SCRUBS.

(*a.*) General Remarks.

These formations are so closely related that they may very well be included under one head. They occupy by far the largest part of the National Park, the forest formations being much smaller in extent. At between 3,000 ft. and 3,500 ft., plains with an even brown covering of the red tussock *Danthonia Raoulii* extend for miles, interspersed, it is true, with that open formation of low-growing shrubs to which I am giving the name of "shrub-steppe," but which is to be found dominant at about 4,000 ft., finally merging into or invaded by deserts of scoria or sand. From an altitude of 5,000 ft. and upwards, with the exception of certain alpine formations on Tongariro, desert, in many places quite without plants, is everywhere. At a distance, the grass-steppe is recognised by its brown colour, the shrubby steppe by the reddish-orange hue afforded by *Dracophyllum recurvum*, while the desert appears black or grey according to the colour of the scoria. The steppes are by no means everywhere in their virgin condition. Large areas have been burned from time to time and again and again. This has taken place especially near the coach-road and on the western side of the volcanoes. But the climatic and edaphic conditions are such that the formations are reproduced almost in their primitive form, and the introduced plants which have entered in are not numerous, if we except, in some places, *Hypochaeris radicata*. Certainly at first it looks as if a burnt area were destined to support a new association, a form of *Epilobium glabellum* being abundant, but this is evidently only a stage in the evolution of the final reproduced formation.

(*b.*) Leading Plants of Physiognomic Importance.

The plants which play the leading part in the physiognomy of the formations are the following:—

Shrubs.—(Epacridaceæ) *Dracophyllum recurvum, Dracophyllum subulatum, Epacris alpina;* (Scrophularinaceæ) *Veronica tetragona, V. lævis, V. spathulata, V. Hookeriana;* (Rubiaceæ) *Coprosma depressa, C. cuneata, C. repens;* (Taxaceæ) *Podocarpus nivalis, Phyllocladus alpinus, Dacrydium laxifolium, D. Bidwillii;* (Compositæ) *Olearia nummularifolia, Cassinia Vauvilliersii, Senecio Bidwillii;* (Leguminosæ) *Carmichaelii Enysii* var. *orbiculata*.

Herbaceous Plants.—(Compositæ) *Celmisia spectabilis, C. glandulosa;* (Scrophularinaceæ) *Ourisia Colensoi;* (Campanulaceæ) *Wahlenbergia saxicola;* (Gentianaceæ) *Gentiana bellidifolia*.

Grasses.—*Danthonia Raoulii, D. semiannularis* var. *setifolia*.

Dracophyllum recurvum is a much-spreading prostrate shrub, forming roundish cushions or patches, with much-branching, rigid, and brittle stems covered with dark-grey or brown bark, except the ultimate slender, wiry, and flexible leaf-bearing ones. The leaves are stiff, coriaceous, narrow, recurved, needle-like, tapering to a point, 1 in., more or less, in length, of a glaucous or reddish colour, and crowded into semi-rosettes at the end of the branches. The flowers are in short bracteate terminal spikes, each about ¼ in. long, and white. The roots are stout, woody, and excessively long.

Dracophyllum subulatum is an erect shrub 2 ft. or more tall. The branches are slender, twiggy, and densely arranged, covered with dark bark, and leafy only near their apices. The leaves are small, erect, hardly an inch long, very narrow, coriaceous, stiff, pungent, dull brownish green, with a pale-coloured short sheathing base. The flowers are small, white, and in short racemes.

Epacris alpina is a small shrub 1 ft., more or less, tall, of an erect and heath-like habit, or frequently with decumbent branches spreading mat-like over a considerable surface of ground. The final branches are vertical and close together, and covered closely with many small, green, thick, hard, coriaceous leaves of an ovate type. The roots descend fairly deep, and are woody, slender, and wiry. The flowers are white, small, and crowded for about half an inch at the ends of the branches.

Veronica tetragona, a whipcord veronica, is a small shrub varying much in height, but frequently from 15 in. to 20 in. tall. It forms rounded bushes of semi-erect flexible stems, prostrate

* Mr. T. F. Cheeseman informs me he has observed it on *living Libocedrus* near the summit of Te Aroha mountain, but that such a growing-place is quite exceptional.

at the base, and branching closely near their extremities into short leafy stems, bearing small, short, thick, coriaceous, smooth, green, scale-like, imbricating leaves. The root is a woody tap-root, deeply descending, very slightly tapering, and of great length, but provided with comparatively few lateral rootlets. The flowers are white and in small terminal heads.

Veronica lævis is a small shrub 2 ft. to 4 ft. tall, or even more, of a rounded habit, made up of close-growing terete branches, which are semi-erect, quite leafless, and little branched below, but much-branching above into short, straight, flexible twigs, covered rather closely with patent or at times imbricating, bright-green, very thick, coriaceous, small leaves, and bearing numerous subterminal racemes or corymbs of lilac or white flowers. Sometimes the bushes are ball-like in shape; at others more open and straggling. The roots are extremely numerous, slender, and fibrous, and with the earth which they hold together form a "ball" when the plant is dug from the ground. It is an excessively variable plant, there being a great number of forms distinct in leaf and flower.* Some of the extreme forms are much unlike one another, and one especially closely resembles *V. buxifolia*.

Veronica spathulata is a prostrate sub-shrub with numerous flexible decumbent stems, branching freely near their extremities, and forming a small close mat upon the ground, 1 ft. or frequently less in breadth. The leaves are small, soft, thick, and bright-green, but their colour is masked by a covering of small white hairs. The main root is of enormous length, and there are also many close and long but more slender adventitious roots from near the base of the stems. The flowers are so excessively numerous as to hide the leaves. They are white, large for size of plant, and in short few-flowered racemes near the ends of the shoots (Photo. No. 5).

Veronica Hookeriana is a semi-prostrate suffruticose plant, forming small mats on the scoria, usually under shelter of rocks. The stems are long and prostrate at first, but give off many erect or semi-erect leafy branches, which bear numerous small, ovate to rotund, thick, fleshy, green, coriaceous, patent or sub-imbricating leaves, and many few-flowered racemes of bright lilac flowers, having a purple ring above the throat and the corolla, and borne on stiff, erect, leafy stalks. The roots are long, and there are also many very slender adventitious roots. The peduncles, pedicels, and calyces are covered with numerous glandular hairs.

Coprosma depressa is a prostrate shrub of the mat or semi-mat habit, made up of slender interlacing branches pressed closely to the ground, though under certain circumstances it is more upright. The leaves are numerous, very small, narrow, short, and rather thick, green or yellowish-green, and glossy. The root is enormously long, stout and flexible, and has a few lateral rootlets.

Coprosma cuneata is an erect or semi-erect closely branched shrub, 3 ft. or 4 ft., more or less, tall, with rigid, frequently interlacing branches covered with greyish or brown bark. The leaves are small, close-set on reduced branchlets, shining, dark-green, rigid, and coriaceous. The roots are thick, woody, flexible, and of great length.

Coprosma repens is a suffruticose creeping plant which forms extensive matted patches on the surface of the ground. The branches are slender, prostrate, rooting, flexible, and more or less herbaceous. The leaves are very numerous, close-set, shining-green, thick, and coriaceous. The drupes are large, red, and succulent.

Podocarpus nivalis is a closely branched and much-spreading shrub, usually of the mat or even cushion form. The branches are prostrate and rooting, and are provided with numerous erect or semi-erect leafy branchlets, furnished with many small, linear, hard, thick, and coriaceous green leaves, which are frequently turned to one side of the shoot-axis. The flowers are axillary and dicœcious, and the fruit a nut seated on a fleshy, enlarged, bright-red peduncle.

Phyllocladus alpinus is a shrub or small tree, normally of regular pyramidal form, but usually of more or less open growth or forming a dense bush. The branches are numerous and stout, and finally give off many straight, very flexible, opposite branchlets, which are "leafless" for their lower half or third, then giving off cladode-bearing stems. The cladodes, which exactly resemble leaves, are numerous, frequently arranged in threes, moderately close, patent or semi-vertical, pale-green with a slight yellowish tinge on upper surface, waxy beneath, giving a bluish tinge to under-surface, thick, coriaceous, brittle, oblong to rhomboid in shape, and variable in size. The flowers are monœcious. The seedlings have true leaves, narrow-linear in shape, and such are frequently borne on older plants as reversion-shoots.

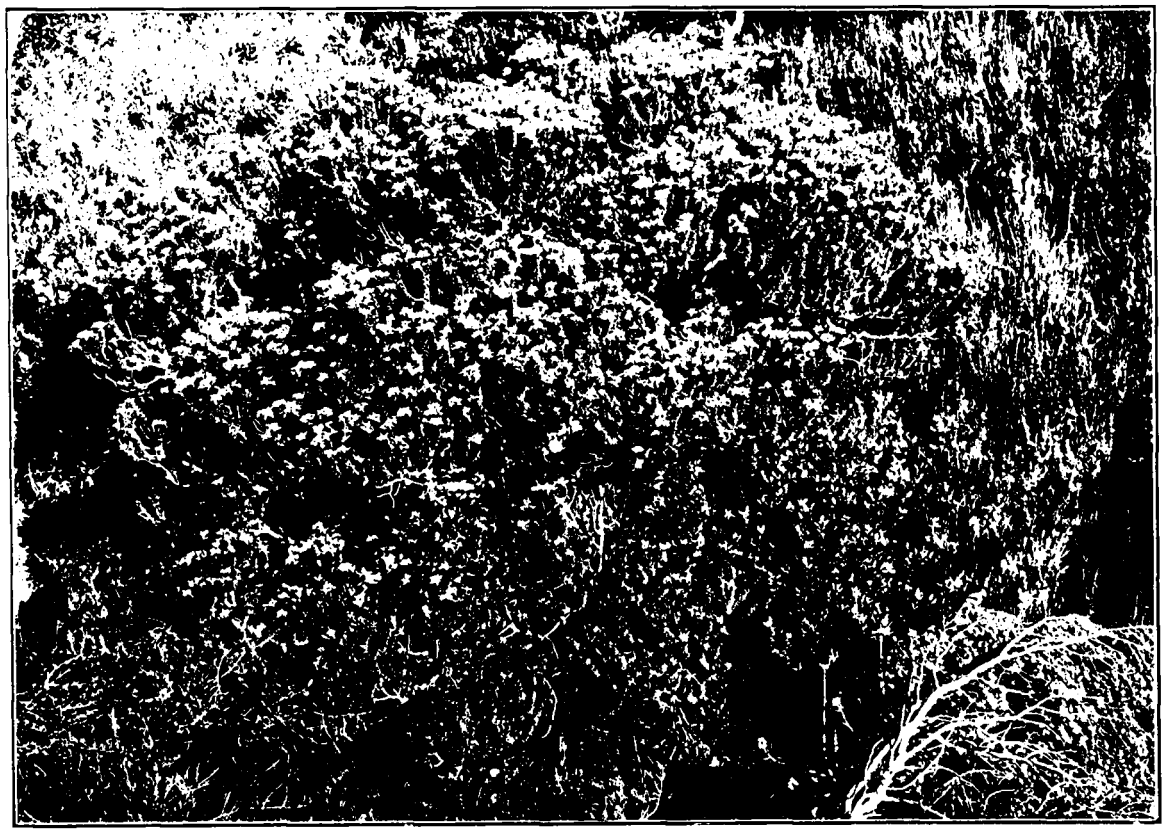
Dacrydium laxifolium is a very low-growing shrub (Photo. No. 18), frequently forming a close mat or turf upon the ground, or at times straggling amongst other plants or trailing over banks. The branches are flexible and moderately stout, branching profusely, and becoming more and more slender until finally they are filiform and almost herbaceous. They are furnished at their extremities either with minute, fleshy, scale-like, imbricating leaves, or with longer and more distant, patent, linear, juvenile leaves. The leaves vary much in colour, and may be bright-green or even almost purple. The flowers are monœcious or dicœcious. The fruit is a nut, seated on a red, fleshy, swollen receptacle. The roots are long and deeply descending, while also numerous short and fibrous adventitious rootlets pass from the creeping stems.

Dacrydium Bidwillii is a shrub of the open, or at times a small tree of the forest, furnished with numerous spreading branches, given off from a very short main trunk, and which in the open are more or less prostrate and rooting, thus giving rise to a wide-spreading flat- or round-topped low shrub of close habit. The leaves are dimorphic, the adult being only on the ultimate or sub-ultimate flexible branchlets, each small final branch-system being dense and of a somewhat pyramidal habit. The adult leaves are very small, thick, coriaceous, scale-like, and bright-green; the juvenile are linear, patent, and in a spiral. The flowers are dicœcious.

* There are two types of inflorescence, one (the true *V. laevis* of Bentham) with a corymbose inflorescence, and the other with the typical racemes of this section of the genus. Between these extremes are many intermediates. The form resembling *V. buxifolia* is very distinct from the average of the "species." It is of very low stature, and has extremely short, spike-like racemes. Probably it comes true from seed, as it occurs in many places distant from one another.

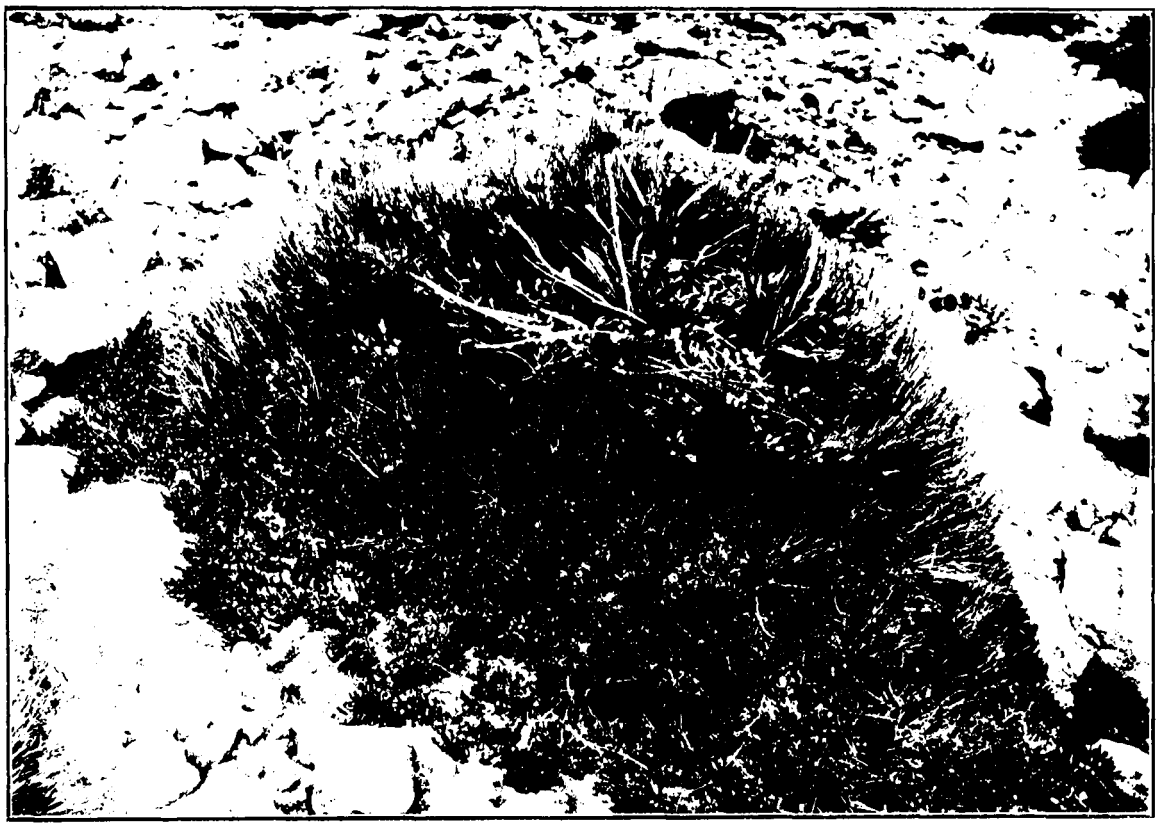
No. 17. Neatherd Mountain from near Wynberg. S.E.

No. 18. Cluster of the Dwarf Pine (*Widdringtonia nodiflora*) on the Lower Slope of Table Mountain.



No. 19. *Olearia nummularifolia*, a Xerophytic Shrub, in bloom. Subalpine Scrub on Base of Ruapehu.

[*Photo, L. Cockayne.*



No. 20. *Carmichaelia Enysii* var. *orbiculata* with *Celmisia spectabilis* and *Danthonia semiannularis* var. *setifolia* growing through it. Desert near River Waihohunu.

To face p. 23.]

[*Photo, L. Cockayne.*

Olearia nummularifolia (Photo. No. 19) is a stiff, erect shrub, with rather thick rigid branches, naked below, covered with grey, scaling, furrowed bark, and finally much-branching into short, straight, vertical twigs, which are very closely covered with extremely thick, coriaceous, resinous, tomentose, pale yellow-green, more or less imbricating, recurved leaves. The flower-heads are solitary, and produced in great profusion. The florets are white, but occasionally purple, and the rays are few in number.

Cassinia Vauvilliersii.—The volcanic-plateau plant differs considerably from the same species as found in the South Island and the N.Z. subantarctic islands. It is a more or less prostrate shrub, with at first stiff, short, and interlaced branches, and finally short, flexible, straight, leafy twigs, which form a quite close mass. The leaves are small, glutinous, densely tomentose, fulvous to different degrees (sometimes almost golden), more or less imbricating, and very close-set. The flower-heads are very numerous and in rounded corymbs, and the florets are white.

Senecio Bidwillii is a small shrub with very stout, frequently twisted branches, covered with a deciduous bark, leafy at their extremities and quite naked beneath. The leaves are of the oblong type, 1 in. or so in length, extremely thick, coriaceous, glabrous, shining-green, and covered beneath thickly with pale-buff tomentum, as are also the final branches and petioles. The flowers are in terminal corymbs of heads $\frac{1}{3}$ in. in diameter, with florets cream-coloured and sweet-scented.

Carmichaelia Enysii var. *orbiculata* (Photo. No. 20) is a low-growing shrub, forming dense flat masses, or sometimes cushions, of green, erect, flat, short, leafless, rigid stems, which are given off from very stout, thick, and woody creeping branches. The flowers are small and of purplish colour; the root woody, stout, and long.

Celmisia spectabilis (Photo. No. 21) is a rather large, herbaceous, or almost suffruticose plant, forming broad roundish mats or low cushions of leafy rosettes which touch one another and are given off from woody, stout, creeping, and sparsely branching stems, which are covered for the most part with dead and rotten leaf-sheaths. The leaves are of the lanceolate type, thick, flexible, coriaceous, of a shining bright-green colour, furnished with a dense, felt-like, pale-buff-coloured tomentum on the under-surface of the leaf, and having long, fleshy, sheathing petioles, which closely overlap one another and build up a kind of "stem" to the rosettes. The roots are numerous, brown-coloured, cord-like, gradually tapering, and very flexible, and have few lateral thread-like rootlets. The flowers are in solitary heads, on stiff cottony scapes, raised high above the mats of rosettes. The leaf-sheaths remain as decayed masses surrounding the living leaf-bases and holding much water.

Celmisia glandulosa is also a mat-forming plant, with habit similar to the above, but altogether more slender, and smaller in every part. The leaves are in small rosettes, about 1 in. long by $\frac{1}{3}$ in. broad, membraneous, pale-yellowish-green, and covered with minute glandular pubescence. The scape is slender, $2\frac{1}{4}$ in. tall, and the head $\frac{1}{2}$ in. in diameter or less.

Ourisia Colensoi forms mats close to the ground, 2 ft. by 1 ft. in extent, or more. The rhizome is slender, creeping, much-branching, and matted. The leaves are of an oblong type, palish-green, thick, coriaceous, and arranged in semi-rosettes. The flowering-stem is 3 in. or 4 in. tall, and bears a few white flower-heads $\frac{1}{2}$ in. or so in diameter.

Wahlenbergia saxicola is a small creeping herb having a number of short leaves arranged more or less in rosette fashion, which are green and moderately coriaceous. The peduncles are 3 in. or 4 in. high and one-flowered. The flowers are nearly an inch in diameter, and vary in colour from white to rather dark blue.

Gentiana bellidifolia is a low-growing herb having a few dark-coloured leaves of the spathulate type arranged as one or more rosettes close to the ground and terminating the short stem, and furnished with a long, stout, and fleshy deeply descending tap-root. The flowers are large for the size of the plant, white, with numerous slender purple lines (Photo. No. 4).

Danthonia Raoulii is a tussock-grass $2\frac{1}{2}$ ft. or more tall. The culms are bunched closely together at the base, which may be 1 ft. in diameter, but the leaves spread outwards as they ascend, arching somewhat near their apices, and here the tussock will be 2 ft. or more through. The leaves are narrow, stiff, thick, coriaceous, strongly involute, so forming a deep channel, tapering gradually to a long filiform point, pale green, tinged more or less deeply with orange or red. The leaf-sheaths are long, stout, brown-coloured, and persist after the blade has rotted away, forming a close covering round the base of the culm many times larger than the living part. The rhizome is short and woody, and is provided with many long rather wiry roots.

Danthonia semiannularis var. *setifolia* is a small straw-coloured tussock-grass, made up of many close-tufted culms furnished with very narrow, wiry, stiff, filiform leaves, with strongly involute margins, persistent leaf-sheaths, and very numerous slender roots.

(*c*.) The Ecological Factors.

With regard to the formations under consideration, the soil factor is of much moment. The very loose nature of the material and its coarse texture render it not merely very porous, but also easily moved, and this is accentuated by the light character of the scoria and ashes. On slopes its instability debars it from being weathered into more fertile material, and it is only on the flatter ground that a better soil can by degrees accumulate, aided by the decaying plants, for which it slowly becomes more suitable. Such level ground of the grass- or shrub-steppe frequently contains a layer, an inch or two deep at any rate, of a sand black through admixture of plant-remains. On the steep slopes, too, the scoria forms a surface layer, beneath which is usually sand, so that distinctly better conditions are offered so far as soil goes than on the shingle-slopes of the non-volcanic mountains.

Rain, even if frequent, is not of such importance as the water supplied from below, and which ascends by capillary attraction, since the water-holding capacity of the soil is of the slightest. Also, here the evaporating-power of sun and wind come into play, and the open soil favours

evaporation to the utmost. During most of the time of my visit and for some weeks previously there was no rain whatsoever. The soil must have become abnormally dry, and, although I had no means of ascertaining its water-content, in many instances this must have reached its limit. *Celmisia spectabilis* occasionally perished with the drought, and frequently was much injured. The young shoots of both *Podocarpus nivalis* and *Phyllocladus alpinus* were damaged, and certainly a period of drought still more prolonged would have killed many of the plants. The truth is that, notwithstanding the apparently desert aspect of the substratum, in a normal season there will be a fair abundance of soil-water—more, indeed, than the plants really require—and the xerophytic adaptations described below are probably in excess of the demand put upon them. But, at the same time, the sun's rays and the frequent wind exercise, as stated above, a powerful effect. On a cloudless summer's day, when insolation reaches its maximum, the scoria and surface soil become burning-hot to the touch, and the heat easily penetrates for some inches into the ground, the scoria absorbing and retaining the heat. As for the wind, I do not think its violence approaches what is experienced in so many places in New Zealand, but still it is usually more or less felt, and, of course, is a strong factor with regard to transpiration, and one of the main causes of the prostrate habit in plants, as evidenced by the fact of shelter conditions causing a more upright growth in such plants as *Dacrydium Bidwillii*, or, indeed, taking the steppe-shrubs as a whole, *shelter eventually transforms the open formation of steppe into the closed one of scrub.*

The plants themselves exert some influence upon one another, some supplying shade conditions, others quickly decaying when dead and turning into humus, while on the other hand others dry up and have no ameliorating effect at all upon the soil. Some, too, of the mat habit help to conserve moisture, as also do those furnished with rotting and water-absorbing leaf-sheaths.

The snow of winter must have a good deal of effect on plant-distribution, chiefly from its melting and the consequent accumulation of water in the flatter and lower ground. This plays a much greater part than was actually visible during my stay, but the presence of bog-associations on quite dry ground pointed plainly to the frequent covering of such by water for no short periods.

(*d.*) General Ecology.

The plants of these deserts and steppes, as may well be expected, show a number of marked xerophytic adaptations. The following are some of the most important:—

(1.) *The Prostrate Form.*—This is rather a mechanical adaptation against the drying effects of wind than anything else, but indirectly its effect in repressing transpiration can hardly be overestimated. With but few exceptions the volcanic-plateau shrubs of the open are prostrate. In some this is possibly non-hereditary, but in others the prostrate habit is the fixed one. Even in the former case it can be by no means certain, for instance, whether *Dacrydium Bidwillii* is normally an erect or prostrate shrub. Bearing in mind the great plasticity of New Zealand plants, who can say, even with experimental evidence, that a shrub like the above, which is prostrate in the open, and which also roots freely with adventitious roots near the apices of the shoots, is merely a wind-prostrate plant because in the forest it assumes a tree-like and quite erect habit? The truth appears to be that the so-called normal form of a plant as it usually exists in nature is due to physiological causes, and there is no fixed and really normal form at all in certain cases, unless we consider the more common one as such, or, in other words, *the special structure is hereditary only so long as the special conditions under which it exists are present.* In other cases the special form with but trifling variation remains fixed even under very different circumstances. Two main classes of the prostrate habit may be noted—viz., (1) where the shoots are merely flattened to the ground, as in *Dracophyllum recurvum;* and (2) where the creeping stems are anchored by means of adventitious roots, as in *Podocarpus nivalis.* Between these two classes there are transitional forms, and the first category even may under certain conditions put forth roots.

(2.) *The Mat or Cushion Habit.*—This is but a variation of the prostrate form, but there is greater density of growth, and consequently stronger resistance against transpiration. *Raoulia australis* is an excellent example (Photo. No. 3). Also the dead portions frequently build up a peat upon which the living plant feeds.

(3.) *Absence of Leaves.*—Here in some instances a distinct action of the environment can be traced, as in the forest and scrub forms of *Aristotelia fruticosa* and *Pittosporum rigidum* already noted, while in others, again, the habit is hereditary, and new organs for transpiration purposes are provided, as in the dwarf Carmichaelias (Photo. No. 20).

(4.) *The Whipcord Form.*—This is exhibited to perfection in *Veronica tetragona,* and occurs in New Zealand even in the most diverse families (Scrophularinaceæ, Compositæ, Taxaceæ, &c.). Here the leaves are not merely reduced to scale-like organs, but their internal structure is quite changed, while an imbricating habit is also adopted (Photo. No. 18).

(5.) *The Divaricating Habit.*—Here the stems are much branched, the branches given off at a wide angle and all interlacing. In extreme cases this common New Zealand ecological form is one of the strongest of xerophytic adaptations. These shrubs are usually wonderfully plastic, and vary enormously according to environment. *Pittosporum rigidum,* already dealt with, is a typical example.

(6.) *Tomentose Leaves.*—These are to be found in many of the plants, and to a varying degree. The tomentum seems to be largely unaffected by change of circumstances. *Celmisia spectabilis* is a typical plant of this class.

(7.) *Leathery and Thick Leaves.*—This is also a most frequent adaptation, and by its means a comparatively large assimilating tissue can be provided without risk of overtranspiration. *Senecio Bidwillii* is typical.

(8.) *Needle-like Leaves.*—These also are strongly xerophytic, on account of their small surface.

No. 21. Piece of Grass steppe at 1,000 ft. altitude, with *Celmisia spectabilis* in bloom and *Danthonia Raoulii* in background.

[Photo, L. Cockayne.

No. 22. Desert and River-bed on Slope of Tongariro, with Piece of Shrub-steppe to centre and to left.

[illegible] [Photo, L. Cockayne.

(9.) *Crowding of Leaves at Ends of Branches, and Bareness of Stems.*—This is another case of leaf-reduction through reducing the number but not the individual area of the leaves.

(10.) *Isolateral Leaves.*—This is shown in the grasses, sedges, and those epacrids with erect or semi-erect leaves, such as *Dracophyllum Urvilleanum* var. *montanum*.

(11.) *Long Roots.*—Many of the desert and steppe plants have excessively long roots. Those of *Veronica spathulata*, for instance, are immensely long.

(12.) *Wiry Underground Stems.*—These are advantageous for creeping in the loose substratum.

(13.) *The Rosette Habit.*—This crowding of leaves depends on shortening of internodes, which is distinctly correlated with poorness of soil, wind, &c., just as lengthening is the result of a moist and still atmosphere (Photo. No. 21).

There are other interesting adaptations, such as the water within the leaf-buds of *Veronica*, the resin on the buds of *Olearia nummularifolia*, incurving of leaves, persistence of grass-sheaths, &c., but space forbids further details. Suffice it to say that usually a number of the above adaptations are to be found in one and the same plant. And it must also be pointed out *that plants which have no special adaptations at all can live under severe conditions, and that plants apparently highly specialised for certain circumstances are to be found where their adaptations are of no benefit whatsoever, but rather the contrary.*

(*e.*) The Deserts (Photo. No. 22).

(1.) *General Remarks.*

To speak of deserts at all in a rain-forest climate seems a paradox, and the truth is that those of New Zealand are edaphic rather than climatic. Still, were the rainfall greater the desert areas would be less. As an example, true oases exist on the otherwise barren scoria slopes of Ruapehu in places where a spring gushes from the ground. Also, on the great scoria fan from Ngauruhoe actual bog-plants such as *Drosera spathulata* dot the black cinders with red where the waters issue from beneath the ground. Desert in this region, too, has an historical meaning, and is merely a very early phase of the development of vegetation. But to this latter there are exceptions, the most extensive of which is the sandy Onetapu Desert, where rain, snow, and wind have changed the face of the country, reducing the shrubby steppe back to its primitive desert condition.

(2.) *Physiognomy, Distribution, &c.*

Desert is, on the whole, the most abundant and characteristic formation of the volcanic plateau. It occurs in valleys, in broad river-beds, on scoria slopes, and in "wash-outs." There may be quite small patches, or, in the higher regions, no other formation. Some of the mountain-slopes, such as those of Ngauruhoe, are absolutely without plant-life, and loose black scoria is alone present. But usually, if the ground is not too steep and unstable, are certain plants, which, far-distant and dotted about, are at first hardly noticeable and affect the landscape not at all, except when in bloom during a limited period. These ultimate desert plants are *Veronica spathulata, Claytonia australasica, Gentiana bellidifolia,* and *Luzula Colensoi* (Photo. No. 4). Flatter slopes bring in the round silvery cushions of *Raoulia australis* and the small straw-coloured tussocks of *Danthonia semiannularis* var. *setifolia,* also *Pimelea lævigata, Ligusticum aromaticum,* and *Gaultheria rupestris.* A further advance is made where ashes, disintegrated andesite, pumice, or scoria make a sand easily carried by the wind. A shrub whose seeds can germinate, producing a seedling that can tolerate the station, may arrest such a drift, and, provided it can increase by rooting near its growing-point, will build up smaller or larger mounds where other plants can settle. Thus we have *Pimelea lævigata, Carmichaelia orbiculata,* building up small dunes, frequently all to themselves (Photo. No. 20). Likewise *Dracophyllum recurvum* can settle on the scoria desert, and the reddish colour of its roundish masses, quite flattened to the ground, is the physiognomic feature *par excellence* of the desert flats or slopes, as indeed it is of a large part of the region under consideration. A slightly less unstable substratum or a more sheltered position, and true desert dunes are formed, either rounded low hills a foot or two in height, or actual mounds or ridges 6 ft. or more tall. The dune association is a very constant one, and will contain usually nearly all the following plants: *Podocarpus nivalis* and *Dacrydium laxifolium* round the periphery, the former putting forth its rooting, prostrate shoots on to the scoria, and occupying the bare ground, a most characteristic habit. *Carmichaelia Enysii* var. *orbiculata,* though not present everywhere, plays a similar role. Right on the dune will be the yellowish-green *Veronica tetragona,* a great deal of *Dracophyllum recurvum* (its peculiar colour noticeable as usual), *Coprosma depressa* (flattened close to the sand), *Gaultheria rupestris,* and another form of the species with small leaves whose far-creeping underground stems help to bind the unstable substratum. *Dracophyllum Urvilleanum* var. *montanum* and *D. subulatum* are common. High above the other plants is frequently the stiff-branched *Olearia nummularifolia,* and, in the centre of the dune, *Phyllocladus* often becomes established, while even in some places there may be a stunted plant or so of *Nothofagus cliffortioides. Coriaria thymifolia* is not an uncommon plant, thanks to its spreading underground stem. As for herbaceous plants, *Celmisia spectabilis, Wahlenbergia saxicola, Fostera Bidwillii,* and *Euphrasia cuneata* var. *tricolor*—this latter very abundant—will be present, and occasionally *Drapetes Dieffenbachii.* Very common are *Epacris alpina, Styphelia Frazeri,* and *Pentachondra pumila.* The grasses are *Danthonia semiannularis* var. *setifolia* and *Poa Colensoi.* In dune-fixing, finally, *Muehlenbeckia axillaris* and *Podocarpus nivalis* play an important part, and the former makes a close mat over the sand, spreading most extensively with its wiry underground stems. *In short, the dunes or the islands of shrubby and herbaceous plants of the desert are nothing more or less than isolated, or, if you like, embryonic, patches of shrub-steppe, and a change in conditions would easily cause the desert to be occupied by plant-life.* It is not the porous substratum and the absence of humus or clay which cause the desert conditions, but the presence of wind and the absence of water. If this latter be present, what a change ensues! Then will come in a true oasis. At a height of 6,500 ft. on Ruapehu, on an unstable scoria slope

where little or no vegetation of any kind is present, a small spring of water issues from the ground, trickling over and keeping the substratum constantly moist. Here is a rich collection of plants (Photo. No. 23). Quite at a distance this oasis can be seen, and the idea that strikes the observer at first is that it is a deposit of sulphur. The yellow colour, however, arises from a moss of that hue, while great masses of the mountain water willow-herb (*Epilobium macropus*) are present in January, a really beautiful sight, covered with the large white flowers, pink in the bud. Blooming at the same time are quantities of the large-flowered *Craspedia* (*C. uniflora* var. *robusta*), the heads cream-coloured and quite showy in the mass. Here, too, is *Montia fontana*, *Carex pyrenaica*, *Poa novæ-zealandiæ*, *Agrostis Muelleri*, and a small *Epilobium* of the pedunculata type—mostly species extremely rare or wanting elsewhere in the district. There is a turf of *Coprosma repens*. Present also are *Calamagrostis setifolia*, *Oreobolus pectinatus*, *Helichrysum bellidioides*, *Ligusticum aromaticum*, and *Gnaphalium paludosum*, another turf-builder, silvery in colour. But more remarkable still is where from beneath the great scoria desert at the base of Ngauruhoe there issues forth on to the scoria plain forming the bed of a branch of the Waihohonu a number of streams. These, keeping the scoria damp in their vicinity, actually favour the growth of bog-plants, and red masses of *Drosera spathulata*, as noted above, are dotted here and there all over the black scoria.

Where stones are scattered over the deserts the vegetation gets a better chance, as these not only provide shelter, but keep the ground moist beneath. *Veronica Hookeriana* is a plant especially of such a position. *Helichrysum bellidioides* forms considerable sheets on the ground under like conditions. Finally, under the lee of the larger stones are combinations of the steppe-shrubs.

The desert is in part a primary and in part a secondary formation. The scoria slopes, with or without rocks, are a geological feature at a certain stage in the evolution of the earth-surface. But where landslips, "wash-outs," or broad river-beds have destroyed the plant formations a secondary desert will arise—*i.e.*, we have a reversion. Also, in some places there is a gradual movement of large areas of scoria and sand which bury the shrubby steppe or the more fully occupied desert (Photo. No. 24), and here again a rejuvenation takes place. But it is, in all these instances, no new formation that occupies the ground, but merely a reversion. *New formations alone occur where introduced animals and plants can gain a foothold, the former destroying or damaging certain species, thus upsetting the balance of nature, and the latter bringing in new competitors in the struggle for existence.* So far as the deserts of the volcanic plateau are concerned, there are no changes of this kind of any moment.

(3.) *The Onetapu Desert.*

The Onetapu desert, being in part situated near the coach-road, is the best-known and at the same time of a somewhat different character to any of the other barren tracts. Situated on the highest part of the eastern plateau, the surface of the ground is exposed to the full fury of the wind. The melting snows and rain also cut furrows into the ground, undermining the surface, and exposing the bare ground to the violence of the gales. In consequence, a large area has become in course of time a sandy waste. That this has not been so always is shown by the curious mounds here and there, covered with grass or shrub steppe, which stand like islands in the sea of sand (see also Colenso, 8, p. 40). All transitions are seen, from such to low mounds where dead stems and roots alone persist. At its lower portion many acres of the desert are quite without plant-life—stretches of sand alone exist, or, where this has blown away, there is consolidated pumice or soft rock. Here lie scattered the bleached remains of former shrubs. But in other places a few plants have gained a foothold. First comes *Danthonia semiannularis* var. *setifolia*, and the sand backing up against it raises low mounds. Single plants may stand far isolated from one another, and, becoming more numerous, a colony is formed, other plants entering in—*e.g.*, the silvery mats of *Raoulia australis*, the vivid-green semi-cushions of *Pimelea lævigata*, and the stiff, erect, pale-green, flattened shoots of *Carmichaelia Enysii* var. *orbiculata*. As Ruapehu is approached the plant covering becomes denser and denser, the tussocks closer and closer, until finally an open grass-steppe results.

In some places the surface is covered with numerous small pieces of lava, and in others the surface is all pumice, many pieces, large and small, lying on the ground. On this latter, *Gentiana bellidifolia* is very abundant. This desert is by no means only a feature of to-day. It changes its position from time to time, but at the time of Colenso's visit it evidently had exactly the same appearance as at present.

(4.) *Rock-vegetation.*

The vegetation of the rocks is usually very scanty, and consists chiefly of those desert plants which can insert their roots into the cracks, such as *Gaultheria rupestris*, *Danthonia semiannularis* var. *setifolia*, *Ligusticum aromaticum*, *Helichrysum bellidioides*, *Veronica spathulata*, all of which were noted growing on a hard lava cliff on Ruapehu at about 7,000 ft. altitude. Among the earliest plants of rocks are mosses, especially species of *Andreæa*, and lichens, both of which form soil on which seeds of spermaphytes germinate. These latter plants are usually rather denizens of the chinks, hollows, and depressions than true chasmophytes.

The lava-flows may be either solid rock, or consist of great blocks, the one piled upon the other. Certain flows at a high altitude on Ngauruhoe are quite without plants, not even a lichen being present. Others, such as the one in the central crater of Tongariro, are occupied by very few plants indeed, and these are chiefly on the terminal face, *Veronica spathulata* and *Danthonia semiannularis* var. *setifolia* being the principal occupants. The older lava in the Oturere Crater has a richer plant covering, and on it are most of the ordinary desert plants and shrubs growing amongst the blocks of lava.

Perhaps the most interesting lava-flow is that from Te Mari through the forest, which consists of immense blocks piled on one another. The vegetation there depends entirely upon the shelter afforded, and where this is strongest is a true subalpine scrub made up of the usual con-

No. 23. Oasis on Ruapehu at 6,500 ft. altitude. *Epilobium macropus* in Bloom, and above growing through it a variety of *Craspedia uniflora*.

[*Photo, L. Cockayne.*

No. 24. Sand-drift advancing and burying the Desert Vegetation. Valley of South Branch of River Oturere.

To face p. 26.]

[*Photo, L. Cockayne.*

stituents. In other places there are merely mosses and lichens. Between the lava-blocks shelter is also provided, and there occur, *e.g.*, *Dracophyllum recurvum*, *Nothopanax Colensoi*, *Pimelea buxifolia*, *Coprosma cuneata*, *Gaultheria antipoda*. There are many blocks with little or no vegetation between them. Of especial importance here is the white xerophytic moss *Racromitrium lanuginosum* as a soil-former. Its outer surface only is alive for an inch or so, and below for a depth of half a foot and more it changes rapidly into peaty humus, which collects the rock-fragments and sand, and holds much water. The moss itself forms round cushions 2 ft. or more across. The earliest plants of this lava are *Leptospermum scoparium* and *Epacris alpina*. The later shrubs—*e.g.*, *Dracophyllum Urvilleanum* var. *montanum* and *Nothopanax Colensoi*—arise in the hollows or crevices between the lava-blocks, where soil, made in the first place by the moss, has collected. Also the lava weathers into small pieces, which are easily occupied by plants, these in their turn further causing disintegration. Quite common on these rocks, too, is the well-known sweet-scented alga (*Trentepohlia sp.*), which paints them a vivid red.

(5.) *Special Ecology.*

Great length of root and closeness to the ground are the chief adaptation-features of the typical desert-plants. The gentian has leaves of a dark brown, but what the significance of this colour is I cannot say. *Ligusticum aromaticum* has a specially thick and long root. *Luzula Colensoi* is also of a dark colour, and forms dense and small cushions much like its ally *L. pumila* of the eastern and driest Southern Alps. The close cushion habit, combined with densely tomatose small leaves, is shown by *Raoulia australis*. *Gaultheria antipoda* has very coriaceous thick leaves, and creeping underground stems. With three exceptions the plants are not special *débris*-plants elsewhere, but here the peculiar conditions have found them suitable. On the contrary, *Celmisia spectabilis* is frequently a plant of very dry stations in the South Island, growing, *e.g.*, on shingle-slips, yet here, abundant as it is, it avoids the extreme desert.

(*f.*) The Grass-steppe.

(1.) *General Remarks.*

The grass-steppe is, next to desert, the most widely spread plant formation of the volcanic region. Look where you will at an altitude of 3,000 ft. to 4,000 ft. and a fairly even surface of waving brown grass, which when in flower looks rather like a field of oats, meets the eye. On the west of the volcanic ranges stretches a flat (in appearance) plain for several miles, bounded by a dark forest-mass, and on the east, passing along the Waiouru–Tokaanu Road, for hours one sees little but the tussock-clad plain.

The grass-steppe is important also for economic reasons, being the sole pasture of the higher levels. For such a purpose it is not of much moment. *Danthonia Raoulii* is a poor fodder-plant, and, as will be seen, shrubs and certain herbaceous plants not relished by stock, rather than grasses, occupy the spaces between the tussocks. Nor does the customary burning do any good, but the contrary rather, by destroying the few good grasses present, and encouraging the useless members of the formation. On the other hand, the soil at 3,000 ft. is able to support white-clover, cocksfoot, and certain other European fodder-plants, and the land is thus capable of a certain amount of improvement from the farmer's point of view. *But with increase of altitude the productiveness of the land decreases, while the power of the indigenous plants to maintain their own against more useful introduced plants increases*, so that within the suggested new boundaries of the park there is no grass land of any value.

(2.) *Physiognomy, &c.*

Seen from a distance the formation looks like a uniform brown covering, and it might well be thought to lack a variety of species. But a closer view shows it to be broken into in places. The brown colour is owing to the dominance of the great tussocks of *Danthonia Raoulii*, which, although brown at a distance, are more or less orange-coloured at close view, whence the popular name in the south of "red tussock."

The tussocks, which are 2½ ft. and more tall, spread out above, the ends of the leaves drooping, but they are bunched in at the base. They may be quite close to one another and touch, or be one or two yards distant, and this latter is the more common. Between them are level spaces containing shallow depressions of bare ground, slightly raised patches of foliage, and plants here and there at the usual surface-level. *Celmisia longifolia* var. *gracilenta*, 6 in. or 8 in. tall, its leaves slender and silvery, is the most common plant, and is almost everywhere. Adding distinctly to the physiognomy in many places are the dark-coloured erect bushes of *Dracophyllum subulatum*, 1 ft. 6 in. or more tall and 1 ft. 3 in. through. The branches are quite erect and dense. The leaves give the colour. They are small, dull brownish-green, and have a pale-coloured base. Quite frequent are more or less circular mats of *Coprosma depressa*, flattened to the ground, the branches spreading fan-like, the yellow-green leaves turned to the light, and so the branch-system is dorsi-ventral. The lateral branches are on the flanks of the main axis, quite straight, and given off at a wide angle. Here, then, is the divaricating habit put to a secondary use. Large mats or cushions, of a green colour, and a yard or so long, of the close-growing rosettes of *Celmisia spectabilis* are frequent in many places. When in bloom, their large white flower-heads, raised on the tall tomentose stalks above the shining green foliage, give a special character to the meadow in December and early January (Photo. No. 21). *Euphrasia cuneata* var. *tricolor*, with its conspicuous and beautiful flowers, white with yellow throat, and marked with delicate purple lines, is everywhere, and a charming attraction to the meadow during January and February. In some places the glaucous-leaved and aromatic *Celmisia glandulosa* is common, its large depressed mats covered in late December and early January with numerous daisy-like blossoms. The small creeping shrub *Pentachondra pumila* forms patches of considerable size of dark bluish-green hard leaves, the

shoots brownish at their apices. Also there are many patches of the rather taller but less dense creeping shrub *Gaultheria antipoda*, its coriaceous small leaves frequently more or less deeply tinged with red. *G. perplexa*, too, a plant with narrow leaves, is abundant in many places. The pale-green, small, creeping shrub *Styphelia Frazeri*, with its short erect stems covered with acerose, imbricating, stiff, and small leaves, tiny white flowers or orange drupes, is everywhere mixed with the general groundwork of the meadow, consisting of *Celmisia longifolia*, *Euphrasia cuneata* var. *tricolor*, and *Wahlenbergia saxicola*. Frequently growing close up to the tussocks are conspicuous mats of the depressed shrub *Styphelia Colensoi*, 2 yards across by 1 yd. and 4 in. or so tall. As for grasses, there are occasional small close tussocks of the slender leaves of *Poa Colensoi*, the flowers raised for some 4 in. above the ground; and the straw-coloured *Danthonia semiannularis* var. *setifolia* dots the ground in places. Also, there is more or less, but not evenly distributed, of *Hierochloe redolens*, *Poa anceps*, *Poa cæspitosa*, and *Agropyrum scabrum*. Finally, one of the most distinctive features of the spaces between the tussocks, and the most striking in many places on account of its colour, is the alpine club moss *Lycopodium fastigiatum*, with its orange-coloured shoots flattened to the ground and close together, thus forming a kind of mosaic, while the spikes are erect and some 2 in. tall. Certain other plants enter into the formation, but they are for the most part of little physiognomic value, and comparatively few in numbers.

(3.) *Meadows of Tongariro.*

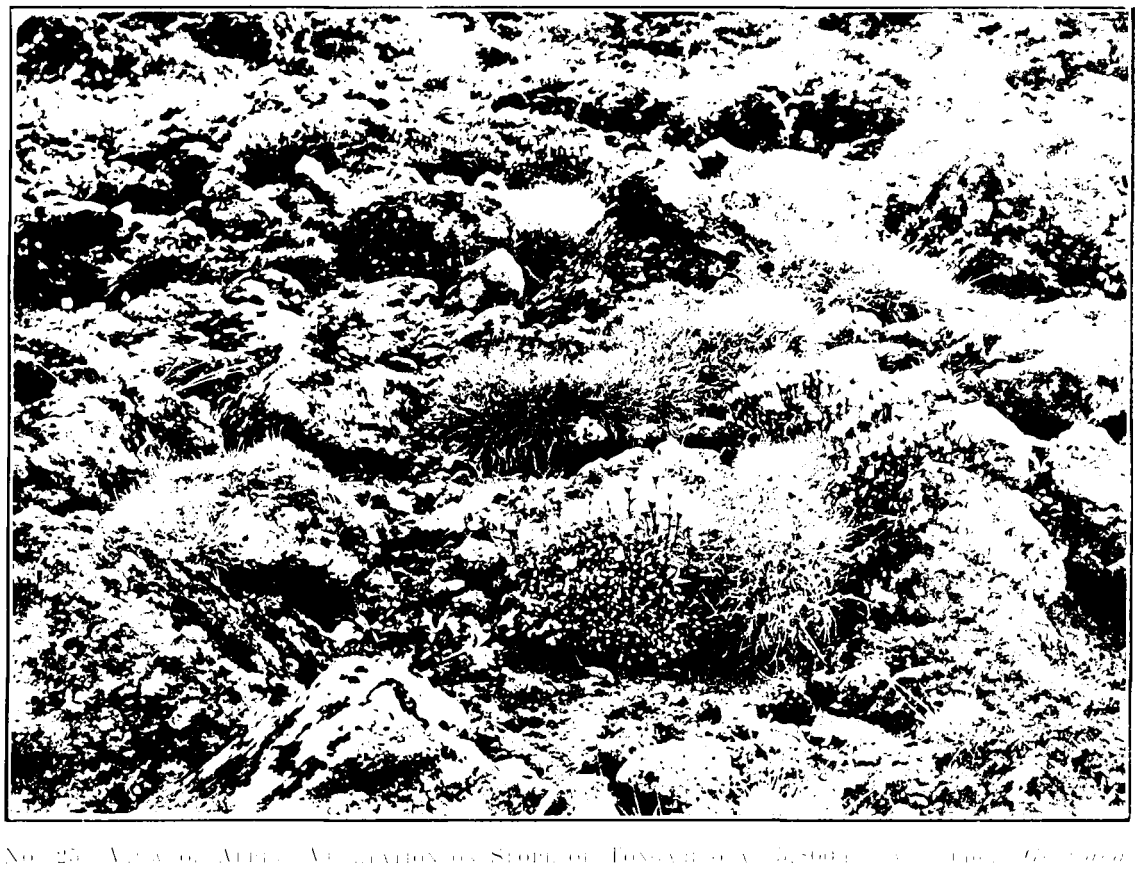
The steppe on Tongariro is of a much more meadow-like character than the typical grass steppe, although the constituents are the same for the most part. The *Danthonia Raoulii* steppe is of closer and more luxuriant growth. In some places *Celmisia spectabilis* is extremely abundant, and gives the dominant character. In others are many cushions of the white xerophytic moss, reminding one of the so-called "moss" of Mount Egmont. But the most interesting formation is the collection of alpine herbs at an altitude of 5,500 ft. or so on some of the slopes. In such places the ground is covered with stones, large and small, between which is almost a closed covering, with small glaucous-coloured tussocks or mats of *Poa Colensoi* everywhere and in the greatest abundance, giving a colour to the whole hillside, which at a distance is of a general grey hue. With them, dotted about in profusion, are large plants of *Gentiana bellidifolia* (Photo. No. 25). Here, too, are *Ranunculus nivicola*, *Carex pyrenaica*, *Coprosma repens*, *Ligusticum aromaticum*, *Helichrysum bellidioides*, *Celmisia spectabilis*.

(*g.*) The Shrub-steppe.

The shrub-steppe is a transitional phase between desert and grass on the one hand or sub-alpine scrub and forest on the other, according to climate and soil conditions. It is most common at altitudes of between 3,600 ft. and 4,500 ft., and occupies the flat ground which is not boggy, such as river-valleys or even gentle slopes. The following are the principal constituents of the formation: (Epacridaceæ) *Dracophyllum recurvum*, *D. subulatum*, *D. Urvilleanum* var. *montanum*, *Epacris alpina*, *Styphelia Frazeri*, *Pentachondra pumila;* (Compositæ) *Cassinia Vauvilliersii*, *Celmisia spectabilis;* (Taxaceæ) *Dacrydium laxifolium*, *D. Bidwillii*, *Podocarpus nivalis;* (Rubiaceæ) *Coprosma depressa*, *C. repens;* (Scrophularinaceæ) *Veronica tetragona*, *Ourisia Colensoi*, *Euphrasia cuneata* var. *tricolor*, *E. revoluta;* (Myrsinaceæ) *Suttonia nummularia;* (Campanulaceæ) *Wahlenbergia saxicola;* (Ericaceæ) *Gaultheria rupestris;* (Umbelliferæ) *Ligusticum aromaticum;* (Gramineæ) *Danthonia Raoulii*, *D. semiannularis* var. *setifolia*, *Poa Colensoi;* (Filices) *Gleichenia dicarpa*.

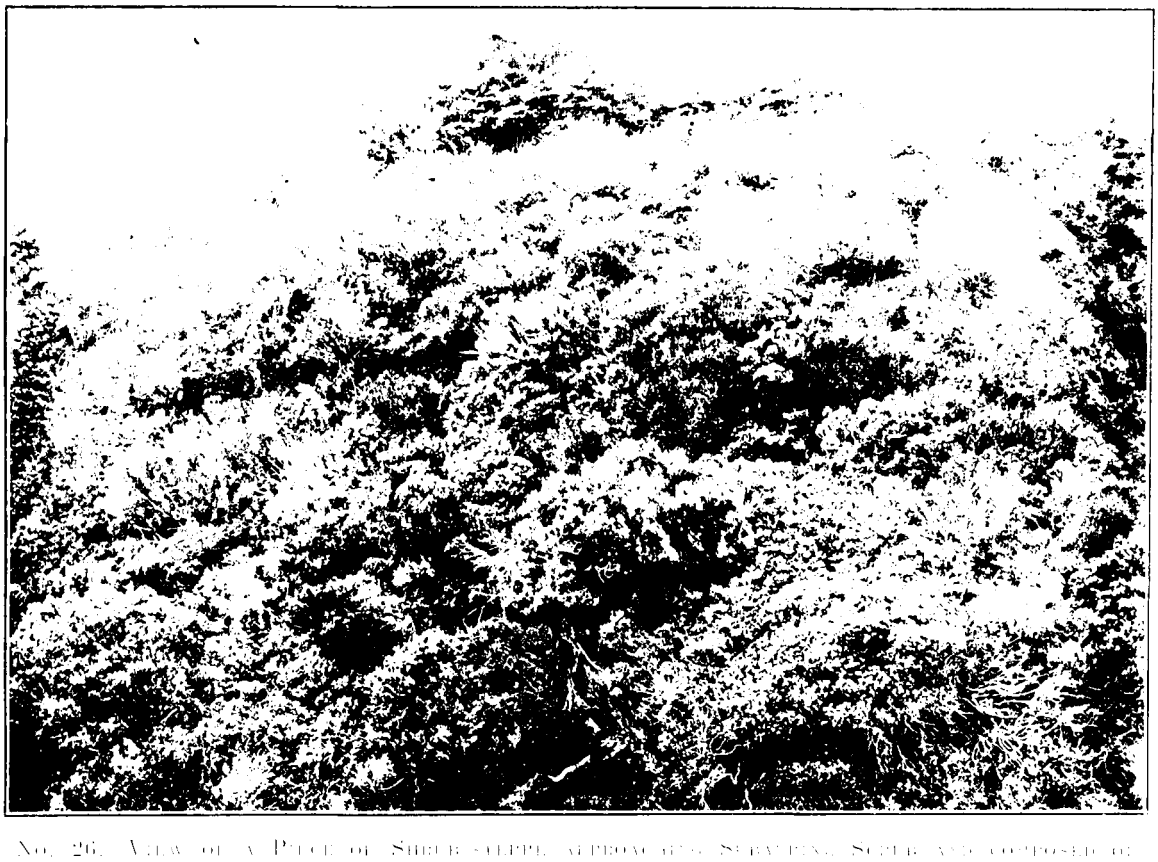
The general colour at a fairly close view is reddish-brown as the groundwork, out of which rise here and there the straw-coloured or somewhat orange tussocks, which first catch the eye and give the physiognomy a quite different stamp to that of a grass-steppe, where the individual tussocks blend one into the other. The tussocks, of course, vary considerably in their relative distance; one or two may be close together, but usually they are isolated and distant, say, 5 ft. to 10 ft. They are of smaller dimensions than those of the grass-steppe.

The formation is an open one, and consists of raised mounds of shrubs separated by patches of flat ground, either quite bare or with a scanty vegetation—the remains of the desert, in fact. These mounds are built up of fine dust-like sand and humus, and are of a dune character. They are a foot or more tall or less, of most irregular shape, and closely covered with the generally prostrate shrubby growth. The dominant colour of these mounds is reddish-brown, owing to the blending of colours of the Dracophyllums, *Dacrydium laxifolium*, and the especial abundance of *Dracophyllum recurvum*. *Veronica tetragona*, both from its upright habit and yellow-green colour, affords a contrast, and is of physiognomic importance consequently. The shrubs are not isolated, but are mixed up together, perhaps almost the entire florula of the formation being present. Thus *Dracophyllum recurvum* may rise out of *Dacrydium laxifolium*, and a solitary plant or so of *Veronica tetragona* will be present, taller still, with a tussock or two growing out of the centre of the mound, while a closer examination reveals *Pentachondra pumila*, *Styphelia Frazeri*, *Wahlenbergia saxicola*, and *Ourisia Colensoi;* or there may be a low bush of yellowish-green *Dacrydium Bidwillii*, and here and there, dotted over the mats of shrubs, a collection of, or even solitary, rosettes of *Celmisia spectabilis*. Here and there the white xerophytic moss *Racromitrium lanuginosum*, its cushions a foot or two across, gives a special colouring. A few plants of the green *Veronica lævis* also add a contrast. Finally, there are the reddish-brown waving tussocks. Sometimes the rims of the mounds may be irregularly torn by weathering, or in other places beautifully and closely edged with a thick, even, and rounded covering of *Dacrydium laxifolium*, or, again, *Podocarpus nivalis* may spread beyond the boundary out on to the flat bare patches of soil. In many places are clumps of the pale-green fern *Gleichenia dicarpa*, 1 ft. or more in depth, the fronds close and entangled, quite hiding its slender, wiry, brown or purple stems. The fern frequently surrounds the base of a *Danthonia* tussock or climbs over the *Dracophyllum* and the taller shrubs.



No. 25. View of Alpine Vegetation on Slope of Ben Nevis at [illegible] Feet above the Sea. *Loiseleuria procumbens* in bloom. The Turfy Grass is *Festuca* [illegible]

[illegible]



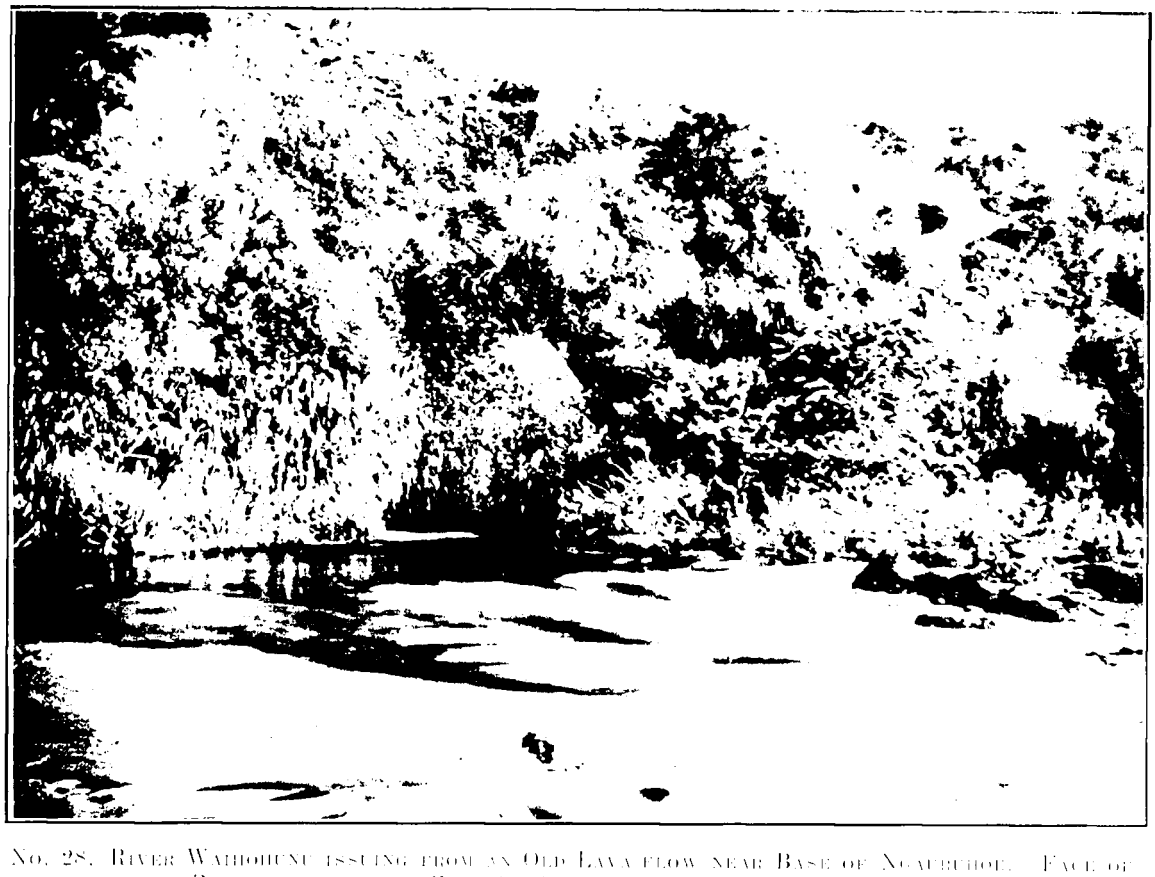
No. 26. View of a Piece of Sheep-pasture at about 4000 Feet, Snowdon, Surface well covered by *Rhytidiadelphus squarrosus*, *Eubrachypus rotundifolius*, *Dicranum Scoparium*, *Hypnum Schreberi*, *Hylocomium splendens*, and *Dicranum undulatum*.

[illegible]

[illegible]

No. 27. *Montia fontana* forming Cushions in Running Water at Source of River Waiohuenui.

Photo, L. Cockayne.



No. 28. River Waiohuenui issuing from an Old Lava Flow near Base of Ngauruhoe. Face of Rock covered with *Veronica lacera* and *Helichrysum bellidioides*.

To face p. 29.

Photo, L. Cockayne.

(*h.*) The Subalpine Scrub.

On the west and south of Ruapehu, between the upper forest and the steppe, there is a more or less continuous belt of shrubs or even low trees such as is usually encountered on a New Zealand mountain, many of the constituents descending into the upper forest, the two formations merging gradually into one another.

The following is from notes taken at 3,700 ft. on the southern slopes of Ruapehu: "The association consists of stunted mountain-beech (*Nothofagus cliffortioides*) 20 ft. tall, and the following: *Phyllocladus alpinus, Dacrydium biforme, D. Bidwillii, Coprosma cuneata, Nothopanax Colensoi, C. fœtidissima, Myrtus pedunculata, Nothopanax simplex, Griselinia littoralis, Astelia montana*, a little *Veronica lævis, Gleichenia Cunninghamii, Blechnum fluviatile, Styphelia fasciculata* (this as a prostrate plant), *Podocarpus nivalis, Gahnia pauciflora, Styphelia acerosa* (as a carpet plant), small *Libocedrus Bidwillii*. The ground is carpeted with moss and the umbrella fern, the *Astelia*, the *Gahnia*, and seedlings growing through." "Approaching the outskirts, the beech gets much lower—say, 12 ft. tall, more or less." Also, patches of scrub appear on the steppe which succeeds it, portions of this latter formation or of semi-bog penetrating into the final scrub-belt, and forming open patches of ground of considerable size.

So far as the east of the volcanoes is concerned, there is no continuous zonal arrangement of the formations. Altitude certainly affects distribution, but the associations are governed chiefly by the nature of the ground, its slope, and its exposure to wind and sun. Thus both forest and scrub do not form belts, but simply patches in favourable positions.

The scrub usually occurs in the shelter of river-gullies, "wash-outs," or ridges. Disintegrated lava-flows, where the stones are in large blocks, also afford shelter to a shrubby growth. Frequently the scrub extends over the river-bank out on to the original flood-plain.

Generally speaking, the formation under consideration has nothing like the denseness of typical New Zealand subalpine scrub (Cockayne, 6). The shrubs touch, it is true, and there are cases where on rocky slopes the rigid stems and branches point downwards, making an obstruction of a more typical kind for the explorer.

Subalpine scrub is an advanced phase of shrub-steppe: the shrubs are much the same, but they are taller, and arranged as a closed formation, whereas the latter is an open one. Also, much more *Veronica lævis* and *Senecio Bidwillii* enter in, while *Phyllocladus* is extremely abundant (Photo. No. 26).

Owing to the varied hues of the shrubs the formation has no uniformity of colour. The bright green of the *Veronica* contrasts with the paler green of other plants, and with the brown or reddish hue of the Dracophyllums.

The chief plants of the eastern scrub are *Veronica lævis, Dracophyllum Urvilleanum* var. *montanum, D. subulatum, Pimelea buxifolia, Phyllocladus alpinus, Olearia nummularifolia, Senecio Bidwillii, Nothopanax Colensoi, Veronica tetragona, Dacrydium Bidwillii, Pittosporum rigidum* South Island var., *Cassinia Vauvilliersii, Dracophyllum recurvum, Aristotelia fruticosa*.

Another phase of subalpine scrub which might almost be classed as forest is not uncommon here and there. *Phyllocladus alpinus*, with its very pale whitish-green "leaves," is dominant and in places almost pure. There is plenty of *Dacrydium Bidwillii*, no longer prostrate, but a small tree, with many stems each half a foot thick or so. *Nothopanax Colensoi* and *N. simplex* are also frequent. In short, the above is rather the beech-forest undergrowth without beech-trees, growing luxuriantly, than a kind of scrub. The plants grow very closely, and this and the strong and stiff stems and branches makes the formation almost impenetrable.

On Tongariro dense subalpine scrub is abundant in the gullies between 4,000 ft. and 5,000 ft., *Phyllocladus alpinus* being dominant. Such scrub, if sheltered or on better soil, assumes larger proportions, the *Phyllocladus* becomes of tree-dimensions, *Podocarpus Hallii* enters in, and there is low forest such as before described. Where the scrub is lowest *Dracophyllum Urvilleanum* var. *montanum* may be dominant. The formation will present a fairly even surface; the physiognomy is dependent also on the green of the two species of *Nothopanax*, the glaucous hue of *Phyllocladus*, and the erect habit of the *Dracophyllum*, here light green rather than brown. In such scrub there are the following species: *Dracophyllum Urvilleanum* var. *montanum, Phyllocladus alpinus, Nothopanax Colensoi, N. simplex, N. Sinclairii, Griselinia littoralis, Olearia nummularifolia, Coriaria thymifolia, Coprosma cuneata, C. fœtidissima, C. parviflora, Leptospermum scoparium, Gleichenia Cunninghamii, G. dicarpa*. Where most exposed this formation gives place to shrub-steppe, which is not only distinguished by its more lowly growth, but by the brownish shrubs and the straw-coloured tussock.

(*i.*) Shrubs of River-gullies.

At about an altitude of 3,000 ft. in such gullies as do not contain forest are close-growing associations of shrubs. Where driest will be *Leptospermum scoparium* and *L. ericoides;* but where more shady conditions prevail, then there is *Pittosporum Colensoi, Veronica salicifolia, Arundo conspicua, Olearia nitida, Griselinia littoralis, Nothopanax arboreum, N. Colensoi, Pseudopanax crassifolium, Phormium tenax*, or *P. Cookianum*.

(D.) STREAMS, BOGS, AND WET GROUND.

(*a.*) Vegetation of Running Water.

The rivers issuing from the volcanic ranges are altogether too rapid for the higher plants, and are populated merely by a few algæ, which are either submerged or mark on the boulders the average level of the stream. Those torrents which issue directly from solid-looking lava-flows are at first wide and pond-like (Photo. No. 28), and, although running rapidly enough, spread out and are shallow at their sides, wetting, too, the adjacent ground and making boggy conditions. In such, *Montia fontana* forms beautiful bright-green cushions (Photo. No. 27), and, where shallower, *Ranunculus rivularis* forms a close growth, spreading out on to the constantly wet silt. With it is mixed *Montia, Juncus novæ-zelandiæ*, and a small-leaved and short-stalked form of *Epilobium pedun-*

*cular*e. Here also the purple-flowered *Epilobium erectum* is plentiful, making almost a zone in the shallow water, and extending on to the drier ground. Where the springs gush from the lava are masses of *Helichrysum bellidioides* (Photo. No. 28) and luxuriant *Hierochloe redolens*. On the banks of rivers, close to the water's edge, is frequently a close growth of *Celmisia glandulosa, Pratia angulosa, Veronica cataractæ, Helichrysum bellidioides, Gunnera dentata, Epilobium macropus*, the small *Epilobium* as above, and *Ourisia Colensoi*. Small and rather deep streams, such as occur on the margins of wide river-beds, originating in springs, have frequently an abundant vegetation, whose presence is manifest at a distance by lines of the reddish-coloured sedge *Schœnus pauciflorus*. Right in the water are close colonies of the brown-leaved *Gunnera dentata*, and side by side with it abundance of *Ranunculus rivularis* (its leaves floating), *Juncus antarcticus, Myriophyllum Votschii*, and *Drosera spathulata;* but these last three in the shallower, muddy parts. *Epilobium macropus*, too, is extremely abundant, and very showy when in full bloom; also *Montia fontana*, and in some places *Claytonia australasica*. These river-bed streams frequently give rise to veritable bogs and water-holes, where *Carex ternaria* and *Schœnus pauciflorus* are dominant, while the reddish-brown leaves of *Potamogeton natans* float on the water-holes or on the sluggish streams. On the boggy ground, where not occupied by taller growths, is *Craspedia uniflora* var. *minor* and *Nertera depressa; Ranunculus rivularis* and *Epilobium macropus* will also be present in greater or lesser abundance.

At a lower elevation—say, about 3,000 ft., as in the bed of the Oturere just where the forest ends — are sphagnum bogs with *Leptospermum scoparium, Arundo conspicua, Carex ternaria, C. virgata*, and, especially on the sphagnum itself, *Viola Cunninghamii* and *Gunnera prorepens*. Unfortunately, I have no notes of this interesting association, and am trusting merely to memory.

(*b.*) Winter-bogs.

Between ground which is exposed to a considerable wetting during the melting of the winter snow or after heavy rain, and veritable bog, where the ground is always saturated with water and springy to the tread, and where frequently water-holes are present, are many transitions. At first, indeed, it looks as if the bog-plants were constituents of the desert or steppe associations, and, in fact, to some extent, certain of the xerophytes are. The close cushions, made up of the distichous, equitant, small, hard eaves of *Oreobolus pectinatus* above and peat from its decay beneath, grow frequently where there can be no bog conditions at any time, while, as noted before, *Gleichenia dicarpa* and *Dacrydium laxifolium*, two of the most frequent of shrub-steppe plants, are usually denizens of wet and boggy ground elsewhere, as on the Southern Alps. During the time of my visit, but for the presence of *Carpha alpina, Oreobolus, Celmisia glandulosa, Viola Cunninghamii*, and *Hypolæna lateriflora* var. *minor*, to quote some examples, one could not have conjectured that the ground in which they grew could ever be wetter than that of the surrounding country, so dry was the season. These "winter bogs," then, to give them a descriptive title, subject their plants to most extreme conditions, and it is not hard in this case to explain how such an intensely xerophytic structure as that of the *Oreobolus* should be a great advantage to its possessor. *Gleichenia alpina*, too, is abundant in such situations, but it is the grass-like *Carpha alpina*, with its pale-green leaves, withered, twisted, and straw-coloured at their extremities, which gives the stamp to all the bogs of the district, no matter their water-content.

(*c.*) Bogs.

The bogs proper are frequently on the bottoms of shallow side gullies leading into dry creeks and "wash-outs," at an altitude of 4,000 ft. and upwards. A small stream may feed them, and probably below is much underground soakage from the scoria slopes, which hinders the surface water sinking, and allows, under these wet conditions, the accumulation of decaying vegetable matter. The ground is covered in a typical case with a close turf, made up of *Carpha alpina;* the dark-green *Liparophyllum Gunni*, whose very thick pale rhizome extends far through the spongy ground and forms close matted masses; *Utricularia monanthos; Drosera arcturi*, with its reddish leaves; *Scirpus lenticularis; S. aucklandicus;* silvery mats of *Gnaphalium paludosum;* tufts of *Celmisia longifolia;* cushions of the species of *Centrolepis*. In such a turf the innumerable white starry flowers of *Liparophyllum*, tiny though they are, and the rather showy purple ones, fading to white, of *Utricularia*, give a distinct character to the bog, while the white flower-heads of *Celmisia longifolia* may add to the colour. Where water lies will be *Potamogeton natans, Hypolæna lateriflora* var. *minor*, and *Carex echinata;* and the leaves of the first-named may cover the wet ground with a reddish mat even where no actual water is visible. Encircling such a bog will be a zone of *Gleichenia alpina* or *G. dicarpa* extending on to the steppe or to the scrub. Other frequent members of the bog association are *Juncus antarcticus, Craspedia uniflora* var. *minor, Ourisia Colensoi, Celmisia glandulosa, Gentiana bellidifolia, Forstera Bidwillii, Coprosma repens, Carex ternaria, Aciphylla squarrosa, Danthonia Raoulii, Calamagrostis setifolia, Schœnus pauciflorus*.

Towards the central saddle is much wettish ground on the slopes, and there *Hypolæna* and *Gleichenia* are in great abundance, the warm-brown colour of the former and the pale-green fronds of the latter marking the physiognomy. With these are the usual steppe-shrubs, much dwarfed, and raised slightly on mounds above the general level, and above all are numerous attenuated examples of *Danthonia Raoulii*, not more than 28 in. tall.

The bog-waters are much charged with iron, and ground or plants are frequently covered with a rusty coating.

(*d.*) Ecology.

As for the adaptations of the bog-plants, these are diverse, some being distinct hygrophytes, such as *Potamogeton*, and other xerophytes, as *Liparophyllum* and *Oreobolus pectinatus*. Even such a typical xerophyte as *Aciphylla squarrosa*, with its *Yucca*-form, is quite at home. Another similar example is afforded by the luxuriant growth of *Luzula Colensoi*, a denizen of the most arid scoria slopes, and of the highest altitudes, so far as the North Island mountains go, but yet which,

where water oozes from the Red Crater of Tongariro, grows to ten times its normal size. Finally may be cited *Claytonia*, equally at home on scoria slopes and in running water. The truth is that this matter of bog xerophytes is as yet not explained in any satisfactory manner. All we know is that certain plants occur in bogs and in the most arid stations, and that they do not occur in those intermediate and more inviting ones. This can, of course, be explained on the supposition that they were driven into these extreme positions during the struggle for existence with the other plants, and there is much in favour of this view, but it does not at all explain the special xerophytic structure, which evidently in some cases is neither a particularly benefit nor hindrance to its possessor. *Drosera* and *Utricularia* are carnivorous plants, and their structure is similar to that of others of the genus elsewhere: so, too, with the sedge form of certain of the bog-plants.

(*e.*) Hot Pools and Streams.

From the boiling springs of Ketetahi flow several streams of warm water, which certainly vary much in temperature at different times. Not far from their margin *Hierochloe redolens* grows both luxuriantly and in great abundance, and there is also plenty of the fern *Hystiopteris incisa*, so common in similar situations at a lower altitude.

The hot pools themselves contain abundance of a blue-green alga, and this also covers with a thick mantle the stones exposed to the stream. Professor Setchell, of the University of California, who came to New Zealand some few years ago in order to study the algæ, has very kindly sent me some notes *re* those of the hot springs of New Zealand. "I found," he writes, on the 20th December, 1904, "particularly at the Terraces at Taupo, conditions very similar to those of the so-called 'jelly-basins' of the Yellowstone, only in miniature. I found, in fact, that while there is the greatest resemblance between the thermal districts of New Zealand and those of the Yellowstone Park, the display of the algæ-growths in the hot waters is comparatively slight in New Zealand. In New Zealand, acid waters and mud-holes abound, and such localities in both regions have very little life. I did find, however, that the main facts given in my 'Upper Temperature-limits of Life' hold for both regions." "I did not find anything living in the New Zealand springs above a temperature of 75° C." The following is the reference alluded to (pp. 934, 935) inasmuch as it applies to New Zealand:—

"1. No animals were found in strictly thermal waters, although careful search was always made for them.

"2. No living diatoms were found in strictly thermal waters. At times a few empty valves were found, but these may easily have been blown in, since the localities were in the neighbourhood of extensive areas of diatomaceous earth.

"3. All the organisms found in my own collecting in strictly thermal waters belong to the groups of plants designated as *Schizophyta*, being either *Schizophyceæ* (*Cyanophyceæ*) or *Schizomycetes* (*Bacteria*). These two groups possess a simple morphology and peculiar cell-structure.

"4. The chlorophyllose *Schizophyceæ* (or *Cyanophyceæ*) commonly continue up to 65°–68° C., and in some cases, but scantily, up to 75°–77° C.

"5. No organisms were found in springs reputed to have a decided acid reaction. This needs more study, but where a strong acid (sulphuric) character is given for a spring the waters are free even from *Schizophyta*."

VII. THE HISTORY OF THE VEGETATION.

The number of species in the Tongariro National Park and its environs, so far as my observations go, is 260 (ferns, &c., 38; spermaphytes, 222). Of these, 188, or 72 per cent., are endemic; 60, or 23 per cent., Australian or Tasmanian; and 17, or 6·9 per cent., South American. As for their distribution in New Zealand itself, 164 species are found also in the Northern Province, but of these a considerable number are found only on the Thames mountains, and so they are not really northern New Zealand plants. By far the greater number of species (236) extend into the Southern Province, which leaves very few as peculiar to the Central Province—*i.e.*, to the land bounded on the north by latitude 38°, and on the south by latitude 42°. The forest-plants number 112, the grass-steppe 59, the shrub-steppe 46, bog and wet ground 48, and the desert 15; but these numbers are at best approximate. The true alpine or subalpine plants are about 42, but it is hard to draw the line as to what plants should be included as such; all the remainder are more or less common at comparatively low altitudes.

The higher land of the Central Plateau, with the two exceptions discussed further on, contains no species which have not been found on the older adjacent land-surfaces, so there can be little doubt but that the plants as a whole have come from thence, and that no direct accessions have been received from the South Island.

Before the uprising of the volcanoes a uniform flora would occupy the present volcanic plateau, containing probably much the same species as exist at similar altitudes in that part of the North Island at the present time, although most likely forest species would predominate, and a richer vegetation on the whole be present owing to the absence of volcanic *débris* on the surface of the ground.

The destruction of the vegetation that would ensue from the building-up of the volcanoes and their many eruptions would supply new ground again and again for colonisation by plants, but there would always be a gradual transition from deeply buried to untouched vegetation, and this latter would extend by tongues, long or short, into the devastated areas. Thus would go on side by side destruction and reoccupation, the one or other gaining the mastery according to the activity of the volcanoes, though after a time the intervals between the eruptions would become much longer and the successive plant-coverings closer and more permanent. Thus in all cases it would be merely a repopulating of new ground from an adjacent fully populated area, and the species of the one would be the species of the other, though fewer in number on the more xerophytic new ground. That this is the case has been abundantly shown in what has gone before in this report. But the species which came would be exposed to quite new conditions which not all could tolerate, and so there would be a survival of the fittest, so that not all the present flora of the

dividing ranges of the North Island are to be found; seeds, &c., of many species having doubtless arrived which could not obtain a final footing, while others would settle down under specially favourable conditions, which in their turn a fresh eruption would remove. That this may have been so is shown by the survival at the present time of certain species in special stations, such as *Poa novæ-zealandiæ, Carex pyrenaica, Ourisia cæspitosa, Danthonia Cunninghamii,* &c.

The plant covering as it now exists is regulated by altitude, the nature of the soil, and the age of the surface. This the zonal distribution, although much broken, shows clearly: grass meadow, shrub-steppe, and desert occurring according to altitude, steepness of ground, and condition of surface soil. The highlands of Tongariro, with their better soil, the result of a somewhat different rock, have a richer vegetation than elsewhere. Ngauruhoe, the youngest volcano, is without plant-life except at its base.

All things considered, it is remarkable how such xerophytic conditions can support even as many species as there now are, especially when it is borne in mind that they were originally, and are now elsewhere, living for the most part under a different environment. The small number of species is due to the paucity of the North Island alpine flora rather than to the conditions offered; and, had there been a steady stream of immigration from the south during the period subsequent to the volcanoes, there would have doubtless been a more abundant flora.

This leads one up to the question of the paucity in general of the North Island alpine flora, and to me it seems perhaps to depend upon the following:—

1. The lowness of the North Island mountains, even at the time of land-connection with the South Island.
2. The small space available above the forest-line on the East Cape – Tararua Ranges.
3. The comparatively short time alpine conditions have existed in the North Island compared with the South, owing to No. 1 and the greater height of the line of arborescent vegetation.
4. The limited distribution of many South Island species owing to their local origin, through isolation, mutation, &c.
5. The birds likely to convey seeds not being usually of long flight.
6. The unsuitability of many alpine plants for wind carriage, and the small chance that even suitably equipped species have in gaining a footing in a virgin vegetation.

The presence of the South Island variety of *Pittosporum rigidum* is a matter of considerable interest. This form is distinguished from the type (a plant ranging from the East Cape mountains to the Tararuas and extending into north-west Nelson) by its fewer, smaller, and narrower leaves, reversion-shoots of a distinct form, and especially its divaricating habit of the most extreme type. This form, as I have shown elsewhere (5) and already mentioned in this report, is distinctly related to its xerophytic environment, but one which the typical form could not assume, it being, indeed, a specific character—or, rather, combination of characters—of the form under discussion. That this variety alone of all South Island plants can have arrived on the volcanic plateau by bird carriage seems almost incredible. Therefore, hard as it is to believe, there certainly seems here, if we consider this form a species, a case of one and the same species having arisen independently in two, at any rate, distinct localities from one and the same parent species (the typical *P. rigidum*), owing to analogous surroundings having either evoked the form or preserved the mutant, the conditions being the edaphic conditions of the volcanic region on the one hand and the steppe climate, together with, perhaps, also, certain edaphic conditions of the eastern South Island during the extension of the glaciers. On the other hand, the presence of *Coprosma Petriei* may, however, be urged as a proof of bird carriage being efficacious; but this latter plant was observed only by me at the south end of the plateau near the Kaimanawas, on to which it doubtless extends, while it probably also reaches further to the south and on to the lower country. At any rate, the matter of *Pittosporum rigidum* is worthy of notice, and students of the flora should watch closely for the occurrence of the South Island form on the Ruahine and Tararua Mountains.

Mount Egmont is always considered as geologically of the same age as the central volcanoes, a matter which the Maori legend also unconsciously corroborates. Its flora presents very considerable affinities to that we are considering—a remarkable fact when its isolated position is considered—but it is richer, and contains certain species absent on the volcanic mountains of the centre, such as *Epilobium chloræfolium*. *Claytonia australasica* and *Luzula Colensoi* are common scoria-desert plants there; as on Tongariro-Ruapehu *Danthonia Raoulii* stamps the physiognomy of its meadow or steppe; cushions of *Racromitrium lanuginosum* earn the vegetation above the scrub-line the title of "the moss," almost as it might do on certain part of Tongariro. But these are exceptions. Especially is *Ourisia macrophylla* enormously abundant, and *Ranunculus nivicola* grows with such an extreme luxuriance as hardly to resemble the Tongariro plant. However, the subject is too large to admit further treatment. Probably the differences arose partly from the different conditions during colonisation of the new ground, and partly from the high rainfall of Egmont and the number of rainy days. Also, this latter mountain has been for a much longer period inactive, and its ground is now more suitable for plant-colonising. Finally, it must be pointed out that its flora, in any delimiting of floristic areas, must be included with that of the volcanic plateau, even though the country between the two districts is classified under another head.

VIII. THE PARK AS A NATIONAL DOMAIN.

The boundaries of the Tongariro National Park as at present constituted consist of the circumferences of three circles drawn round Tongariro, Ngauruhoe, and Ruapehu respectively, and having a radius of three miles for the two former and four miles for the last-named. These circles are joined by a neck of land two miles wide occupying the saddle between Ruapehu and the other volcanic masses.

A consideration of the purposes for which such a domain is intended shows that the above boundaries are inadequate and inconvenient. For instance, the park presents the curious anomaly of being, except for the narrow piece of forest on the north of Tongariro and one or two small patches on the spurs of Ruapehu, practically without a tree. Even the Mountain House near

Ruapehu and the adjacent forest-areas are far without the park, and this at an altitude of 3,700 ft. and more. Moreover, the southern and western boundaries pass over spurs of Ruapehu at more than an altitude of 4,000 ft. *In fact, the park at present is, with few exceptions, a true desert.*

It has been shown in the introduction what an important *rôle* plants and plant formations play with regard to scenery, and that these special expressions of nature in the park are really far more uncommon than are the volcanoes themselves and the thermal phenomena connected therewith. Thus in any national domain representations of the special plant-life of the district should be the first care, and a national park of the importance of that of Tongariro should contain typical examples of every primitive formation which is to be found in the neighbourhood.

It seems, then, imperative that the boundaries of the park should be extended, and the accompanying map shows what Mr. E. Phillips Turner and myself consider to be the smallest area that should be included in the park.

In this choice we have been guided by certain principles—namely, (1) that no land should be included which is of economic value, either for agriculture or as having forests containing milling-timber; (2) the adding to the park examples of all the special plant formations of the region which are not already within its boundaries. From this it may be seen that, large as the proposed area undoubtedly is, no one can object to its size on economic grounds. Further, these have also been attended to in our third principle—the retention of the forest covering on slopes liable to denudation, as a protection for the farms of the future. This last principle surely requires no special explanation when it is borne in mind how disastrous has been the custom in the past of removing the natural forest covering from steep slopes, turning them finally into deep gullies and barren wastes.

Certain areas proposed to be included in the park are either Maori or private lands, and such should undoubtedly be acquired. Especially is this important in the case of the forest covering of the south and west Ruapehu spurs, where, if merely the Crown land is added, a considerable area would be liable to destruction of forest and consequent denudation, which would detract much from the value of the new boundaries from the climatic standpoint, and from the value of the important farm-lands along the Main Trunk line.

From the details given in the body of the report it can be seen that the park contains much of great interest, and will in consequence year by year increase in importance as a resort not only for tourists, but for our own citizens. The high altitude, the dry, bracing air, the number of interesting sights, render it especially a resort for those requiring a complete change and who are worn out with city life. At the present time the accommodation is quite of a primitive type (Photo. No. 29), and as the park becomes better known so will more adequate accommodation be called for. The hot springs at Ketetahi have a considerable repute locally as a cure for various diseases. The water is of several distinct classes, and the high altitude should, for certain constitutions, add much to their efficiency.

IX. FAUNA OF THE PARK.

(A.) Indigenous.

Compared with the settled parts of the Dominion, the bird-life of the park is abundant—indeed, it is probably much as it has ever been. In the forests of the proposed new boundaries are large flocks of whiteheads (*Clitonyx albicapilla*) and paroquets (*Platycercus novæ-zealandiæ*). Specially abundant is the rifleman (*Acanthidositta chloris*), numbers of these birds being round our camp all the time we were there, and coming constantly into the cooking-tent. The following birds are also quite plentiful: The tui (*Prosthemadera novæ-zealandiæ*), the kaka (*Nestor meridionalis*), the pigeon (*Carpophaga novæ-zealandiæ*), the morepork owl (*Spiloglaux novæ-zealandiæ*), the North Island tomtit (*Myiomoira toitoi*), the pied fantail (*Rhipidura flabellifera*), the shining cuckoo (*Chrysococcyx lucidus*), the long-tailed cuckoo (*Eudynamis taitensis*), the grey warbler (*Gerygone flaviventris*), and the New Zealand pipit (*Anthus novæ-zealandiæ*). A few North Island wekas (*Oxydromus Greyi*) were seen on the south of Ruapehu. The North Island kiwi (*Apteryx Bulleri*) is said to be in abundance in some parts of the Kaimanawas, and also is stated to occur in the forest near the Waihohonu. The mutton-bird ("titi" of the Maoris), Buonaparte's shear-water (*Puffinus tenuirostris*), is very common, flying near the camp at night, uttering strange cries. It nests in deep holes, honeycombing the loose ground of the shrub-steppe on old lava slopes and river-banks. Finally the New Zealand dottrel (*Charadrius obscurus*) is frequent during the summer on the barren slopes of the volcanoes.

As for the invertebrata, the park affords an interesting field for the entomologist. There appear to be a considerable number of species of insects. Right on the summit of Ruapehu and Ngauruhoe was an abundance of beetles, ladybirds, and diptera, while a species of spider is very common amongst the scoria at a high altitude. Grasshoppers are numerous, and the cry of the cicada sounds all day long in the beech forests and scrubs. A number of insects were collected, but there has been no time as yet for their determination by specialists.

(B.) Introduced.

The introduced animals are chiefly important on account of the damage they may do to the vegetation.

The grass lands in the vicinity of the park, excepting to the south-east, have never been let for grazing purposes. At the same time, the Natives own land in close proximity, and their cattle or the wild progeny of these have roamed at large over the Crown lands. Especially is this the case at the north end of Tongariro, where the pasture is much richer than elsewhere. Also, for a long time there have been herds of wild horses pasturing on the grass-steppe. Quite recently, too, a few sambur deer have been liberated. Hares also are very abundant. But, so far as I was able to observe, all the above have not been in sufficient numbers as yet to work much, if any, change in the vegetation, though this fact is no excuse for their presence in what is virtually a sanctuary for the indigenous plants and animals

X. LIST OF THE INDIGENOUS PTERIDOPHYTES AND SPERMAPHYTES.

EXPLANATION OF ABBREVIATIONS USED.

N. = Northern botanical province of New Zealand. C. = Central botanical province of New Zealand. S. = Southern botanical province of New Zealand. Ch. = Chatham Islands province. Sub. = New Zealand subantarctic islands province. Ker. = Kermadec Islands province. End. = Endemic. Aus. = Australian and Tasmanian (one or both). S.A. = South American and subantarctic (one or both). Pol. = Polynesian. Mal. = Malayan and South Asian (one or both). Cos. = Generally distributed in temp. (= temperate) or trop. (= tropical) lands.

Species and Natural Order.	Maori Name.	English Name.	Distribution.		
			Beyond New Zealand, or Endemic.	Within New Zealand.	On the Volcanic Plateau, &c.
PTERIDOPHYTA.					
HYMENOPHYLLACEÆ.					
Hymenophyllum rarum R. Br.	..	Thin-leaved filmy fern	Aus.	N. C. S. Sub. Ch.	Forest
—— *sanguinolentum* (Forst. f.) Sw.	..	Scented filmy fern	End.	N. C. S. Sub.	„
—— *pulcherrimum* Col.	..	Tufted filmy fern	„	N. C. S.	„
—— *flabellatum* Lab.	..	Fan-leaved filmy fern	Aus. Pol.	N. C. S. Ch. Sub.	„
—— *Malingii* (Hook.) Mett.	..	Silvery filmy fern	Aus.	N. C. S.	„
—— *multifidum* (Forst. f.) Sw.	..	Sharp-toothed filmy fern	Aus. Pol. Mal.	N. C. S. Ch. Sub.	„
CYATHEACEÆ.					
Dicksonia lanata Col.	..	Woolly tree-fern	End.	N. C.	„
Hemitelia Smithii (Hook. f.) Hook.	..	Pale-leaved tree-fern	„	N. C. S. Sub.	„
POLYPODIACEÆ.					
Polystichum vestitum (Forst.) Presl.	Punui ..	Prickly shield fern	Aus. S.A.	N. C. S. Sub. Ch.	„
—— *Richardi* (Hook.) J. Sm.	Pipiko ..	Black shield fern	Fiji	N. C. S.	„
—— *Cystotegia* (Hook.) Armstg.	..	Alpine shield fern	End.	C. S. Sub.	Rocky ground.
Asplenium adiantoides C. Chr. (syn. *A. falcatum* Lam.)	..	Lance-leaved spleenwort	Aus. Asia, Pol. E.Af.	N. C. S. Ch.	Forest.
—— *Hookerianum* Col.	..	Maidenhair spleenwort	Aus.	N. C. S.	
—— *Richardi* Hook. f.	..	Richard's spleenwort	End.	C. S.	Shelter of rock on Ruapehu (Townson).
—— *flaccidum* Forst. f.	Raukatauri ..	Drooping spleenwort	Aus. S.Af.	N. C. S. Sub. Ch. Ker.	Forest.
Blechnum Patersoni (R. Br.) Mett var. *elongata* Hook. & Bak. (syn. *Lomaria Patersoni* Spr.)	..	Paterson's fern	Mal. S.Asia, Fiji	N. C. S. Sub.	„
—— *discolor* (Forst. f.) Keys (syn. *Lomaria discolor* Willd.)	Petipeti ..	Common hard fern	Aus.	N. C. S. Ch. Sub.	„
—— *vulcanicum* (Bl.) Kuhn (syn. *Lomaria vulcanicum* Bl.)	..	Triangular hard fern	Aus. Pol. Mal.	N. C. S.	Forest; moist banks in open.
—— *lanceolatum* (R. Br.) Sturm. (syn. *Lomaria lanceolata* Spr.)	Rereti ..	Lance-leaved hard fern	Aus. Pol.	N. C. S. Ch.	Forest.
—— *pennamarina* (Poir.) Kuhn (syn. *Lomaria alpina* Spreng.)	..	Alpine hard fern	Aus. S.A.	N. C. S. Ch. Sub.	„
—— *capense* (L.) Schlch. (syn. *Lomaria capensis* Willd.; *L. procera* Spr.)	Kiokio, piu ..	Long hard fern	Aus. Mal. Pol. S.A. S.Af., trop. Am.	N. C. S. Ch. Sub. Ker.	„
—— *fluviatile* (R. Br.) Lowe (syn. *Lomaria fluviatile* Spr.)	Kiwikiwi ..	Creek-fern	Aus.	N. C. S. Ch. Sub.	„
Hypolepis millefolium Hook.	..	..	End.	C. S. Sub.	„
Histiopteris incisa (Thnb.) J. Sm. (syn. *Pteris incisa* Thnb.	Matata ..	Cut-leaved bracken	Cos. trop., Aus. S.A.	N. C. S. Ch. Sub.	Near hot streams on Tongariro.
Pteridium esculentum (Forst. f.) comb. nov. (syn. *Pteris esculenta* Forst. f.; *Pteris aquilina* L., var. *esculenta* (Forst. f.) Hook. f.)	Rau-aruhe ..	Common bracken	Aus. S.A.	N. C. S. Ch. Sub. Ker.	Forest.
Polypodium Billardieri (Willd.) Ch. Chr. (syn. *P. australe* Mett.)	..	Narrow-leaved polypody	Aus. S.A. Mal. S.Af.	N. C. S. Sub.	„
—— *grammitidis* R. Br.	..	Saw-edged polypody	Aus.	N. C. S. Chat. Sub.	„
—— *diversifolium* Willd. (syn. *P. Billardieri* R. Br.)	Paraharaha ..	Climbing polypody	Aus., Norf. Isld., New Cal.	N. C. S. Ch. Sub. Ker.	„
—— *novæ-zealandiæ* Bak.	..	Giant polypody	End.	N. C.	„
GLEICHENIACEÆ.					
Gleichenia dicarpa R. Br.	..	Bog umbrella fern	Aus., New Cal.	N. C. S. Ch.	Grass and shrub steppe.
—— *alpina* R. Br.	..	Alpine umbrella fern	Aus. Samoa	N. C. S.	Bog.
—— *Cunninghamii* Hew.	Tapuwaekotuku ..	Umbrella fern	End.	„	Forest.
OSMUNDACEÆ.					
Leptopteris hymenophylloides (A. Rich.) Pr.	Tukurū ..	Single crape fern	„	„	„
—— *superba* (Col.) Pr.	..	Crape fern, Prince of Wales's feather, double crape fern	„	„ Sub. (?)	„

LIST OF THE INDIGENOUS PTERIDOPHYTES AND SPERMAPHYTES—*continued*.

Species and Natural Order.	Maori Name.	English Name.	Distribution.		
			Beyond New Zealand, or Endemic.	Within New Zealand.	On the Volcanic Plateau, &c.
LYCOPODIACEAE.					
Lycopodium Selago L.	..	Fir club-moss	Cos. temp.	C. S.	Forest.
—— *fastigiatum* R. Br.	..	Alpine club-moss	Aus.	N. C. S. Sub. Ch.	Grass and shrub steppe, forest.
—— *scariosum* Forst. f.	..	Creeping club-moss	..	N. C. S. Ch. Sub.	Grass and shrub steppe.
—— *volubile* Forst. f.	Waewaekoukou	Climbing club-moss	Pol., New Cal., Aus., Mal.	N. C. S. Ch.	Forest and outskirts.
SPERMAPHYTA.					
TAXACEÆ.					
Podocarpus Hallii Kirk	Totara	Thin-barked totara	End.	N. C. S.	Forest, subalpine scrub.
—— *nivalis* Hook.	..	Mountain-totara	,,	,,	Shrub-steppe.
Dacrydium biforme (Hook.) Pilger	..	Yellow-pine, tarwood	,,	C. S.	Sub. scrub, upper forest of S. and W.
—— *Bidwillii* Hook. f.	..	..	,,	N. C. S.	Shrub-steppe, forest.
—— *Colensoi* Hook.	Monoao	Silver-pine	,,	,,	Forest north of Tongariro, Hauhungatahi forest.
—— *laxifolium* Hook. f.	..	Pigmy pine	,,	C. S.	Shrub-steppe, bog.
Phyllocladus alpinus Hook. f.	..	Mountain-toatoa	,,	N. C. S.	Forest, sub. scrub, shrub-steppe.
PINACEÆ.					
Libocedrus Bidwillii Hook. f.	Pahautea, kawaka	Cedar	,,	,,	Forest.
POTAMOGETONACEÆ.					
Potamogeton natans L.	..	Pond-weed	Cos. temp.	,,	Slow-moving or still water, bog.
GRAMINEÆ.					
Microlæna avenacea (Raoul) Hook. f.	..	Bush rice-grass	End.	N. C. S.	Forest.
Hierochloe redolens (Forst. f.) R. Br.	..	Holy grass	Aus. S.A.	N. C. S. Ch. Sub.	Grass-steppe, bog, wet ground, near warm streams
—— *Frazeri* Hook. f.	..	Alpine holy grass	Aus.	C. S.	Shrub-steppe, alpine meadow on Tongariro.
Agrostis Muelleri Benth.	..	Alpine bent-grass	,,	,,	Alpine meadow on Tongariro; oasis, Ruapehu.
—— *Dyeri* Petrie	..	New Zealand bent-grass	End.	,,	Grass-steppe.
Calamagrostis filiformis (Forst. f.) (= *Deyeuxia Forsteri* Kunth)	..	Toothed bent-grass	Aus., Norf. Isld.	N. C. S. Ch.	,,
—— *setifolia* (Hook. f.)	..	Bog bent-grass	End.	C. S. Sub.	Wet ground.
—— *avenoides* (Hook. f.)	..	Oat-like bent-grass	,,	N. C. S.	Grass- and shrub-steppe.
Trisetum antarcticum (Forst. f.) Trin.	..	Shining oat-grass	,,	N. C. S. Ch.	Forest, shady places.
—— *Youngii* Hook. f.	..	Young's oat-grass	,,	C. S.	Shady place in subalpine scrub.
Danthonia Raoulii Steud.	..	Snow-grass, red tussock	,,	,,	Grass-steppe, shrub-steppe, dunes.
—— *Cunninghamii* Hook. f.	..	Tussock oat-grass	,,	N. C. S.	Grass-steppe, Tongariro and Western Plateau.
—— *pilosa* R. Br.	..	Purple-awned oat-grass	Aus.	,,	Grass-steppe.
—— *semiannularis* R. Br., var. *setifolia* Hook. f.	..	Desert oat-grass	End.	C. S.	Shrub-steppe, desert.
Arundo conspicua Forst. f.	Teetoe-kakaho	New Zealand reed	,,	N. C. S. Ch.	Low ground near rivers.
Poa novæ-zealandiæ Hack.	..	Large flowered poa	,,	C. S.	Oasis on Ruapehu.
—— *anceps* Forst. f.	..	Nodding plumed poa	,,	N. C.	Grass-steppe, rocks and moist banks in forest.

LIST OF THE INDIGENOUS PTERIDOPHYTES AND SPERMAPHYTES—*continued*.

Species and Natural Order.	Maori Name.	English Name	Distribution. Beyond New Zealand, or Endemic.	Within New Zealand.	On the Volcanic Plateau, &c.
GRAMINEÆ—*continued*.					
Poa cæspitosa Forst. f.	..	Common tussock-grass	Aus.	N. C. S.	Grass-steppe.
—— *Colensoi* Hook. f.	..	Blue tussock	End.	„	Grass-steppe, shrub-steppe.
—— *imbecilla* Forst. f.	..	..	Aus. (?)	N. C. S. Ch.	Forest.
Agropyrum scabrum (R. Br.) Beauv.	..	Blue-grass	Aus.	N. C. S. Ker.	Grass- and shrub-steppe.
CYPERACEÆ.					
Elæocharis Cunninghamii Boeck.	..	..	End.	N. C. S.	Wet ground at about 3,000 ft.
Scirpus lenticularis Poir.	..	..	Aus.	N. C. ..	Bogs.
—— *aucklandicus* (Hook. f.) Boeck.	..	..	End.	C. S. Sub.	„
Carpha alpina R. Br.	..	..	Aus., New Guinea	N. C. S. Sub.	Bogs, shrub- and grass-steppe.
Schœnus pauciflorus Hook. f.	..	False snow-grass	End.	C. S. ..	Bog.
Cladium Vauthiera Clarke	..	..	„	N. C. S.	„
Gahnia pauciflora Kirk	..	..	„	N. C. ..	Forest of west, south, and north of Tongariro.
Oreobolus pectinatus Hook. f.	..	..	„	N. C. S. Sub.	Bog and shrub-steppe.
—— *strictus* Bergg.	..	..	„	C. S. ..	Bog.
Uncinia cæspitosa Boott	..	Narrow-leaved uncinia	„	N. C. S.	Forest.
—— *australis* Pers.	Matau-a-Maui	Broad-leaved uncinia	„	N. C. S. Ch.	„
—— *leptostachya* Raoul	..	Tall uncinia	„	N. C. S.	„
—— *rubra* Boott	..	Red uncinia	„	C. S. ..	Grass-steppe.
—— *rigida* Petrie	..	Stiff uncinia	„	„	„
Carex pyrenaica Wahl.	..	Pyrenees sedge	Eur., Japan, N. Am.	„	Oasis, Ruapehu; meadow, Tongariro.
—— *virgata* Sol.	..	Small swamp-sedge	End.	N. C. S.	Wet ground.
—— *echinata* Murr.	..	Prickly sedge	N. temp. region, Aus.	„	Bog.
—— *ternaria* Forst. f.	Rautahi	Cutting-grass	End.	N. C. S. Sub.	Bog, stream.
RESTIONACEÆ.					
Hypolæna lateriflora Benth. var. *minor*	..	..	End.	C. S. ..	Bog, wet ground.
CENTROLEPIDACEÆ.					
Centrolepis pallida (Hook. f.) Cheesem.	..	..	End.	C. S. Sub.	Bog.
—— *viridis* T. Kirk.	..	..	„	„	„
JUNCACEÆ.					
Juncus effusus L.	Wiwi	Common rush	Cos.	N. C. S.	Wet ground.
—— *antarcticus* Hook. f.	..	Antarctic rush	End.	C. S. Sub.	Bog.
—— *novæ-zeæ andiæ* Hook. f.	..	Alpine rush	„	C. S. ..	„
Luzula Colensoi Hook. f.	..	..	„	„ ..	Desert, wet scoria.
—— *campestris* D.C. var.	..	Woodrush	„	„ ..	Desert, wet ground.
LILIACEÆ.					
Luzuriaga parviflora (Hook. f.) Kunth	Puwatawata	Snowberry	S.A.	N. C. S.	Forest.
Cordyline australis (Forst. f.) Hook. f.	Ti, tikauka	Cabbage-tree, palm-lily	End.	„	Margin of forest, north of Tongariro.
—— *indivisa* (Forst. f.) Steud.	Toi ..	Broad-leaved cabbage-tree	„	„	Forest.
Astelia Cunninghamii Hook. f.	Kowharawhara	..	„	N. C. ..	„
—— *nervosa* Banks and Sol.	..	Bush-flax	„	N. C. S. Ch.	„
—— *montana* sp. nov. = *A. nervosa* Banks and Sol. var. *montana* T. Kirk	..	Alpine bush-flax	„	C. S. ..	„
Dianella intermedia Endl.	Turutu ..	Blueberry	Pol., Norf. Isld.	N. C. S.	„
Phormium tenax Forst. f.	Harakeke	New Zealand flax	Norf. Isld.	N. C. S. Ch.	Wet ground near creeks.
—— *Cookianum* Le Jolis	Whaririki	Mountain-flax	End.	N. C. S.	Ditto.
**Bulbinella Hookeri* (Col.) Benth. and Hook.	..	Maori onion	„	C. S. (?)	Grass-steppe, but local.
Herpolirion novæ-zelandiæ Hook. f.	..	..	Aus.	C. S. ..	Grass-steppe.

* This seems to me a very distinct plant from the one bearing the same name in the eastern part of the South floristic province of New Zealand.

LIST OF THE INDIGENOUS PTERIDOPHYTES AND SPERMAPHYTES—*continued.*

Species and Natural Order.	Maori Name.	English Name.	Distribution.		
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IRIDACEÆ.					
Libertia pulchella Spreng.	..	Forest libertia	Aus.	N. C. S.	Forest.
ORCHIDACEÆ.					
Thelymitra longifolia Forst. f.	Makaika	Common thelymitra	„	N. C. S. Ch. Sub.	Grass-steppe.
——— *uniflora* Hook. f.	..	Blue thelymitra	End.	N. C. S.	Wet ground.
Microtis unifolia (Forst. f.) Reichen.	..	Onion-leaved orchid	Aus.	N. C. S. Ch.	Grass-steppe.
Prasophyllum Colensoi Hook. f.	..	..	End.	N.C.S. Sub.	„
Pterostylis Banksii R. Br.	..	Common hooded orchid	„	N. C. S. Ch.	Forest.
——— *graminea* Hook. f.	..	Grass-like hooded orchid	„	N. C. S.	„
Caladenia bifolia Hook. f.	..	..	„	C. S. Sub.	Grass-steppe.
Corysanthes triloba Hook. f.	..	..	„	N. C. S.	Forest.
Gastrodia Cunninghamii Hook. f.	Makaika, perei	..	„	N. C. S. Ch.	„
FAGACEÆ.					
Nothofagus Menziesii (Hook. f.) Oerst.	Tawhai	Silver-beech	„	N. C. S.	„
——— *fusca* (Hook. f.) Oerst.	Tawhai, tawhai-raunui	Toothed-leaved beech	„	„	„
——— ——— var. *Colensoi* Hook. f.	Ditto	„	„	C.	„
——— *Solandri* (Hook. f.) Oerst.	„	Entire-leaved beech	„	C. S.	„
——— *cliffortioides* (Hook. f.) Oerst.	Tawhai-rauriki, tawhai	Mountain-beech	„	„	„
LORANTHACEÆ.					
Elytranthe tetrapetala (Forst. f.) Engler (syn. *Loranthus Fieldii* Buch.)	..	Scarlet mistletoe	„	N. C. S.	„
——— *flavida* (Hook. f.) Engler	..	Yellow mistletoe	„	C. S.	„
POLYGONACEÆ.					
Muehlenbeckia complexa (A. Cunn.) Meissn.	Pohuehue	..	„	N. C. S.	„
——— *axillaris* Walp.	..	..	Aus.	C. S.	Desert, on dunes.
PORTULACACEÆ.					
Claytonia australasica Hook. f.	..	..	„	„	Desert.
Montia fontana L.	..	Water chickweed	Cos. temp.	C. S. Sub.	Running water.
CARYOPHYLLACEÆ.					
Colobanthus Billardieri Fenzl.	..	..	Aus.	„	Desert (in shelter of rock) and oasis (?).
Stellaria parviflora Banks and Sol.	..	Small-flowered chick weed	End.	N. C. S. Ch.	Forest.
RANUNCULACEÆ.					
Ranunculus nivicola Hook.	..	Egmont buttercup	„	C.	Desert, under shelter of rock; alpine meadow, Tongariro.
—— *hirtus* Banks and Sol.	Maruru	Common New Zealand buttercup	Aus.	N. C. S. Ch.	Grass-steppe.
——— *rivularis* Banks and Sol.	Wauriki, waoriki	Marsh-buttercup	End.	N. C. S. Ch.	Bog, stream.
MAGNOLIACEÆ.					
Drimys colorata Raoul	Horopito	Pepper-tree	„	N. C. S.	Forest.
CRUCIFERÆ.					
Cardamine hirsuta L.	..	Hairy bitter-cress	Cos. temp.	N. C. S. Ch. Sub.	Forest, near gully-streams.
DROSERACEÆ.					
Drosera arcturi Hook.	..	Alpine sundew	Aus.	C. S.	Bog.
——— *spathulata* Labill.	..	Spoon-leaved sundew	„	N. C. S.	„
SAXIFRAGACEÆ.					
Carpodetus serratus Forst.	Piripiriwhata, putaputawheta	New Zealand hawthorn	End.	„	Forest.
PITTOSPORACEÆ.					
Pittosporum tenuifolium Banks and Sol.	Kohuhu	Thin-leaved pittosporum	„	„	Forest and outskirts.
——— *Colensoi* Hook. f.	..	Colenso's pittosporum	„	C. S. (?)	Ditto.
——— *rigidum* Hook. f. (South Island variety)	..	Shrubby pittosporum	„	C. S.	Shrub-steppe, sub. scrub, forest.

LIST OF THE INDIGENOUS PTERIDOPHYTES AND SPERMAPHYTES—*continued.*

Species and Natural Order.	Maori Name.	English Name.	Distribution.		
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CUNONIACEÆ.					
Weinmannia racemosa L. f.	Towai, kamahi		End.	N. C. S.	Forest.
ROSACEÆ.					
Rubus australis Forst. f.	Tataramoa	Bush-lawyer	„	„	„
Acæna Sanguisorbæ Vahl.	Piripiri, hutiwai	Biddy-bid, New Zealand burr	Aus., Tristan da Cunha	N. C. S. Ch. Sub.	„
—— *novæ-zelandiæ* Kirk	Piripiri		End.	N. C. S.	Grass-steppe.
—— *microphylla* Hook. f.			„	C. S.	„
LEGUMINOSÆ.					
Carmichaelia Enysii Kirk var. *orbiculata* (Col.) Kirk		Enys's native broom	„	C. S. (?)	Desert.
—— *flagelliformis* Col.		Slender native broom	„	N. C. S.	Grass-steppe.
GERANIACEÆ.					
Geranium microphyllum Hook. f.		Small-leaved cranesbill	„	N. C. S. Sub.	„
—— *sessiliflorum* Cav.		Short-flowered cranesbill	Aus. S.A.	N. C. S.	„
RUTACEÆ.					
Melicope simplex A. Cunn.			End	„	Forest.
CORIARIACEÆ.					
Coriaria ruscifolia L.	Tutu, tupakihi		S.A.	N. C. S. Ch.	Forest, near creek.
—— *thymifolia* Humb. and Bonp.			„	C. S.	Shrub-steppe.
STACKHAUSIACEÆ.					
Stackhousia minima Hook. f.			End.	„	Grass-steppe.
ELÆOCARPACEÆ.					
Aristotelia racemosa (A. Cunn.) Hook. f.	Makomako	Wineberry, native currant	„	N. C. S.	Forest.
—— *fruticosa* Hook. f.		Mountain wineberry	„	„	Forest, sub. scrub.
Elæocarpus Hookerianus Raoul	Pokaka		„	„	Forest.
VIOLACEÆ.					
Viola filicaulis Hook. f.		Slender violet	„	„	„
—— *Cunninghamii* Hook. f.		Common New Zealand violet	Aus.	C. S.	Semi-bog.
THYMELIACEÆ.					
Pimelea buxifolia Hook. f.		Box-leaved pimelea	End.	N. C.	Sub. scrub.
—— *lævigata* Gaertn.		Common pimelea	„	N. C. S.	Desert.
MYRTACEÆ.					
Leptospermum scoparium Forst.	Manuka	Red tea-tree	Aus.	„	Sub. scrub, steppes.
—— *ericoides* A. Rich.	Kanuka maru, manuka	White tea-tree	End.	„	Shrubs near river in gully.
Myrtus pedunculata Hook. f.	Rohutu	Small-leaved myrtle	„	„	Forest.
ONAGRACEÆ.					
Epilobium erectum Petrie		Tall willowherb	„	N. C.	Shallow water.
—— *alsinoides* A. Cunn.			„	N. C. S. Ch. Sub. (?)	Grass-steppe.
—— *linnæoides* Hook. f.		Forest willowherb	„	N. C. S. Sub.	Forest.
—— *pedunculare* A. Cunn.		Long-stemmed willowherb	„	N. C. S. Sub.	River-bed.
—— *macropus* Hook.		Mountain water-willowherb	„	C. S.	Running water
—— *glabellum* Forst. f.		Glossy-leaved willowherb	„	N. C. S.	Near creek.
Fuchsia excorticata (Forst. f.) Linn. f.	Kotukutuku	Native fuchsia	„	„	Forest.
HALORRHAGIDACEÆ.					
Haloragis uniflora T. Kirk.			„	N. C. S. Sub.	Grass-steppe.
—— *micrantha* R. Br.		Marsh haloragis	Aus. Mal. India, E. Asia	N. C. S.	Wet ground.
Myriophyllum Votschii Schindl.			End.	„	Bog.
Gunnera prorepens Hook. f.		Creeping gunnera	„	„	Sphagnum bog
—— *dentata* Kirk		Red-fruited gunnera	„	C. S.	Running water, banks of creek near water.

LIST OF THE INDIGENOUS PTERIDOPHYTES AND SPERMAPHYTES—*continued.*

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ARALIACEÆ.					
Nothopanax simplex (Forst. f.) Seem.	Haumakaroa	Simple-leaved panax	End.	N. C. S. Sub.	Forest, sub. scrub.
—— *anomalum* (Hook.) Seem.	Wauwaupaku	Shrubby panax	„	N. C. S.	Forest.
—— *Sinclairii* (Hook. f.) Seem.		Sinclair's panax		N. C.	Sub. scrub.
—— *Colensoi* (Hook. f.) Seem.		Mountain ivy-tree	End.	N. C. S.	Forest, sub. scrub.
—— *arboreum* (Forst. f.) Seem.	Whauwhaupaku	Common ivy-tree	„	„	Forest.
Pseudopanax crassifolium (Sol.) C. Koch	Horoeka, hohoheka	Lancewood	„	„	„
UMBELLIFERÆ.					
Hydrocotyle tripartita R. Br.			„	C. S.	Forest, near creek, on stones.
Aciphylla squarrosa Forst.	Taramea, kurikuri	Speargrass	„	„	Grass-steppe.
Ligusticum aromaticum Hook. f.		Common alpine ligusticum	„	„	Desert.
CORNACEÆ.					
Corokia Cotoneaster Raoul			„	N. C. S.	Forest.
Griselinia littoralis Raoul	Kapuka, papaumu	Broadleaf	„	„	Forest, sub. scrub.
ERICACEÆ.					
* *Gaultheria antipoda* Forst. f.		Snowberry	Aus.	„	Grass-steppe.
—— *perplexa* Kirk			End.	C. S.	„
* —— *rupestris* (Forst. f.) R. Br.			„	N. C. S.	Shrub-steppe, desert.
—— *fagifolia* Hook. f. (?)			„	C.	Shrub-steppe on Tongariro.
EPACRIDACEÆ.					
Pentachondra pumila (Forst. f.) R. Br.			Aus.	N. C. S.	Grass- and shrub-steppe.
Styphelia acerosa (R. Br.) (prostrate variety)	Mingimingi	Sharp-leaved heath	„	N. (?) C. S. (?)	Forest.
—— *empetrifolia* (Hook. f.) F. Muell. (syn. *Cyathodes empetrifolia* Hook. f.)			End.	N. C. S. Sub.	Steppes.
—— *Colensoi* (Hook. f.) Diels (syn. *Cyathodes Colensoi* Hook.)			„	C. S.	„
—— *fasciculata* (Forst. f.) Diels (syn. *Leucopogon fasciculatus* A. Rich.)	Mingimingi, mingi	Tall bearded heath	„	N. C. S.	Forest.
—— *Frazeri* (A. Cunn.) F. Muell. (syn. *Leucopogon Frazeri* A. Cunn.)		Dwarf heath	Aus.	„	Steppes.
Epacris alpina Hook. f.		Alpine epacris	End.	C.	„
Dracophyllum recurvum Hook. f.			„	„	Shrub-steppe, desert.
—— *Urvilleanum* A. Rich. var. *montanum* Cheesem.			„	C. S.	Shrub-steppe.
—— *subulatum* Hook. f.	Monoao		„	N. C.	Steppes.
MYRSINACEÆ.					
Suttonia divaricata Hook. f.		Weeping matipo	„	N. C. S. Sub.	Forest, sub-alpine scrub.
—— *nummularia* Hook. f.		Creeping matipo	„	C. S.	Shrub-steppe.
GENTIANACEÆ.					
Gentiana Griesbachii Hook. f.		Small New Zealand gentian	„	„	Grass-steppe.
—— *bellidifolia* Hook. f.		Common mountain-gentian	„	„	Desert, shrub-steppe, bog.
Liparophyllum Gunnii Hook. f.			Aus.	„	Bog.
APOCYNACEÆ.					
Parsonsia heterophylla A. Cunn.	Kaiku, kaiwhiria	New Zealand jasmine	End.	N. C. S.	Forest, Tongariro.
BORAGINACEÆ.					
Myosotis Forsteri Lehm.		Forster's forget-me-not	„	„	Forest (rare).
SCROPHULARINACEÆ.					
Veronica salicifolia Forst. f.	Koromiko	Common veronica	„	„	Forest near creeks, margin of forest.
—— *lævis* Benth.			„	C.	Subalpine scrub, forest, shrub-steppe, grass-steppe.
—— *buxifolia* Benth.		New Zealand box	„	C. S.	Wet ground of shrub-steppe.
—— *tetragona* Hook.		Square-stemmed veronica	„	C.	Shrub-steppe.
—— *catarractæ* Forst. f., var. *diffusa* Hook. f.			„	N. C. S.	Bank of rivers, near water.
—— *Hookeriana* Walp.		Hooker's veronica	„	C.	Desert.
—— *spathulata* Benth.		Snowy veronica	„	„	„

* Doubtless a number of species are included under these two names.

LIST OF THE INDIGENOUS PTERIDOPHYTES AND SPERMAPHYTES—*continued*.

Species and Natural Order.	Maori Name.	English Name.	Distribution.		
			Beyond New Zealand, or Endemic.	Within New Zealand.	On the Volcanic Plateau, &c.
SCROPHULARINACEÆ—*continued*.					
Ourisia macrophylla Hook.		Large-leaved ourisia	End.	C.	Wet banks.
—— *Colensoi* Hook. f.		Colenso's ourisia	„	„	Shrub-steppe, bog.
—— *cæspitosa* Hook. f.		Creeping ourisia	„	C. S.	Alpine meadows.
Euphrasia cuneata Forst. f., var. *tricolor* Col.			„	C.	Steppes.
—— *revoluta* Hook. f.			„	C. S.	„
LENTIBULARIACEÆ.					
Utricularia monanthos Hook. f.		Common bladder-wort	Aus.	„	Bog.
RUBIACEÆ.					
Coprosma robusta Raoul	Karamu		End.	N. C. S.	Forest.
—— *tenuifolia* Cheesem.		Narrow-leaved coprosma	„	N. C.	„
—— *parviflora* Hook. f.		Small-leaved coprosma	„	N. C. S. Sub.	„
—— *acerosa* A. Cunn., var. *brunnea* Kirk			„	N. C. S.	Grass-steppe.
—— *fœtidissima* Forst.		Stinkwood	„	„ Sub.	Forest, sub. scrub, shrub-steppe.
—— *Colensoi* Hook. f.		Colenso's coprosma	„	N. C. S.	Forest.
—— *Banksii* Petrie		Banks's coprosma	„	C. S.	„
—— *cuneata* Hook. f.		Wedge-leaved coprosma	„	„ Sub.	Forest, sub. scrub.
—— *microcarpa* Hook. f.		Small-fruited coprosma	„	C.	Forest.
—— *depressa* Col.		Prostrate coprosma	„	C. S.	Steppes, bog.
—— *repens* Hook. f.		Alpine creeping coprosma	„	„ Sub.	„
—— *Petriei* Cheesem.		Petrie's coprosma	„	C. S.	Grass-steppe.
Nertera dichondræfolia Hook. f.			„	N. C. S.	Forest.
—— *setulosa* Hook. f.			„	„	Near creeks.
CAPRIFOLIACEÆ.					
Alseuosmia macrophylla A. Cunn	Hoihoi		„	„	Forest.
CAMPANULACEÆ					
Wahlenbergia saxicola (R. Br.) A. D. C.		Bluebell	„	C. S.	Steppes.
Pratia angulata (Forst. f.) Hook f.		Common pratia	„	N. C. S.	Near streams.
STYLIDIACEÆ.					
Phyllachne Colensoi (Hook. f.) Bergg.			„	C. S.	Meadow on Tongariro.
Oreostylidium subulatum (Hook. f.) Bergg.			„	„	Grass-steppe.
Forstera Bidwillii Hook. f.			„	„	Shrub-steppe. Shady banks near bog. Shrubs.
COMPOSITAE					
Lagenophera petiolata		New Zealand daisy	„	N. C. S.	Forest.
Olearia nitida Hook. f.		Glossy-leaved daisy-tree	„	C. S.	Near streams. forest.
—— *nummularifolia* Hook. f.			„	„	Sub. scrub.
Celmisia incana Hook. f.		Mountain musk	„	N. C. S.	Shrub-steppe, south and west.
—— *spectabilis* Hook. f.		Cotton plant	„	C. S.	Steppes.
—— *longifolia* Cass., var. *gracilenta* Kirk		Common celmisia	„	N. C. S.	Grass-steppe.
—— *longifolia* Cass., var. *major* Kirk			„	„	„
—— *longifolia* var.			„	„	Grass-steppe, bog.
—— *glandulosa* Hook. f.		Bog celmisia	„	C. S.	Steppes, wet ground, bog.
Gnaphalium keriense A. Cunn. form.			„	N. C. S.	Near margin of stream.
—— *paludosum* Petrie		Marsh cudweed	„	„	Bog.
Raoulia australis Hook. f.		Silvery raoulia	„	„	Desert, shrub-steppe.
—— *tenuicaulis* Hook. f.		Slender raoulia	„	„	River-beds.
—— *grandiflora* Hook. f.		Large-flowered raoulia	„	C. S.	Meadow on Tongariro.
Helichrysum bellidioides (Forst. f.) Willd.		Mountain daisy	„	C. S. Ch. Sub.	Desert, shrub-steppe.
Cassinia Vauvilliersii (Homb. and Jacq.) Hook. f.		Mountain cassinia	„	C. S. Sub.	Steppes, sub. scrub.
Craspedia uniflora Forst. f., var. *robusta* Hook. f.			„	C. S.	Oasis in high desert.
—— —— var. *minor* Hook. f.			„	„	Bog.
Erechtites glabrescens T. Kirk.			„	„	Forest.
Senecio Bidwillii Hook. f.		Bidwill's shrubby groundsel	„	„	Shrub-steppe, sub. scrub.
Microseris Forsteri Hook f.			Aus.	„	Grass-steppe.

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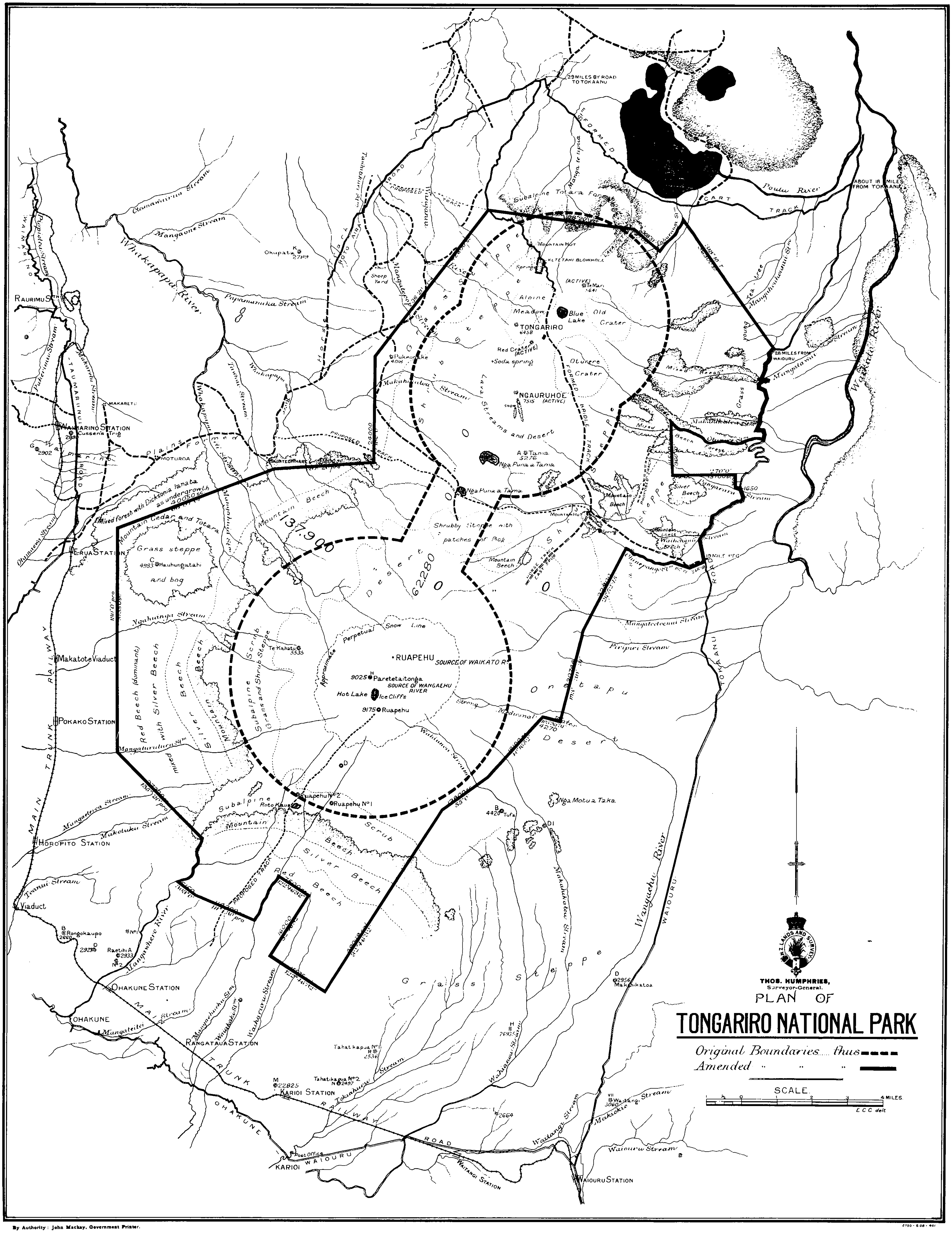
Approximate Cost of Paper.—Preparation, not given; printing (2,250 copies), £28 18s.

By Authority: JOHN MACKAY, Government Printer, Wellington.—1908

Price 1s.]


THOS. HUMPHRIES,
Surveyor-General.
PLAN OF
TONGARIRO NATIONAL PARK
Original Boundaries thus
Amended " " "
SCALE
4 MILES
RUAPEHU
TONGARIRO
NGAURUHOE
OHAKUNE STATION
WAIOURU STATION
KARIOI STATION
RANGATAUA STATION
HOROPITO STATION
POKAKO STATION
ERUA STATION
RAURIMU STN
Waikato River
Wangaehu River
Whakapapa River
Poutu River
MAIN TRUNK RAILWAY
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62,280