

two thin white lines to enclose a dark-greenish dorsal line. A thin red line in conjunction with a white line from tip of frontal horn to tip of tail horn. Two fainter lines from wing-cover to tip of abdomen. A white line edged both sides with red from centre of wing-case, not reaching to end of abdomen. A dark line with a white line below along the top of wings. Veins of future wings clearly outlined. As the insect neared emergence the dark spots on the wings showed plainly through the pupa skin.

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CORRECTION.

In the "Transactions of the New Zealand Institute," vol. 43, 1911, pp. 127, 128. I find I have carelessly written "lines" where it should be "mm." Unfortunately, this not only makes the description read wrongly as to the wing-expanse, but has also mislead those responsible for the reproduction of the illustrations, so that these have been printed much over their natural size.

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ART. XXII.—*The Raised Beaches of Cape Turakirae.*

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Plates XIII, XIV.

CAPE TURAKIRAE is the north-western point facing Cape Palliser, the two capes enclosing that noble stretch of water known as Palliser Bay. The remarkable geological and botanical features of Turakirae hitherto appear to have escaped the attention they merit, and it is with the hope of remedying this neglect that this paper is written.

The Orongorongo River, near the mouth of which is situated Mr. Riddiford's homestead, cuts through a series of raised beaches, now more or less obscured by drifting sand or overgrown by herbage. They are, moreover, composed of finer material—mostly coarse sand—than those same beaches a mile nearer the cape. Their finer nature is accounted for by the fact that the rivers would bring down quantities of fine debris, which would be thrown up by the sea. Three beaches are here to be distinguished, and, as their altitude is the same, they are undoubtedly of the same age as those three hereafter described as being nearer the sea. The beach presumably elevated at the time of the 1855 earthquake is here very well developed. The influence of the fineness of beach-particles on the flora will be presently noticed. It is not until one has crossed the river, and proceeded a mile or so towards Palliser Bay, that the eye of the observer is arrested by the extraordinary physiographical aspect of the country lying between the track at the base of the steep hillside and the sea. The track follows a course close to the foot of the hills, about 100 ft. above sea-level, and between this and the sea is a stretch of rocky country varying from 250 to 400 yards in width, and extending some two or three miles, narrowing to nothing on the further side of the cape. This rocky plain consists mostly



Fig. 1.



Fig. 2.



Fig. 3.



Fig. 4.

- FIG. 1.—CORYNOCARPUS ASSOCIATION ON SHINGLE FANS, PALLISER BAY, LOOKING TOWARDS HEAD OF BAY. (Shown also in Fig. 3.)  
FIG. 2.—CORYNOCARPUS AND MUEHLENBECKIA COMPLEXA ASSOCIATIONS ON BEACH NO. 4 (80 FT. ABOVE SEA), LOOKING SEAWARDS.  
FIG. 3.—POND FORMED IMMEDIATELY ABOVE BEACH NO. 2 (40 FT. ABOVE SEA), LOOKING TOWARDS CAPE TURAKIRAE.  
FIG. 4.—BEACH NO. 1 (9 FT. ABOVE SEA), ELEVATED AT 1855 EARTHQUAKE. Mukumuku cliffs and shingle fans in the distance.





FIG. 1.—BEACH No. 5 (95 FT. ABOVE SEA).  
Showing recently rolled boulders and *Corynocarpus* growing on Beach No. 4, immediately below.



FIG. 2.—BOULDER PLAIN WITH NO. 3 BEACH (60 FT. ABOVE SEA, ON EXTREME LEFT OF PHOTO) RUNNING THROUGH IT.  
The black patches on beach are *Muehlenbeckia complexa*. On extreme right of photo may be seen in the distance No. 2 Beach (40 ft. above sea).

of large boulders 3 ft. to 8 ft. in diameter, but running roughly parallel with the sea throughout the length of the boulder-strewn plain are two excellently defined shingle beaches. These stand out most conspicuously, and form natural roadways along which one may drive. For the greater part the shingle presents an appearance differing little from that of beaches which often exist now at the ocean's marge. In many places the shingle is, however, overgrown with *Muehlenbeckia complexa*, or with grasses and other plants. The main impression left on one's mind is that marvellously little alteration has taken place in the peopling of these areas by plants, and in the external appearance of the shingle generally, in the hundreds of years which have probably elapsed since each was rapidly elevated. The survival of the beaches as shingle involves the fact that it is composed of the harder portions of the country rock, and which would hence, in the equable climate, offer a considerable resistance to the weathering influences; isolated by boulder plains on all sides, little dust could blow in and form soil between the interstices, and without soil little atmospheric moisture could be retained. Only specially adapted shingle-plants, such as *Muehlenbeckia*, could, therefore, hope to survive in such a station.

Happily, we are not entirely in the dark as to the rapidity with which these beaches may be elevated beyond the reach of the breakers. It is well known that the coast at Mukumuku was elevated 9 ft. during the earthquakes of 1855 (see Crawford, Trans. N.Z. Inst., Essay, vol. 1, p. 18). Knowing this, the author carefully searched the boulder-strewn shore a little above high-water mark, and was rewarded by finding traces of a shingle beach about that altitude above high-water mark. Further search nearer Mukumuku showed a long strip of shingle beach quite as well developed as the older beaches. The fact that the sea is now breaking on boulders and monoliths somewhat discounts the thought that beach No. 1 may be a mere storm beach. Exploring the country adjacent to the hills, two much older shingle beaches were found. These nearly everywhere have been obliterated by the debris carried down by temporary creeks from the steep hillsides, the site of the older beaches being now occupied by fans of angular shingle, mixed with finer detritus, many acres in extent, which may or may not support a flora. This recent alluvium has buried these two older beaches many feet below the surface, but where fragments of them remain one is again struck with the extremely recent appearance of the beach, as Plate XIV, fig. 1, truly depicts. The interesting fact that the younger of these beaches is that more thickly populated by a flora is probably accounted for by the difference in size of the component stones, which explanation must also suffice for the fact that much of the newer fan-material supports dense formations of herbage or arboreal growth. Five distinct shingle beaches have now been mentioned, which for the sake of ease of reference may be designated by the numbers 1, 2, 3, 4, and 5, No. 1 being the youngest (the 1855) beach and No. 5 the oldest. Observations taken with a surveying aneroid show that the level of each of these beaches is practically constant along its entire length—that is to say, beach No. 1 is approximately 9 ft. (see Plate XIII, fig. 4), beach No. 2 is 40 ft., beach No. 3 is 60 ft. (see Plate XIV, fig. 2), beach No. 4 is 80 ft. (see Plate XIII, fig. 2), and beach No. 5 is 95 ft. (see Plate XIV, fig. 1) above high-water mark.

The material of which all this elevated country is composed has so far been roughly classified as boulders and shingle, but there is a third most extraordinary component, the solitary monoliths which stand out some-

times as much as 15 ft. above the surrounding country, enabling a comprehensive view of it to be obtained from their summits. There are no monoliths or disproportionately sized boulders on the beaches, with a few unimportant exceptions. Plate XIV, fig. 1, shows a few large boulders have rolled, perhaps comparatively recently, on or near beach No. 5. These monoliths are often very much undercut, and present the appearance of having rolled into the positions they now occupy, rather than of having been weathered into their present shape by wave-action. Where the sea broke at the tide-limits a shingle beach would form; above and below the tide-limits less weathering would occur. Sudden elevation would remove an area beyond reach of the waves, and as this was repeated the alternation of shingle and boulder is thus accounted for. Possibly the original relation of shore to sea-floor was that of a perpendicular or overhanging cliff with the floor projected at an obtuse angle from the base of it. Successive movements of the earth might dislodge much of the cliff-material, and build up a submarine platform. One would like to find some explanation for the fact that these rolled monoliths occur such a distance from the base of the present cliffs. It is not easy to see how faulting at the base of the cliffs can have been a factor in the uplift, as this would have to take place in a semicircular sweep round the cape, and there is plenty of evidence of recent dislodgment of large masses of rock from the hillside. Earthquakes may have played a considerable part in loosening large masses of rock. One rolled monolith examined was roughly cubical in shape, and its side measured 15 ft., its estimated weight being 250 tons.

The age of these beaches is a most fascinating theme to speculate upon. The fresh appearance of the shingle makes it hard to realize that centuries must have elapsed since they were removed beyond the reach of the tide. Mr. Elsdon Best informs me of a Maori tradition which relates that the Miramar Peninsula, previously an island, was elevated about four hundred years ago to its present position, which is evidence, of a kind, of coast-elevation within historic-times, prior to 1855. (See also Cotton, p. 245 of this volume.)

If the geological features of this area are intensely interesting, the botanical features are even more so. Within a few hundred yards may be found the plants of the arid rock-faces, the fresh-water swamps and ponds, the sea littoral, the grass meadows, and the forest.

Starting from the sea-shore a little above high-water mark, in a situation well moistened by sea-spray are found the usual halophytic plants, *Salicornia australis* Sol., *Samolus repens* Pers., *Triglochin striatum* var. *filifolium* Buch., *Apium prostratum* Labill., *Selliera radicans* Cav., *Scirpus nodosus* Rottb., *Carex ternaria* Forst., *Juncus effusus* Linn. These are growing between boulders 3 ft. to 4 ft. in diameter, which formation occupies some 10 or 20 yards until the shingle of beach No. 1 is reached. On this grow the beautiful *Glaucium flavum* Crantz (naturalized), *Senecio laetus* Forst., *Apium prostratum* Labill., *Poa anceps* Forst., *Calystegia soldanella* R. Br., and the naturalized *Picris echioides* Linn. and *Plantago lanceolata* Linn.

Now comes a stretch of big boulders and monoliths, amongst which are growing in very wet or very dry stations the following: *Leptocarpus simplex* A. Rich., *Mariscus ustulatus* Clarke, *Phormium Cookianum* Le Jolis, *Selliera radicans* Cav., *Raoulia australis* Hook. f., *Muehlenbeckia complexa* Meissn., *Olearia Solandri* Hook. f., *Cassinia leptophylla* R. Br., *Plagianthus divaricatus* Forst., *Hymenanthera crassifolia* Hook. f., *Arundo conspicua* Forst., *Euphorbia glauca* Forst., *Clematis Colensoi* Hook. f., *Epilobium*

*erectum* D. Petrie, *Deyeuxia Forsteri* Kunth., *Poa anceps* Forst., *P. caespitosa*, Forst., *Myoporum* and *Coprosma Baueri* Endl. shrubs (occasionally), *Australina pusilla* Gaud., *Adiantum affine* Willd., and the naturalized *Picris echioides* Linn., *Nasturtium officinale* R. Br., *Myosotis palustris* Linn. Parts of this rockery may not be so wet, and may then contain *Leptospermum scoparium* Forst., *L. ericoides* A. Rich., *Coprosma rhamnoides* A. Cunn., *C. robusta* Raoul, *C. parviflora* Hook. f., *Pimelea laevigata* Gaertn., *Olearia Cunninghamii* Hook. f., and a sward of introduced *Medicago lupulina* Linn., and *Hypochaeris radicata* Linn., and some *Caucalis nodosa* Scop., *Cnicus lanceolatus* Willd., *Rosa rubiginosa* Linn. occurs.

This boulder terrace occupies a width of from 50 to 150 yards, and at the further side of it an abrupt rise consisting of shingle is encountered. This is beach No. 2, and growing on it is often a sward of naturalized *Rumex acetosella* Linn., *Lolium perenne* Linn., *Festuca myuros* Linn., *Hordeum murinum* Linn., and *Erodium cicutarium* L'Herit., or a thicket of *Silybum Marianum* Gaertn.; while the native plants present are *Muehlenbeckia complexa* Meissn., *Aciphylla squarrosa* Forst., *Hymenanthera crassifolia* Hook f., *Bulbinella Hookeri* Benth., *Plagianthus divaricatus* Forst., *Olearia Solandri* Hook f., *Coprosma propinqua* A. Cunn. At the Orongorongo River, where the beach is composed of coarse sand, it is almost covered in parts, with the beautiful silvery *Raoulia australis* Hook f., with *Zoysia pungens* Willd. growing through it. Near Mukumuku Stream this plant covers a sandhill some 30 ft. high, which can easily be picked out by its colour some three miles away.

Towards the north-east end of these beaches, on the landward side, just above No. 2 beach, are two ponds. The vegetation surrounding and growing in the larger of these presents considerable contrasts. On the dry shingle of the beach characteristic rounded clumps of *Muehlenbeckia complexa* Meissn. dominate that position. In wet ground, nearer the pond, *Mariscus ustulatus* Clarke abounds. Nearer still is *Eleocharis acuta* R. Br. and plants of *Rumex crispus* Linn. (natd.). The entire margin of the pond is fringed with a yellow *Conferva*, and the whole of the pond itself is filled with a dense dark-red growth of *Myriophyllum elatinoides* Gaud. and a little *Potamogeton Cheesemanii* Bennett. The landward shore of the pond is covered by *Eleocharis* and *Typha angustifolia* Linn., with some *Leptocarpus simplex* A. Rich., *Scirpus lacustris* Linn., *Juncus effusus* Linn., *Cladium junceum* R. Br., *Phormium tenax* Forst., *Carex ternaria* Forst., *Calystegia tuguriorum* R. Br. The naturalized *Nasturtium officinale* R. Br. and *Myosotis palustris* Lam. also occur in considerable quantity. In the dry boulder-bank or in boggy places above are to be found the rare *Sebaea ovata* R. Br. (a yellow-flowered gentianous plant now for the first time recorded from Wellington Province), *Potentilla anserina* Linn., *Pelargonium australe* Jacq., *Geranium molle* Linn., *Hydrocotyle asiatica* Linn., *Vittadinia australis* A. Rich., *Gnaphalium collinum* Labill., *Craspedia uniflora* Forst., *Festuca multinodis* Hack., *Microtis parvifolia* R. Br., *Linum monogynum* Forst., *Epilobium Billardierianum* Ser., *Ranunculus hirtus* Banks & Sol., *Samolus repens* Pers., *Galium umbrosum* Sol., *Euphrasia cuneata* Forst., *Haloragis alata* Jacq., *H. depressa* Walp., *Lagenophora pumila* Cheesm., *Ranunculus rivularis* Banks & Sol., *Dichelachne crinita* Hook. f., and the naturalized *Silene gallica* Linn., *Briza maxima* Linn., *Cyperus vegetus* Willd., *Vicia* sp. Near Orongorongo Stream *Eryngium vesiculosum* Labill. occurs plentifully above the beach. In the centre of the stony plain, clustering round the monoliths on the upper edge of beach

No. 2, is to be found a little forest, consisting of *Corynocarpus* (sometimes 18 in. in circumference), *Melicytus ramiflorus* Forst., *Myrsine Urvilleana* A. D. C., *Coprosma Cunninghamii* Hook f., *Panax arboreum* Forst., *Cordylina australis* Hook. f., *Piper excelsum* Forst., *Coriaria ruscifolia* Linn., *Asplenium lucidum* Forst., *Coprosma Baueri* Endl., *Olearia Cunninghamii* Hook. f., *Pellaea rotundifolia* Hook. f. On beach No. 3 flourish most of the plants mentioned as found on No. 2. *Muehlenbeckia complexa* Meissn. is the most characteristic on this beach, which is the best developed of the five described. *Danthonia semiannularis* R. Br., and the naturalized *Polycarpon tetraphyllum* Linn., *Poa pratensis* Linn., and *Bromus mollis* Linn. also occur.

The next strip of boulder terrace, between beach No. 3 and beach No. 4, is most interesting for the number and variety of species it contains. Some portions consist of boulders 5 ft. to 8 ft. in diameter, and fairly uniform in size, and growing among them are *Phormium Cookianum* L. Jolis, *P. tenax* Forst., *Dichondra repens* Forst., *Epilobium insulare* Haussk., *Hymenanthera crassifolia* Hook. f., *Mariscus ustulatus* Clarke, *Hydrocotyle asiatica* Linn., *H. novae-zelandiae*, *Dichelachne crinita* Hook. f., *Carex ternaria* Forst., *Astelia nervosa* Banks & Sol., *Cordylina australis* Hook f., *Leptospermum scoparium* Forst., *Olearia Solandri* Hook f., *Scirpus prolifer* Rottb., *Drosera binata* Labill., and the naturalized *Ranunculus acris* Linn. and *Myosotis palustris* Lam. are common. Extensive *Phormium* and *Typha angustifolia* Linn. swamps occur, which also contain *Juncus caespiticius*, *J. prismatocarpus* R. Br., *J. bufonius* Linn., *J. vaginatus* R. Br., *Schoenus axillaris* Poir., and ponds may form. In this area occur most of the monoliths, the flora of which is utterly distinct from that of the swamp, pond, or damper ground immediately below them. The most remarkable constituent of the monoliths' flora is *Dendrobium Cunninghamii*, which is growing as a thick sward 6 in. or 7 in. high, and fully exposed to the wind and sun, a fact first noticed by Colenso in this very spot (see "First Journey to the Ruahine Range," p. 11). Four other epiphytic orchids are growing on the rock-faces—*Sarcocylus adversus* Hook. f., *Bulbophyllum pygmaeum* Lindl., *Earina mucronata* Lindl., and *E. suaveolens* Lindl.—and yellow clumps of *Scleranthus biflorus* Hook. f., the climbing *Polypodium serpens* Forst., and *Mesembryanthemum australe* Sol. In chasms or small clefts or on the tops some soil has formed, and here are to be found *Coprosma Baueri* Endl., *Hymenanthera crassifolia* Hook. f., *Arthropodium candidum* Raoul, *Helichrysum filicaule* Hook. f., *Agropyrum scabrum* Beauv., *Craspedia uniflora* Forst., *Clematis Colensoi* Hook. f., *Luzula campestris* D. C., *Festuca multinodis* Hack., *Poa anceps* Forst., *Danthonia semiannularis* R. Br., *Pimelea laevigata* Gaertn., *Linum monogynum* Forst., *Trisetum antarcticum* Prin., *Tillaea Sieberiana* Schultz, *Aciphylla squarrosa* Forst., *Rhagodia nutans* R. Br., *Thelymitra longifolia* Forst., *Dichondra repens* Forst., *Asplenium flabellifolium* Cav., *Metrosideros robusta* A. Cunn. may even occur.

Above beach No. 3, in wet parts, occur *Cotula coronopifolia* var. *integrifolia* Linn., *Ranunculus rivularis* Banks & Sol., *Eleocharis Cunninghamii* Boeck., *Juncus pallidus* R. Br., *J. maritimus* Lam., *J. lampocarpus* Ehr., *Carex virgata* Sol., *C. lucida* Boott., *Azolla rubra* R. Br., *Lobelia anceps* Linn. f., *Nertera depressa* Banks & Sol.; and in the drier parts *Olearia Forsteri* Hook. f., *Prasophyllum Colensoi* Hook. f., *Urtica ferox* Forst., *Calystegia sepium* R. Br., *Apium prostratum* var. *filiforme* Labill., *Rubus cissoides* A. Cunn., *Lomaria capensis* Willd., and the naturalized *Lythrum hyssopifolium* Linn., *Sherardia arvensis* Linn., *Bromus sterilis* Linn.



On beach No. 4, in places, true forest is found. This is nearly a pure *Corynocarpus* association. Some of the trees are very old, measuring up to 6 ft. in circumference, and may be two hundred years old. Plate XIV, fig. 1, shows No. 5 beach with one quick-growing tree, *Myoporum laetum* Forst., on it; but the *Corynocarpus* is confined to No. 4 beach, immediately below and contiguous to No. 5 beach. Where *Corynocarpus* has not established itself on No. 4, *Muehlenbeckia complexa* Meissn. covers the beach (see Plate XIII, fig. 2). On the slopes of it grow a charming shrubbery of *Pennantia corymbosa* Forst., *Melicope ternata* Forst., *Myoporum laetum* Forst., *Sophora tetraptera* J. Mull., *Pittosporum tenuifolium* Banks & Sol., *Parsonsia heterophylla* A. Cunn., *Passiflora tetrandra* Banks & Sol., *Cordyline australis* Hook f., *Clematis Colensoi* Hook. f., *Piper excelsum* Forst., among the herbaceous plants being *Parietaria debilis* Forst., *Wahlenbergia gracilis* A. D. C., *W. saxicola* A. D. C., and the naturalized *Fumaria muralis* Sond.

On beach No. 5 an unusual sight is *Muehlenbeckia australis* Meissn. adopting the habit and station affected by its congener *M. complexa* Meissn., and scrambling over the horizontal stones, instead of climbing over trees in its usual manner.

The flora of the fans which have covered up so much of the two oldest beaches may be briefly described. The oldest material supports pure woods of *Corynocarpus* (karaka), often with a pure fringing wood of *Myoporum*. Plate XIII, fig. 1, shows a good example of a karaka grove. The action of the wind in bunching the topmost leaves and branchlets together at the southern, seaward, and exposed extremity of the grove, while they regain their normal habit as they approach the hills, is most instructive. The younger alluvium supports a dense sward of indigenous *Danthonia pilosa* R. Br. and *Microlaena stipoides* R. Br., and naturalized grasses and clovers. The youngest fan-material grows chiefly the naturalized thistles *Cnicus lanceolatus* Willd. and *Silybum Marianum* Gaertn., the latter often impenetrable thickets acres in extent. Reference must be made to that remarkable new species, *Muehlenbeckia Astoni* Petrie (figured in Trans. N.Z. Inst., vol. 43, p. 257). This rare plant grows on the talus slopes and shingle fans. It is remarkable for the regularity of the angle of branching (approximately 120 degrees) and for the fact that it is the only New Zealand species with an erect habit of growth.

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#### SUMMARY.

The raised marine beaches at Cape Turakirae show that there has occurred comparatively recently, and perhaps within historic times, rapid elevation of the coast-line near Palliser Bay at least four times prior to the sudden elevation of 9 ft. which took place in 1855. Violent earth-movements have so altered the physiography of the littoral as to result in some unusual ecological features.