THE COASTAL COMMUNITIES OF MAROTIRI ISLAND

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INTRODUCTION:

Cliff communities in New Zealand have been a little discussed ecological topic. Their inaccessability makes study difficult and the variety of cliff habitats provide many interesting problems. But Marotiri Island offers splendid ecological studies within the confines of its small rugged coastline and observations were made on cliff communities with attention to their composition, life form of the component species and the pattern of zonation of the cliff vegetation as a whole.

CLIMATE:

No meteorological data is available for these islands. However, the climate may be very similar to that of Little Barrier Island and due to oceanic influences, equable conditions would be expected to prevail.

GEOLOGY:

The cliff rock is composed of greywacke and argillite penetrated by igneous dykes. In places it is deeply weathered and is continually collapsing under the influence of marine erosion. The rugged relief of the coastline is accentuated by the presence of off-shore reefs, rock platforms and resistant stacks. Steep cliffs rising to 300 feet or more in height are interrupted by rock ledges and outcrops, and resistant bluffs which supply streams of rock debris to talus slopes. Boulder beaches are not frequent as off-shore waters are deep. Sand and shingle beaches are even less common and occur in the sheltered south and south-western regions of the island.

ZONATION:

A basic zonation pattern is described below but it is modified by changes in aspect and exposure.

(1) *The Black Zone:*

The only plant growing in this part of the Supra-littoral zone is *Salicornia australis.* This plant occurs frequently as small clumps established in rock crevices just above high-water mark within reach of salt-water splash and heavy spray. Generally the plants are stunted and not as lush as the salt marsh form.

(2) *The Lichen Community:*

Immediately above the black zone is an Adlittoral lichen community Crustose lichens colonize rock faces beyond the reach of salt water and a few other plants thrive in the crevices. *Samolus repens* is particularly abundant as a crevice plant, reproducing vegetatively by sending out stolons. Where it finds shelter along cracks or in seepages in the rock face the growth form is particularly vigorous with lengthy stolons and linearobovate leaves often over an inch in length. Great variability in form was observed under conditions of moderate to extreme exposure. The plants in the regions of high exposure were densely tufted with reduced, fleshy and abnormally shaped leaves.

(3) *The Halophyte Community:*

This community is extensive on the exposed cliffs and crags of the northern coast but is noticeably compressed where shelter permits and encourages the growth of species with higher growth form. *Mesembryanthemum australe* is the most important fleshy-leaved form. It is apparently well suited to the dry cliffs. The long, prostrate adventitiously rooted stems build up a substantial mat over the base soils and fragmentals and effectively binds them. Isolated ledges or bluffs are often clothed with long trailing 'weeps' of the stems of *Mesembryanthemum.* This is another species which exhibits noticeable change in form. In shelter the leaves are long, flaccid and fleshy, but in exposed habitats they are erect, reduced and more leathery although still fleshy. *Senecio lautus,* showing variable life form in the same way, is also abundant. *Paspalum distichum* is an important binder, often occuring in patches. *Stipa teretifolia, Scirpus cernuus* and *Juncus polyanthemos* are locally abundant. They occur frequently on less stable talus or may be closely associated with regeneration on slips where the caespitose clumped growth form is probably advantageous. Other important component species of the community are *Pimelea Urvilleana, Tillaea sieberiana, Brassica olearcea, Hypochaeris radicata, Angelica rosaefolia, Asplenium lucidum, Asplenium flaccidum* (terrestrial coastal form), *Dichondra repens, Arthropodium cirrhatum* (peculiar to moist situations) and *Linum monogynum.* Fleshy and small-leaved forms predominate in exposed habitats. *Muehlenbeckia complexa* in prostrate, tight wiry mats and *Coprosma repens* of low growth form are found in patches of varying extent where they eliminate *Mesembryanthemum* which requires full light for successful growth.

(4) *Coastal Scrub:*

Higher up the cliff above the halophyte community there is usually a zone of coastal scrub. The vegetation has a tight even canopy, is almost impenetrable and does not exceed 4 feet in height. The individual tree canopies exhibit most growth to leeward. Due to the killing-off of shoots on the weather side of the canopy and continued growth of the leeward shoots, trees have assumed an asymmetric growth form of the type which has been attributed to wind-shear or salt-spray effects (Boyce, 1954). In nearly all localities where exposure is moderate to extreme this is characteristic of scrub and coastal forest trees. The remnant shoots of the previous growth season project dead and leafless above the even clipped canopies. As a result of this type of growth the scrub species are stunted, gnarled and closely adpressed to the substratum. The root systems are extensive, strong and well developed, penetrating deep into joints and crevices.

Erect blocks and rock outcrops projecting above the canopy support a dense covering of lichen. Where the conditions are more favourable in the sheltered or rarely moist positions the growth of smaller ferns (*Cheilanthes Sieberi, C. distans*, and occasionally liverworts (*Pellia* and *Lunularia*) is promoted. Few bryophytes are to be found, except around seepages. The main species of the scrub canopy are: *Metrosideros excelsa, Myoporum laetum, Hymenanthera novae-zelandiae, Paratrophis opaca.* A number of ferns, grasses and herbaceous species are important components of the sub-canopy vegetation: *Polystichum richardi, Asplenium lucidum, Polypodium diversifolium, Oplismenus undulatifolius, Carex virgata, Peperomia urvilleana,* and *Angelica rosaefolia.*

Flax (*Phormium tenax*) is locally dominant or dispersed amongst the scrub. *Astelia cunninghamii* is not as important physionomically as is flax in the low scrub, but it is extremely abundant under taller pohutukawa forest at higher levels. Toitoi (*Arundo conspicua*) is locally abundant on sheltered gently-sloping ground.

Coastal Forest:

Coastal scrub grades more or less gradually into coastal forest, dominated on its lower fringes by pohutukawa. Long tongues of forest extend down towards the sea in the shelter of ridges or headlands. The dominants are mainly broadleaf species: *Corynocarpus laevigata, Dysoxylum spectabile* and *Meryta sinclairii.*

MODIFICATION WITH CHANGE IN ASPECT:

The prevailing winds for the islands are from the south-westerly quarter, while storms with winds of high velocity are from the northe-ast or south-east. Exposure is greatest on the north and south-west coasts.

(i) In exposed regions, as on the northern cliffs, the lower zones are extensive (i.e. halophyte zone, etc.) and coastal scrub covers the whole upper cliff regions. The scrub canopy is clipped, even and relatively low.

(ii) In sheltered regions, as at South-east Bay, the scrub canopy is not as markedly clipped or adpressed but there is still definite differential growth of the tree canopies to leeward.

The valley vegetation of the south bay has responded more noticeably in this way, probably because the valley is a funnel for winds from the south and south-west.

(iii) Some additional species are restricted to sheltered positions, e.g., *Sicyos angulata* (a scrambling vine which will not tolerate buffeting by wind), *Rhabdothamnus solandri, Edwardsia microphylla, Nothopanax arboreum, Olea apetala* and *Olearia furfuracea* (species associated with coastal forest), *Haboragis erecta* (delicate herbaceous type).

(iv) In the South-east Cove the higher reaches of a steep boulder beach is being colonized *Muehlembeckia australis,* flax (*Phormium tenax*), a few species from the scrub communities, *Coprosma repens, Pittosporum crassifolium,* and occasional herbaceous species—*Pimelea urvilleana, Linum monogynum* and *Tetragonia trigyna.* The boulder beaches beneath the eastern cliffs have not built up high enough to allow colonization.

On the west end of the island the only sand beach is backed by small dunes supporting a typical dune community dominated on the foreshore by *Spinifex hirsutus* and *Desmoschoenus spiralis.*

FACTORS AFFECTING COASTAL CLIFF VEGETATION:

1. *Rainfall and Soil Moisture*

Cockayne (1928) comments on the strong influence that rainfall has on the general vegetation of the shoreline and the inability of many coastal species to tolerate frost. In this latitude and environment the possibility of frost may be neglected but in connection with rainfall both the water-holding capacity of the substratum and the depth of soil are significant in controlling available soil moisture. Flax (*Phormium tenax*) is usually only found where soil of reasonable depth has collected in hollows or crevices and on soil accumulations or debris at the base of slips. Because of its life form (sheathing leaf bases, clumped habit and rotting bases) flax, where it is established, catches and conserves water.

2. *Salt Concentration in the Soil*

Much more work needs to be done before any significance may be attached to chloride ion concentration in cliff or coastal soils. Robertson (1951) after carrying out tests on cliff soils during the year 1949 at St Cyrus, Kincardineshire, concluded 'that soil moisture and salt content may be of importance in influencing the types of vegetation found in various parts of the cliff'.

3. *The Effect of Salt Water and Salt Spray*

In the Black Zone wetting by salt water prevents the establishment of all except those which are salt tolerant (e.g. *Salicornia australis*). The higher parts of the cliff, out of reach of salt water still receive wind-borne salt spray. Boyce (1954) recently made intensive investigation of effects of salt-spray on dune vegetation. Examination of his work suggests that many of the characters in the growth and life-form of species in the cliff vegetation may also be attributed to the effects of salt spray. It was noted that:

(a) Growth forms are typically low and prostrate, particularly in the more exposed lower regions of the cliff, e.g., *Pimelea urvilleana, Coprosma repens,* and *Muehlenbeckia complexa.*

(b) Shoots of the previous season's growth projecting above the canopy have died off before reaching any height and are bereft of leaves. This is apparently of frequent occurrence in coastal vegetation and was also found by Boyce (1954) in sand dune habitats. Shoot initiation takes place below the canopy but only the leeward sheltered shoots survived, thus allowing differential growth which gives rise to a canopy of asymmetric form. *Coprosma repens* and *Hymenanthera novae-zelandiae,* two important components of the stunted coastal scrub, exhibit this condition in exposed positions.

(c) Leaves often show necrosis typically caused by entry of salt where wilting takes place in the apical and marginal regions of the leaf. The condition commonly occurs on Ngaio (*Myoporum laetum*) *Olea apetala* and Pukanui (*Meryta sinclairii*).

4. *Wind*

This is probably more important in its general effect of drying out the habitat. It must also contribute in part to alteration in plant form by mechanical damage and abrasion. Boyce (1954) found mechanical damage caused by wind as the means of entry of chloride to leaves and shoot apices so as to cause their eventual death. There has been much discussion on the part played by wind in development of the typical low canopy angles and asymmetric forms of coastal species. The effect of mechanical injury by winds of high intensity combined with deposition and entry of salt into the aerial parts of a cliff plant may prove a much more plausible explanation for the death of exposed shoots. It may play some part in the selectivity seen in the cliff habitats where some species survive and others are eliminated or fail to establish.

BIOTIC FACTORS:

Petrels burrowing on the upper cliffs have in places accelerated soil erosion and partly destroyed undergrowth. The burrows are usually beneath the higher coastal scrub or coastal forest and it is difficult to assess the real affect of the presence of these birds.

FIRE:

Fires have destroyed the vegetation in some areas of the island including the western aspects, where coastal forest as a result is absent. There is now a *Leptospermum* community surmounting the cliffs below which are a number of escarpments covered with a mixed scrub and flax (*Phormium tenax*) community.

VEGETATION DYNAMICS ON THE CLIFFS:

In many parts of the coast marine erosion is the cause of numerous slips which strip extensive areas of vegetation leaving the ground open for recolonization. The instability of the cliff in some areas retards colonization. Here fresh rock falls or further slips complicate the normal succession, giving rise to a complex mosaic pattern in the vegetation.

A three-year-old slip on the north coast of the island was at the time of observation (August 1955) only partially colonized. *Mesembryanthemum australe*, a number of crevice plants and a few naturalised species or weeds had made their appearance. Colonization is probably slow in this case because of the rocky nature of the terrain. Old slips on the north coast are frequently dominated by extensive flax communities in which *Hebe parviflora*, *Hebe bollonsii* and occasionally *Meryta sinclairii* are found.

An extensive slip of recent origin (not more than four years old, according to A. H. Pickmere, pers. comm.) presented an example of regeneration of another type. It is approximately 150 feet in height and 60 feet in breadth at the base, the angle of slope being 70°. The whole surface of the slip was covered in a felt of lichens (*Stereocaulon ramulosum* and Cladonia sp. 4 to 6 inches in depth). Growth is prolific on soil-covered areas. Many herbaceous types and soil binders have firmly established themselves among the lichens in a completely natural succession. Pohutukawa regeneration is most striking and in accordance with its habit is one of the toughest and

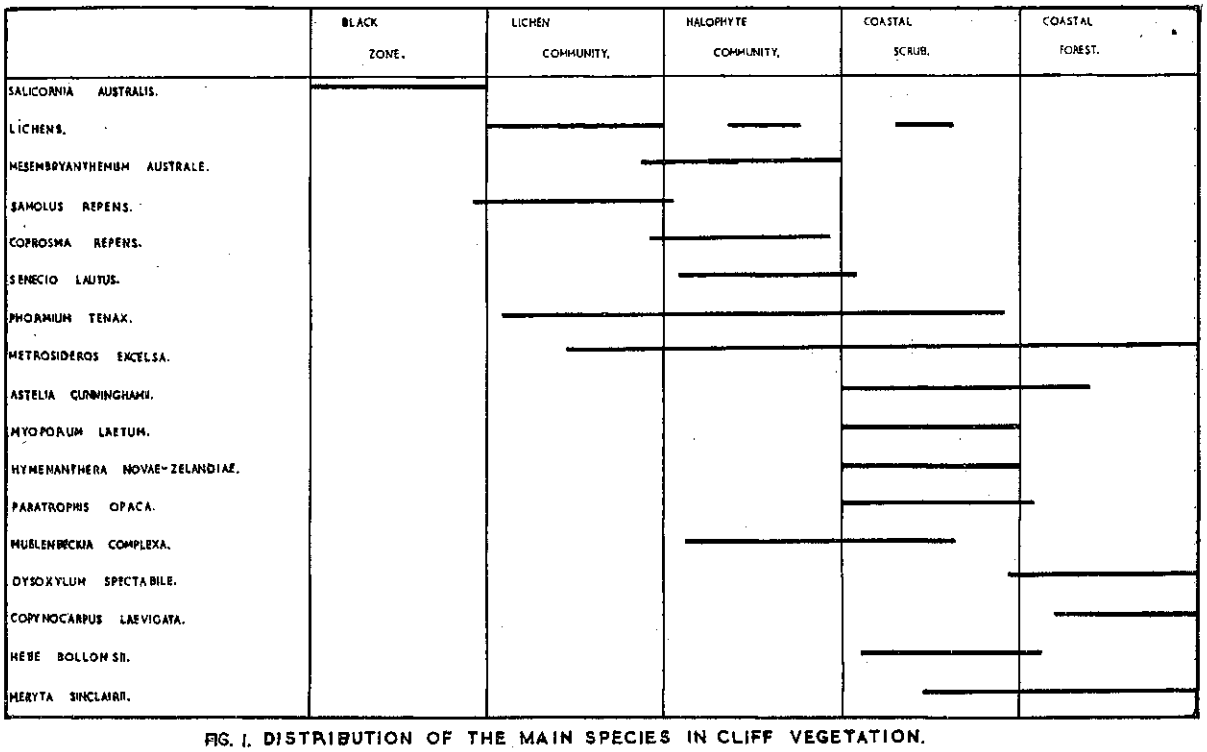

FIG. 1. DISTRIBUTION OF THE MAIN SPECIES IN CLIFF VEGETATION.

hardiest of coastal trees. Young trees and seedlings are fairly evenly distributed over the whole face of the slip and even on bare rock some young plants have taken root where other species could not survive. Some of the older trees have reached 3 to 4 feet in height and there are indications that these were established almost immediately following the slip. Colonization is also taking place by marginal advance of species from the bush.

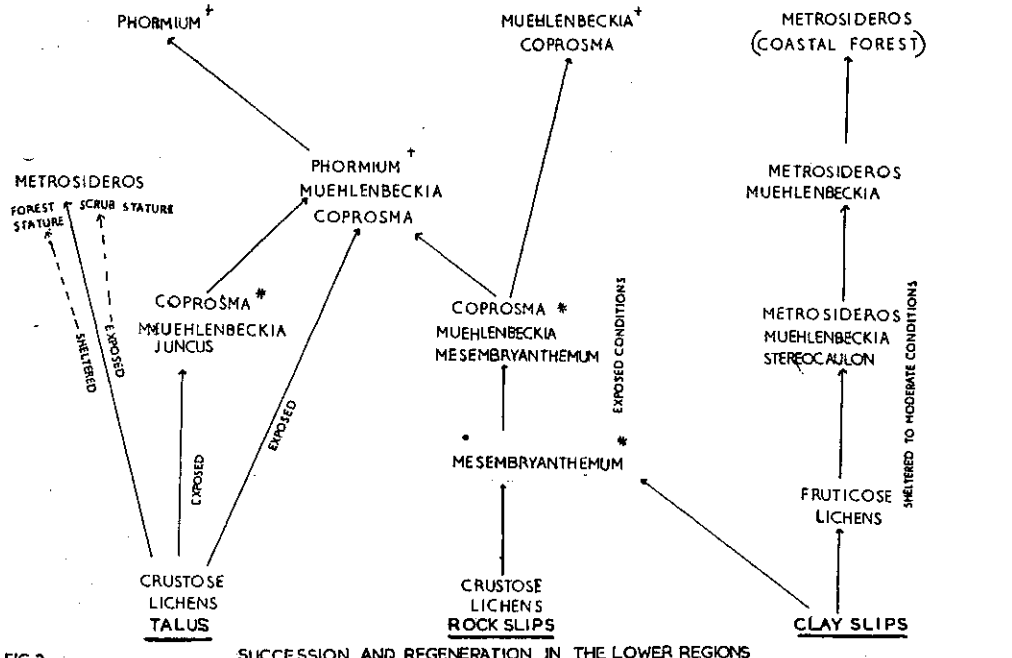

FIG. 2. SUCCESSION AND REGENERATION IN THE LOWER REGIONS OF THE CLIFFS.

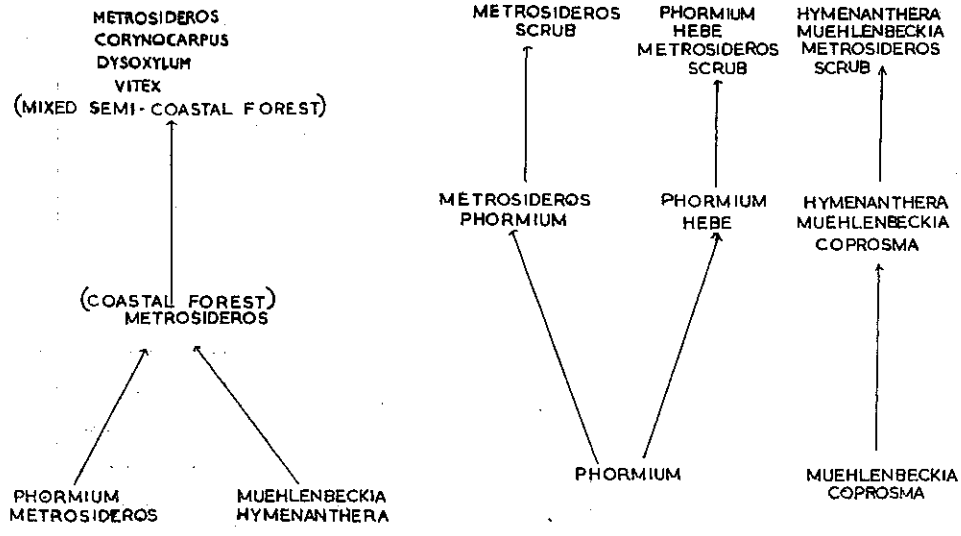

FIG. 4. FORMATION OF COASTAL FOREST (CONFINED TO SHELTERED & SOUTHERN ASPECTS.)

FIG. 3. SUCCESSIONS UP TO COASTAL SCRUB (TYPICAL OF THE HIGHLY EXPOSED HABITATS OF THE NORTH COASTS.)

SUCCESSIONS IN THE HIGHER REGIONS OF THE CLIFFS (THESE SUCCESSIONS MAY FOLLOW ON FROM THE TYPE DEPICTED IN FIG. 2.)

THESE SUCCESSIONS MAY BE SUBJECT TO MUCH VARIATION & ARE SPECULATIVELY BASED ON OBSERVATIONS OVER A SHORT PERIOD OF TIME. THERE MAY ALSO BE REPETITION OF THE SUCCESSION AT ANY STAGE FOLLOWING A SLIP.

The more important of these are *Leptospermum scoparium, Muehlenbeckia complexa* and again *Metrosideros excelsa. Muehlenbeckio complexa* and *Phormium tenax* (flax) have both established successfully on the upper and middle regions of the slip.

The approximate frequencies of the species established on this slip are recorded for future reference:

Species	Frequency
Stereocaulon ramulosum	A
Asplenium lucidum	C
A. flaccidum	O
Cyathea dealbata	R
Blechnum procerum	R
Doodia media	F
Lycopodium volubile	L.A
Astelia cunninghamii	C
Dianella intermedia	C
Phormium tenax	L.A
Thelymitra longifolia	O
Peperomia urvilleana	C
Acianthus sinclairii	C
Microtis unifolia	O
Muehlenbeckia complexa	C
Oxalis corniculatus	F
Pimelea urvilleana	C
Leptospermum scoparium	C
Nothopanax arboreum	R
Hebe parviflora	O
H. bellonsii	O
Olearia furfuracea	O
Hypochaeris radicata	F
Geniostoma ligustrifolium	R

A = abundant; C — common; F — frequent; 0 — occasional; R — rare; L.A. — locally abundant.

2. *Talus Succession*

The type of succession taking place on talus accumulations is largely dependent on proximity to the sea. Accumulations at higher levels are out of reach of heavy salt spray, and therefore initial establishment is influenced mainly by the lack of moisture and unstable nature of the talus. The lower accumulations are quickly covered by *Muehlenbeckia complexa, Mesembryanthemum australe, Coprosma repens, Samolus repens, Aster subulatus* and other species peculiar to the upper regions of boulder beaches. The more important physionomic species are soil binders found in similar situations or habitats in the maritime vegetation.

A great number of weeds is found established in the earlier stages of colonization. They are probably opportunists, as they do not occur in the later stages of succession where they are unable to compete with larger native species such as *Phormium tenax* (flax) and various scrub components. Among the more important weeds and herbaceous species are: *Hypocharis radicata, Haloragis erecta, Phytolacca octandra, Bidens pilosa, Sonchus asper, S. oleraceus, Senecio lautus, Gnaphalium luteoalbum, G. japonicum, G. collinum* and *Erigeron canadense.* Clumps of *Astelia cunninghamii, Arundo conspicua, Juncus polyanthemos* and creeping mosses of *Tetragonia trigyna* add to the complexity of the overall pattern of the plant cover.

The progress of talus succession beyond these initial stages appears to be quite slow and from observations made more than one type of succession is possible.

Discussion of Successions

Succession on slips and talus slopes follow the same general pattern The course of succession .is limited by the factors influencing the cliff zonation Succession proceeds no further than the 'climax' for the zone in which it occurs.

In the lowest regions the succession may not proceed beyond the form of a halophyte community typical of the lower zone. See fig. 2.

At higher altitudes the succession passes through this halophyte stage to either a pure flax community of a coastal scrub community. Alternatively flax may give way to coastal scrub. See fig. 3.

The establishment of coastal forest (pohutukawa dominant) or semi-coastal forest (karaka-kohekohe-puriri-pohutukawa dominant) is seldom achieved in the exposed regions of the cliff. In sheltered positions, pure stands of pohutukawa forest have developed in proximity to the sea which grade into semi-coastal forest. There is evidence to suggest that coastal forest (pohutukawa dominant) may have developed directly from a lichen community of the type seen on slips. See fig. 4.

SUMMARY:

1. There is a definite zonation of communities in the cliff vegetation of Marotiri.

2. This zonation is modified with changes in aspect and exposure. In exposed situations the Black Zone, the lichen community, the halophyte community and the zone of coastal scrub increase in width. In sheltered situations these zones are compressed and there is a corresponding increased development of coastal forest. Certain of the coastal scrub species are eliminated and the halophyte community may entirely disappear.

3. The most important factor controlling the zonation described is believed to be wind-carried salt-spray.

4. This basic zonation is extensively modified by local environmental conditions, in particular:

(a) Available soil moisture.

(b) Nature of the substratum and depth of soil.

(c) Cliff erosion.

5. Cliff successions are initiated by slips and rock falls. The final equilibrium or 'climax' state of the vegetation on slips is determined by its position within the local zonation pattern.

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