thinner towards the north-east and on the northern side of Rakino Island is about 7 in. thick—probably a thin dusting of it has influenced soil fertility on the Noisies Is. further north. On both islands, it covers fossil yellow-brown earths which, on Motutapu, appear to have been podzolised in places, indicating that at some stage prior to the eruption kauri had been a component of the vegetation.

A profile near Islington Bay is:

Rangitoto ash	A_1	6 in. black sandy loam with fine granular structure,
	A_{11}	10 in. dark grey free medium sand,
	C	5 in. slightly compact dark greyish brown structureless sand,
Buried podzolised soil		3 in. white structureless silt loam,
		on yellowish clay.

On Rakino Island, the profile is:

Rangitoto ash	A_1	7 in. black to dark grey-brown friable fine sandy loam, with strongly developed medium granular structure,
Buried yellow brown soil		*on* yellowish brown clay.

The pH of the soil from Islington Bay is 6.9 in the topsoil and 7.3 in the subsoil. The base saturation of the topsoil is 83 per cent, and of the subsoil 6.3 per cent. Both of the soils are youthful, having reached the nigrescent stage of soil formation, the main morphological features being a deep dark topsoil containing much well-decomposed humus and the absence of a B horizon.

The ash appears to be only slightly weathered, but the high base saturation figures indicate that weathering is almost sufficiently rapid to keep pace with the rate of leaching. Considering the age attributed to it, the soil appears to have undergone little development.

The lack of old forest roots in exposed profiles of the buried soils suggests the possibility of a scrub cover at the time of the eruption and calls for further work.

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Forest Vegetation of the Inner Islands of the Hauraki Gulf

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Forest Remnants and the Primitive Vegetation

The primitive vegetation of Auckland's larger inshore islands, with the exception of Rangitoto, has been either destroyed or greatly modified. Nevertheless, on some islands, particularly Waiheke (26,000 acres) and Ponui (4,400 acres), there are many remnants of both primary and secondary forest. When considered in relation to the present soil pattern and to early accounts, these indicate an original pohutukawa-taraire-kauri forest pattern in which kauri *(Agathis australis)* was associated with the strongly leached and in parts podzolised northern yellow-brown earths of the upper valley walls and ridges; taraire *(Beilschmiedia tarairi)* was associated with the moderately leached northern yellow-brown earths of the sheltered coastal and inland valleys; and pohutukawa *(Metrosideros excelsa)* occurred on the weakly leached and skeletal northern yellow-brown earths of the coastal slopes and cliffs exposed to wind-carried salt spray (cf. Taylor, 1960).

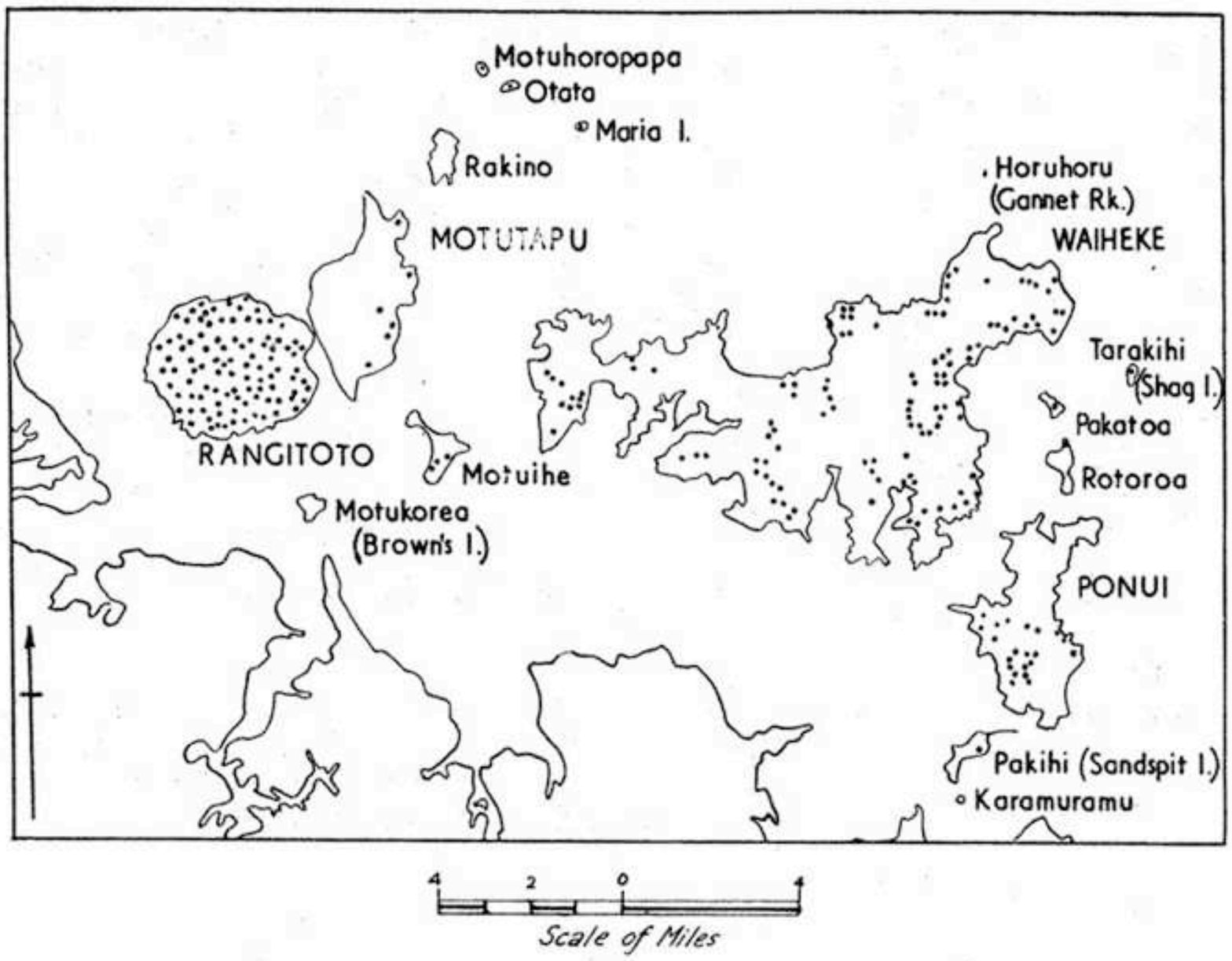

FIGURE 1.—*Distribution of remnants of original forest cover on the islands of the inner Gulf.*

Kohekohe *(Dysoxylum spectabile)*, puriri *(Vitex lucens)*, and karaka *(Corynocarpus laevigata)*, occurred with pohutukawa on the less exposed coastal slopes. In the valleys kohekohe and tawa *(Beilschmiedia tawa)* were second in numbers to the taraire. Rimu *(Dacrydium cupressinum)* was also present while pukatea *(Laurelia novaezelandiae)* and kahikatea *(Podocarpus dacrydioides)* occurred on more poorly drained sites. Kirk (1878) records hard beech *(Nothofagus truncata)* from near sea-level on Waiheke and Miss M. Sexton (pers. comm.) reports that it is still present at Onetangi. A single stand of this species, and some scattered trees, are also present on the southern slopes of Ponui.

The positions of the remaining forest stands are shown on the accompanying map. In a typical stand the slopes and ridges are occupied by kauri-dominated or mixed-dominant secondary forest which usually surrounds a remnant of primary taraire-dominated forest in the valley. Tree species commonly present in the secondary forest are taraire, tawa, kohekohe, puriri, mamangi *(Coprosma arborea)*, pigeonwood *(Hedycarya aborea)*, rewarewa *(Knightia excelsa)*, and nikau *(Rhopalostylis sapida)*. Houpara *(Pseudopanax lessonii)* and kowhai *(Sophora microphylla)* are prominent near the coast.

The presence of secondary kauri is dependent on seed sources and where, as on Ponui, large hollow trees were left standing by millers, dense stands of young kauri with some tanekaha *(Phyllocladus trichomanoides)* have developed. All sizes of kauri can be found between small saplings and trees up to 24 in. in diameter. In those valleys where browsing and trampling by cattle is slight, taraire, tawa, and kohekohe are also regenerating. Thus, when seed is available, successional trends are towards re-establishment of the vegetation pattern described earlier.

The critical factors involved in the development of this pattern are as yet poorly understood. Seedlings and small saplings of taraire and tawa can be found among the kauri stands but larger size classes are seldom seen. There is no indication of a replacement of kauri by taraire on these soils. Kauri seedlings are practically never seen under the taraire canopy, a fact which is usually attributed to a postulated inability of kauri to establish and grow under low light intensities.. Recent work by Bieleski (1959), however, has shown that kauri can establish in light intensities as low as 1.5% that of full daylight, so that it is clear that other factors are involved. Much might be learnt by focussing attention on the bound-

ary between the kauri and taraire communities.

There are few forest remnants on Motutapu (3,800 acres), Motuihe (450 acres), or Pakihi (270 acres). No sizable stands have survived on Rakino (370 acres), Rotoroa (220 acres), Motukorea (140 acres), Pakatoa (65 acres) or Karamuramu (12 acres). It is probable that the vegetation of these islands was similar to that already described though taraire would have been more prominent on the weakly leached red-brown loams of Motukorea.

On the smallest islands, pohutukawa, karo *(Pittosporum crassifolium)* and houpara are the most important species. The vegetation of Tarakihi or Shag Rock (12 acres), the Four Islands (David Rocks) and parts of Motuhoropapa (25 acres) and Maria Island (4 acres), is apparently close to the primitive condition. Mr. P. A. S. Stein (pers. comm.) reports that vegetation on the central part of Maria Island was destroyed by bombing practice during the war but has since regenerated. The vegetation of Otata (45 acres), the largest of the Noises group, includes mahoe *(Melicytus ramiflorus)*, mapou *(Myrsine australis)*, manuka and flax *(Phormium tenax)* communities, most of which have developed following fires. There are also a number of smaller islets, some with unmodified vegetation, where studies could be made to elucidate the relationships between the plants and nesting sea-birds present. These include Papakohatu (Crusoe Is.), Tombolo Is. (Noises group), The Three Sisters, Horuhoru (Gannet Rock), and two unnamed islets at the mouth of Putiki Bay, Waiheke.

Effects of Maori and European Settlement

There is evidence of intensive Maori settlement around most of the coastline of these islands. Many terraced pa sites and ridges covered with pits, indicate the extent to which the coastal vegetation was altered. To the Maori, an embayed coastline would have offered a source of food from fishing, headlands which could be turned into defensive positions, and a means of communication by sea. He would have required timber for stockade posts, canoes, and firewood, apart from any land he cleared for cultivation.

Alteration of the vegetation by the Maori was almost certainly not restricted to the coastline. Where direct archaeological evidence is not available, some measure of the extent to which land was cleared further inland may be possible from botanical evidence. On many of the inland slopes and ridges of Ponui and Waiheke, there are present large-diameter pohutukawa trees which probably established before the arrival of the European; annual ring counts are necessary to verify this. Observations of relatively undisturbed coastal forest on some of the outer islands of the Hauraki Gulf have shown that pohutukawa does not normally occur at any distance from the coast. It does not establish under a closed forest canopy, or even in small canopy gaps caused by fallen trees. Thus it appears likely that the trees mentioned above have established under high light intensities with manuka *(Leptospermum scoparium)* and kanuka *(L. ericoides)* following clearing of the original forest.

The few accounts of the early nineteenth century do not help greatly in obtaining a clearer picture of Maori land use at this time. Marsden noted that part of Motukorea was under cultivation in 1820 (Elder, 1932), and in 1827 D'Urville described the island as "almost completely covered with a thick carpet of very green grass".

An intriguing question concerns the vegetation history of Motutapu. The major event in the island's history has been the eruption of Rangitoto in approximately 1200 ± 50 A.D. (Fergusson and Rafter, 1959) which mantled both Motutapu and the neighbouring Rakino with a layer of basaltic ash. This shower was still hot enough to carbonise vegetation when it reached the ground (Brothers and Golson, 1959; Grant-Mackie, 1960), but so far carbonised remains of large trees have not been found (cf. Taylor, 1960). This may be due to insufficient searching but if not, then it is possible that even as early as 1200 A.D., Polynesians had made extensive clearings of the original forest. The presence of man on Motutapu at this time is shown by the finding of artefactual and food remains beneath the Rangitoto ash by Mr. J. Golson (pers. comm.). There is as yet no evidence to determine how large the population is likely to have been.

The arrival of the European in the early part of the nineteenth century initiated

widespread destruction of the remaining large areas of forest. Cruise (1820) records visiting the inner islands in that year to collect kauri for spars. In the succeeding years large quantities of kauri were taken from the eastern slopes of Waiheke and also from Ponui. After logging came gum-digging, widespread fires and the establishment of pastures, which reduced the forest to the steeper slopes and gullies. Manuka and kanuka communities established on sites where management was inadequate to maintain pasture and Waiheke was for many years one of the chief sources of Auckland's firewood.

Various mammals were introduced during the latter part of the nineteenth century. Rabbits and opossums established on most of the larger islands. Wallabies and fallow deer were introduced to Motutapu and have subsequently spread to the adjacent Rangitoto.

The Problem of Rangitoto

The vegetation of Rangitoto (5,800 acres) is a complete contrast to that of the other islands and although in places it has been modified by fire or damaged by introduced mammals, the greater part is still little disturbed. The island's communities constitute the finest example of vegetation development on basaltic lava flows in New Zealand. These flows are of the aa type and are partially covered by a discontinuous short forest of pohutukawa *(Metrosideros excelsa)* and pohutukawa x rata hybrids *(M. excelsa* x *M. robusta)*. The intervening areas of lava are often completely bare of plants, apart from lichens.

The apparent youth of this vegetation was pointed out by Millener (1953) who described a process of plant colonisation in which isolated plants, usually pohutukawa, establish directly on the broken surface of the lava. *Senecio kirkii*, puka *(Griselinia lucida)*, fivefinger *(Nothopanax arboreum)*, karamu *(Coprosma robusta)*, *Astelia banksii*, and many other species establish in the shade and litter of these initial colonisers thus forming "islands" of vegetation. Millener (loc. cit.) estimated that the larger "islands" were spreading at rates averaging 15 cms per year and that the rate of spread decreased with decreasing size of the "island". Ring counting gave figures up to 130, and Millener considered that 150-200 years could be taken as the maximum age of any tree on the island. Thus this evidence suggests that plant colonisation of Rangitoto began somewhere between 1750 and 1800.

On the other hand, the exposure of Rangitoto ash described from Motutapu by Brothers and Golson (1959) shows only one primary ash shower, that of 1200 A.D., and this ash is not exposed above the lava flows of Rangitoto itself. On the evidence of human occupation levels in the Motutapu site, Brothers and Golson (loc. cit.) suggest that scoria cone building and lava emission took place quite quickly after the ash eruption since it is unlikely that people would have lived close to an active volcano. If this is the case there is apparently a period of 450-500 years following the eruption during which little or no plant colonisation took place.

The large uncolonised areas of lava do show that vegetation succession is extremely slow on some parts of the gently sloping lava cone. These areas have remained bare for at least 150 years, during which time pohutukawa seeds would have been blown on to the lava each year. The difference between colonised and uncolonised areas cannot be explained satisfactorily by correlation with topography, since in many places both lava ridges and gullies are covered with vegetation while in others they are bare.

Part of the explanation for the discontinuous pattern of vegetation establishment may lie in the occurrence of localised ash eruptions subsequent to the lava outpouring. Mr. N. H. Taylor (pers. comm.) found what appeared to be a young coarse ash soil overlying one of the outer scoria cones and it may be found that the vegetation pattern is correlated with the distribution of ash accumulations. However, this would not explain the apparent long delay in initial colonisation. An answer to this problem may have to be sought in the unfavourable but variable edaphic conditions of the aa lava flows themselves. Any factors which influence moisture and available nitrogen levels must be studied in relation to the establishment and growth of the vegetation "islands". It will be of value to measure the number of new centres of plant colonisation which establish each year as well as their initial

rate of growth. If a satisfactory explanation is not possible along these lines, it may be necessary to postulate a more recent date for the formation of the lava flows. An exact geological dating for this event would avoid the dangers of arguing from botanical evidence alone. Dr. R. L. Bieleski (pers. comm.) has suggested that an endeavour be made to collect carbonaceous material from beneath the margin of the lava flows at their contact with the old sea floor.

Conclusion

Apart from Rangitoto, there has as yet been little intensive work carried out on the vegetation of the inner islands. A number of ecological topics worthy of further study emerge from the foregoing discussion.

1. Analysis and mapping of the larger remnants of primary and secondary forest with the objective of determining the factors responsible for development of the basic pohutukawa-taraire-kauri vegetation pattern and its variations.
2. Investigation of the history of this vegetation with particular respect to the length of time and areal extent of modification by Maori and Moa-hunter settlement. There is an excellent opportunity here for ecologists and field archaeologists to carry out co-operative studies.
3. Survey of the various introduced animals present on each of the islands and determination of the extent to which each is altering vegetation succession.
4. Vegetation surveys of the smaller islands and islets with particular attention given to the relationships between the plants present and colonies of nesting sea birds.
5. Study of the edaphic conditions limiting plant growth on Rangitoto, together with a more detailed examination of the island's recent geological history.

In the inner islands of the Hauraki Gulf, biologists and naturalists have a readily accessible field for study which can throw light on the natural communities originally present on lowland areas of the Auckland isthmus. It is to be hoped that some definite programme of vegetation conservation can be implemented on these islands so that at least representative stands are preserved for the benefit of future generations.

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