Plant Invasions of New Zealand with Reference to Lord Howe, Norfolk, and the Kermadec Islands.

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With three Diagrams and eleven Tables in the Text.

IN a series of eight papers in this journal, 1916–19, I have dealt with the floras of New Zealand proper and the islands which outlie from it to the north (Kermadecs), east (Chathams), and south (Stewart and Aucklands), islands which must have received a large part of their flora either directly from New Zealand or from invasions which passed near to them on the way thither. In these papers I have made a great many predictions based upon my hypothesis of age and area, and have always found them borne out by the facts. It is almost needless to say that in some cases these facts were already known to New Zealand and other botanists, though very many are new. My chief object in making all these predictions was to marshal the facts and to show (and I venture to think that I have shown) that age and area can be relied upon as a guide in the taxonomic distribution problems of a well-defined area like New Zealand and its immediately outlying islands. I shall now go farther afield, and endeavour to trace farther towards their source some of the invasions of plants which appear to have reached New Zealand from the north or north-west.

One of the principal objects kept in view in this work is to show that the floras of the islands which lie between New Zealand and Australia or Polynesia fit in with my hypothesis of age and area, and are explicable on that hypothesis; further, that they are also capable of being dealt with by aid of numerical methods, like the floras of New Zealand itself, and, therefore, that the invasions of plants must have been by land—casual trans-aqueous carriage would not produce such results.

In the first papers of this series, dealing with Ceylon (7), by means of statistics of actual distribution of the various species, which were taken from Trimen's Flora, and which showed that the least widely distributed species in the island were those confined to Ceylon, the next those confined to Ceylon and South India, and the most widely distributed in the island those

which had a greater distribution abroad than merely to South India, I deduced the conclusion that in a given country the area of distribution of a species (working always with groups of at least ten allied species) depended upon its age in that country. The correctness of this deduction was then confirmed by observations upon the floras of New Zealand and its surrounding islands, which gave exactly parallel results, and also by observations on the floras of Hawaii, Jamaica, &c.

In my first paper on the New Zealand flora (9), I assumed the correctness of the hypothesis (which for convenience I have termed that of 'age and area'), and by means of the diagram here reproduced I predicted the result

DIAGRAM I.

of the entrance of a single species (W) at the centre of New Zealand, which spread at a uniform rate (represented by the triangle), and which subsequently gave rise to local endemic species (E 1 to E 10) in a casual way. The length of New Zealand, supposed 1,000 miles, being divided into ten zones of equal width, and the number of endemics found in each zone being counted (each endemic of course being supposed to spread uniformly like the parent species, as indicated by the similar triangles), the result shows a curve rising and falling to and from a maximum (sometimes two) which is somewhere near the point of entry of the original species. In the present case, for example, the numbers of endemics in each consecutive zone are—

0 3 5 8 9¹ 8 7 3 2 2

It will be well to make clear at this point that if the entry of the original species be at one end, instead of in the middle of New Zealand, the curve will in general show its maximum at or near that end. The maximum,

¹ The thicker type indicates the maximum in this and the following table.

in other words, is in general at or near the point of entry of the original species. Further, it is not necessary that the entry should be at a point. If it were, for example, by the whole zone from 300 to 700 miles, the resulting curve would be of the same type.

Examination of the actual figures for the distribution of the New Zealand flora soon showed that every genus did in fact give a curve of this type, so that a fact of great significance was thus discovered, and one which may be considered without reference to the hypothesis of age and area, by whose assistance it was originally found. The distribution of the numbers followed two general types, as seen in the examples quoted below :

TABLE I.

	0-100m.	1-200	2-300	3-400	4-500	5-600	6-700	7-800	8-900	9-1000	10-1080
<i>Ranunculus</i> . .	—	2	3	5	7	11	12	18	18	10	2
<i>Drimys</i> . . .	2	2	2	2	2	3	3	2	1	1	1
<i>Pittosporum</i> .	11	11	11	11	8	7	6	6	5	5	1
<i>Colobanthus</i> .	—	—	—	—	—	2	3	3	4	2	—
<i>Coprosma</i> . .	12	12	15	16	17	18	18	16	15	12	3
<i>Metrosideros</i> .	8	8	8	8	5	6	6	2	1	1	1
<i>Ligusticum</i> .	—	1	1	1	2	7	8	9	7	6	3
<i>Veronica</i> . .	6	6	10	14	15	39	41	43	38	26	2
<i>Utricularia</i> .	3	3	3	1	1	1	1	1	—	—	—
<i>Pimelea</i> . . .	4	4	5	5	7	8	8	6	5	4	1

In all cases the figures show a maximum with a regular falling off, but in some, e.g. *Pittosporum*, the maximum is to the north, with no falling off to northwards, in others, e.g. *Ranunculus*, it is further south, with a falling off in both directions, and, as the examples chosen illustrate, the maximum may be at any zone from 5-600 to 8-900 miles. This phenomenon of a simple curve to a maximum (or two) is shown by every genus in the flora.

These curves represent simply the naked unvarnished facts of taxonomic distribution, and they may be considered without reference to my hypothesis of age and area. It is quite clear from them that, for example, the previous distributional history of *Pittosporum* was different from that of *Ranunculus* or *Veronica*. And it is equally clear that in broad outline—which is all that we are as yet concerned with in taxonomic distribution—that distribution was not determined by biological agents, but by a more purely mechanical cause.

Not only so, but it is also extremely difficult to believe that such regularity as this, and regularity of *two* types, would be shown as the result of casual arrivals across a wide expanse of water. It is hard to believe that it can be explained—again in broad outline, and to the extent of say 90 per cent. of the flora—by anything but a previous *land* connexion of New Zealand with Indo-Malaya, and with other sources of flora. My critics, who frequently insist upon applying age and area to individual cases, force upon me the opinion that neither biological agencies nor casual distribution across the sea have had any hand in the present distribution of the New Zealand flora.

This, however, is not my own opinion; what I maintain is that in about 90 per cent. or perhaps more of the cases, the distribution has been by land, and has been chiefly mechanical, so far as its broad outline is concerned. Age and area must not be applied to individual cases.

Another point whose misunderstanding is frequently a stumbling-block in the way of acceptance of age and area, is a confusion of the two types of distribution known as taxonomic and ecological. The former, with which alone age and area is concerned, takes no account of the density or rarity of a given species upon the ground, but simply of the total area over which it is found, while the latter is much more concerned with the density or rarity of a given species under a given set of ecological conditions. From the taxonomic or age and area point of view there is no difference between the species represented by the two groupings of letters below:

and in this connexion it is a pleasure to acknowledge the justice and value of Mrs. Arber's criticism (1), while drawing attention to the fact that she incidentally refers to, that people have in general regarded species with small areas as species that are dying out (cf. 10, p. 349). If this can no longer be accepted, then my general contention that endemics of small area are not necessarily relics of past floras, but are usually young species that have not had time to spread, receives very strong support.

Examining these zonation figures in detail, one at once finds that a great many genera show their maximum at the far north of New Zealand, like *Pittosporum*, *Metrosideros*, and *Utricularia* in Table I. They do not show any falling off to the northwards, even though the figures may be the same for the first two, three, or even four zones. Now a consideration of Diagram I, given on p. 472, will show that the maximum of endemics must *in general* occur somewhere near to the point or zone of original entry of the first species to arrive from abroad. Consequently when one deals, as is now the case, with a large number of different genera, it is clear that the variations to one side or the other will cancel one another, and, therefore, that the region of entry into New Zealand (*as now limited* by the ocean) was within the first 300 or at most 400 miles of the northern part of the North

Island. These species with northern entry are fairly easily segregated from the rest of the flora.

As already indicated in (10), p. 356, Table I, we may look upon about thirty-three families of the ninety-one of the New Zealand flora as showing this northern maximum. But it would be a great mistake to assume that all members of these families entered from the north. So many of them show a northern maximum that their figures swamp those of any that may have entered in any other way, but a more satisfactory result is obtained by going through the figures genus by genus. Even then one finds genera in which there are some wides with evident northern entry, and others with equally evident entry by some other route, but these are few in comparison with the total, and for the present it is better not to attempt to go into too minute detail.

Examining the whole of the genera of the New Zealand flora as given by Cheeseman (all the larger of them are given in Tables V and VI of (9)), I have arrived at the general tentative result given in Table II below. While the northern types seem to divide into a northern (proper) and a Kermadec invasion (11, p. 279), the rest seem to nie to split into a western and a southern invasion, a considerable number (western) having their centre of greatest density between 4-500 and 6-700 miles from North Cape; for instance, *Drimys*, *Coprosma*, and *Pimelea* in Table I. In such cases

the very marked tapering off of the numbers both to north and to south makes it fairly probable that they must have commenced at the middle, but these genera run imperceptibly into those of the more southern group which we have already considered in a previous paper, so as to render it very difficult in many cases to separate them. A glance at the map, showing the broadly triangular way in which the water of less than 1,000 fathoms meets the west coast of New Zealand, will help to make it more clear why this should be so. But I am inclined to think, none the less, that my figures indicate that there were probably two different invasions, a western and a southern. At the time when the greater part of the sea floor to 1,000 fathoms was dry land, it is clear that a species arriving at the point where stands the N of 'North I.' would be able to spread out fanwise, and might ultimately reach (the existing) New Zealand along a wide front.

DIAGRAM 2. New Zealand and outlying islands. The dotted line is the 1,000 fathom limit.

There is so distinct a group with maxima in the far south, comprising a great part of eighteen families (10, p. 359), that I am inclined to think that they formed a separate southern invasion, but as I have pointed out (10, 361), the origin of this invasion is a complex question that must be left for the present unanswered, though I am inclined to put it down to Antarctica. It is conceivable, though improbable, that its route was along the southern side of the bridge by which the western invasion probably arrived.

There follows a complete list of the New Zealand genera, giving in each case the invasion to which I incline to attribute it, whether northern (N), northern by the Kermadecs (K), western (W), southern (S), and giving also the northern islands, Kermadecs (K), Norfolk (N), or Lord Howe (H), on which they occur.

TABLE II.

The first entry after the name of a genus, e.g. SW, refers to the invasion or invasions (Northern, Kermadec, Western, or Southern) to which the general distribution of its endemics (and wides when they do not range the whole length of New Zealand) points.

A ? after a letter refers only to that letter, e.g. SW ? means pretty certainly S and perhaps W.

The second entry (K, N, H) refers to the islands (Kermadecs, Norfolk, Howe) in which the genus is found.

Genera in brackets (in small letters) occur only in the Kermadecs in the New Zealand area.

Genera in capitals are endemic; if in brackets endemic in the Chathams or Aucklands.

DICOTYLEDONS	Invasion.	Islands.	DICOTYLEDONS	Invasion.	Islands.
1. Ranunculaceae			27. <i>HOHERIA</i>		
1. <i>Clematis</i>	W	NH	28. <i>Gaya</i>	S	—
2. <i>Myosurus</i>	W?	—	29. <i>Hibiscus</i>	N	NH
3. <i>Ranunculus</i>	SW?	N	11. Tiliaceae		
4. <i>Caltha</i>	WS	—	30. <i>ENTELEA</i>		
2. Magnoliaceae			31. <i>Aristolelia</i>	W?	—
5. <i>Drimys</i>	WN	H	32. <i>Elaeocarpus</i>	W?	—
3. Cruciferae			12. Linaceae		
6. <i>Nasturtium</i>	W?	N	33. <i>Linum</i>	W?	N
7. <i>Cardamine</i>	S	K	13. Geraniaceae		
8. <i>Sisymbrium</i>	W	—	34. <i>Geranium</i>	W?	KN
9. <i>PACHYCLADON</i>			35. <i>Pelargonium</i>	W?	NH
10. <i>Capsella</i>	?		36. <i>Oxalis</i>	W?	KH
11. <i>Lepidium</i>	SW	H	14. Rutaceae		
12. <i>NOTOTHLASPI</i>			37. <i>Phebalium</i>	N	
4. Violaceae			38. <i>Melicope</i>	N	KH
13. <i>Viola</i>	WS	N	15. Meliaceae		
14. <i>Melicytus</i>	WN	KN	39. <i>Dysoxylum</i>	N	NH
15. <i>Hymenanthera</i>	W	NH	16. Olacineae		
5. Pittosporaceae			40. <i>Pennantia</i>	NW	N
16. <i>Pittosporum</i>	N	KNH	17. Stackhousiaceae		
6. Caryophyllaceae			41. <i>Stackhousia</i>	W	—
17. <i>Gypsophila</i>	W?	—	18. Rhamnaceae		
18. <i>Stellaria</i>	SW		42. <i>Pomaderris</i>	N	—
19. <i>Colobanthus</i>	S	—	43. <i>Discaria</i>	W?	—
20. <i>Spergularia</i>	?	—	19. Sapindaceae		
7. Portulacaceae			44. <i>Dodonaea</i>	N	NH
21. <i>Claytonia</i>	S	—	45. <i>Alectryon</i>	N	—
22. <i>Montia</i>	S	—	20. Anacardiaceae		
23. <i>HECTORELLA</i>			46. <i>Corynocarpus</i>	KW	K
8. Elatinaceae			21. Coriariaceae		
24. <i>Elatine</i>	?	—	47. <i>Coriaria</i>	WN	K
9. Hypericaceae			22. Leguminosae		
25. <i>Hypericum</i>	W?	—	48. <i>CORALLOSPARTIUM</i>		
10. Malvaceae			49. <i>Carmichaelia</i>	WS	H
26. <i>Plagianthus</i>	W?	—	50. <i>NOTOSPARTIUM</i>		

DICOTYLEDONS	Invasion.	Islands.	DICOTYLEDONS	Invasion.	Islands
51. <i>Clanthus</i>	N	N	103. <i>Galium</i>	W?	—
52. <i>Swainsona</i>	W	—	104. <i>Asperula</i>	W?	—
53. (<i>Canavalia</i>)		(KNH)	38. Compositae		
54. <i>Sophora</i>	W?	H	105. (<i>Ageratum</i>)		(K)
23. Rosaceae			106. <i>Lagenophora</i>	W?	K
55. <i>Rubus</i>	W?	—	107. <i>Brachycome</i>	SW	H
56. <i>Geum</i>	W? S?	—	108. <i>Olearia</i>	W	H
57. <i>Potentilla</i>	W?	—	109. (<i>PLEUROPHYLLUM</i>)		
58. <i>Acaena</i>	?	K	110. <i>Celmisia</i>	S?	—
24. Saxifragaceae			111. <i>Vittadinia</i>	W?	—
59. <i>Donatia</i>	S	—	112. <i>HAASTIA</i>		
60. <i>Quintinia</i>	WN?	—	113. <i>Gnaphalium</i>	WS?	KNH
61. <i>IXERBA</i>			114. <i>Raoulia</i>	S?	—
62. <i>CARPODETUS</i>			115. <i>Helichrysum</i>	W	—
63. <i>Ackama</i>	N	—	116. <i>Cassinia</i>	W	H
64. <i>Weinmannia</i>	W?	—	117. <i>Craspedia</i>	W?	—
25. Crassulaceae			118. <i>Stegesbeckia</i>	K	K
65. <i>Tillaea</i>	WS?	—	119. <i>Bidens</i>	K	KNH
26. Droseraceae			120. <i>Cotula</i>	SW	KNH
66. <i>Drosera</i>	NWS?	—	121. <i>Centipeda</i>	W?	—
27. Haloragidaceae			122. <i>Abrotanella</i>	S	—
67. <i>Haloragis</i>	?	K	123. <i>Erechtites</i>	WS	NH
68. <i>Myriophyllum</i>	?	—	124. <i>BRACHYGLOTTIS</i>		
69. <i>Gunnera</i>	S?	—	125. <i>Senecio</i>	W	KNH
70. <i>Callitriche</i>	?	K	126. <i>Microseris</i>	W?	—
28. Myrtaceae			127. <i>Picris</i>	N?	N
71. <i>Leptospermum</i>	NW	H	128. <i>Crepis</i>	S?	—
72. <i>Metrosideros</i>	N	KH	129. <i>Taraxacum</i>	W?	—
73. <i>Myrtus</i>	N	—	130. <i>Sonchus</i>	W?	KNH
74. <i>Eugenia</i>	N	—	39. Stylidiaceae		
29. Onagraceae			131. <i>Phyllachne</i>	S	—
75. <i>Epilobium</i>	SW?	—	132. <i>ORÉOSTYLIDIUM</i>		
76. <i>Fuchsia</i>	?	—	133. <i>Forstera</i>	S?	—
30. Passifloraceae			40. Goodeniaceae		
77. <i>Passiflora</i>	N	NH	134. <i>Selliera</i>	W?	—
31. Cucurbitaceae			135. (<i>Scaevola</i>)		(K)
78. <i>Sicyos</i>	KN	KNH	41. Campanulaceae		
32. Ficoideae			136. <i>COLENSOA</i>		
79. <i>Mesembryanthemum</i>	NW	KNH	137. <i>Pratia</i>	WS?	—
80. <i>Tetragonia</i>	NW	KNH	138. <i>Lobelia</i>	WS?	KNH
33. Umbelliferae			139. <i>Isotoma</i>	SW?	—
81. <i>Hydrocotyle</i>	W	KH	140. <i>Wahlenbergia</i>	W?	KNH
82. <i>Asorella</i>	S?	—	42. Ericaceae		
83. <i>Eryngium</i>	W	—	141. <i>Gaultheria</i>	W	—
84. <i>Actinotus</i>	S	—	142. <i>Pernettya</i>	S	—
85. <i>Apium</i>	N?	KNH	43. Epacridaceae		
86. <i>Oreomyrrhis</i>	W	—	143. <i>Pentachondra</i>	W?	—
87. <i>Crantzia</i>	W?	—	144. <i>Cyathodes</i>	SW	—
88. <i>Aciphylla</i>	SW?	—	145. <i>Leucopogon</i>	NW?	H
89. <i>Ligusticum</i>	S	—	146. <i>Epacris</i>	W?	—
90. <i>Angelica</i>	S?	—	147. <i>Archeria</i>	W?	—
91. <i>Daucus</i>	W?	—	148. <i>Dracophyllum</i>	W	H
34. Araliaceae			44. Primulaceae		
92. <i>STILBOCARPA</i>			149. <i>Samolus</i>	?	KN
93. <i>Aralia</i>	S	—	45. Myrsinaceae		
94. <i>Panax</i>	W	KH	150. <i>Myrsine</i> (incl. <i>Rapanea</i>)	W?	KNH
95. <i>Meryta</i>	N	N	46. Sapotaceae		
96. <i>Schefflera</i>	?	—	151. <i>Sideroxylon</i>	N	NH
97. <i>PSEUDOPANAX</i>			47. Oleaceae		
35. Cornaceae			152. <i>Olea</i>	N	NH
98. <i>COROKIA</i>			48. Apocynaceae		
99. <i>Griselinia</i>	W?	—	153. <i>Parsonsia</i>	W?	—
36. Caprifoliaceae			49. Loganiaceae		
100. <i>Alseuosmia</i>	N	—	154. <i>Mitrasacme</i>	?	—
37. Rubiaceae			155. <i>Logania</i>	?	—
101. <i>Coprosma</i>	W	KNH	156. <i>Geniostoma</i>	N	H
102. <i>Nertera</i>	NWS?	—			

DICOTYLEDONS	Invasion.	Islands.	DICOTYLEDONS	Invasion.	Islands.
50. Gentianaceae			205. <i>Laurelia</i>	N?	—
157. <i>Sebaea</i>	W?	—	69. Lauraceae		
158. <i>Gentiana</i>	WS	—	206. <i>Beilschmiedia</i>	N	—
159. <i>Liparophyllum</i>	S?	—	207. <i>Litsaea</i>	N	—
51. Boraginaceae			208. <i>Cassytha</i>	N	—
160. <i>Myosotis</i>	WS	—	70. Proteaceae		
161. (<i>MYOSOTIDIUM</i>)			209. <i>Persoonia</i>	N	—
162. <i>TETRACHONDRA</i>			210. <i>Knightia</i>	N	—
52. Convolvulaceae			71. Thymelaeaceae		
163. <i>Ipomoea</i>	?	KNH	211. <i>Pilea</i>	W	H
164. <i>Calystegia</i>	WN?	KNH	212. <i>Drapetes</i>	S?	—
165. <i>Convolvulus</i>	W?	—	72. Lorantheae		
166. <i>Dichondra</i>	W?	—	213. <i>Loranthus</i>	WS	—
167. <i>Cuscuta</i>	?	—	214. <i>TUPEIA</i>		
53. Solanaceae			215. <i>Viscum</i>	WS	NH
168. <i>Solanum</i>	W?	KNH	73. Santalaceae		
54. Scrophulariaceae			216. <i>Fusanus</i>	N	—
169. <i>Calceolaria</i>	W?	—	217. <i>Exocarpus</i>	WS	NH
170. <i>Mimulus</i>	W?	—	74. Balanophoraceae		
171. <i>Mazus</i>	W?	—	218. <i>DACTYLANTHUS</i>		
172. <i>Gratiola</i>	W?	—	75. Euphorbiaceae		
173. <i>Glossostigma</i>	W?	—	219. <i>Euphorbia</i>	?	NH
174. <i>Limosella</i>	W?	—	220. <i>Poranthera</i>	W?	—
175. <i>Veronica</i>	S	KN	221. (<i>Aleurites</i>)		(K)
176. <i>Ouwisia</i>	S	—	222. (<i>Homalanthus</i>)		(K)
177. <i>Euphrasia</i>	WS?	—	76. Urticaceae		
178. <i>ANAGOSPERMA</i>			223. <i>Paratrophis</i>	N?	—
179. <i>SIPHONIDIUM</i>			224. <i>Urtica</i>	SW?	—
55. Lentibulariaceae			225. <i>Elatostema</i>	N	H
180. <i>Utricularia</i>	NWS?	—	226. (<i>Boehmeria</i>)		(KNH)
56. Gesneriaceae			227. <i>Parietaria</i>	N	KNH
181. <i>RHABDOTHAMNUS</i>			228. <i>Australina</i>	W?	—
57. Myoporaceae			77. Cupuliferae		
182. <i>Myoporum</i>	NW	KNH	229. <i>Fagus</i>	W?	—
58. Verbenaceae					
183. <i>Vitex</i>	N	N	MONOCOTYLEDONS		
184. <i>TEUCRIDIMUM</i>			78. Orchidaceae		
185. <i>Avicennia</i>	N	H	230. <i>Dendrobium</i>	?	NH
59. Labiatae			231. <i>Bulbophyllum</i>	N	NH
186. <i>Mentha</i>	W?	—	232. <i>Earina</i>	N?	—
187. <i>Scutellaria</i>	W	—	233. <i>Sarcocilus</i>	N?	—
60. Plantaginaceae			234. <i>Spiranthes</i>	N	—
188. <i>Plantago</i>	SW	H	235. <i>Thelymitra</i>	N	—
61. Nyctaginaceae			236. <i>Orthoceras</i>	N	—
189. <i>Pisonia</i>	N	NH	237. <i>Microtis</i>	N?	KNH
62. Illecebraceae			238. <i>Prasophyllum</i>	?	—
190. <i>Scleranthus</i>	W?	—	239. <i>Caleana</i>	N	—
63. Amarantaceae			240. <i>Pterostylis</i>	W	—
191. <i>Alternanthera</i>	N	—	241. <i>Actanthus</i>	K	K
64. Chenopodiaceae			242. <i>Cyrtostylis</i>	N	—
192. <i>Rhagodia</i>	K	KH	243. <i>Calochilus</i>	N?	—
193. <i>Chenopodium</i>	WS?	—	244. <i>Lyperanthus</i>	S?	—
194. <i>Atriplex</i>	W?	H	245. <i>Calademia</i>	WS?	—
195. <i>Salicornia</i>	W	H	246. <i>Chiloglottis</i>	W?	—
196. <i>Suaeda</i>	W	—	247. <i>Adenochilus</i>	W?	—
197. <i>Salsola</i>	W	—	248. <i>TOWNSONIA</i>		
65. Polygonaceae			249. <i>Corysanthes</i>	N?	—
198. <i>Polygonum</i>	W?	—	250. <i>Gastrodia</i>	NW	—
199. <i>Rumex</i>	?	KNH	79. Iridaceae		
200. <i>Muehlenbeckia</i>	W?	NH	251. <i>Libertia</i>	W?	—
66. Piperaceae			80. Amaryllidaceae		
201. <i>Piper</i>	K	KNH	252. <i>Hypoxis</i>	W?	—
202. <i>Peperomia</i>	K	KNH	81. Liliaceae		
67. Chloranthaceae			253. <i>Rhipogonum</i>	W?	N
203. <i>Ascarina</i>	?	K	254. <i>Enargea</i>	W?	—
68. Monimiaceae			255. <i>Cordylone</i>	N?	KN
204. <i>Hedycarya</i>	N?	—	256. <i>Astelia</i>	N	—

MONOCOTYLEDONS	Invasion.	Islands.	MONOCOTYLEDONS	Invasion.	Islands.
257. <i>Dianella</i>	N?	NH	290. <i>Schoenus</i>	WN	—
258. <i>Phormium</i>	?	N	291. <i>Cladium</i>	N	H
259. <i>Bulbinella</i>	?	—	292. <i>Lepidosperma</i>	N	—
260. <i>Arthropodium</i>	?	—	293. <i>Gahnia</i>	WN	H
261. <i>Herpolirion</i>	W?	—	294. <i>Oreobolus</i>	?	—
262. <i>Iphigenia</i>	S?	—	295. <i>Uncinia</i>	SW	H
82. Juncaceae			296. <i>Carex</i>	SW	KNH
263. <i>Kostkovia</i>	S	—	91. Gramineae		
264. <i>Juncus</i>	NWS	H	297. <i>Imperata</i>	N	K
265. <i>Luzula</i>	S	H	298. <i>Zoysia</i>	N	—
83. Palmae			299. <i>Paspalum</i>	N	NH
266. <i>Rhopalostylis</i>	N	KN	300. <i>Isachne</i>	N	—
84. Pandanaceae			301. (<i>Panicum</i>)		(KN)
267. <i>Freyinetia</i>	N	N	302. <i>Oplismenus</i>	K	KNH
85. Typhaceae			303. (<i>Cenchrus</i>)		(K)
268. <i>Typha</i>	N	KN	304. <i>Spinifex</i>	N	H
269. <i>Sparganium</i>	N	—	305. <i>Ehrharta</i>	S?	—
86. Lemnaceae			306. <i>Microlaena</i>	?	N
270. <i>Lemna</i>	?	—	307. <i>Hierochloa</i>	?	—
87. Naiadaceae			308. <i>Stipa</i>	?	—
271. <i>Triglochin</i>	W?	—	309. <i>Echinopogon</i>	NW?	NH
272. <i>Potamogeton</i>	W?	—	310. <i>Alopecurus</i>	W?	—
273. <i>Ruppia</i>	W?	—	311. <i>Sporobolus</i>	N?	N
274. <i>Zannichellia</i>	W	—	312. <i>SIMPLICIA</i>		
275. <i>Lepilaena</i>	?	—	313. <i>Agrostis</i>	SW	
276. <i>Zostera</i>	?	—	314. <i>Deyeuxia</i> (<i>Calama-</i> <i>grostis</i>)	?	KNH
88. Centrolepidaceae			315. <i>Dichelachne</i>	NW	NH
277. <i>Trithuria</i>	?	—	316. <i>Deschampsia</i>	SW	
278. <i>Centrolepis</i>	?	—	317. <i>Trisetum</i>	NS?	
279. <i>Gaimardia</i>	S		318. <i>Amphibromus</i>	N	
89. Restionaceae			319. <i>Danthonia</i>	S	—
280. <i>Lepyrodia</i>	?	—	320. (<i>Eleusine</i>)		(K)
281. <i>Leptocarpus</i>	?	—	321. <i>Arundo</i>	W?	—
282. <i>Hypolaena</i>	?		322. <i>Triodia</i>	S	—
90. Cyperaceae			323. <i>Koeleria</i>	S	
283. <i>Kyllinga</i>	N	NH	324. <i>Poa</i>	WS	KII
284. <i>Cyperus</i>	N	N	325. <i>Atropis</i>	W?	—
285. <i>Mariscus</i>	N	NII	326. <i>Festuca</i>	W?	
286. <i>Eleocharis</i>	NW?	N	327. <i>Bromus</i>	N	
287. <i>Fimbristylis</i>	N		328. <i>Agropyrum</i>	NW?	KNH
288. <i>Scirpus</i>	NW?	KNH	329. <i>Asperella</i>	?	
289. <i>Carpus</i>	WS				

Looking at the map, it is evident that the western invasion most probably arrived by the ridge which reaches the western coast of New Zealand, and has two branches, one by Lord Howe Island, and one by Norfolk (the new map is a more recent one than the old, which shows the ridge not quite reaching Norfolk). The northern invasion is not so certain as to route. It may have passed by way of the Kermadecs, though we have already seen (11, p. 280) that this seems improbable; or it may have come by way of the belt of comparatively shallow water which unites the northern end of New Zealand with New Caledonia, and which passes through Norfolk Island. As this water is deeper than that over the western ridge, the northern may have been a more ancient invasion than the western, and there are other facts which point to the possibility of this, as we shall see in later papers. But in any case, northern, western, and Kermadec invasions all came from parts of

Indo-Malaya, and there now exist on their probable tracks the islands of Lord Howe, Norfolk, and the Kermadecs.

One may go on to say at once, that while these islands show great traces of all these invasions, they do not by any means, even if all their floras be added together, contain the whole of the genera, or even of the wides, of those invasions. In actual fact, of the genera in the above list that

DIAGRAM 3. Soundings in the New Zealand area. ----- 100 fathoms. 1,000 fathoms. Numbers inserted here and there give the depth in fathoms at those points.

are marked N, W, K, NW, NW?, NWS, NWS?, N?, NS?, WN, WN?, WS, WS?, W?S?, KW, KN, or SW, they contain 82 out of 152, or 54 per cent., and if the genera marked W? be added they contain 96 out of 219, or 44 per cent. Of the New Zealand wides of these genera 50 (38 per cent.) occur in the islands (29 Dicotyledons and 21 Monocotyledons) and 81 do not (33 and 48). One may feel inclined to say that this shows that transport must have been casual, but one must remember the very small area of these islands. Lord Howe is 7 miles long and has a maximum

breadth of 1 mile, and Norfolk is only 5 miles long and a little broader, while the largest of the Kermadecs has an area of 12 sq. miles, and in all three cases the soil is purely volcanic. It would not, I think, be difficult to pick out of New Zealand, even in the centre, which is the richest area, a small area of uniform soil which would not contain more species than one of these islands. As a test, it is difficult to find an area of this size that has been sufficiently well botanized, but in the Flora of Cambridgeshire by Babington, I find that of 388 genera with 950 species in the county, only 230 genera with 388 species occur in the Wisbech district, which is about 15 miles by 10 with fairly uniform soil and conditions, though even there a number of coast (*halophytic*) species enter in one part. I do not, therefore, feel surprised that these little islands do not contain more of the northern and western invasions of New Zealand. It is worthy of a passing note that Lord Howe contains 160 species (52 locally endemic) and Norfolk 162 (43 locally endemic), and that these islands are of approximately the same area.

After these preliminary remarks, we may go on to the usual method of prediction and verification, and endeavour to see what can be made of the floras of these islands in this manner. For convenience in making predictions, we give below the complete list of the genera of these islands, with the islands (K, N, or H) upon which they occur. The list is compiled from the Floras of Howe by Hemsley (3) and Oliver (5), Norfolk by Maiden (4), and the Kermadecs by Cheeseman (2).

TABLE III.

FLORA OF LORD HOWE, NORFOLK, AND THE KERMADEC ISLANDS.

Families and genera given in italics are found in New Zealand.

Genera in capitals are endemic.

	No. of spp.	Occur in		No. of spp.	Occur in
1. <i>Ranunculaceae</i>			8. <i>Pittosporaceae</i>		
1. <i>Clematis</i>	1	NH	14. <i>Pittosporum</i>	3	KNH
2. <i>Ranunculus</i>	1	N	9. <i>Frankeniaceae</i>		
2. <i>Magnoliaceae</i>			15. <i>Frankenia</i>	1	N
3. <i>Drimys</i>	1	H	10. <i>Malvaceae</i>		
3. <i>Menispermaceae</i>			16. <i>Malvastrum</i>	1	N
4. <i>Stephania</i>	1	H	17. <i>Abutilon</i>	1	N
4. <i>Cruciferae</i>			18. <i>Hibiscus</i>	3	NH
5. <i>Nasturtium</i>	1	N	19. <i>Lagunaria</i>	1	NH
6. <i>Cardamine</i>	1	K	11. <i>Sterculiaceae</i>		
7. <i>Cakile</i>	1	N	20. <i>Ungeria</i>	1	N
8. <i>Lepidium</i>	1	H	12. <i>Linaceae</i>		
5. <i>Capparidaceae</i>			21. <i>Linum</i>	1	N
9. <i>Capparis</i>	1	N	13. <i>Geraniaceae</i>		
6. <i>Violaceae</i>			22. <i>Geranium</i>	2	KN
10. <i>Viola</i>	1	N	23. <i>Pelargonium</i>	1	NH
11. <i>Melicytus</i>	1	KN	24. <i>Oxalis</i>	1	KH
12. <i>Hymenanthera</i>	2	NH	14. <i>Rutaceae</i>		
7. <i>Bixineae</i>			25. <i>Melicope</i>	2	KH
13. <i>Xylosma</i>	1	H	26. <i>Evodia</i>	2	NH

	No. of spp.	Occur in		No. of spp.	Occur in
27. <i>Acronychia</i>	2	NH	75. <i>Siegesbeckia</i>	1	K
28. <i>Xanthoxylum</i>	2	NH	76. <i>Wedelia</i>	1	NH
15. <i>Meliaceae</i>			77. <i>Cassinia</i>	1	H
29. <i>Dysoxylum</i>	2	NH	78. <i>Bidens</i>	1	KNH
16. <i>Olacaceae</i>			79. <i>Erechtites</i>	2	NH
30. <i>Pennantia</i>	1	N	80. <i>Cotula</i>	1	KNH
17. <i>Celastraceae</i>			81. <i>Senecio</i>	2	KNH
31. <i>Elaeodendron</i>	1	NH	82. <i>Sonchus</i>	1	KNH
18. <i>Sapindaceae</i>			83. <i>Picris</i>	1	N
32. <i>Guioa</i>	1	H	34. <i>Goodeniaceae</i>		
33. <i>Dodonaea</i>	1	NH	84. <i>Scaevola</i>	2	KH
19. <i>Anacardiaceae</i>			35. <i>Campanulaceae</i>		
34. <i>Corynocarpus</i>	1	K	85. <i>Lobelia</i>	1	KNH
20. <i>Coriariaceae</i>			86. <i>Wahlenbergia</i>	1	KNH
35. <i>Coriaria</i>	1	K	36. <i>Epacridaceae</i>		
21. <i>Leguminosae</i>			87. <i>Leucopogon</i>	1	H
36. <i>Millettia</i>	1	N	88. <i>Dracophyllum</i>	1	H
37. <i>Glycine</i>	1	N	37. <i>Plumbaginaceae</i>		
38. <i>Carmichaelia</i>	1	H	89. <i>Plumbago</i>	1	N
39. <i>Mucuna</i>	1	H	38. <i>Primulaceae</i>		
40. <i>Canavalia</i>	1	KNH	90. <i>Samolus</i>	1	KN
41. <i>Vigna</i>	1	NH	39. <i>Myrsinaceae</i>		
42. <i>Sophora</i>	1	H	91. <i>Rapanea</i>	4	KNH
43. <i>Caesalpinia</i>	1	NH	92. <i>Aegiceras</i>	1	H
44. <i>Chianthus</i>	1	N	40. <i>Sapotaceae</i>		
22. <i>Rosaceae</i>			93. <i>Sideroxylon</i>	2	NH
45. <i>Acaena</i>	1	K	41. <i>Styracaceae</i>		
23. <i>Saxifragaceae</i>			94. <i>Symplocos</i>	1	H
46. <i>COLMEIROA</i>	1	H	42. <i>Oleaceae</i>		
24. <i>Haloragaceae</i>			95. <i>Jasminum</i>	2	NH
47. <i>Haloragis</i>	1	K	96. <i>Olea</i>	2	NH
48. <i>Callitriche</i>	1	K	97. <i>Notelea</i>	1	H
25. <i>Myrtaceae</i>			43. <i>Apocynaceae</i>		
49. <i>Metrosideros</i>	2	KH	98. <i>Melodinus</i>	1	N
50. <i>Leptospermum</i>	1	H	99. <i>Alyxia</i>	4	NH
51. <i>Melaleuca</i>	1	H	100. <i>Ochrosia</i>	1	H
52. <i>Acicalyptus</i>	1	H	101. <i>Lyonsia</i>	1	H
53. <i>Rhodomyrtus</i>	1	N	44. <i>Asclepiadaceae</i>		
26. <i>Lythraceae</i>			102. <i>Vincetoxicum</i>	1	H
54. <i>Lythrum</i>	1	N	103. <i>Tylophora</i>	1	NH
27. <i>Passifloraceae</i>			104. <i>Marsdenia</i>	1	H
55. <i>Passiflora</i>	3	NH	45. <i>Loganiaceae</i>		
28. <i>Cucurbitaceae</i>			105. <i>Geniostoma</i>	1	H
56. <i>Bryonopsis</i>	1	N	46. <i>Gentianaceae</i>		
57. <i>Sicyos</i>	1	KNH	106. <i>Erythraea</i>	1	N
58. <i>Melothria</i>	1	N	47. <i>Boraginaceae</i>		
29. <i>Ficoideae</i>			107. <i>Cynoglossum</i>	1	N
59. <i>Mesembryanthemum</i>	2	KNH	48. <i>Convolvulaceae</i>		
60. <i>Tetragonia</i>	2	KNH	108. <i>Ipomoea</i>	5	KNH
61. <i>Sesuvium</i>	1	H	109. <i>Calystegia</i>	4	KNH
30. <i>Umbelliferae</i>			49. <i>Solanaceae</i>		
62. <i>Hydrocotyle</i>	2	KH	110. <i>Solanum</i>	3	KNH
63. <i>Apium</i>	2	KNH	50. <i>Scrophulariaceae</i>		
31. <i>Araliaceae</i>			111. <i>Veronica</i>	2	KN
64. <i>Nothopanax</i>	2	KH	51. <i>Gesneriaceae</i>		
65. <i>Meryta</i>	2	N	112. <i>NEGRIA</i>	1	H
32. <i>Rubiaceae</i>			52. <i>Bignoniaceae</i>		
66. <i>Randia</i>	1	H	113. <i>Tecoma</i>	2	NH
67. <i>Psychotria</i>	1	H	53. <i>Acanthaceae</i>		
68. <i>Coprosma</i>	8	KNH	114. <i>Eranthemum</i>	1	H
33. <i>Compositae</i>			54. <i>Myoporaceae</i>		
69. <i>Ageratum</i>	1	K	115. <i>Myoporum</i>	3	KNH
70. <i>Lagenophora</i>	1	K	55. <i>Verbenaceae</i>		
71. <i>Vernonia</i>	1	N	116. <i>Verbenia</i>	1	N
72. <i>Brachycome</i>	1	H	117. <i>Vitex</i>	1	N
73. <i>Olearia</i>	2	H	118. <i>Avicennia</i>	1	H
74. <i>Gnaphalium</i>	3	KNH			

No. of spp.		Occur in	No. of spp.		Occur in
56. Labiatae			73. Amaryllidaceae		
119. Westringia	1	H	161. Crinum	1	N
120. Plectranthus	1	H	74. Liliaceae		
57. Plantaginaceae			162. Smilax	1	1 NH
121. Plantago	1	H	163. Rhipogonum	1	N
58. Nyctaginaceae			164. Geitonoplesium	1	NH
122. Boerhaavia	1	H	165. Cordyline	2	KN
123. Pisonia	1	NH	166. Phormium	1	N
59. Amaranthaceae			167. Dianella	2	NH
124. Achyranthes	2	NH	75. Commelinaceae		
60. Chenopodiaceae			168. Commelina	1	NH
125. Rhagodia	2	KH	76. Flagellariaceae		
126. Atriplex	1	H	169. Flagellaria	1	H
127. Salicornia	1	H	77. Juncaceae		
61. Polygonaceae			170. Juncus	1	H
128. Rumex	2	KNH	171. Luzula	1	H
129. Muehlenbeckia	2	NH	78. Palmae		
62. Piperaceae			172. Rhopalostylis	2	KN
130. Macropiper	1	KNH	173. HEDYSCEPE	1	H
131. Peperomia	4	KNH	174. Clinostigma	1	H
63. Chloranthaceae			175. HOWEA	2	H
132. Ascarina	1	K	79. Pandanaceae		
64. Lauraceae			176. Pandanus	1	H
133. Cryptocarya	2	H	177. Freycinetia	1	N
65. Thymelaeaceae			80. Typhaceae		
134. Pimelea	1	H	178. Typha	1	KN
135. Wikstroemia	1	N	81. Araceae		
66. Loranthaceae			179. Colocasia	1	N
136. Koithalsella	1	NH	82. Cyperaceae		
67. Santalaceae			180. Cyperus	2	N
137. Exocarpus	2	NH	181. Mariscus	1	NH
68. Euphorbiaceae			182. Kyllinga	1	NH
138. Aleurites	1	K	183. Cladium	1	H
139. Homalanthus	1	KH	184. Eleocharis	1	N
140. Euphorbia	4	NH	185. Gahnia	1	H
141. Hemicyclia	1	H	186. Uncinia	1	H
142. Baloghia	1	NH	187. Scirpus	5	KNH
143. Excoecaria	1	N	188. Carex	5	KNH
69. Urticaceae			83. Gramineae		
144. Celtis	2	NH	189. Oplismenus	2	KNH
145. Malaisia	2	NH	190. Spizifex	1	H
146. Ficus	1	H	191. Paspalum	2	NH
147. Pseudomorus	1	N	192. Panicum	4	KN
148. Procris	1	N	193. Imperata	1	K
149. Elatostema	1	H	194. Cenchrus	1	K
150. Boehmeria	3	KNH	195. Andropogon	2	N
151. Parietaria	1	KNH	196. Microlaena	1	N
70. Hydrocharidaceae			197. Echinopogon	1	NH
152. Halophila	1	H	198. Sporobolus	1	N
71. Orchidaceae			199. Calamagrostis	1	KNH
153. Oberonia	1	N	200. Dichelachne	2	NH
154. Dendrobium	4	NH	201. Phragmites	1	H
155. Bulbophyllum	2	NH	202. Cynodon	1	N
156. Phreatia	1	N	203. Eleusine	1	K
157. Microtis	1	KNH	204. Poa	2	KNH
158. Acianthus	1	K	205. Agropyrum	1	KNH
159. Cleisostoma	1	H	206. Triticum	1	N
72. Iridaceae					
160. Moraea	1	H			

(1) If, as I maintain, these islands lie upon the tracks of previous plant-invasions of New Zealand by *land*, then one will expect to find that a large part of their flora consists of families, genera, and species which also occur in New Zealand.

TABLE IV.

	Species.	of	Genera.	and	Families.
Occur in N.Z.	93 (none) (none) (none)		75 23 17 (none)		41 same 15 (others) 11 (others)
Total occurring in N.Z.	93 sp.		115 gen.		67 fams.
Not found in N.Z.	209 do.		91 do.		16 do.
Total for all the islands	302		206		83

Thus nearly one-third of the species, more than half of the genera, and four-fifths of the families occur in New Zealand.

(2) One will expect the 23 genera of the same families to be chiefly represented by endemic forms, or by Australian or Polynesian wides which have been too late to reach New Zealand. In actual fact the 23 genera are represented in the islands by 31 species, of which 21 are endemic to the islands, 1 (*Imperata Cheesemani*) to the Kermadecs, 8 to Norfolk, 11 to Howe, and 1 (*Mariscus haematodes*) to both Norfolk and Howe. A further 7 species are Australian wides, 2 are Polynesian wides, and 1 (*Nasturtium sylvestre*) is probably introduced. The prophecy is thus fully borne out.

(3) One will also expect the 17 New Zealand genera, belonging to the 15 families which are not represented in New Zealand by any species that occur on these islands, to be similarly made up of endemic species and Australian and Polynesian wides. In actual fact these 17 genera show on the islands 26 species, which are composed of 18 endemics, 7 Australian wides, and 1 Polynesian wide.

(4) The 11 New Zealand families, which are not represented on the islands either by genera or by species that occur in New Zealand, are Saxifragaceae, Goodeniaceae, Apocynaceae, Gentianaceae, Boraginaceae, Gesneriaceae, Labiatae, Amarantaceae, Lauraceae, Iridaceae, and Amaryllidaceae, and are represented on the islands, as one would rather expect, by 11 endemic species, including two endemic genera (*Colmeiroa* and *Negria*) and 10 Australian wides. One of the endemic species, *Moraea Robinsoniana*, belongs to an African genus, which probably arrived by sea carriage.

(5) Passing on now to the species, genera, and families given in Table IV as not found in New Zealand, one will expect that a large proportion of the species will be endemic in the islands. In fact, of the 209 species that occur on the islands and have not been found in New Zealand, no less than 105 appear to be endemic to the islands.

(6) One will expect that the remaining 104 species will be Australian or Polynesian wides, especially the former. In fact 93 of them are Australian and 9 Polynesian, while 2 (*Nasturtium sylvestre* and *Cakile maritima*) are perhaps introduced, being European types.

(7) One will also expect to find that the 209 species that do not reach New Zealand will be largely members of genera and still more of families that do reach it. Those families and genera that reach New Zealand will on the whole be the earliest arrivals of their respective affinity groups. These groups will thus, so to speak, have the start of the others, and there will be more likely to be more of them in the islands than of other groups, of which none have reached New Zealand. Testing this we find in the island flora :

TABLE V.

Not reaching N.Z.	209 species of 155 genera and 74 families					
Found in N.Z. of these	(none)	64	„	(with 130 spp.)	and 58 families	
Leaving		91	„	„ 112	„	16 „

(8) One will expect to find the families and genera that have reached New Zealand better represented in the islands, on the whole, as being older, than those that have not.

TABLE VI.

The 58 families contain 137 genera, or 2.3 genera per family					
„ 16	„	18	„	1.1	„
„ 64 genera contain 130 species, or 2.0 species per genus					
„ 91	„	112	„	1.2	„

(9) The 16 families that do not reach New Zealand at all, are all, as one would expect (they being probably young, and therefore on the average small, in the islands), small and not widely distributed in the islands. They are Menispermaceae (1 sp. Howe), Capparidaceae (1 Norf.), Bixaceae (1 Howe), Frankeniaceae (1 Norf.), Sterculiaceae (1 Norf.), Celastraceae (1 Norf., 1 Howe), Lythraceae (1 Norf.), Plumbaginaceae (1 Norf.), Styraceae (1 Howe), Asclepiadaceae (2 on Howe only 1 Norf., 1 Howe), Bignoniaceae (1 Norf., 1 Howe), Acanthaceae (1 Howe), Hydrocharidaceae (1 Howe), Commelinaceae (1 Norf., 1 Howe), Flagellariaceae (1 Howe), Araceae (1 Norf.). All are small, and little distributed among the islands. Similarly, of the 91 genera, 65 have only one species reaching one island, 10 one species reaching two.

(10) Of the 91 genera that do not occur in New Zealand, one will expect the greater proportion (both absolute and per family) to belong to families that have reached New Zealand, for these will be the older families in their affinity circles. In actual fact 73 belong to 42 families that have reached New Zealand, or four-fifths of the total, and 1.7 genera per family, while 18 belong to 16 families that have not reached New Zealand, or one-fifth of the total, and 1.1 genera per family. The prophecy is thus borne out.

(11) To turn now to another type of consideration, one will expect the bulk of the floras of these islands to belong to genera and families that in Table II are marked as probably belonging to northern, Kermadec, or

western invasions of New Zealand. In actual fact, of the 115 genera that reach New Zealand, we find that they are marked as follows :

TABLE VII.

$\left. \begin{array}{l} \text{N} \\ \text{N?} \\ \text{NW} \\ \text{NWS} \\ \text{NW?} \end{array} \right\} \begin{array}{l} 28 \\ 6 \\ 6 \\ 1 \\ 5 \end{array} \left. \vphantom{\begin{array}{l} \text{N} \\ \text{N?} \\ \text{NW} \\ \text{NWS} \\ \text{NW?} \end{array}} \right\} 46$	$\left. \begin{array}{l} \text{K} \\ \text{KN} \\ \text{KW} \end{array} \right\} \begin{array}{l} 7 \\ 1 \\ 1 \end{array} \left. \vphantom{\begin{array}{l} \text{K} \\ \text{KN} \\ \text{KW} \end{array}} \right\} 9$	$\left. \begin{array}{l} \text{WN} \\ \text{WN?} \\ \text{W} \\ \text{W?} \\ \text{WS?} \\ \text{WS} \end{array} \right\} \begin{array}{l} 4 \\ 1 \\ 11 \\ 14 \\ 2 \\ 6 \end{array} \left. \vphantom{\begin{array}{l} \text{WN} \\ \text{WN?} \\ \text{W} \\ \text{W?} \\ \text{WS?} \\ \text{WS} \end{array}} \right\} 38$	$\left. \begin{array}{l} \text{SW} \\ \text{SW?} \\ \text{S or S?} \end{array} \right\} \begin{array}{l} 6 \\ 1 \\ 3 \end{array} \left. \vphantom{\begin{array}{l} \text{SW} \\ \text{SW?} \\ \text{S or S?} \end{array}} \right\} 10$	$\left. \vphantom{\begin{array}{l} \text{WN} \\ \text{WN?} \\ \text{W} \\ \text{W?} \\ \text{WS?} \\ \text{WS} \end{array}} \right\} 12$
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Thus 55, or just less than half, are of unquestionably northern origin (N or K) as judged simply by their distribution in New Zealand, and 38 more are probably western, while 12 have so few species, and so widely distributed in New Zealand, that one cannot tell from their local distribution by which route they may have entered.

There remain 10 genera, marked in Table II as SW or S. The six SW genera are represented in the islands by (i) *Lepidium Howeiinsulae*, endemic and allied to *L. oleraceum* of New Zealand, therefore probably derived from New Zealand; (ii) *Brachycome segmentosa*, endemic and allied to an Australian species; (iii) *Cotula australis*, found in all three islands, and in New Zealand down to Foveaux Strait, as well as in Australia, and therefore probably an Australian species which entered by the west; (iv) *Plantago Headleyi* (Howe), endemic and near *P. aucklandica* of New Zealand, and therefore probably derived from New Zealand; (v) *Uncinia filiformis* (Howe), found in New Zealand from 280 miles south of N. Cape down to Stewart Island, and therefore possibly a western type; also found in Australia; and (vi) *Carex semiforsteri* (Kermadecs), found down to Foveaux Strait in New Zealand and thus probably not southern, *C. Neesiana*, endemic in Norfolk, *C. inversa* (Norfolk), down to Foveaux Strait and in Australia, and therefore (on both counts) probably western, *C. breviculmis*, the same, and *C. gracilis*, otherwise found in Australia only.

The one genus marked SW? is *Ramunculus*, which is represented in Norfolk by *R. parviflorus*, an Australian species that does not reach New Zealand.

The three southern genera are (i) *Cardamine*, represented in the Kermadecs by *C. stylosa*, found from 60 to 820 miles in New Zealand, and therefore probably western; also found in Australia; (ii) *Veronica*, represented by *V. calycina*, an Australian species, in Norfolk, and by *V. salicifolia* in the Kermadecs, a very widely spread New Zealand type which probably reached the Kermadecs early; and (iii) *Luzula*, represented in Howe by the endemic *L. longiflora*, allied (?) to the New Zealand antarctic island *L. crinita*.

(12) The Kermadecs, Norfolk, and Howe contain a large number of endemic forms. It is clear that on the hypothesis of age and area, these should occur principally in the families and genera which have been in the

islands for the longest time, i. e. in those which are the most likely to have reached New Zealand. The endemics are:

TABLE VIII.

The letters K, N, H refer to the islands in which the families or species are found.

1. Magnoliaceae (NH)		19. Goodeniaceae (KH)	
1. <i>Drimys Howeana</i>	H	43. <i>Scaevola gracilis</i>	K
2. Cruciferae (KNH)		20. Epacridaceae (H)	
2. <i>Lepidium Howeianum</i>	H	44. <i>Dracophyllum Fitzgeraldi</i>	H
3. Violaceae (KNH)		21. Myrsinaceae (KNH)	
3. <i>Hymenanthera latifolia</i>	N	45. <i>Rapanea kermadecensis</i>	K
4. Pittosporaceae (KNH)		46. <i>platystigma</i>	H
4. <i>Pittosporum bracteolatum</i>	N	47. <i>myrtilina</i>	H
5. <i>erioloma</i>	H	22. Sapotaceae (NH)	
5. Malvaceae (NH)		48. <i>Sideroxylon Howeianum</i>	H
6. <i>Abutilon Julianae</i>	N	23. Styracaceae (H)	
7. <i>Hibiscus insularis</i>	N	49. <i>Symplocos candelabrum</i>	H
6. Sterculiaceae (N)		24. Oleaceae (NH)	
8. <i>Ungeria floribunda</i>	N	50. <i>Notelaea quadristaminea</i>	H
7. Rutaceae (KNH)		25. Apocynaceae (NH)	
9. <i>Melicope confertissima</i>	H	51. <i>Alyxia Lindii</i>	H
10. <i>Evodia polybotrya</i>	H	52. <i>squamulosa</i>	H
11. <i>littoralis</i>	N	53. <i>gynopogon</i>	N
12. <i>Acronychia Endlicheri</i>	N	54. <i>Melodinus Baueri</i>	N
8. Meliaceae (NH)		26. Asclepiadaceae (NH)	
13. <i>Dysoxylum Patersonianum</i>	N	55. <i>Tylophora biglandulosa</i>	NH
14. <i>pachyphyllum</i>	H	27. Loganiaceae (H)	
9. Celastraceae (NH)		56. <i>Geniostoma petiolosum</i>	H
15. <i>Elaeodendron curtispendulum</i>	N	28. Convolvulaceae (KNH)	
10. Sapindaceae (H)		57. <i>Ipomoea cataractae</i>	N
16. <i>Gaioa coriacea</i>	H	58. <i>Calystegia affinis</i>	N
11. Leguminosae (KNH)		29. Solanaceae (KNH)	
17. <i>Carmichaelia exsul</i>	H	59. <i>Solanum Bauerianum</i>	N
18. <i>Milletia australis</i>	N	30. Gesneriaceae (H)	
19. <i>Chianthus Baueri</i>	N	60. NEGRIA RHABDOTHAM- NOIDES	H
12. Saxifragaceae (H)		31. Myoporaceae (KNH)	
20. COLMEIROA CARPODETOIDES H		61. <i>Myoporum obscurum</i>	N
13. Myrtaceae (KNH)		32. Plantaginaceae (H)	
21. <i>Acicalyptus Fullagari</i>	H	62. <i>Plantago Headleyi</i>	H
22. <i>Metrosideros nervulosa</i>	H	33. Amarantaceae (NH)	
14. Passifloraceae (NH)		63. <i>Achyranthes arborescens</i>	N
23. <i>Passiflora Baueriana</i>	N	34. Piperaceae (KNH)	
24. <i>glabra</i>	N	64. <i>Peperomia Baueriana</i>	N
15. Cucurbitaceae (KNH)		35. Chloranthaceae (K)	
25. <i>Bryonopsis affinis</i>	N	65. <i>Ascarina lanceolata</i>	K
26. <i>Melothria Baueriana</i>	N	36. Lauraceae (H)	
16. Araliaceae (KNH)		66. <i>Cryptocarya Gregsoni</i>	H
27. <i>Nothopanax cissodendron</i>	H	37. Thymelaeaceae (NH)	
28. <i>Meryta latifolia</i>	N	67. <i>Pimelea congesta</i>	H
29. <i>angustifolia</i>	N	68. <i>Wikstroemia australis</i>	N
17. Rubiaceae (KNH)		38. Santalaceae (NH)	
30. <i>Randia stipulosa</i>	H	69. <i>Exocarpus homalolada</i>	H
31. <i>Psychotria Carronis</i>	H	70. <i>phyllanthoides</i>	N
32. <i>Coprosma prisca</i>	H	39. Euphorbiaceae (KNH)	
33. <i>lanceolaris</i>	H	71. <i>Euphorbia obliqua</i>	N
34. <i>putida</i>	H	72. <i>Norfolkiana</i>	N
35. <i>pilosa</i>	N	73. <i>Homalanthus polyandrus</i>	K
36. <i>petiolata</i>	K	40. Urticaceae (KNH)	
37. <i>acutifolia</i>	K	74. <i>Celtis amblyphylla</i>	H
18. Compositae (KNH)		75. <i>Ficus columnaris</i>	H
38. <i>Brachycome segmentosa</i>	H	76. <i>Procris montana</i>	N
39. <i>Olearia Balli</i>	H	77. <i>Boeckmeria dealbata</i>	K
40. <i>Mooneyi</i>	H	78. <i>australis</i>	N
41. <i>Cassinia tenuifolia</i>	H	79. <i>calophleba</i>	H
42. <i>Senecio insularis</i>	H		

41. Orchidaceae (KNH)		92. <i>Clinostigma Mooreanum</i>	H
80. <i>Dendrobium gracilicaule</i>	H	93. <i>HOWEA BELMOREANA</i>	H
81. <i>Moorei</i>	H	94. <i>FORSTERIANA</i>	H
82. <i>brachypus</i>	N	95. <i>Rhopalostylis Baueri</i>	N
83. <i>macropus</i>	N	96. <i>Cheesemani</i>	K
84. <i>Bulbophyllum argyropus</i>	N	47. Pandanaceae (NH)	
85. <i>Cleisostoma erectum</i>	H	97. <i>Pandanus Forsteri</i>	H
42. Amaryllidaceae (N)		98. <i>Freycinetia Baueriana</i>	N
86. <i>Crinum Norfolkianum</i>	N	48. Cyperaceae (KNH)	
43. Iridaceae (H)		99. <i>Mariscus haematodes</i>	NH
87. <i>Moraea Robinsoniana</i>	H	100. <i>Cladium insulare</i>	H
44. Liliaceae (KNH)		101. <i>Carex Neesiana</i>	N
88. <i>Rhipogonum dubium</i>	N	49. Gramineae (KNH)	
89. <i>Cordylina oblecta</i>	N	102. <i>Imperata Cheesemani</i>	K
45. Juncaceae (H)		103. <i>Panicum Norfolkianum</i>	N
90. <i>Luzula longiflora</i>	H	104. <i>Poa polyphylla</i>	K
46. Palmaceae (KNH)		105. <i>Triticum Kingianum</i>	N
91. <i>HEDYSCEPE CANTERBURYANA</i>	H		

These sum up to 105 species, belonging to 81 genera and 49 families. Of these 63 belong to 44 genera and 33 families which occur in New Zealand, while 38 species of 33 genera more belong to families that occur (though not the genera) in New Zealand. Thus, as predicted, the greater proportion occur in genera that have reached New Zealand, whilst nearly all the families that contain endemics have also reached that country, including the families (Saxifragaceae, Gesneriaceae, Palmaceae) that contain the endemic genera (*Colmeiroa*, *Negria*, *Hedyscepe*, *Howea*).

The families that contain endemics and do not reach New Zealand are Sterculiaceae, Celastraceae, Styracaceae (Symplocaceae), and Asclepiadaceae, each with one endemic species only, and represented, the first two each by the endemic species only in Norfolk Island, the third by the endemic only in Howe, and Asclepiadaceae by the endemic *Tylophora* in both Norfolk and Howe, and by *Vincetoxicum carnosum* and *Marsdenia rostrata*, both Australian species, in Howe.

The genera that contain endemics and do not reach New Zealand belong, all but these four, to families that reach New Zealand. They are *Abutilon*, *Ungeria*, *Evodia*, *Acronychia*, *Elaeodendron*, *Millettia*, *Guioa*, *COLMEIROA*, *Acicalyptus*, *Bryonopsis*, *Melothria*, *Randia*, *Psychotria*, *Scaevola*, *Symplocos*, *Notelaea*, *Alyxia*, *Melodinus*, *Tylophora*, *NEGRIA*, *Achyranthes*, *Cryptocarya*, *Wikstroemia*, *Baloghia*, *Homalanthus*, *Celtis*, *Ficus*, *Procris*, *Cleisostoma*, *Crinum*, *Moraea*, *HEDYSCEPE*, *Clinostigma*, *HOWEA*, *Pandanus*, *Panicum*, *Triticum*. Most are represented by one species only, but *Evodia* has two, *Alyxia* three, and *Boehmeria* three.

(13) It is evident, on my hypothesis, that the endemics should belong to the families that have been longest in the islands, i.e. on the whole to the largest families. In actual fact they belong to 49 families with 157 genera, or 3.2 genera per family, while the families that contain no endemics are 34 with 49 genera, or 1.4 genera per family. Twenty-three families with 3 or more genera contain 64 of them, 16 with 2 genera contain 16, and 44 with one genus contain 25 only.

(14) In the same way they should belong to the larger genera of the island floras. In actual fact, they belong to 81 genera which contain altogether 150 species, or 1.8 species per genus. The genera that contain no endemics are 125 with 152 species, or 1.2 species per genus.

(15) One will expect the island genera which contain endemics, inasmuch as they will on the whole be old, to be fairly large in New Zealand (when they reach there). There are 81 in all of them, and 37 do not reach New Zealand. The remaining 44 contain in New Zealand 362 species, or an average of 8.2 species per genus, while the average size of a genus in New Zealand is only 4.2 species. Even if the 362 be divided by the whole 81, the result is 4.4.

It is worthy of note, with reference to Professor Sinnott's hypothesis of 'swamping' (6, p. 214), that of the 362 species in New Zealand only 38 are wides. But on the other hand, the genera which are represented by wides in the islands are usually represented by wides in New Zealand.

(16) One will expect the families with endemics in the islands to be on the whole the same as the families with endemics in New Zealand, being the older families in each case. In New Zealand 76 families out of 91 contain endemics, but of these 18 (10, p. 359) are chiefly southern. In the islands 49 families contain endemics, and of these 38 are the same as in New Zealand. The other 11 include Sterculiaceae, Celastraceae, Styracaceae, and Asclepiadaceae, which do not occur in New Zealand, and also Cucurbitaceae, Goodeniaceae, Sapotaceae, Convolvulaceae, Amarantaceae, Piperaceae, and Amaryllidaceae, 7 families with only 17 species in all, and 15 of them wides, while the average range in New Zealand is only 587 miles (against a possible range of 1,080), all of them facts which point to the probably (comparatively) recent arrival of these families in New Zealand.

(17) In the same way, the genera with endemics in the islands should in general be genera that have endemics in New Zealand, or genera probably only comparatively recently arrived there. Of the 81 island genera with endemics, 37 do not occur in New Zealand, leaving 44 that do, of which no fewer than 38 possess endemics in New Zealand. It may be said, by those who have not worked at the matter in detail, that this is probably only the normal percentage of New Zealand genera that possess endemics, but in actual fact 95 genera out of 321 have no endemics in New Zealand, or a much higher percentage. The 6 genera that have no endemics in New Zealand are *Hibiscus*, *Ipomaea*, *Calystegia*, *Solanum*, *Peperomia*, and *Euphorbia*, which have in all 12 wides with an average range of 647 miles, and are thus small and slightly ranging genera, therefore probably on the whole young in New Zealand (in their affinity groups).

(18) One will expect the endemics of the islands to belong chiefly to the families that reach most islands.

TABLE IX.

Reaching Kerm., Norf., Howe	22 fams.	50 gen.	69 spp.
Norf., Howe	13 } 14	17 } 18	22 } 23
Kerm., Howe	1	1	1
Howe	10 } 13	10 } 13	10 } 13
Norf.	2	2	2
Kerm.	1	1	1

Thus much the best representation is among the families that reach all three groups of islands, the second best among those reaching two.

(19) Turning now to more general predictions, one will expect that the largest families in the islands will be those reaching three groups, then those reaching two, and lastly those reaching one only.

TABLE X.

Reaching	No. of fams.	1	2	3	4	Containing more genera
Three groups	27	3	8	5	2	5, 6, 6, 7, 8, 9, 9, 15, 18
Two groups	24	13	5	4	2	
One group	32	28	4	-	-	

Thus the families reaching three groups are 27 with 125 genera, or an average of 4.7, those reaching two are 24 with 43 (average 1.8), those reaching one are 32 with 36 (average 1.1).

(20) One will expect the same of the genera. In fact the 29 genera that reach three groups contain 73 species, or 2.5 per genus, while the 54 that reach only two groups contain 97 species (1.8 per genus) and the 123 that only reach one contain 132 species, thus completely fulfilling the prediction.

(21) Again, one will expect the families that reach three groups of islands, as oldest in their various affinities, to be best represented in New Zealand. The 27 families that reach all three groups of islands are represented in New Zealand by 79 out of 115 genera that reach New Zealand, the remaining 56 families only containing 36 genera.

(22) In the same way, the genera reaching all three groups of islands should be best represented in New Zealand. There are 30 of these, and 28 of them are represented in New Zealand, while of the remaining 176 only 87 are represented. The two genera reaching all three groups of islands and not reaching New Zealand are *Canavalia*, represented in all by *C. obtusifolia*, one of the stock plants of the drift of sea currents, and which one would expect in New Zealand, and *Boehmeria*, represented by a separate endemic in each of the three groups of islands.

(23) The species in common between three groups of islands, as oldest, should show the largest proportion of wides, and then those occurring in two or one groups.

TABLE XI.

<i>Occurring in</i>	<i>Wides.</i>	<i>Endemics.</i>
Three groups	23 (100 %)	—
Two groups	35 (90 %)	4
One group	139 (58 %)	101

Looking at the results that have been set forth in this paper, one is rather inclined to come to at least one important general conclusion. From the fact that by using age and area as a basis, 23 successful predictions have been made, many of which involve the mutual relationships of these islands and New Zealand in the matter of floras and their distribution, one may reasonably, I think, infer that age and area is as valid for these islands as for the mainland of New Zealand, not only as regards their local flora (considered entirely by itself) but as regards their floral relationships with New Zealand. But if the latter be the case, then it is clear that in all probability these islands must once have been a part of, or close to, the *land* communications over which the Indo-Malayan invasions of New Zealand travelled (cf. 5, p. 112). It is almost impossible to imagine them receiving by casual transport across the water a flora which would show such striking numerical relationships, and relationships in such detail, to the flora of New Zealand. One cannot imagine that age and area should hold for the *mutual* relationships of two areas that were peopled with plants by independent invasion of casual waifs across the ocean. Taking these facts together with those set forth for New Zealand on p. 473, above, one may, I think, come to the conclusion that the peopling of New Zealand from Indo-Malaya was by land (not, of course, necessarily absolutely continuous, but with at most comparatively narrow straits), and that the islands which have been dealt with in this paper formed part of, or were very near to, that land.

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SUMMARY.

In this paper age and area is applied to the floras of the islands outlying between New Zealand and the nearest larger areas of land to the north or north-west. It proves to be equally applicable to them, both for themselves and for their relationships to New Zealand, showing that they must in all probability have formed part of a land mass or masses running down to New Zealand from Indo-Malaya. Lists are given of the New Zealand genera (Table II), showing the invasions of which each may be supposed to have formed a part, deduced from their local distribution in New Zealand; of the genera of the islands (Table III), showing those that reach New Zealand; and of the endemics of the islands (Table VIII). It is shown that the

invasions of New Zealand were probably four—northern, Kermadec, western, and southern—the western probably arriving by the ridge on which stand Norfolk and Lord Howe.

Applying the usual method of prediction and verification, it is then shown that (1) a large part of the floras of these islands also occurs in New Zealand; (2), (3), and (4), genera and families not represented in New Zealand by actual species, are represented by endemics or by Australian and Polynesian wides in the islands; (5) more than half the species not found in New Zealand are endemic to the islands, and (6) the rest are Australian and Polynesian wides; (7) these species belong very largely to genera and families that do reach New Zealand; (8) families and genera that have reached New Zealand are better represented on the islands than those that have not; (9) the families that do not reach New Zealand at all are all small and little distributed in the islands; (10) the genera that do not reach New Zealand belong mainly to families that do; (11) the bulk of the island floras belongs to genera and families of the northern, Kermadec, and western invasions of New Zealand; (12) the island endemics occur chiefly in genera and families that have reached New Zealand; they occur chiefly in (13) the larger families of the islands, and (14) the larger genera; (15) the island genera with endemics are usually large in New Zealand; (16 and 17) the island families and genera with endemics are in general the same as in New Zealand; (18) the island endemics belong chiefly to the families that reach three islands; (19) the largest families in the islands are those reaching all three, and (20) similarly the largest genera; (21) the families that reach three are best represented in New Zealand, and (22) similarly the genera; (23) the species in common between three islands show the largest proportion of wides, then those from two and from one.

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