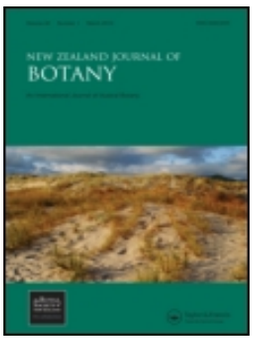

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Influence of Man on Vegetation and Wildlife of Enderby and Rose Islands, Auckland Islands

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SUMMARY

Two small adjacent sub-antarctic islands having many features in common, but with markedly different modified vegetation, are considered in the light of historical records and field work in 1954 and 1966.

When the Auckland Islands were discovered in 1806 Enderby and Rose Islands probably had the same general vegetative pattern with southern rata (*Metrosideros umbellata*) forest and scrub on south-eastern parts giving way to *Poa litorosa* tussock on the more exposed north-western parts.

Much of the present vegetation on the two islands has been induced by fire and introduced mammals, the legacy of a period of shipwrecks and attempts at settlement and farming. Large areas of short sward and of dead trees now occur. Tussock grassland has practically disappeared from Enderby, but still covers much of Rose Island.

Nowadays, mice (*Mus musculus*), rabbits (*Oryctolagus cuniculus*), and feral cattle (*Bos taurus*) occur in Enderby, and rabbits alone on Rose Island. Their numbers, distribution, and inter-relations with the vegetation are discussed. On Rose Island, where tussock and scrub are increasing, rabbits have markedly declined since 1954, whereas on Enderby an apparent balance has been reached between the introduced mammals and the much modified vegetation.

The history and present status of bird and seal populations are described. After early exploitation and virtual extermination, southern royal albatrosses (*Diomedea e. epomophora*) and seals (*Arctocephalus forsteri* and *Neophoca hookeri*) are now increasing. On Enderby there are breeding sea-lions, many native bird species, cattle, and rabbits all in an interacting relationship which is not obviously detrimental to any of them or to the present vegetation.

The Auckland Islands have been reserves for the preservation of flora and fauna since 1934 and are potentially valuable for studying interactions between native and introduced species. Existing environmental trends on Enderby and Rose Islands have positive conservation and scientific values and any manipulation, such as the control of cattle and rabbits, now seems undesirable.

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INTRODUCTION

Since their discovery in the late 18th and early 19th Centuries, all of New Zealand's sub-antarctic islands (Fig. 1) have been modified by man or his introduced animals. Campbell Island and some of the Auckland Islands have been drastically altered, while others such as Antipodes Islands and Adam Island in the Auckland Group are little changed. Early exploitation of seal stocks led to the virtual extinction of fur seals (*Arctocephalus forsteri*), and the introduction of pigs (*Sus scrofa*), cats (*Felis catus*), rats (*Rattus novegicus*), and mice (*Mus musculus*) to some islands. Then, from about 1840, came the period of greatest modification with the liberation of animals as food for castaways and attempts at settlement and farming. The next phase started soon after 1900 when farming was abandoned, leaseholds reverted to the Crown, and eventually all the islands were made reserves for flora and fauna.

This paper describes the changes caused by man on Enderby and Rose, two small islands in the Auckland Group, and discusses current relationships between the vegetation, introduced mammals, and indigenous wildlife.

The Auckland Islands (50°26'–50°56'S, 165°62'–166°22'E), consisting of two large and four smaller islands and numerous small islets and rocks (Fig. 1), are now uninhabited, but pigs, cattle, goats, rabbits, cats, and mice exist in various combinations on Auckland, Enderby, and Rose Islands, and on some of the smaller islets (Taylor, 1968). The group is 55 kilometers (34 miles) long by 35 kilometers (22 miles) wide and has a land area of about 56,600 hectares (140,000 acres). The main island and Adams Island to the south are mountainous with peaks over 600 m (2,000 ft). Their western and southern coasts are high and precipitous, but the eastern seaboard has a drowned shoreline with many deep bays and inlets (Eden, 1955). The climate is characterised by strong westerly winds, frequent cloud, moderate rainfall (125–150 cm at Port Ross) spread over more than 300 days a year, cool temperatures with little annual and daily variation, and high humidity (De Lisle, 1965). Encompassing Port Ross, at the north-east of the main island, are a number of lower lying islands and islets, the two largest being Enderby Island and Rose Island. Because of their low relief and northern position these small islands receive less rain and more sunshine than the mountainous islands of the group, for frequently while the main island is shrouded in cloud there is only broken cloud over the northern islands and the sea.

Enderby Island rises to about 45 m altitude and has an area of 688 hectares (1700 acres). Rose Island is slightly lower, has an area of 81 hectares (200 acres), and lies about 800 m to the south-west of Enderby. Except for coastal cliffs and rocks and a few acres of sandhills on Enderby, both islands are entirely covered with a thick blanket of peat. The peat surface appears remarkably stable although there is evidence of a very slow down-slope movement (Leamy and Blakemore,

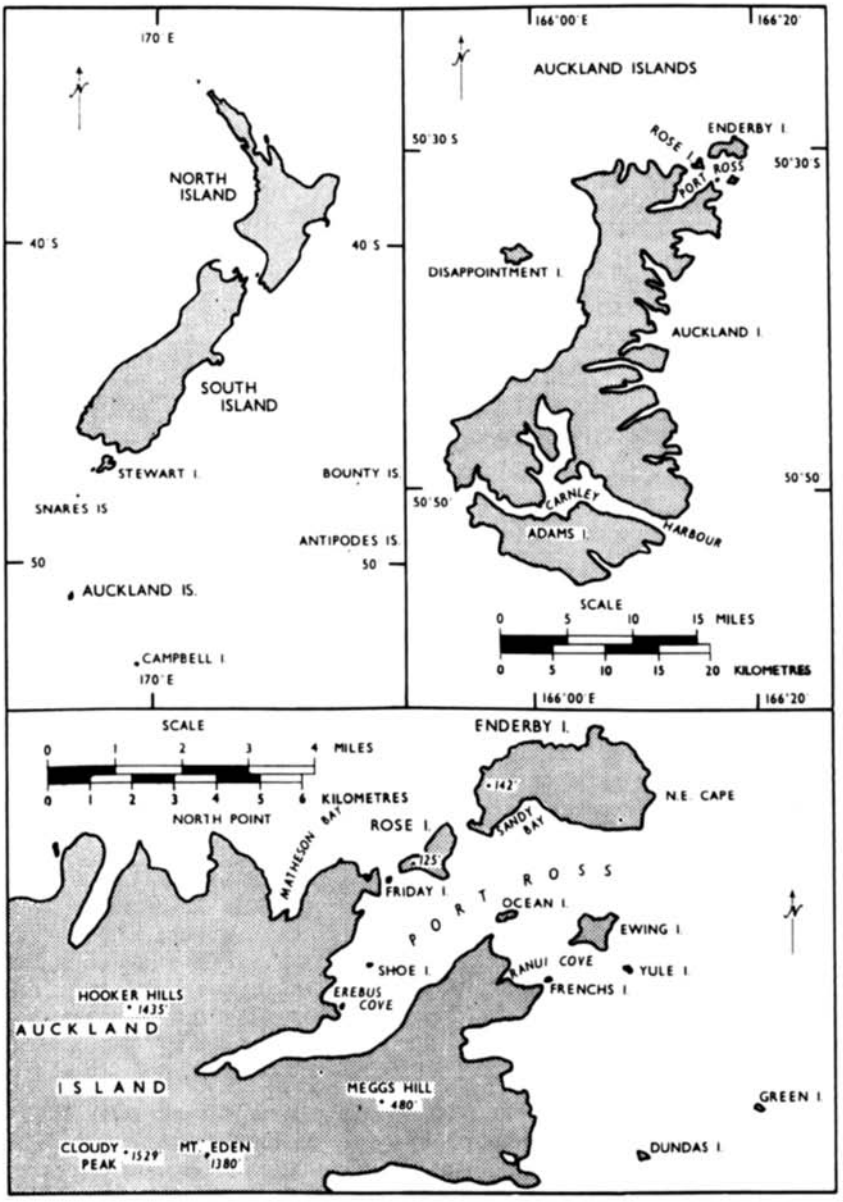

FIG. 1--Location map, the Auckland Islands, and detail of the Port Ross area.

FIG. 2—The north coast of Enderby Island west of Derry Castle Reef.

1960), and on both islands small patches are actively eroding in a narrow exposed strip directly above the north-west cliffs.

The western end of Enderby is almost entirely edged by cliffs, those to the north-west rising over 30 m (Fig. 2), but those along the southern shore being only about half this height as the land surface generally slopes to the south and south-east. To the east, and at Sandy Bay, the island slopes to the sea and cliffs are usually confined to headlines. Boulder beaches occur east of Derry Castle Reef and in the eastern bays. At Sandy Bay, on the south coast, a fine sand beach provides a good landing.

Although much smaller, Rose Island is physiographically similar to Enderby. The highest parts of the island are close to the 30 m high cliffs along the north-west coast, and from here the land slopes away to the south and south-east. Along the southern coast are low cliffs and two small stretches of sloping shore. North of Lucas Head there are cliffs at the headlands but elsewhere peat slopes continue down to the shore. Boulder beaches occur at the head of North-West Bay and in most of the smaller bays on the Port Ross coast of the island.

Although Enderby and Rose Islands have much in common, modification of the original vegetation has differed markedly on each. The present account is based on historical information from many sources and on personal observations made during three expeditions during 1954–1966. In 1954, Enderby Island was visited from 15–19 March and from 10–12 November, and Rose Island for a few hours on 19 March and from 7–10 November. These visits were mainly to collect

rabbits (*Oryctolagus cuniculus*) for studies of reproduction, age structure, and parasites (Bull, 1960, 1964; Wodzicki, 1965). However, all of Rose Island and much of Enderby was examined, and the vegetation of Rose Island mapped. On both islands many photographs were taken, vegetation samples collected, and the distribution and numbers of rabbits and other introduced mammals noted. During the 1966 expedition, 8 days (17–23 January and 2 February) were spent on Enderby Island and 5 days (27–31 January) on Rose Island. Priority was given to studying the introduced mammals and mapping the vegetation of both islands, and many 1954 photographs were re-taken.

Voucher specimens of plants are deposited in the herbarium of the Botany Division, DSIR, Lincoln.

HISTORY

The Auckland Islands were discovered by the whaler *Ocean* on 18 August 1806, and the first exotic mammals were introduced the following year when pigs were liberated at the north end of the main island. In 1806 fur seals and sea-lions (*Neophoca hookeri*) abounded but were soon indiscriminately slaughtered for their skins and oil. Vessels from New South Wales and America made numerous voyages to the islands and sealing reached its height there about 1822 and 1823 (McNabb, 1907). By 1830 the seals were almost extinct but whalers continued regular visits until declining whale stocks led to the abandonment of the industry in these waters about 1852.

Scientific expeditions from America, Britain, and France, visited the group in 1840 and found pigs, cats, and mice well established on the main island (Wilkes, 1845; Ross, 1847; D'Urville, 1854). The first recorded introduction of mammals to either Enderby or Rose Islands (Fig. 3) was the landing of rabbits on Enderby in 1840 by the British expedition of Sir James Clark Ross.

In the summer of 1842–43, a number of Chatham Island Maoris arrived at Port Ross in the brig *Hannah* to settle at the Auckland Islands. They subsequently split into two main groups, one living on Enderby Island and the other at the north-east end of the main island. The Southern Whale Fishery Company obtained a lease of the islands under charter from the Crown and established a settlement at Port Ross in 1849. When Charles Enderby, as chief commisioner to the Company and "Lieutenant Governor of the Auckland Islands", and his English colonists arrived they found that the Maori population numbered about 70. The Maoris had brought dogs *(Canis familiaris)* and pigs with them from the Chathams and many of these were allowed to run wild (Malone, 1854; McLaren, 1948). Concerning the pigs, Enderby (1875) wrote: "On the two islands of Auckland and Enderby there are a vast number of pigs. I have seen (when standing on the cliffs of the latter island) as many as one hundred at a time feeding on the rocks beneath; but those were by no means the only pigs on that island, for I have

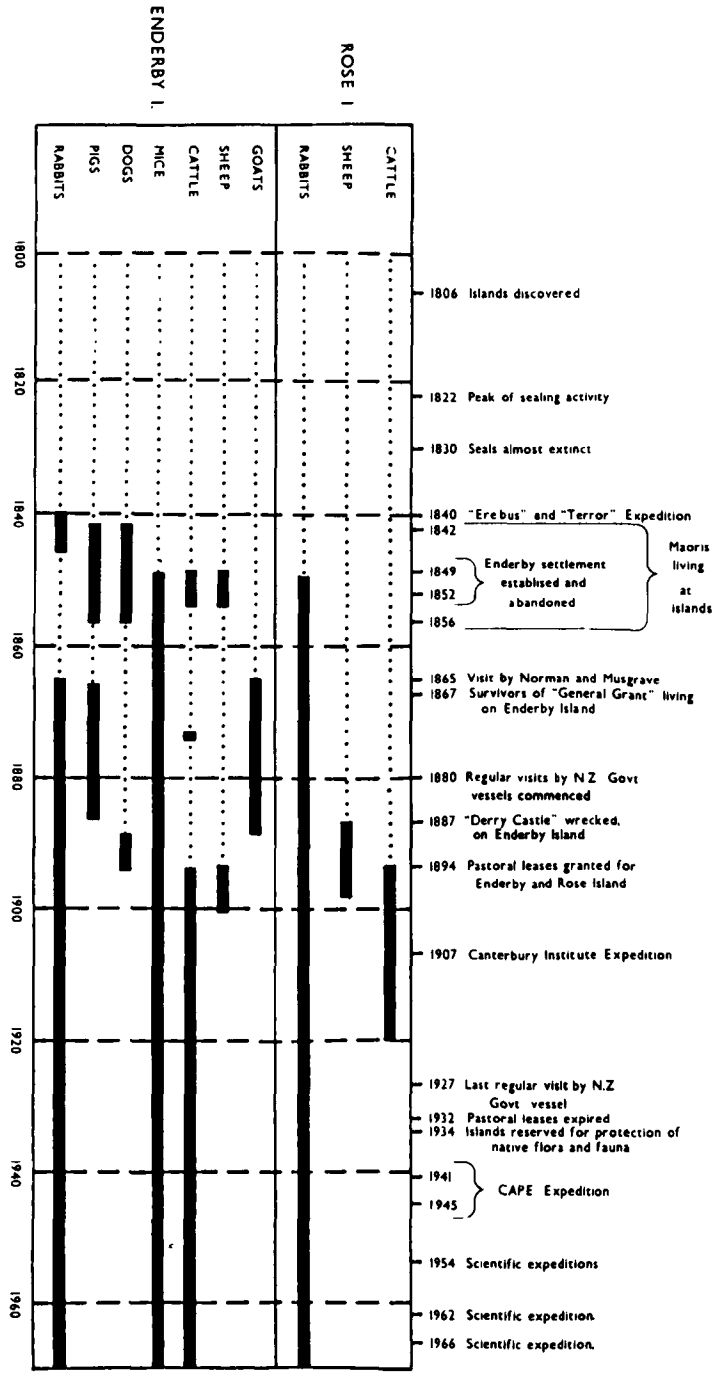

FIG. 3—Historical summary of introduced mammals on Enderby and Rose Islands

likewise seen as many as six splendid black boars running in the woods of apparently a different breed".

Rabbits were liberated by Charles Enderby, who "had rabbits in the first instance on a small piece of detached land [Friday Island] between Auckland and Rose Islands, but they multiplied so rapidly that there was not sufficient food", so he transferred them to Rose Island (Enderby, 1875).

The settlement of the Southern Whale Fishery Company was on the main island at Erebus Cove, but most of their stock was kept on Enderby Island (Findlay, 1863; Shillinglaw, 1866) and included forty-five horned cattle (*Bos taurus*), about 300 sheep (*Ovis aries*), and three horses (*Equus caballus*) (Malone, 1854; McLaren, 1948). The house mouse was probably introduced on to Enderby Island about this time and still thrives there.

When the English abandoned the settlement in August 1852 the horses and some other stock were removed but many pigs, sheep, and cattle were left on Enderby Island (Malone, 1854; Enderby, 1875; McLaren, 1948). These soon disappeared, probably being eaten by the Maoris who did not leave the islands until March 1856, and by visiting sealers (Cockayne, 1904). In 1863 Enderby's rights were formally cancelled, and by Imperial statute the islands were added to New Zealand (Hall-Jones, 1945).

In 1865 survivors of the wrecked ship *Invercauld* found rabbits plentiful on Rose Island (Anon, 1865; Ingram and Wheatley, 1936), and later in the same year Norman and Musgrave (1866), who found no stock on Enderby, landed 10 goats (*Capra hircus*) and 12 rabbits and "set fire to the native grass . . . thus giving an opportunity to the English grass to spread itself more freely". The rabbits liberated on Enderby by Ross in 1840 must have died or been killed by the Maoris for they were not recorded in 1852 (Malone, 1854) or 1865 (Norman and Musgrave, 1866).

During 1867 the survivors of the wreck of the *General Grant* lived on Enderby Island and caught many rabbits, two goats and two kids, but there were no pigs left and 17 were reintroduced to Enderby from the main island by the castaways (Sanguilly, 1869). The following year the brig *Amherst* established the first "depot of necessaries for Castaways" on Enderby Island and reported rabbits on both Rose and Enderby Islands, and that the goats on Enderby were thriving and increasing (Armstrong, 1868).

H.M.S. *Cossack* visited the islands in 1873 when, according to Findlay (1884), "numbers of rabbits were seen on Enderby Island". This visit is also referred to in *Brett's New Zealand and South Pacific Pilot* (Tilly, 1880), which states: "Rabbits and a number of cattle were on Enderby Island when visited by H.M.S. *Cossack*". These cattle may have belonged to Dr F. A. Monckton of Invercargill who obtained a lease of the Auckland Islands in May 1873. Monckton ran sheep at the northern

end of Auckland Island for a few years but whether he stocked Enderby and Rose is unknown. An attempt to ship cattle to the Auckland Islands from Riverton in May 1784 was unsuccessful and Monckton's scheme was abandoned in 1877 (Giles, 1887; McLaren, 1948).

In 1874, H.M.S. *Blanche* found Enderby Island "over-run with black rabbits" (Anon., 1875), and rabbits were still plentiful on both Enderby and Rose Islands in 1876 (Newton, 1876). H.M.S. *Sapphire* (Anon., 1877) found goats and an "abundance of rabbits" on Enderby Island in March 1877 and the S.S. *Stella* returned in May 1808 to report that Enderby Island was "well stocked with pigs, goats and rabbits" (McKenzie, 1880). It was on this latter voyage, the first of a long series of regular visits by New Zealand government vessels, that the small "tent shaped" provision depot (Taylor, 1968 fig. 3a) was erected at Sandy Bay.

There were still some pigs on Enderby Island in 1886 but they were in very poor condition and the rabbit population was much reduced (Grey, 1886). Likewise, Greig (1886) reported to the Royal Society of Victoria that "since '82 the rabbits have been fast dying out or rather starved out. They eat off the grass and then grew up a low thickly set mossy plant which took the place of the grass and at the present time the rabbits are few in number and I would suppose are still decreasing. I saw only one goat and indeed caught (shot) it on Enderby Island but it was little better than skin and bone".

In March 1887 the *Derry Castle* was wrecked on Enderby Island and the survivors remained there for three months before making a punt and reaching the castaway depot at Erebus Cove. Apparently many of the introduced animals had already died out or become very scarce, for during their 91 days on Enderby the survivors saw neither dogs nor pigs and very few goats, but were able to catch numbers of rabbits (Anon., 1887; McGhie, 1888a), which apparently were again on the increase. As a result of this wreck the present boatshed at Enderby Island was built, a boat left there, and signboards erected about Port Ross to direct shipwrecked sailors to the depot at Erebus Cove (Reischek, 1888).

Rabbits in 1888 were in "hundreds" and "very numerous" on Enderby Island; and dogs, probably recently left by sealers, were seen there (Dougall, 1888; Reischek, 1888). About this time, Government steamers started regularly to take sheep, goats, and sometimes cattle, to the various sub-antarctic islands on their twice yearly inspections of the castaway depots (Kirk, 1891; Waite, 1909). Sheep must have been liberated on Rose Island in the late 1880's, for Joyce (1894) mentions two of Lincoln type, taken off Rose Island in 1894 by the *Hinemoa*, as being in perfect condition with fleeces of 4 to 5 years growth. Joyce also records that "on Enderby and Rose Islands . . . rabbits swarm, and greatly reduce the value of the pasturage . . . one of the "Hinemoa's" party shot over twenty in the course of a short excursion".

Cockayne (1904) states that the Hinemoa landed cattle and sheep on Enderby Island, and cattle on Rose Island, in 1894. Three head of cattle were also landed on Enderby Island in 1895 (Bollons, 1925; Eden, 1955). In 1896 another 9 cattle and 20 sheep were landed on Enderby Island for Mr Moffett of Invercargill who had obtained a pastoral lease of Enderby and Rose Islands. Rabbits were still plentiful on Enderby Island at this time (Lukins, 1896). The sheep must have soon died for they were not recorded by later visitors.

By 1903, Cockayne (1904) estimated that there were about 10 cattle on Enderby Island and 15 on Rose Island, and he found "considerable numbers" of rabbits on both islands. The following year the ships of the National Antarctic Expedition, 1901–04, stayed at Port Ross for about 2 weeks. Edward Wilson, a member of this expedition, noted in his diary that there were cattle on both Rose and Enderby Islands, and that although these were left to fend for themselves they seemed to do very well. He also found that rabbits thrived on the sandhills on Enderby Island (Wilson, 1966).

Cattle were hunted for food on both Enderby and Rose Islands by survivors of the wreck of the *Dundonald* in 1907. Most hunting was done on Enderby Island and about a dozen beasts were killed or wounded. Most were small and not very fat (McLaughlin, 1907; Escott-Inman, 1911). This party found plenty of rabbits on Rose Island, but there is no mention of them or of pigs on Enderby. Rabbits must have been scarce on Enderby Island at this time for Waite (1909) only records "traces" of them during the Canterbury Institute Expedition. By 1912, however, they were again plentiful (Davis, 1919). Waite (1909) "understood" pigs were on Enderby Island in 1907 but this is unlikely: the last first hand report of pigs there was in 1886 and they were not found there by either the *Derry Castle* or *Dundonald* castaways, nor have they been reported since.

In 1916 the *Rachel Cohen* returned from the Auckland Islands and one of the crew informed the *Otago Daily Times* (Anon., 1916) that the cattle on Enderby and Rose Islands were in very poor condition and many were dying of starvation due to overstocking and competition from rabbits. Apparently the cattle on Rose Island died out in the next few years, for by 1925 the only cattle reported on the Auckland Islands were about 20 head on Enderby Island. These animals were in very poor condition, as food was short and rabbits were plentiful on both Enderby and Rose Islands (Bollons, 1925). Many rabbits and some cattle were seen on Enderby Island in 1927 (Oliver, 1927).

After 1927 the regular twice yearly inspection by New Zealand Government Steamers of the castaway depots in the subantarctic was discontinued. The chances of shipwrecks at these islands had become remote, for with steam replacing sail and with the opening of the Panama Canal, few ships took the great circle route past islands between Australia and Cape Horn.

The S.S. *Tutanekai* made a final trip to the Auckland Islands in 1929 and apparently the group was not visited again until World War II. The pastoral licence for Enderby and Rose Islands expired in 1932 and was not renewed. In 1934 these, and all other previously unreserved islands in the group, were made reserves for the preservation of native flora and fauna. From 1941 until 1945 coast-watching parties were established on Auckland Island. Those based at Ranui Cove, Port Ross, found cattle on Enderby Island and substantial rabbit populations on both Enderby and Rose Islands (Falla, 1948; Sorenson, 1951; Eden, 1955), but there were no cattle on Rose Island (E. F. Doley, pers. comm., 1966). Dr R. A. Falla (pers. comm.) notes that during this period rabbits were shot throughout the year for sport, and especially on Enderby Island in winter for the skins of the "blue variety". No tally was kept but each year approximately 1000 rabbits were killed, about one-third of those on Enderby Island, where they were concentrated in three areas: the sand dunes and flats around Sandy Bay, the lower middle section of the north coast, and an area of light soil at the eastern end. There were only a few rabbits in the bush and on the "turfy plateau" in the centre of the island.

Scientific expeditions, organised by the Dominion Museum and the Department of Scientific and Industrial Research, visited the islands in 1954, 1962–63, and 1966; and recently a number of commercial fishing interests have investigated the group as potential crayfishing and crab-fishing grounds.

VEGETATION

PRESENT DISTRIBUTION

A belt of southern rata (*Metrosideros umbellata*) forest and scrub lies along the south and east sides of both islands. There is a narrow strip of dead trees surrounding much of the living forest, and larger areas with nearly all the trees destroyed occur elsewhere, particularly to the north-east of both islands. Beneath the dead trees the ground is usually covered with a short sward vegetation and scattered scrub. On Rose Island most of the north and north-west is covered with *Poa litorosa* tussock-grassland and patches of sward. On Enderby Island, where only remnants of tussock-grassland exist, the rata forest gives way towards the north and west to a wider belt of *Cassinia vauvilliersii* scrub which merges into *Oreobolus* moor on the highest parts of the island. Nearer to the north-west cliffs are extensive areas of close cropped sward, large patches of which are dominated by *Bulbinella rossii*. The vegetation of the two islands (Fig. 4) is described in more detail below.

RATA FOREST

The rata forests of the Auckland Islands, with their low, dense, wind-flattened canopy and twisted trunks and branches, are well described by Cockayne (1904, 1909). About half of the southern part of Rose Island

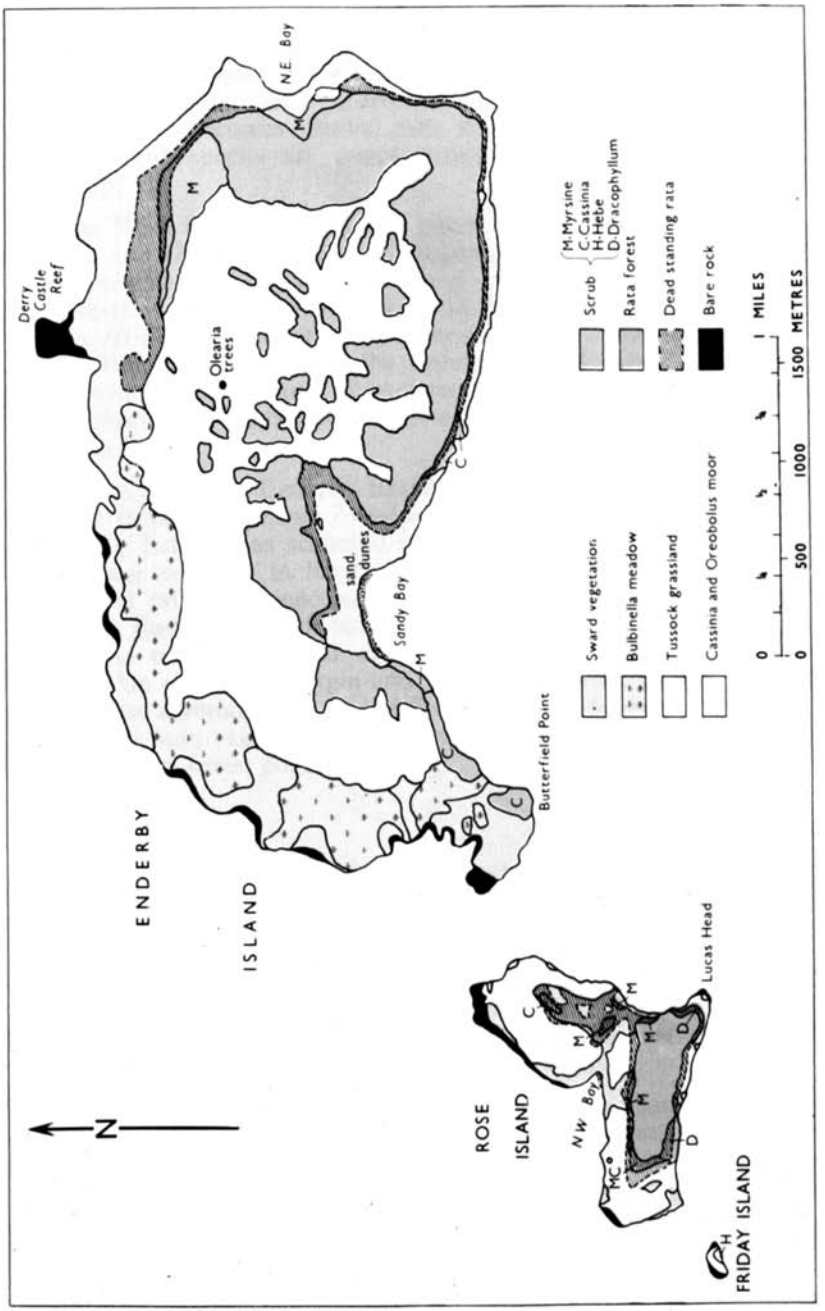

FIG. 4—Sketch map showing the distribution of vegetation on Enderby and Rose Islands in 1966.

is covered with healthy rata forest, but nearly all the rata trees in the north-east part of the island are dead (Fig. 5). In the living forest (Fig. 6) beneath a canopy of almost pure rata, there is a sparse undergrowth of *Myrsine divaricata* and scattered *Dracophyllum longifolium* with patches of ferns, mosses, and liverworts on the forest floor. However, where the rata becomes stunted near the northern and western forest margins, scrub species are common and assume more importance in the canopy.

In the Rose Island forest young plants and seedlings of *Myrsine* are common and *Dracophyllum* is also regenerating. *Coprosma foetidissima* occurs only as very old trees or young seedlings and, although looked for, *Pseudopanax simplex* was not found. The common fern of the forest floor is *Histiopteris incisa*, while *Polystichum vestitum* and *Blechnum capense* occur occasionally in the undergrowth. Within the forest other ferns including *Asplenium obtusatum*, *Grammitis crassa*, *Phymatodes diversifolium*, and *Blechnum durum* are largely confined to rata trunks and steep banks.

The rata forest on Enderby Island is similar in most respects to that on Rose Island. *Coprosma foetidissima* occurs in both the canopy and understory but only as scattered mature trees up to 12 cm in diameter at the base and 3 m in height, and as seedlings on rata stumps and trunks and on banks inaccessible to cattle. *Pseudopanax simplex* still exists on Enderby Island but only along the banks of deep narrow creeks. As on Rose Island, *Hebe elliptica* and *Cassinia vauvilliersii* occur within the forest margin and in low rata scrub; *Histiopteris incisa* is again the common fern of the forest floor, with *Asplenium lucidum* and *Polystichum vestitum* confined mainly to stream banks and scrubby areas near the forest edge.

SCRUB FRINGE

Scrub consisting mostly of *Myrsine divaricata* surrounds, and in places penetrates, the rata forest on both islands. *Dracophyllum longifolium*, *Cassinia vauvilliersii*, *Hebe elliptica*, and *H. odora* are generally minor elements in this formation but become dominant locally (Fig. 6). As in the forest, *Histiopteris incisa*, *Polystichum vestitum*, and a few other ferns from dense ground cover in some places. *Cassinia* and *Dracophyllum* are major components of scrub regenrating beneath dead rata in sheltered parts of both Rose and Enderby Islands.

The growth form of the scrub varies considerably regardless of species composition. In exposed places, a closely packed, wind-trimmed tangle of *Myrsine* often forms an almost impenetrable barrier. In more sheltered places, mature *Myrsine* and *Dracophyllum*, with bare stems and bushy canopies, grow up to 2 m high with a continuous sward beneath (Fig. 7). An unusual variation occurs on the highest part of the plateau at the north-east of Enderby Island where 40–50 cm-high cushions of *Myrsine*, kept hedged by wind and animal browsing, form a mosaic with sward over several acres (Fig. 8).

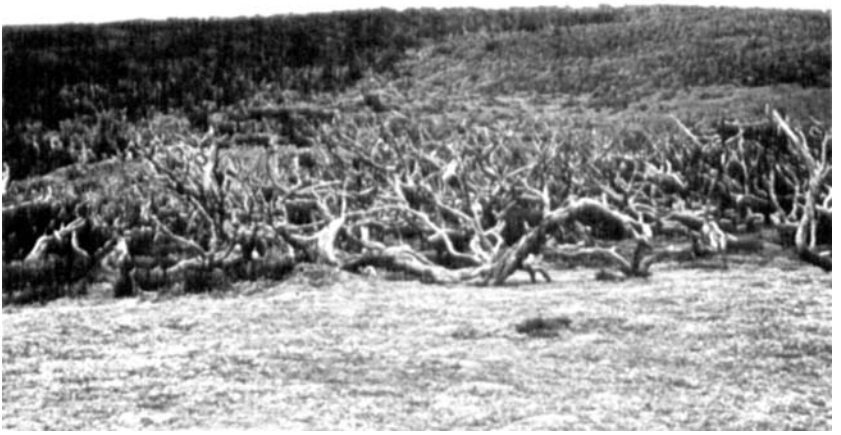

FIG. 5—Dead rata trees on the north-east part of Rose Island, January 1966. View looking south-west with short sward in front and living rata forest and tussock grassland in the background.

FIG. 6—A sheltered part of the rata forest edge near the eastern shore on Rose Island, January 1966. *Dracophyllum longifolium* on left, *Histiopteris incisa* beneath the trees on right, and *Carex appressa* and sward in foreground. The rata trees are about 5 m high.

FIG. 7—Scrub fringe behind Sandy Bay, Enderby Island, January 1966. Sward is growing beneath mature *Myrsine divaricata* on right. Note some *Myrsine* hedged by browsing.

FIG. 8—A mosaic of sward and *Myrsine divaricata* on plateau at the north-east of Enderby Island, January 1966. The scrub is hedged to about 45 cm by wind, cattle and rabbits.

CASSINIA AND OREOBOLUS MOORLAND

A moorland dominated by *Cassinia vauvilliersii* and *Oreobolus pectinatus* covers a broad belt in the centre of Enderby Island and is really a patchwork of two distinct communities. At its southern edge, nearest the scrubby margin of the rata forest, there is a dense cover of *Cassinia* 1–2 m high, with some *Myrsine divaricata* and *Dracophyllum longifolium*. Further to the north-west this tall scrub is confined to sheltered slopes and hollows. The exposed ridges are covered with cushions of *Oreobolus pectinatus* (Fig. 9), with patches of dwarf *Cassinia* and scattered low plants of *Myrsine*, *Dracophyllum*, and seedlings and small plants of southern rata. *Bulbinella rossii* also occurs in this community (Fig. 10), particularly where it adjoins the sward. *Scirpus aucklandicus* is common among the *Oreobolus* on the high tops, and small scattered tussocks of *Chionochloa antarctica* and *Poa litorosa* also occur. Many old tussock mounds were found along these higher ridges and leaf sheath remains collected from them were identified as almost certainly *Chionochloa antarctica* (Dr E. J. Godley, pers. comm.).

Within, and particularly towards the eastern end of, the *Cassinia* and *Oreobolus* moor are isolated strips and pockets of rata scrub and forest (Fig. 11). These are in relatively sheltered places, usually in hollows and along water-courses, and their associated species are the same as in the main rata forest. In the same area there is also an isolated clump of

FIG. 9—Boggy areas near the centre of Enderby Island are covered with cushions of *Oreobolus pectinatus* and stunted *Cassinia vauvilliersii*. Small plants of southern rata and *Myrsine divaricata* also occur. The yellow-eyed penguin (*Megadyptes antipoda*) is about 60 cm high. January 1966.

FIG. 10—The summit of Enderby Island to the north of Sandy Bay, January 1966. View looking south to Ocean Island and Auckland Island. Vegetation is mainly *Oreobolus pectinatus*, *Cassinia vauvilliersii* and *Bulbinella rossii*.

FIG. 11—Enderby Island, January 1966. Small strips and pockets of rata scrub forest occur throughout much of the *Oreobolus* and *Cassinia* belt. Looking south-west: Port Ross and Auckland Island in distance.

FIG. 12—Clump of *Olearia lyallii* about 3.5 m high among *Cassinia* scrub near the middle of Enderby Island, January 1966. This species has not been found elsewhere on either Enderby or Rose Islands.

three *Olearia lyallii* trees (Figs 4, 12). In 1966, the largest was about 3.5 m high and its trunk had a basal diameter of about 25 cm. There were no seedlings nearby and this species was not found elsewhere on either Enderby or Rose Islands. Godley (1965) discussed the interesting occurrence of *Olearia lyallii* on the Auckland Islands (confined to the Port Ross area) and suggested that it was a relatively recent immigrant, probably from the Snares.

TUSSOCK-GRASSLAND

On Rose Island *Poa litorosa* tussock-grassland occurs around much of the coast, but on the southern side it forms only a narrow strip between the rata forest and the shore. Tussock-grassland is most extensive on the exposed north-west side of the island where it is the main vegetation. In extremely exposed places above the northern cliffs the tussocks are low and prostrate, but in more sheltered localities large tussocks of *Poa litorosa* form a very dense cover up to 1 m high (Fig. 13). Tall sedges (*Carex appressa* and *C. trifida*) and scattered *Chionochloa antarctica* grow amongst the *Poa litorosa* tussocks in certain sites.

On Enderby Island about one acre of tall *Poa litorosa* occurs in a poorly drained patch behind North-east Bay. Elsewhere on this island scattered plants of *Poa litorosa* are found in sward, *Oreobolus*, and scrub communities, and are common on the more sheltered southern and eastern cliffs (Fig. 14).

FIG. 13—*Poa litorosa* tussock grassland in foreground and background at the north-east of Rose Island, January 1966. Looking south-east towards Ewing and Ocean Island (right).

FIG. 14—Tussocks of *Poa litorosa* and *P. foliosa* at cliff edge near Butterfield Point, Enderby Island, January 1966. Note old tussock stumps on sward at left.

SWARD VEGETATION

Large areas on both Enderby and Rose Islands are covered with a very short lawn-like vegetation. Godley (1965) refers to this as "sward" or "sward grassland", and although grass species are generally only minor elements, these terms appropriately describe the formation. For example, behind Sandy Bay on Enderby Island where this vegetation grows on peat, sand, and mixtures of both, the dominant species vary from place to place but the overall lawn-like appearance remains.

On Rose Island small strips of sward occur within the tussock-grassland, especially around the coast; with larger patches (usually including scattered *Poa litorosa*) between the dead rata and tussock zones (Fig. 5). Sward is often a major component of the vegetation under dead rata trees.

The very extensive sward areas on Enderby Island occur around the coast, mainly on the exposed northern side and behind Sandy Bay. Old tussock stumps can often be found among the sward (Figs. 14, 15) particularly along the south and east coasts and at Butterfield Point.

Samples of sward (four plugs of turf about 15 cm square) were taken from several sites on both islands in 1954 and 1966. These were examined by Mr A. P. Druce, Botany Division, DSIR, and the plants in them are listed in Table 1. All the samples from Enderby came from near Sandy Bay, and this may explain the absence of certain species

FIG. 15—View south across North-east Bay, Enderby Island, January 1966. Old tussock mounds show in sward at middle right.

identified from more exposed locations on Rose Island. *Plantago triantha* was very common above the north-western cliffs on Enderby in 1966, and *Scirpus cernuus, Tillaea moschata, Colobanthus muscoides, Samolus repens,* and *Gentiana cerina* also occurred in the sward there.

BULBINELLA MEADOW

Large expanses on the north and north-west sides of Enderby Island are dominated in spring and summer by *Bulbinella rossii* which grows thickly throughout the sward (Fig. 16). In winter *Bulbinella* dies back to the ground and the underlying sward becomes more obvious. Moar (1958a) was told that *Bulbinella rossii* was "abundant" on Rose Island, but I could not find it in 1954 or 1966 and nor could Godley (1965) in 1963.

CLIFF VEGETATION

The steep coastal cliffs of Rose and Enderby Islands (Fig. 17) support a distinctive vegetation including predominantly maritime species adapted to this environment. Here also, out of reach of introduced mammals, are plants now rare or missing in other parts of both

FIG. 16—*Bulbinella rossii,* Enderby Island, January 1966. *Bulbinella* grows thickly throughout much of the sward on the north and west of the island.

islands. On the wet southern cliffs of Rose Island, *Poa litorosa*, *P. foliosa*, *P. ramossissima*, *Urtica australis*, *Acaena minor*, *Cotula plumosa*, *C. lanata*, *Scirpus praetexatus*, *S. aucklandicus*, *Asplenium obtusatum*, and *Blechnum durum* are common, and many of these species were noted in similar sites on Enderby Island. In addition, many components of the sward vegetation occur on exposed cliffs of both islands. On Enderby Island *Poa litorosa* and *Carex appressa* are largely restricted to cliff sites, and on both islands *Poa foliosa* is fairly common on the cliffs but completely missing elsewhere. *Anisotome latifolia* survives only on ledges on the northern cliffs of both Rose and Enderby Islands.

PRIMITIVE VEGETATION

Dr M'Cormick, of the *Erebus* and *Terror* Expedition, landed at Sandy Sandy Bay, Enderby Island (Fig. 18) several times during November and December 1840, and has left the only record of the original distribution and composition of the vegetation. "Above the centre of the beach is a hollow, filled with long grass, growing in a rich, boggy soil in such rank luxuriance as to be up to the hips, and flanked by a sand-hill clad to the summit by the same kind of grass, having the whole

FIG. 17—North cliffs of Enderby Island, January 1966. *Anisotome latifolia* (right foreground) is now confined to such places. Sward vegetation above cliffs. *Bulbinella* meadow shows darker in right distance.

skirted by a thicket of trees and bushes . . . on landing I shaped a WNW course through the thickets . . . till I reached the grassy summit above the brushwood . . . and crossed to the opposite side of the island, coasting it round to the right along the long grass, with here and there a few flowers . . . I returned to the beach through a tangled thicket of trees, bushes, and long grass" (M'Cormick, 1884).

Apart from what can be gleaned from M'Cormick's account, and from later decriptions and old photographs of the partly modified environment (see later), the best guide to the original vegetation on Rose and Enderby is in present remnants on these and other less modified islands in the group. On Enderby, plants of *Poa litorosa, P. foliosa,* and *Anisotome latifolia* still exist on cliffs where they have survived fire and browsing (Figs 14, 17). Mounds and old root bases (Figs 14, 15) show where tussocks once flourished in areas now dominated by *Bulbinella rossii* and sward species, and long-dead rata trees stand at the original forest edge. At the northern end of the main Auckland Island there are various locations topographically and climatically similar to Enderby and Rose Islands but where the vegetation has been far less modified. For instance, strips of lowland tussock grassland near North Point and Matheson Bay occupy stations comparable to much of the exposed northern and western sides of the two smaller islands.

FIG. 18—Sandy Bay, Enderby Island, January 1966. The main breeding ground of the southern sea-lion.

This available evidence suggests that the primitive vegetation on Enderby consisted of:

(i) A narrow strip of lowland tussock (*Poa litorosa*) grassland along the south-east coast, and on the sand-dunes at Sandy Bay.

(ii) A belt of rata forest, and its associated scrub fringe, on the southern and eastern sides of the island.

(iii) A broad mixed belt of lowland scrub and *Oreobolus* bog to the north-west of the rata forest and in the centre of the island. This vegetation may have ben very similar to that still occurring on the flat-topped spur stretching inland from Ranui Cove to Meggs Hill on the main island, where, as described by Moar (1958b) and Godley (1965), the scrub occurs in patches or in lines, often in an east-west direction. Here in many places the scrub has colonised sheltered hollows but patches also occur on mounds. Between the scrub patches are extensive lanes of open ground covered with hard cushions of *Oreobolus pectinatus* in which grow scattered plants including gentians, orchids, tussocks of *Chionchloa antactica*, and stunted scrub species. This type of vegetation could well have occupied that portion of Enderby Island today covered with *Cassinia* and *Oreobolus* bog and scattered pockets of rata (Fig. 11).

(iv) *Poa litorosa* tussock grassland on the more exposed north-westerly parts of the island. Scattered *Anisotome* and *Stilbocarpa* would have grown amongst the tussocks, but probably *Bulbinella* was not common for M'Cormick (1884) does not mention it on Enderby, although elsewhere in his narrative he describes it growing in profusion on the main island, near Port Ross.

(v) Strips and patches of sward vegetation along exposed cliff edges and on coastal rocks.

Rose Island has been far less modified than Enderby (Godley, 1965), so although there is no contemporary account of the completely undisturbed vegetation, much can be inferred from the present plant cover and from a description of the island in 1890. "It was flat, covered with grass so heavy that walking was very difficult. On the margins of the cliffs we found several beautiful flowers. The most noteworthy of these was a gentian . . . Here and there among the tall tussock grass we saw the very handsome *Ligusticum* [*Anisotome*] *latifolum* . . . We passed through a characteristic piece of low bush as we went towards the shore. The trees were pressed down by the weight of the wind. The major part of them consisted of the New Zealand rata, *Metrosideros lucidia*" (Chapman, 1895). Except for the absence of sand-dunes and *Oreobolus* bogs the original vegetation pattern here was probably very similar to that on Enderby Island.

MODIFICATION OF THE VEGETATION

Changes in the vegetation of Enderby Island would have started in 1842 with the introduction of domestic animals and human settlement. Pigs would soon destroy most of the large-leaved herbaceous sub-

antarctic endemics such as *Stilbocarpa polaris*, *Pleurophyllum*, and *Anisotome*. Concerning the depredations of pigs, Ross (1847) remarked that their food consisted of *Stilbocarpa polaris* which was "greedily eaten", and he also repeated the observations of Hooker (1847) that *Pleurophyllum criniferum* formed "the larger proportion of the food of the hogs which now run wild upon the islands of Lord Auckland's Group. It is indeed, so abundant in the marshy spots . . . that these animals frequently live entirely amongst it, especially when it grows near the margins of woods, where they form broad tracks or runs through the patches, grubbing up the roots to a great extent, and by trampling down the soft stems and leaves use them as warm and soft forms to litter in". Later observations on Auckland Island also found whole patches of vegetation turned over, "*Bulbinella* and *Pleurophyllum* evidently being favourites" (Waite, 1909), the pigs grubbing up the plants to get at the roots (Aston, 1912).

The early colonists and visitors cleared patches of ground on Enderby and planted vegetables and introduced grasses (Malone, 1854; Findlay, 1863; Norman and Musgrave, 1866), but the overall vegetation pattern would have altered only gradually. A description of Enderby Island in 1868 reads: "The N.W. side is precipitous; the tops of the cliffs covered with mosses and lichens but very bare of pasture. Down the middle of the island runs a belt of scrub, rata (iron wood), enaki (black oak) [*Dracophyllum*], and a tree of which I only know the native name, Ahnokoroa [haumakaroa, *Pseudopanax simplex*]. The S.E. side is well clothed with nettles, McQuarrie cabbage [*Stilbocarpa polaris*], Maori cabbage, patches of white clover, and Yorkshire fog grass (of fine growth), and the common English daisy and buttercup" (Armstrong, 1868). Rather surprisingly there is no mention of tussock for it still covered large parts of the island Dougall (1888) refers to "deep tussock" behind Sandy Bay and several of his photographs show extensive areas of *Poa litorosa* on the north coast near Derry Castle Reef. Lukins (1896) also mentions "tussock" at Sandy Bay, and in 1903 Cockayne (1904) examined and photographed a "lowland tussock" formation "between the dunes and the rata forest". Cockayne also records that "all that part of Enderby island fully exposed to the wind is occupied by a tussock formation".

The stands of dead rata on both islands and the virtual elimination of tussock from Enderby Island almost certainly result from widespread burning and the introduction of sheep and cattle, between 1895 and about 1910. In 1903 Cockayne (1904) noted that at Sandy Bay "cattle, and perhaps rabbits, have loosened the sand, so that dunes originally stable are now moving inland, and have already invaded the forest zone, destroying some of its outermost members", although one of his photographs (Plate XVII) shows that there was still tussock grassland at a part of the bush edge behind Sandy Bay where today there is dead rata and sward. In 1904 Wilson (1966) described Sandy Bay as follows: "This is a wide sandy beach, then a sand bank and then coarse tussock grass leading to a hollow, which, full of tussock grass

itself, leads into dense scrub as you rise to the top of the island nowhere much more than 200 ft above sea level". He also noted that a "clearing" had been made all along the southern coast of Enderby Island. In 1907 Aston (1912) found that "at Enderby Island the cattle had considerably cut up the bush, but their greatest effect was noticeable on the tussocks of *Poa litorosa*, a grass which is evidently being exterminated."

Elimination of the tussock on Enderby must have progressed rapidly, for when Davis (1919) crossed from Sandy Bay to the northern coast in 1912 he recorded: "After passing through some bush we came to the level top covered with short grass in which were a few swampy patches".

Evidence of the widespread use of fire can still be seen in the almost continuous fringe of dead rata around the present forest, where, in 1966, charcoal was occasionally found among the dead roots, and in signs of old burning of scrub and tussock in the centre of the island. That cattle alone could not eliminate *Poa litorosa* tussock is shown by the small patch of about one acre still growing at the eastern end of Enderby Island where by chance it escaped burning. And on the one small part of Campbell Island where cattle have grazed for over 60 years (Taylor *et al.*, 1970), much of the vegetation is dominated by *P. litorosa*.

Where forest and tussock were destroyed by fire, the grazing of cattle and rabbits prevented regeneration and the original cover was replaced by a short sward composed of species previously confined to exposed coastal situations. Similarly the *Bulbinella* on Enderby Island may have derived from scattered plants occurring along the cliffs, as Godley (1965) suggests, or among *Oreobolus* and dwarf scrub on the higher tops. Since *Bulbinella* dies back in winter and has fleshy roots it is less susceptible to burning and grazing than many other plants and, in the absence of pigs, would readily invade depleted areas.

The cliff vegetation of both islands has been least modified by fire and introduced mammals, and Cockayne's (1904) description of the vegetation on the south cliffs of Rose Island is still appropriate today.

INTRODUCED MAMMALS

PRESENT STATUS

Mice, rabbits, and cattle are the only introduced mammals now found on Enderby, and only rabbits occur on Rose Island.

HOUSE MOUSE (*Mus musculus*)

Snap traps for mice were set on Enderby and Rose Islands in 1954 and 1966. Mice were plentiful on Enderby Island in both years, and many were seen or trapped in the old boatshed near the beach, and in the scrub and rata forest behind and to the west of Sandy Bay, where they lived in burrows and holes under roots. No mice or sign of them were

seen on Rose Island and none were trapped in a total of 48 trap nights. Some old candles and biscuits found in 1954 in the boatshed on Rose Island were untouched by mice.

EUROPEAN RABBIT (*Oryctolagus cuniculus*)

The rabbits on Rose and Enderby Islands are of striking colour forms quite distinct from those usual on the main islands of New Zealand (Wodzicki, 1965). The 12 rabbits released on Enderby in 1865 came from the Acclimatisation Society of Victoria which, a few years earlier, had been presented with four "silver-grey" rabbits (Anon., 1864; 1866). These must have belonged to the French breed known as "Argenté de Champagne" (Robinson, 1958), and the population on Enderby has bred true to this type for over 100 years. The adults' winter coat is silvery grey, but in summer many are reddish-brown on the back and flanks.

The Rose Island rabbits are descended from those put there by Charles Enderby about 1850. The liberation must have been of mixed stock, or there may have been other unrecorded liberations, for the present population includes both agouti and silver-black rabbits both with and without white markings.

In 1954 and 1966, the distribution of rabbits was mapped and their abundance assessed during several traverses and circuits of both islands. Population densities were estimated from counts, aided by experience with rabbit populations of known density in New Zealand (Taylor and Williams, 1956; Wodzicki and Taylor, 1956; Taylor, 1967 and unpublished). Scratchings and droppings, as well as the number of rabbits seen, were used to map sparse, scattered populations. In 1966, counts of undisturbed rabbits grazing on measured areas at dusk confirmed that rabbits were as dense as 40 to the acre in places behind Sandy Bay on Enderby Island, but reached only about half this density on the most favoured parts of Rose Island.

On Enderby Island in 1966 (Fig. 19), rabbits were apparently distributed much as Falla (pers. comm.) recorded in 1941–45 (see p. 234). They were concentrated around the sward areas though their sign was found over most of both islands, including the rata forest. As much of the peat is water-logged and not suitable for burrows, the heaviest populations were often associated with dead rata, where stumps and scrubby undergrowth provided cover and sward prevailed (Figs 20, 21). Rabbits also found cover within the rata forest, and in the dense *Poa litororosa* tussock on Rose Island. On Enderby Island, burrows were common on the sandhills and in a narrow strip of well drained peat above the northern cliffs. At the extreme north-eastern point of Rose Island, and at Derry Castle Reef and elsewhere along the north-west coast of Enderby Island, rabbits sheltered in extensive areas of bare rocks and grazed on nearby sward.

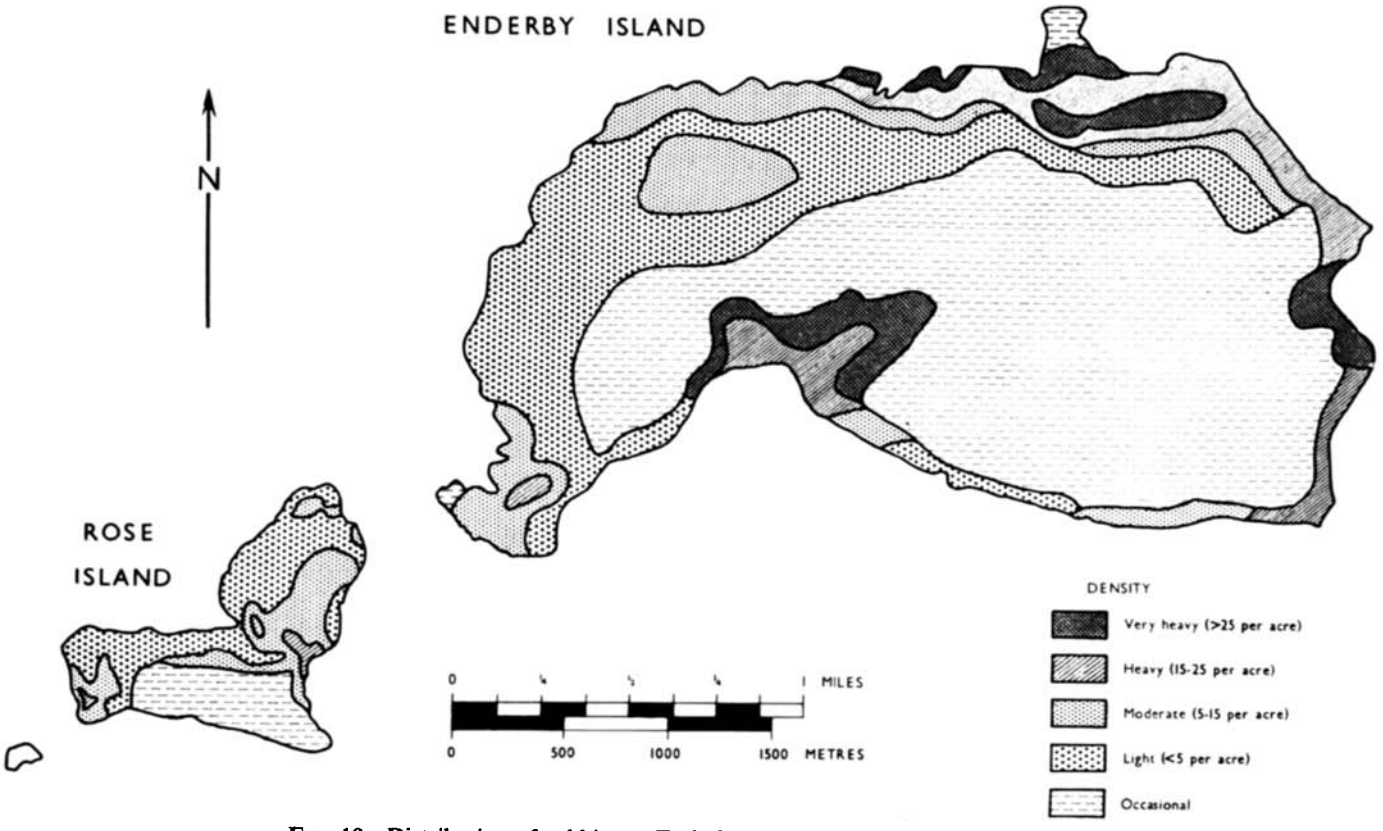

FIG. 19—Distribution of rabbits on Enderby and Rose Islands in January 1966.

FIG. 20—Dead rata forest on seaward slopes near Derry Castle Reef, Enderby Island, January 1966. Areas such as this, with logs, low scrub, and sward, provided ideal rabbit habitat and carried heavy populations.

FIG. 21—Feral cattle grazing short sward at Sandy Bay, Enderby Island, January 1966. Dead trees in the background provided cover for a heavy population of rabbits.

Rabbit numbers changed between visits. There seemed slightly fewer on Enderby Island during November 1954 than in the previous March, probably due to winter mortality and the timing of the breeding season; at the Auckland Islands all young are born between early October and early January (Ecology Division, unpublished file). In general, comparable numbers were found on Enderby in 1954 and in January 1966. Rabbit numbers declined slightly on Rose Island between March and November 1954, as on Enderby. In January 1966, however, rabbits on Rose Island were only about half as numerous as in 1954.

CATTLE (*Bos taurus*)

The feral cattle on Enderby Island (Fig. 21) are derived from pedigree Shorthorn stock (Falla, 1948). Most are black, or black and white, but a few are red with white markings. Many of the cows and a few bulls are polled.

Not all parts of Enderby were visited in 1954, so cattle numbers could not be asessed. In March, 25 cattle were seen near Derry Castle Reef, most being cows and young stock including two calves. During November about 22 cattle were seen: herds of 6 and 10 beasts were encountered near Sandy Bay, and smaller groups of 2 and 3 at the eastern end of the island. From their appearance at least 4 of these animals were additional to those noted in March. In January 1963, a total of 50–60 cattle were seen and 7 bulls were shot (Brian Bell, pers. comm.).

During 8 days on Enderby Island in January 1966, field notes were kept on all cattle encountered. Although most were shy and moved into cover if approached closely, it soon became possible to recognise separate herds retaining their distinctive composition, as well as several more solitary males. The total of 48 beasts comprised 16 adult bulls, 19 adult cows, 4 yearlings, and 9 calves. Thirty-seven were in 5 herds of from 4 to 11; each herd included 1 adult male, 2 or more cows, and their yearlings and calves.

RELATIONSHIP WITH THE VEGETATION

In November, January, and March the cattle on Enderby Island showed a marked prefernce for grazing on the short sward (Fig. 22). They were also commonly seen eating kelp on the shore and signs of recent browsing were found on *Bulbinella* and on tussocks, rushes and sedges at cliff edges, along stream banks, and in swampy places. Cattle were not observed feeding in the forest, although they used it for cover and in places had considerably cut up the forest floor. However, during winter, when plant growth is retarded, they would be forced to browse more in the forest and scrublands, and well hedged *Myrsine divaricata*, apparently browsed by both cattle and rabbits, was common near scrub-sward boundaries (Figs 7, 20). The canopy of the rata forests appears

Photo K. Wodzicki

FIG. 22—(a) North-east end of Rose Island looking south-west. November 1954. Sward grassland and dead rata. The small *Poa litorosa* tussock near the binocular case has been browsed by rabbits.

(b) The same view January 1966. *P. litorosa* has increased and invaded the sward.

healthy and there is no evidence of recent premature mortality. Certainly on Enderby Island in January 1966, almost no sign of browsing could be found on the crowns of low rata shrubs near bush edges, although cattle had been feeding on small prostrate rata in the exposed *Oreobolus* bogs and on adventitious shoots from rata trunks and roots in the forest.

An old photograph taken behind Sandy Bay in 1888, shortly before cattle were introduced, shows that the area had been burned and was then covered with low *Cassinia vauvilliersii* and *Dracophyllum longifolium*. This has regenerated to rata and tall *Myrsine divaricata* in the presence of cattle (see photographs in Taylor, 1968). Although browsing in the taller parts of the forest confines regeneration of palatable species, such as *Pseudopanax simplex* and *Coprosma foetidissima*, to inaccessible places, the forest can apparently replace itself through a succession of fern to impenetrable scrub thereby allowing canopy species to re-establish. Although rata seedlings and shrubs were virtually absent from the ground cover and understory in the taller forest on Enderby Island, they were equally rare in similar situations on Rose Island, without cattle for over 40 years, and at Ranui cove on the main island.

The present density of rabbits on both Enderby and Rose Islands is correlated with the occurrence of sward (Figs 4,19). By microscopic examination of plant fragments Miss R. Mason, Botany Division, DSIR, identified the principal foods in the stomachs of six rabbits (three from each island), collected in November 1954. Most fragments were parts of leaves that were themselves small and so could be identified. All six stomachs contained mainly small fine-leaved grasses and sedges, *Poa annua* and/or *Scirpus* sp. being major constituents in five stomachs and an unidentified grass or sedge in the sixth. Other plants identified in significant amounts in one or more stomachs were *Callitriche* sp. (*C. aucklandica* ?), *Colobanthus muscoides*, *Colobanthus* sp. (*C. apetalus* ?), *Nertera depressa*, *Tillaea moschata*, *Chionochloa antarctica*, and *Cerastium* sp. Traces of bryophytes and herbs were also found. Most of these plants were common in sward vegetation on both islands (Table 1).

The vegetation of the sward is short not only because it is closely grazed, but also because close grazing by introduced mammals has favoured low-growing plant species. On Enderby Island the composition and distribution of this sward is maintained by continued grazing of both cattle and rabbits, which prevent the vegetation from reverting to tussock or scrub.

In 1966 the vegetation on both Rose and Enderby Islands was compared in the field with that shown in photographs and sketch maps of 1954, and many of the earlier photographs were retaken from the same positions. Later, all these photographs were compared with those taken on both islands during the CAPE Expedition (1941–45). Major changes were readily apparent in the vegetation of Rose Island since 1954, whereas on Enderby Island the plant cover appears to have remained virtually unchanged for at least the last 25 years.

TABLE 1—Composition of samples of sward vegetation from Rose and Enderby Islands, collected 1954 and 1966.

	ROSE ISLAND										ENDERBY ISLAND							
SAMPLE †	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
SOIL	Spongy peat										Greasy Peat		Spongy peat		Peat and little sand		Sandy peat	Sand
Marchantia berteroana	X	X	X	X	X	—	X	X	X	—	x	x	X	X	x	—	—	—
Other bryophytes	X	—	X	—	X	—	X	—	x	X	X	X	o	X	X	X	X	—
**Agrostis tenuis*	—	—	—	—	—	—	—	—	X	—	—	X	X	x	x	X	—	—
Poa breviglumis s.s.	—	—	—	—	—	—	—	—	X	—	—	—	—	—	o	—	—	—
**Poa annua*	—	X	—	o	—	—	o	—	—	—	x	x	—	—	—	—	X	x
**Poa* sp. (*P. pratensis*?)	—	x	—	x	—	—	—	X	x	—	—	—	X	X	o	—	—	—
**Festuca rubra commutata*	—	—	—	—	—	—	o	—	—	—	—	—	—	—	X	X	X	—
Scirpus aucklandicus	X	X	X	X	X	—	X	X	X	—	o	—	—	x	—	—	—	—
Scirpus cernuus	—	—	—	—	—	X	—	—	—	X	x	—	—	—	—	—	—	—
Juncus sp. (*J. scheuchzerioides* or *J. pusillus*)	x	o	o	—	—	—	—	o	—	—	x	—	—	o	o	—	—	x
Rumex neglectus	—	x	—	—	—	X	X	X	o	x	—	X	x	X	—	X	x	x
Montia fontana s.s.	—	—	—	—	—	—	o	—	o	—	—	—	—	—	—	—	—	—
Neopaxia sp.	—	—	—	—	—	—	—	o	—	—	—	—	—	—	—	—	—	—
Stellaria decipiens	—	—	—	o	—	—	—	—	o	—	—	—	—	—	—	—	—	—
Colobanthus muscoides	—	—	—	—	—	—	—	—	—	X	—	—	—	—	—	—	—	—
Colobanthus apetalus	x	X	X	o	o	—	X	x	—	X	o	—	—	x	—	—	—	—
**Cerastium holosteoides*	—	—	—	—	—	—	—	—	—	—	—	x	x	o	—	x	x	X
**Sagina procumbens*	—	—	—	—	—	—	—	X	—	—	x	—	—	—	—	—	x	—
Ranunculus acaulis	—	—	—	—	—	x	—	x	—	—	—	o	X	—	—	—	x	o
Cardamine corymbosa	—	o	—	—	—	—	—	x	o	—	o	o	o	x	—	—	—	—
Tillaea moschata	—	—	—	—	—	X	—	o	—	X	—	—	—	—	—	—	—	—
Callitriche sp. (*C. aucklandica*?)	o	X	x	—	o	—	—	o	—	—	x	—	—	—	—	—	—	—
Epilobium confertifolium	X	o	—	X	X	—	x	x	x	—	—	—	—	X	—	—	—	—
Epilobium sp.	—	—	—	—	—	—	—	—	—	—	—	o	x	x	—	—	X	x
Lilaeopsis sp.	—	X	—	—	—	x	x	X	—	X	x	x	—	x	—	—	x	—
Plantago triantha	—	—	—	—	—	—	X	—	—	X	—	—	—	—	—	—	—	—
Pratia arenaria	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	o
Lagenophora sp.	—	o	—	—	—	—	X	x	X	—	o	X	x	o	o	x	x	X
**Bellis perennis*	—	—	—	—	—	—	—	—	—	—	—	—	X	—	—	—	—	x

* Adventive species
X Large amount in at least one of four plugs
x Small amount in at least one of four plugs
o Trace only in one or more plugs
† Location: Rose Island; A,B, near boat shed on south coast; C,D, under dead rata on north-east part of island; E,F, extreme north end of island; G,H, south-west corner of island; I,J, above head of North-West Bay. Enderby Island: K,L,M, behind western end of Sandy Bay beach; N, dead rata behind centre of Sandy Bay beach; O,P, behind sand hills at east end of Sandy Bay; Q, sand hills near middle of Sandy Bay; R, behind dunes 450 metres north-east from Sandy Bay beach. Date: November 1954; A,C, E,G,I,K,O,Q,R. January 1966; B,D,F,H,J,L,M,N,P.

On Rose Island in 1966 there was less sward than in 1954, tussock having invaded it and *Dracophyllum* scrub having spread around the forest margin. In 1954 *Poa litorosa* grassland was growing among dead rata in only a few places near the centre of the north east part of the island, and elsewhere scattered tussocks were found in sward under dead trees along the southern shore and at the north-eastern edge of the present rata forest. In 1966, *P. litorosa* grew thickly under the dead forest along the southern shore and only fragments of sward were left here between the tussocks. Tussock had also increased on the north-eastern forest edge. Tussocks had invaded the sward in many other parts of Rose Island (Fig. 22, Taylor, 1968, fig. 4). These changes were often among or near dead rata, but many small patches of sward along the southern and eastern shore had also decreased in size. The reduction of sward on Rose Island between 1954 and 1966 is shown in Fig. 23.

Apparently the disappearance of cattle about 1920 allowed the tussock to invade the sward. Although *Poa litorosa* seedlings and small plants are grazed by rabbits (Fig 22a), it is obvious that rabbits alone cannot stop the gradual invasion of tussock into sward including that under dead rata forest. Presumably the declining rabbit population on Rose Island is associated with the dwindling area of sward on which they feed most.

CHANGES IN BIRD POPULATIONS

The birds of the Auckland Islands comprise 52 breeding species of which more than half are sea-birds, including 3 species of penguins and

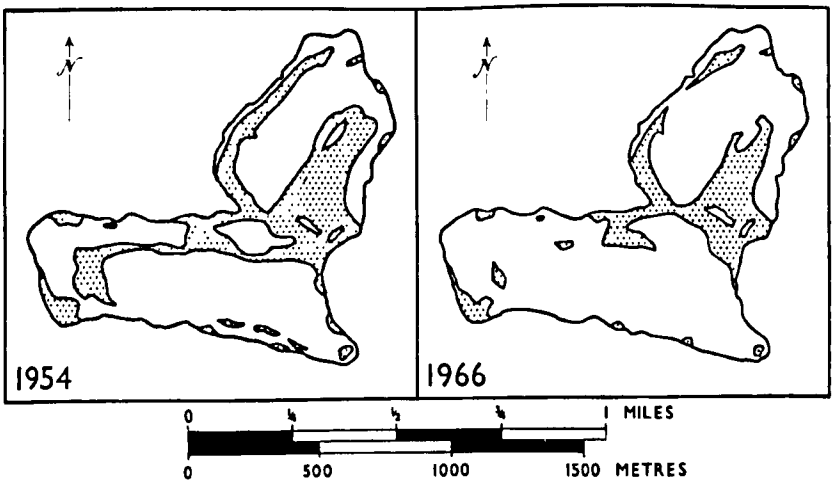

FIG. 23—The major disposition of sward grassland (stippled) on Rose Island in 1954 and 1966. The change is due to the invasion of sward by tussock and scrub.

17 albatrosses and petrels (Falla, 1965). The endemic Auckland Island merganser (*Mergus australis*), last seen in 1904, is the only known extinction since the islands were discovered.

Discussing Auckland Island land-birds, Falla (1965) remarked that introduced mammals, particularly pigs and cats, have made the main Auckland Island "unfavourable for the breeding of one or two vulnerable species, notably the snipe, the flightless duck and the red-fronted parakeet, but there is extensive safe terrain for all these on Adams Island and on several sizeable outlyers around Port Ross", namely Enderby, Rose, and Ewing Islands.

The 1840 British Antarctic Expedition collected two birds on Enderby Island that no longer occur there: the Auckland Island snipe (*Coenocorypha aucklandica aucklandica*) and the South Georgian diving petrel (*Pelecanoides georgicus*) (M'Cormick, 1884; Falla *et al.*, 1966). The snipe probably became rare on Enderby soon after pigs and dogs were introduced and was last recorded there in 1891 (Wilson, 1891). Like the Auckland Island rail (*Rallus pectoralis muelleri*) the snipe has been found only on Adams and Ewing Islands in recent years (Falla, 1967). The disappearance of *P. georgicus* from Enderby Island is probably linked with habitat changes since it nests in shallow burrows in sandy soil (Falla *et al.*, 1966) and such areas on Enderby are now denuded of tussock, trampled by cattle, and burrowed by rabbits. Similar vegetation and soil changes will have made both Enderby and Rose Islands less suitable for burrowing by other small petrels, particularly storm petrels, and will have reduced the populations breeding there.

In 1840 M'Cormick found southern royal albatrosses (*Diomedea epomophora epomophora*) "breeding in considerable numbers on the tops of the cliffs, to the north-westward" of Port Ross (Ross, 1847) and many, it not all, of these were nesting on Enderby Island (M'Cormick, 1884; Oliver, 1955). Most of these birds must have quickly fallen victim to the Maoris who arrived in 1842 with dogs and pigs; and probably there was little or no successful nesting on Enderby until sometime after 1856 when the Maoris had left and feral dogs and pigs died out. Sanguilly (1896) records that, while on Enderby Island in 1866 and 1867, the survivors of the *General Grant* used albatrosses for food and sewed with needles made from albatross bones, and instructions left on Enderby in 1868 for the benefit of castaways included the information that "albatross and other sea-birds lay their eggs on the high land" (Armstrong, 1868). Continuing exploitation by castaways and sealers must have completely exterminated the royal albatross on Enderby Island for it is significant that such a conspicuous bird is not to be found in the many descriptions and photographs of Enderby Island that appeared between 1868 and 1900. In an account of two trips to the southern islands in 1900 and 1901 to collect birds for the British Museum of Natural History (Ogilvie-Grant, 1905), F. W. Hutton noted that the royal albatross "is no longer found on Enderby Island". Likewise, Wilson (1966) did not see any in 1904, but he did find on the beach

below the sandhills "the remains of a lot of albatross, bleached bones, for which I couldn't account". These middens would have been the remnants of early feasts and are still evident in the Enderby sandhills today.

The southern royal albatross was not recorded from Enderby by the Canterbury Institute Expedition in 1907 (Waite, 1909) nor was it reported in 1912 or 1923 (Davis, 1919; Archey, 1923). However, a few were found breeding there by CAPE Expedition personnel in 1941-45, and by the 1954 expedition. Ten pairs were breeding on Enderby Island in summer 1962–63 (Brian Bell, pers. comm.) and 15 pairs in January 1966 (Fig. 24). Thus, since being unmolested by man, southern royal albatrosses have re-colonised Enderby Island and seem to be increasing.

Apart from birds killed by hungry Maoris, sealers and castaways, many bird skins and eggs were collected and a large number of species hunted for sport by passengers and crews of visiting vessels. Malone (1854), who was on H.M.S. *Fantome* stationed at Port Ross for 3 months during the breaking up of the settlement in 1852, left an interesting record of the contemporary attitude towards the wildlife: "We had some good pot-shooting here. Toois were the most numerous . . . two guns have brought down four dozen in a few hours. While there our fellows (the officers) killed 302 toois, 144 wild duck, 12 sealions, 6 parrots, 2 snipe . . . Our boatswain (a kind of Robinson Crusoe), with three men, remained six week on an island [almost certainly Enderby], and lived on the birds, pigs, etc., he shot. They had four dogs with them."

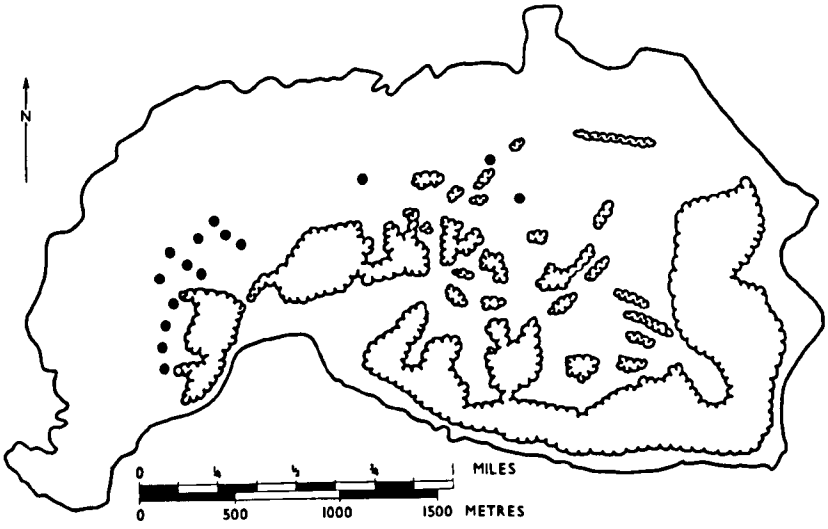

FIG. 24—Distribution of nesting southern royal albatrosses on Enderby Island in January 1966. Each dot represents one breeding pair. Areas of rata forest are also indicated.

Although the numbers of many bird species on Enderby and Rose Islands have probably changed markedly since man discovered the islands there are few records on which to base comparisons. For instance, in 1840 M'Cormick found red-crowned parakeets (*Cyanoramphus novaezelandiae novaezelandiae*) on Enderby, but the *Discovery* Expedition in 1904 saw none there or elsewhere in Port Ross (Wilson, 1966) and apparently the bird was "really scarce" at the Auckland Islands about that time (Waite 1909). Nowadays, red-crowned parakeets are common on both Enderby and Rose Islands. In contrast, a species that may have declined in recent times is the New Zealand falcon (*Falco novaeseelandiae*). Apparently they were numerous about Port Ross in March 1840 (Wilkes 1845), and Wilson (1966) encountered several on Enderby Island in March 1904 where they were preying on rabbits. None were seen on either Enderby or Rose Islands during March or November 1954 or in January 1966.

The land-bird fauna of Enderby and Rose Islands now includes at least eight of the nine Europeans passerines that have dispersed naturally to the Auckland Islands from New Zealand (Williams, 1953; Falla, 1965). The song thrush (*Turdus philomelos*), blackbird (*Turdus merula*), redpole (*Carduelis flammea*), chaffinch (*Fringilla coelebs*), house sparrow (*Passer domesticus*), hedge sparrow (*Prunella modularis*), skylark (*Alauda arvensis*), and starling (*Sturnus vulgaris*) were all noted on Rose and Enderby in 1954 and/or 1966, but the goldfinch (*Carduelis carduelis*) was not seen. The few bird species liberated in the Auckland Group—domestic fowls and ducks in 1840 and 1865 (Ross, 1847; Greig, 1865) and wekas (*Gallirallus australis*) on Rose Island in the 1850's (Enderby, 1875) and on Enderby Island in 1868 (Armstrong, 1868) have not become established.

Very little has been written about the birds of Enderby or Rose Islands and the status of many species is uncertain. Casual field observations in 1954 and 1966 showed that yellow-eyed penguins (*Megadyptes antipodes* Fig. 9) breed in large numbers, and that light-mantled sooty albatrosses (*Phoebetria palpebrata*) nest on the cliffs of both islands. In 1966 northern giant petrels (*Macronectes giganteus halli*) were breeding on Rose Island, and on both islands Auckland Island prions (*Pachyptila desolata alter*), sooty shearwaters (*Puffinus griseus*), white-headed petrels (*Pterodroma lessoni*), and subantarctic diving petrels (*Pelecanoides urinatrix exsul*) were found in burrows or ashore. Auckland Island shags (*Leucocarbo campbelli colensoi*) nest on the cliffs, particularly on Enderby where some large colonies are easily accessible. Other breeding species include antarctic terns (*Sterna vittata bethunei*), two species of gulls (*Larus dominicanus* and *L. novaehollandiae scopulinus*), and the southern skua (*Stercorarius skua lonnbergi*). Members of the coastwatching parties in 1943 also found breeding in small numbers on Rose Island the lesser fulmar prion (*Pachyptila crassirostris eatoni*) and the grey-backed storm petrel (*Garrodia nereis*), a species characteristically associated with heavy growths of tussock in the clumps of which it nests (Dr R. A. Falla, pers. comm.).

Most of the species of land birds of the Auckland Island group still occur on Enderby and Rose Islands. Auckland Island tits (*Petroica macrocephala marrineri*), bellbirds (*Anthornis melanura melanura*), tuis (*Prosthemadera novaeseelandiae*), white-eyes (*Zosterops lateralis*), pipits (*Anthus novaeseelandiae novaeseelandiae*), red-crowned parakeets, and the Auckland Island flightless duck (*Anas aucklandica aucklandica*) are common.

Compared with other islands of the group the most notable features of Enderby and Rose Island birdlife are the nesting royal albatrosses on Enderby, the large numbers of yellow-eyed penguins and Auckland Island shags breeding, and the healthy populations of red-crowned parakeets and flightless ducks. The depredations of wild cats have made the last two species extremely rare on the main island.

CHANGES IN SEAL POPULATIONS

Within 20 years of the Auckland Islands being discovered, their once abundant stocks of fur seals (*Arctocephalus forsteri*) and southern sea-lions (*Neophoca hookeri*) were all but annihilated. From the first, Enderby Island was noted as a base for sealing operations and as a place "where seals mostly congregated", for the sealer *Commerce* landing a party in 1808 found two other sealing gangs already ashore (MsNab, 1907). However, no doubt because of the difficulties of working the Auckland Islands' rugged coastline, maximum attention was not directed to this group until all other southern grounds had been fully exploited (Allen, 1899). Consequently, sealing reached its height at the Auckland Islands about 1822 and 1823, but catches fell off rapidly and by 1826 the southern sealing trade was virtually finished (McNab, 1907).

Morrell (1832) visited the group in 1830 and found that "although the Auckland Isles once abounded with numerous herds of fur and hair-seals [sea-lions], the American and English seamen engaged in this business have made such clean work of it as scarcely to leave a breed [? breeding animal]". A boat party sent to look for seals rowed right round the Auckland Islands without seeing a single fur seal and not more than 20 sea-lions. However, even these remnants continued to be exploited and in 1833 the *Caroline* stationed a sealing gang at the Auckland Islands. They took only 350 skins, a pitiful return compared with the 13,000 obtained here during one voyage of the schooner *Henry* only 10 years before (McNab 1907, 1913).

M'Cormick (1884), who was at the islands in 1840, makes no mention of seals in his detailed account of the natural history of the Port Ross area, even though he landed several times during November and December at Sandy Bay, Enderby Island, nowadays the main population centre of the southern sea-lion. Apparently sea-lions were scarce at Port Ross during the period of human settlement (1842–56) although by then seals were increasing at the southern end of the group (Malone, 1854). With the departure of the settlers, sea-lions began to re-colonise Port

Ross and "plenty" were reported from Rose and Enderby Islands in 1865 (Anon., 1865). However sporadic exploitation of both fur and hair-seals continued and the schooner *Friendship* was reportedly "hunting sea-lions" at Enderby in 1880 (McKenzie, 1880). In 1881 the first official steps were taken to close the New Zealand seal fishery (Wilson, 1893) and both fur seals and sea-lions became fully protected by law. Despite this, poaching continued at the Auckland Islands into the 1890's (McGhie 1888b; Joyce, 1894). Since then, occasional open seasons (the first in 1892) have been declared for fur seals in New Zealand waters but these have not been profitable (Chapman, 1893; Falla, 1962).

After 1888 sea-lions were regularly reported ashore on Enderby and Rose Islands. Lukins (1896) states that sea-lions were "swarming" on Sandy Bay beach in 1896, but the earliest reference to their breeding there is for 1904 (Wilson, 1966).

All subsequent expeditions have found numbers of sea-lions on both Enderby and Rose Islands and apparently the breeding colony at Sandy Bay is still increasing (Waite, 1909; Oliver, 1927; Falla, 1965). From 1942 to 1944, Falla found that about 350 cows pupped at Sandy Bay each season, and today this beach is the main breeding ground of the southern sea-lion, a species which now breeds only on New Zealand's subantarctic islands (Falla, 1965).

In recent years, more than 1,000 sea-lions have come ashore at Sandy Bay during the breeding season (November to March). On 22 January 1966, 407 pups and almost as many adults were counted on the beach, while many other adults and immature animals were on the grass or in the scrub behind the bay or ashore in small groups at other parts of the island. Rose Island, although not a breeding area, is a favoured hauling-out place for immature animals, unemployed bulls, and a few old cows.

Pebbles regurgitated by sea-lions (Fleming, 1951) are common on all parts of both islands and during all three expeditions (March, November, and January) bulls and cows were found inland, throughout the rata forest, and even on the higher central portion of both islands. Since they come ashore at all times of year and travel extensively on land, sea-lions are a significant part of the terrestrial environment, although their effect on the vegetation is relatively slight.

During the coastwatching period (1941–1945) leopard seals (*Hydrurga leptonyx*), of which two or three per year visited Port Ross, were occasionally seen ashore on Enderby and Rose Islands (Dr R. A. Falla, pers. comm.). Other marine mammals encountered, in ones or twos, at Enderby and Rose since 1954 are the fur seal and the elephant seal (*Mirounga leonina*). When on land, fur seals stay near the shore and are mainly confined to the rocky north-west coast. Elephant seals have only been found ashore at Sandy Bay.

THE FUTURE

The array of introduced mammals (pigs, cattle, goats, rabbits, cats, and mice) occuring in different combinations on several of the islands of the Auckland Island group, together with some completely unmodified islands, presents a unique opportunity for studying the effects of man and his introduced animals of the native flora and fauna (Taylor, 1968). While further deterioration of the group should be prevented, every opportunity should be taken to profit from the natural experiments now taking place. Such a course has recently been advocated for other modified southern islands by Holdgate and Wace (1961) and specifically for Enderby Island by Knox (1965). Much would be learned by a continuing comparative study of Enderby and Rose Islands, because of the great similarity of their original vegetation, their differing and fairly well-documented histories, and present contrasting environmental trends.

As Rose and Enderby Islands have no steep land there is little or no danger of rabbit induced or accelerated erosion, unlike sub-antarctic Macquarie Island (Taylor, 1955; Costin and Moore, 1960). Even in the most modified situations on Enderby the short sward and unpalatable plants such as *Bulbinella rossii* protect the underlying peat. The originally dominant and only stabilising species on the steeplands of Macquarie Island were highly palatable *Poa foliosa* and *Stilbocarpa polaris*, whereas the original dominants on Rose and Enderby were unplatable tussock (*Poa litorosa*), scrub, and forest species which rabbits cannot further invade without the help of fire.

Left undisturbed, most of the sward on Rose Island should gradually revert to tussock grassland and the rabbits continue to decline and perhaps eventually die out. In time, through a succession of tussock, fern, and scrub, forest could become re-established on the old burnt rata areas (Fig. 25). On Enderby Island, only time will tell whether any long-term balance exists between the vegetation and the introduced mammals, but southern royal albatrosses and seals should continue to increase after their long exploitation. Existing conditions also appear suitable for exceptional numbers of yellow-eyed penguins and of landbirds such as pipits, Auckland Island tits and red-crowned parakeets.

Thus, unless man once more intervenes, future environmental trends can be predicted to some extent. One possible, but in my opinion undesirable, disturbance would be control or removal of rabbits and cattle in a fumbling atempt to re-establish the natural vegetation or protect the native fauna (Taylor, 1968; Taylor *et al.*, 1970). On Enderby there are breeding sea-lions, many native bird species, cattle, and rabbits all in an interacting relationship which is not obviously detrimental to any of them or to the present vegetation; and existing trends here and on Rose Island have positive conservation values and scientific interest. Another possible disturbance is that, as a side-line of a proposed crabmeat industry at the Auckland Islands, commercial interest is being shown in the islands' feral mammals; during 1969 one fishing vessel carried a helicopter to survey the game-meat potential of the group

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REFERENCES

ANON. 1864: "Report of the Council for the Year 1863". Acclimatisation Society of Victoria. Melbourne.

———— 1865: The loss of the ship *Invercauld* at the Auckland Islands 12 months ago. Narrative of the Mate. *Glasgow Mail, 20 Oct. 1865.*

———— 1866: "Report of the Council for the Year 1865". Acclimatisation Society of Victoria. Melbourne.

———— 1875: "The New Zealand Pilot" (4th edition). Hydrographic Office, London.

———— 1877: Unpublished. Proceedings H.M.S. Sapphire, No. 9, 14 March 1877. New Zealand National Archives.

———— 1887: The wreck of the *Derry Castle*—suffering of the survivors—five months on an uninhabited island. *Evening Post, Wellington, 5 Oct. 1887.*

———— 1916: Editorial. *Otago Daily Times, Dunedin, 18 Nov. 1916:* 6.

ALLEN, J. A. 1899: Fur-seal hunting in the southern hemisphere. In "The Fur Seals and Fur-Seal Islands of the North Pacific Ocean". Ed. D. S. Jordan. Part 3: 307–19. Government Printing Office, Washington.

ARCHEY, G. 1923: Notes on birds of the sub-antractic islands of New Zealand. *Records of the Canterbury Museum 2:* 117–20.

ARMSTRONG, H. 1868: Cruise of the brig *Amherst*. Official Report. *New Zealand Government Gazette, Province of Southland* 6 (9): 51–6.

ASTON, B. C. 1912: Some effects of imported animals on the indigenous vegetation. *Transactions of the New Zealand Institute* 44: 19–24.

BERRY, K. 1970: Giant crab industry to rival crayfish bonanza? *New Zealand Weekly News, 9 Feb. 1970.*

BOLLONS, I. 1925: Unpublished. Memo. to Secretary of Marine, 26 September 1925. New Zealand Marine Dept. files.

BULL, P. C. 1960: Parasites of the European rabbit, *Oryctolagus cuniculus* (L.) on some subantarctic islands. *New Zealand Journal of Science 3:* 258–73.

———— 1964: "Ecology of Helminth Parasites of the Wild Rabbit *Oryctolagus cuniculus* (L.) in New Zealand". *New Zealand Department of Scientific and Industrial Research Bulletin 158.*

CHAPMAN, F. R. 1893: Notes on the depletion of the fur-seal in the southern seas. *Canadian Record of Science*, October 1893: 446–59.

——— 1895: Illustrations from sub-arctic New Zealand. *Otago Witness, 2181, 19 Dec. 1895.*

COCKAYNE, L. 1904: A botanical excursion during midwinter to the southern islands of New Zealand. *Transactions of the New Zealand Institute 36:* 225–333.

——— 1909: The ecological botany of the subantractic islands of New Zealand. In "The Subantarctic Islands of New Zealand". Ed. C. Chilton. Philosophical Institute of Canterbury, Wellington.

COSTIN, A. B.; and MOORE, D. M. 1960: The effects of rabbit grazing on the grasslands of Macquarie Island. *Journal of Ecology 48:* 729–32.

DAVIES, J. K. 1919: "With the 'Aurora' in the Antarctic, 1911ffl1914". Andrew Melrose, London.

DE LISLE, J. F. 1965: The climate of the Auckland Islands, Campbell Island and Macquarie Island. *Proceedings of the New Zealand Ecological Society 12:* 37–44.

DOUGALL, W. 1888: "Far South: Stewart Island, The Snares, Auckland, Campbell, Antipodes, and Bounty Islands". Southland Times, Invercargill.

D'URVILLE, J. S. C D. 1854: "Voyage au Pole sud dans l'Oceanie sur les corvettes *l'Astrolabe* et la *Zèlée*". Paris.

EDEN, A. W. 1955: "Islands of Despair". Andrew Melrose, London

ENDERBY, C. 1875: In "The New Zealand Pilot" (4th edition). Hydrographic Office, Admiralty, London.

ESCOTT-INMAN, H. 1911· "The Castaways of Disappointment Island". S. W. Partridge and Co., London.

FALLA, R. A. 1948: The outlying islands of New Zealand. *New Zealand Geographer 4:* 127-54.

——— 1962: Exploitation of seals, whales and penguins in New Zealand. *Proceedings of the New Zealand Ecological Society 9:* 34–8.

——— 1965: Birds and mammals of the subantarctic islands. *Proceedings of the New Zealand Ecological Society 12:* 63–8.

——— 1967: An Auckland Island rail. *Notornis 14:* 107–13.

FALLA, R. A., SIBSON, R. B.; and TURBOTT, E. G. 1966: "A Field Guide to the Birds of New Zealand". Collins, London.

FINDLAY, A. G. 1863: "A Directory for the Navigation of the South Pacific Ocean; with Descriptions of its Coasts, Islands, etc." (2nd edition). R. H. Laurie, London.

——— 1884: "A Directory for the Navigation of the South Pacific Ocean; with Descriptions of its Coast, Islands, etc." (5th edition). R. H. Laurie, London.

FLEMING, C. A. 1951: Sea lions as geological agents. *Journal of Sedimentary Petrology 21:* 22–5.

GILES, S. 1887: Unpublished. Journal of a voyage from Bluff to McQuarrie Island, 1887.

GODLEY, E. J. 1965: Notes on the vegetation of the Auckland Islands. *Proceedings of the New Zealand Ecological Society 12:* 69–72.

GREIG, J. B. 1865: Report on expedition to the Auckland Islands. *Southland Provincial Government Gazette 3:* 120–2.

——— 1886: Unpublished. Letter to Royal Society of Victoria from master of Government Schooner *Kekeno*. New Zealand National Archives.

GREY, W. J. 1886: Unpublished. Report by captain of S.S. *Stella*, 16 Aug. 1886. New Zealand National Archives.

HALL-JONES, F. G. 1945: "Historical Southland". H. & J. Smith, Invercargill.

HOLDGATE, M. W.; and WACE, N. M. 1961: The influence of man on the floras faunas of southern islands. *The Polar Record 10*: 475–93.

HOOKER, J. D. 1847: "Flora Antarctica". Vol. 1. Reeve Bros, London.

INGRAM, C. W. N.; and WHEATLEY, P. O. 1936: "Shipwrecks—New Zealand Disasters". Dunedin Book Publishing Association, Dunedin.

JOYCE, J. P. 1894: "Auckland, Campbell, and other Islands (Report on), and on their Seals, and Seal-Rookeries". Report to New Zealand Parliament, Government Printer, Wellington.

KIRK, T. 1891: Report on a botanical visit to Lord Auckland, Campbell and Antipodes, and other antarctic islands. *Journal of the Linnean Society (Botany) 28:* 327–30.

KNOX, G. A. 1965: The subantarctic islands: Past, present, and future. *Proceedings of the New Zealand Ecological Society 12:* 69–72.

LEAMY, M. L. and BLAKEMORE, L. C. 1960: The peat soils of the Auckland Islands. *New Zealand Journal of Agricultural Research 3:* 526–45.

LUKINS, E. 1896: "Round Southern Isles". Bond, Finney and Co., Nelson.

MALONE, R. E. 1854: "Three Years' Cruise in the Australasian Colonies". Bentley, London.

MCLAREN, F. B. 1948: "The Auckland Islands". A. H. & A. W. Reed, Wellington.

M'CORMICK, R. 1884: "Voyages of Discovery in the Arctic and Antarctic seas, and Round the World", Vol. 1. Sampson Low, London.

MCGHIE, J. 1888a: Unpublished. Letter to Captain Musgrave from a survivor of the wreck of the *Derry Castle*. 22 Aug. 1888. New Zealand National Archives.

——— 1888b: Sealers at work. *The Evening Star, Dunedin, 5 Jan. 1888.*

MCKENZIE, (?) 1880: Unpublished. Report on visit of S.S. *Stella* to Snares and Auckland Islands. 22 May 1880. New Zealand National Archives.

MCLAUGHLIN, D. 1907: Castaway mariners—the survivors of the Dundonald—diary of the second mate. *The New Zealand Times, 7 Dec. 1907*: 5–6.

MCNAB, R. 1907: "Murihiku and the Southern Islands". William Smith, Invercargill.

——— 1913: "The Old Whaling Days". Whitcombe and Tombs, Wellington.

MOAR, N. T. 1958a: Notes on the botany of the Auckland Islands. *New Zealand Journal of Science 1:* 466–79.

———— 1958b: Contributions to the quaternary history of the New Zealand flora: I. Auckland Island peat studies. *New Zealand of Science 1:* 449–65.

MORRELL, B. 1832: "A Narrative of Four Voyages, 1822–1831". Harper, New York.

NEWTON, T. W. 1876: Unpublished. Diary of a member of the crew of the sealing schooner *Awarua.*

NORMAN, W. H.; and MUSGRAVE, T. 1866: "Journals of the Voyage and Proceedings of H. M. C. S. *Victoria* in Search of Ship-wrecked people at the Auckland and other Islands". Government Printer, Melbourne.

OGILVIE-GRANT, W. R. 1905: On the birds procured by the Earl of Ranfurly in New Zealand and the adjacent islands. *The Ibis 8:* 543–602.

OLIVER, W. R. B. 1927: Unpublished. New Zealand's subantarctic isles. Dominion Museum, Wellington.

———— 1955: "New Zealand Birds". (2nd edition). A. H. & A. W. Reed, Wellington.

REISCHEK, A. 1888: Notes on the islands to the south of New Zealand. *Transactions of the New Zealand Institute 21*: 378–389.

ROBINSON, R. 1958: Genetics of the rabbit. *Bibliographia Genetica 17:* 229–558.

ROSS, J. C. 1847: "A Voyage of Discovery and Research in the Southern and Antarctic Regions, during the years 1839–43". John Murroy, London.

SANGUILLY, W. M. 1869: Shipwreck of the *General Grant. Harpers Magazine, 38:* 535–40. New York.

SHILLINGLAW, J. J. 1866: A short account of the Auckland Islands. Appendix II. In "Castaways on the Auckland Islands". T. Musgrave. Lockwood and Co., London.

SORENSON, J. H. 1951: "Wild Life in the Subantarctic". Whitcombe and Tombs, Wellington.

TAYLOR, B. W. 1955: "The Flora, Vegetation and Soils of Macquarie Island". Australian National Antarctic Research Expedition Reports, Series B.2. Botany.

TAYLOR, R. H. 1967: Mammals and birds, with a note on lizards. In "Motunau Island, Canterbury, New Zealand—An Ecological Survey." New Zealand Department of Scientific and Industrial Research Bulletin 178: 42–67.

————1968: Introduced mammals and islands: Priorities for conservation and research. *Proceedings of the New Zealand Ecological Society 15:* 61–7.

TAYLOR, R. H.; WILLIAMS, R. M. 1956: The use of pellet counts for estimating the density of populations of the wild rabbit, *Oryctolagus cuniculus* (L.). *New Zealand Journal of Science and Technology B38:* 236–56.

TAYLOR, R. H.; BELL, B. D.; and WILSON, P. R. 1970: Royal albatrosses, feral sheep and cattle on Campbell Island. *New Zealand Journal of Science 13:* 78–88.

TILLY, T. C. (Ed.) 1880: "Brett's New Zealand and South Pacific Pilot and Nautical Almanac for 1881, 1882, and 1883". H. Brett, Auckland.

WAITE, E. R. 1909: Vertebrata of the subantarctic islands of New Zealand. In "The Subantarctic Islands of New Zealand". Ed. C. Chilton. Philosophical Institute of Canterbury. Wellington.

WILKES, C. 1845: "Narrative of the United States Exploring Expedition During the Years 1838, 1839, 1840, 1841, 1842". Vol. 2. Philadelphia.

WILLIAMS, G. R. 1953: The dispersal from New Zealand and Australia of some introduced european passerines. *The Ibis 95:* 676–92.

WILSON, E. 1966: "Diary of the 'Discovery' Expedition to the Antarctic 1901–1904". Blandford Press, London.

WILSON, L. B. 1893: New Zealand seal-fisheries. *Appendix to the Journal of the House of Representatives New Zealand* A1: 2–3.

WILSON, R. A. 1891: Unpublished. Diary of a trip to Milford Sound and the sub-antarctic islands, October–November 1891.

WODZICKI, K. 1965: The status of some exotic vertebrates in the ecology of New Zealand. In "The Genetics of Colonising Species". Eds. N. G. Baker and G. L. Stebbings. Academic Press, New York.

WODZICKI, K.; TAYLOR, R. H. 1956: An experiment in rabbit control–Kourarau poison trials. *New Zealand Journal of Science 38:* 389–99.