CHAFFINCH — Birds seen on Red Mercury and Double Island, but no song heard. Common on Great Mercury, flocks of up to 15 birds.

YELLOWHAMMER — Common on Great Mercury (one flock of 23 birds) but not seen on outer islands.

SPARROW — None seen on outer islands; 15 in a flock at Great Mercury.

STARLING — Common on Great Mercury (one flock c. 50 birds); small parties on and around Double Island and Red Mercury, seven birds on the cliff at Stanley (according to J.B. much larger numbers are sometimes seen there). A good deal of movement takes place between the islands, and flocks of 30-40 birds were seen offshore on several occasions. One flock seen near Stanley included an albino bird. Some birds use the outer islands as a roost; one evening a flock of 40 flew along the south coast of Great Mercury heading for Red Mercury, and c. 20 were seen leaving the western shore of Red Mercury at first light on 30th August.

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EXTINCTION AND THE LAND AND FRESHWATER-INHABITING BIRDS OF NEW ZEALAND

By G. R. WILLIAMS
Zoology Dept., Lincoln College, Canterbury

The depletion of New Zealand's avifauna since the first impact of European man on these islands is often cited as a melancholy example of the results to be expected from the ever-increasing effect of modern man upon natural ecosystems. But unfortunate though these results may have been, the degree to which they have hastened the extinction of various species is frequently overemphasised. Early local authors were understandably pessimistic at a time when rapid changes were occurring and wholesale exterminations seemed imminent (Buller 1873, 1888, 1905) and this mood has been echoed by many other authors since. Even the following cautious statement by Lack (1954: 202) seems to imply widespread extinction: "A casual impression would suggest that the native birds have been largely driven out by Palaearctic introductions." (It also implies a competition that has not yet been shown to occur, as does the comment by Hesse, Allee and Schmidt (1951: 113) that "the endemic birds of New Zealand give way before the buntings, starlings and goldfinches.") These statements no doubt originate from such influential local authorities as Buller (1905: xxxiii) and Oliver (1930). A healthy scepticism about such assumptions, for example that of Myers (1923) is seldom quoted. Great though the diminution in numbers has been since European settlement, only a few species have become totally extinct, in spite of the extensive changes that have taken place in the environment and in spite of the introduction and establishment of a comprehensive new fauna of mammals, birds and insects. The number of bird species dying out before 1800 far exceeds that vanishing since; though when

New Zealand is considered as a whole, the obvious changes in the environment over the last 160 years appear, superficially at least, to have been greater and more sudden than those of the previous 1600 or so.

A start has been made in the study of the historical changes in the patterns of distribution of rare New Zealand birds and of their population ecology (Turbott 1957, Williams 1956, 1960b) but this is in only a preliminary stage. By careful study of the changes in the distribution of species that have become extinct or near-extinct, it may be possible to decide whether there is any common pattern. Should one be found it might offer a clue to causes, either pre- or post-human.

In this paper I deal only with land- and freshwater-inhabiting birds (in which groups by far the greatest number of extinctions of New Zealand birds has occurred) and my definition of "New Zealand" includes only the North Island (44,000 sq. m.), South Island (58,000 sq.m.), Stewart Island (670 sq.m.) and the Chatham group (370 sq.m.). Unless otherwise stated, the small offshore islands of each of these major subdivisions will be considered part of the nearest mainland. The North Island is separated from the South by Cook Strait which has a minimum width of 15 miles. Foveaux Strait, 20 miles wide, separates the South Island from Stewart Island. The Chathams lie 400 miles ESE of the South Island.

Other islands generally included in the New Zealand faunal area: the Kermadecs, Bountys, Antipodes, Snares, Aucklands, Campbell and Macquarie, have not been included in this paper on the grounds that in most instances a great deal more needs to be learned about their early avifaunas and the changes that have taken place in them in historic times.

The extinct species are listed in some detail and there is a brief account of the status of each of those apparently in danger of extinction. The data at present are such that speculation about causes cannot be usefully advanced much beyond what has already appeared (Williams 1956, 1960b). That is, briefly, that a too-ready acceptance of theories suggesting human interference (direct or indirect) as the prime cause is unjustified. Extinction is a common natural process which can occur in a number of ways. (For the final stages of the process genetical theory offers some attractive explanations involving the Sewall-Wright effect, population size and variations in selection pressure.)

PRE-EUROPEAN EXTINCTIONS

Relying mainly upon Oliver (1955), the Checklist of New Zealand birds (Fleming *et al.* 1953), Dawson (1958, 1959, 1960) and Scarlett (pers. comm.), I find that approximately 40 full species have become extinct in Recent times before European settlement. How many of these have vanished since the arrival of Polynesian man in New Zealand approximately 1000 or more years ago cannot at present be decided, but it is safe to say that a number have. Fleming (1953) thinks most have. Eventually many of the remains may be dated by radioactive techniques and light may then be thrown on the order in which the species became extinct and the rate at which the process took place; but it is important to point out that the finding of bones in middens with a frequency of occurrence that diminishes as the end of the 18th or 19th century is approached is no proof that human predation has been an important cause of this diminution. The process could well have been going on independently of either hunting or habitat

destruction; and the point has already been made (Williams 1956, 1960b) that there must have been very extensive sparsely-populated or mountainous areas which remained virtually unmodified or unexploited by the moderate pre-European Polynesian population of these islands. Yet even in such areas diminutions and extinctions occurred and especially would this be true of the South Island.

The extinct forms consist of about 25 species of moa (the number depending upon the system of classification adopted), at least six species of rail (a number of new species have yet to be described — Scarlett, pers. comm.), five of waterfowl, a hawk, an eagle, two snipe and a crow. Nearly all of these are endemic genera, the moas being also an endemic order. Distribution is as follows:—

NORTH ISLAND (about 23 species)

Moas (about 15 species of the genera *Pachyornis, Euryapteryx* (which includes *Zelornis* — Scarlett, pers. comm.), *Anomalopteryx, Dinornis*);

Rails: the Cave Rail *Capellirallus karamu,* N.I. Takahe, *Notornis m. mantelli,** aptornis, *Aptornis otidiformis* (= *A. defossor* — Scarlett, pers. comm.); waterfowl: N.I. Goose, *Cnemiornis septentrionalis* (= *C. gracilis*), Chatham Island Swan, *Chenopis sumnerensis* (? = *C. chathamicus*); Large N.Z. Harrier, *Circus teauteensis*† (? = *C. hamiltoni*, ? = *C. eyelsi*) (Dawson 1958), N.Z. Eagle, *Harpagornis moorei;* N.Z. Crow, *Palaeocorax moriorum.*

SOUTH ISLAND (about 31 species)

Moas (about 19 species of the genera *Pachyornis, Euryapteryx, Anomalopteryx, Dinornis, Emeus, Megalapteryx*); the Little Weka, *Gallirallus minor,*† N.Z. Gallinule, *Pyramida hodgeni,* aptornis, N.Z. Coot, *Palaeolimnas chathamensis;* Finsch's Duck, *Euryanas finschi,* S.I. Goose, *Cnemiornis calcitrans,* Chatham Island Swan, Auckland Island Merganser, *Mergus australis;* snipe, *Coenocorypha ?aucklandica** (Scarlett, pers. comm.); N.Z. Eagle (I accept Oliver's suggestion that *H. moorei* and *H. assimilis* may be conspecific), Large N.Z. Harrier; N.Z. crow.

STEWART ISLAND (3 species)

Moa *Euryapteryx gravis, Euryapteryx* n.sp. (Scarlett 1957); Little Weka (Scarlett pers. comm.).

CHATHAM ISLANDS (12 species)

Giant Rail, *Diaphorapteryx hawkinsi,* N.Z. Coot, Little Weka (Falla 1960), Weka, *Gallirallus australis;** Chatham Island Swan, C.I. Duck, *Pachyanas chathamica.* Extinct C.I. Snipe, *Coenocorypha chathamica;*† Kakapo *Strigops habroptilus,** Kaka, *Nestor meridionalis;** N.Z. Falcon, *Falco novaeseelandiae;** Laughing Owl, *Sceloglaux albifacies;** N.Z. Crow.

This list will no doubt have to be modified as our knowledge increases. Even now, little is known of the early avifauna of sparsely-settled Stewart Island or of much of the west coast of the South Island. Some of the species represented by midden remains may not be truly native to the area where these remains have been found.

I have not accepted the Pink-eared Duck *Malacorhynchus* (see Oliver 1955) or the Musk Duck *Biziura* (see Dawson 1958) as natives because both could have been Australian vagrants; and the claim for

* Species still extant elsewhere in New Zealand
† Genus still extant elsewhere in New Zealand

a local species of the Cape Barren Goose *(Cereopsis novaehollandiae)* cannot at present be maintained (Dawson 1960). Phillips (1959) has proposed that the North Island Takahe may have lingered on until the end of the 19th century, though I consider the evidence unsatisfactory. It is likely that the moa *Megalapteryx* may have survived into European times in the South Island.

EXTINCTIONS OCCURRING IN EUROPEAN TIMES

Over approximately the last 160 years, five full species and five subspecies have become totally extinct — perhaps rather fewer than might be expected when one considers the great changes that have occurred in New Zealand environments during this period. In addition, two subspecies have become locally extinct in the South Island and three full species locally extinct in the Chathams. Distribution and the approximate dates of extinction, or of the last official record, of these birds are as follows:—

NORTH ISLAND (5 species)

N.Z. Quail *Coturnix n. novaezealandiae*
1860-70 (Buller 1883, 1905)

Little Barrier Snipe *Coenocorypha aucklandica barrierensis**
1870 (Oliver 1955)
(Turbott 1961)

N.I. Kakapo *Strigops habroptilus innomminatus**
1930 (Williams 1956)

N.I. Laughing Owl *Sceloglaux albifacies rufifacies**
1890 (Williams unpubl.)

Huia *Heteralocha* (=*Neomorpha*) *acutirostris*
1907 (Oliver 1955)

SOUTH ISLAND (4 species)

N.Z. Quail
1875 (Buller 1883)

Eastern Weka *Gallirallus australis hectori***
1920 (Oliver 1955)

S.I. Saddleback *Philesturnus c. carunculatus***
1925 (Williams unpubl.)

Stephen Island Wren *Xenicus lyalli*†
1894 (Buller 1905)

STEWART ISLAND (none)

CHATHAM ISLANDS (7 species)

All dates from Fleming (1939)

C.I. Fernbird *Bowdleria punctata rufescens**	1900
Brown Teal *Anas castanea chlorotis***	1915
Shoveler *Anas rhynchotis variegata***	1925
C.I. Rail *Rallus modestus*†	1900
Dieffenbach's Rail *R. dieffenbachi*†	1840
Bittern *Botaurus stellaris poiciloptilus***	1910
C.I. Bellbird, *Anthornis melanura melanocephala**	1906

There have been unconfirmed reports of sightings of the Fernbird

* Species still extant elsewhere in New Zealand
** Subspecies still extant elsewhere in New Zealand
† Genus still extant elsewhere in New Zealand

and Bellbird in recent years (Lindsay *et al.* 1959); but B. D. Bell, who made an ornithological survey of the Chathams in 1961, thinks it extremely unlikely that either species still survives.

The Eastern Weka, which may have been the race of *Gallirallus australis* native to the Chatham Islands, was established there by an introduction from the South Island in about 1905 (Oliver 1955). Since then it has become extinct in the South Island but was reintroduced in 1961 from the now-abundant Chatham Island stock. It is not yet known whether re-establishment has been successful.

Greenway (1958) listed approximately six full species and four subspecies as becoming extinct in New Zealand in a period about equivalent to my European. "Approximately" because some are given as extinct in one part of his book and as small populations in danger in another, e.g. the Huia and North Island Laughing Owl. Though his lists differ appreciably from mine, the general impression he gives of the extent to which extinction has actually occurred is closer to the mark than most.

SPECIES AT PRESENT IN SOME DANGER OF EXTINCTION

A list of birds considered to be threatened or near-extinct must, to some extent, be subjective. The one given here contains seven full species plus nine (perhaps 10) subspecies. Three (perhaps four) subspecies are such that should they disappear the species becomes extinct with them; so in effect 10 species are in danger. Should the remaining six subspecies fail to survive, the species to which they belong would not be under any immediate threat of extinction:—

Full species endangered or reduced to low numbers:

Orange-fronted Parakeet *Cyanoramphus malherbi*
Chatham Island Robin *Petroica (Miro) traversi*
Stitchbird *Notiomystis cincta*
Saddleback *Philesturnus carunculatus* (both subspecies)
Kokako *Callaeas cinerea* (both subspecies)
Piopio *Turnagra capensis* (both subspecies)
Bush Wren *Xenicus longipes* (all three subspecies)

Species reduced to a threatened and/or rare subspecies:

S.I. Takahe *Notornis m. hochstetteri*
S.I. Kakapo *Strigops h. habroptilus* (including "*S.h. parsoni*" and a possible new subspecies from Stewart I., Williams 1960a).
S.I. Laughing Owl *Sceloglaux a. albifacies*

Subspecies endangered or very reduced:

Brown Teal *Anas chlorotis*
Stewart Island Snipe *Coenocorypha aucklandica iredalei*
C.I. Snipe *C.a. pusilla*
C.I. Pigeon *Hemiphaga novaeseelandiae chathamensis*
Forbes Parakeet *Cyanoramphus auriceps forbesi*
C.I. Tui *Prosthemadera novaeseelandiae chathamensis*

DISTRIBUTION AND NOTES ON STATUS

North Island (6 species)

BROWN TEAL: Once widespread, this duck is now found only in a few localities in Northland and on Great Barrier Island. Only locally common and very demanding in its habitat requirements of swamp, forest and intertidal creeks, the future of the Brown Teal

is unsafe though it does occur in some hundreds on Great Barrier. (Bell, in press). A flightless race *A.c. aucklandica* persists at the Auckland Islands 200 miles south of New Zealand.

STITCHBIRD: A small but apparently stable population persists in no obvious immediate danger on Little Barrier Island in Hauraki Gulf (Turbott 1961), though cats are also present. Stitchbirds once occurred fairly widespread on the North Island mainland and on Great Barrier Island but they are now regarded as being extinct except on Little Barrier. However there have been occasional unconfirmed reports of them still occurring in the Ruahine Ranges and perhaps elsewhere in remote parts of the North Island, where they would in any event be extremely rare. (Williams, unpubl.). Reports of Stitchbirds at Ngugnuru near Whangarei in 1936 could refer to birds blown from Little Barrier some 50 miles to the south-east.

N.I. SADDLEBACK: *P.c. rufusater:* Broadly distributed last century, the northern subspecies of the saddleback is now regarded as being confined to Hen Island (or Taranga) of the Hen and Chickens Group where it is common over the area of approximately 1000 acres (Turbott 1940). The race's hold on existence depends upon the island remaining in its present state. That part of the vegetation modified by early Maori settlement has now reverted virtually to its primitive condition and the only mammal present is the harmless Polynesian rat, *Rattus exulans.* Oliver (1955) stated that saddlebacks still occur in the Raukumara Range near East Cape, but this report as well as a few recent ones from the Urewera Country (Williams, unpubl.) await confirmation.

N.I. BUSH WREN: *Xenicus longipes stokesi:* Only two specimens have ever been taken of this subspecies and those in 1850 (Oliver 1955). Though it must be very rare, recent records by reliable observers (e.g. Edgar 1949) indicate that it still exists in the Lake Waikaremoana area. It is important to be sure that those who claim to see this bird do not confuse it with the Rifleman.

N.I. KOKAKO: *C.c. wilsoni:* This is certainly the most widespread and perhaps the most numerous of the five rare North Island forms though it is much less common than formerly and never seen except singly or in pairs. It has been occasionally recorded from a number of localities: the Hunua Range, the Rotorua Lakes district, western Urewera, Bay of Plenty, East Cape district, the Coromandel Peninsula, Northland and inland Taranaki. It is interesting that its South Island cogener, inhabiting more remote areas, is much closer to extinction. The Kokako was reported as becoming rare in the North Island at least as early as 1877 (Wilson 1877) and the same author is one of a number who remarked on the (temporary) great scarcity of Bellbirds about this time.

N.I. PIOPIO: *T.c. tanagra:* Rare reports of this bird in recent years (Fleming *et al.* 1953, Sopp 1957) have not been confirmed and this once widely distributed species may now be extinct in the North Island. Buller (1888) remarked that it had already become very scarce, and this early decrease can hardly be ascribed to the establishment of mustelids (which did not occur until the mid-1880's; Wodzicki 1950) nor to the extensive destruction of the North Island forests which began about the same time (Cumberland 1944).

SOUTHERN CRESTED GREBE: *Podiceps cristatus australis:* Never common anywhere in New Zealand, this species has not been reported from the North Island for many years. The only records seem to be one by Buller (1888) from Lake Waikareiti near Lake Waikaremoana in 1879 and another by Vaile (1939: 156) who claims to have seen one near Lake Taupo about 1920. This grebe may therefore be reasonably regarded more as a vagrant to the North Island from the South Island, or even Australia, than as a true native of this part of New Zealand.

South Island (8 species)

BROWN TEAL: Just as in the North Island, this species once occurred much more widely in the South Island than at present (Buller 1888, Oliver 1955). Now it is rarely reported and only from Fiordland (e.g. Bull & Falla 1951). However, as it is mainly nocturnal it may be a little commoner than at present believed.

S.I. TAKAHE: Now known only from the Murchison and Kepler Mountains of Fiordland, to which compass it had been reduced before European times from an earlier distribution over the whole of the eastern side of the South Island, the Takahe at present numbers well under 500 (Williams 1960b). However, as long as its very limited habitat can be preserved the species seems assured of an indefinite survival.

S.I. KAKAPO: This is another species once found over much of the South Island but whose range was decreasing before European settlement. Rarely encountered, it occurs in apparently very small numbers in scattered parts of the West Coast — especially in northern Fiordland (Williams 1956).

ORANGE-FRONTED PARAKEET: There is no indication that this bird was ever common in European times. Reports of it are few (Buller 1883, Tily 1949, Oliver 1955, Breen 1956, 1959) and most of them unconfirmed. Though smaller than the other two parakeets and rather differently coloured, this predominantly-alpine species would usually be hard to distinguish from them in the field. Thus it is not possible to estimate the degree of its rarity.

S.I. LAUGHING OWL: Once well-distributed over the eastern part of the Island and in places fairly common, this owl suffered a reduction in numbers and range which had already become very marked by the end of the 19th century. There have been no official reports over at least the last 25 years (Williams, unpubl.) though one or two unconfirmed reports from southern Canterbury and northern Fiordland during this time deserve investigation (Oliver 1955).

S.I. BUSH WREN: There is little doubt that *X.l. longipes* is now rare and only sporadically distributed over the great expanse of the higher mountain-forests that were previously its range. Seldom reported and superficially similar to the S.I. Rifleman *Acanthisitta c. chloris* which is common, most reports of it are doubtfully correct. Buller (1905) quoted observations which imply that the Bush Wren noticeably decreased in numbers after 1880.

S.I. KOKAKO: Though once, apparently, locally common (Smith 1888, Buller 1888, Pascoe 1959), the Kokako does not seem to have been

widely distributed during European times. It is now certainly very rare indeed and there are few recent reliable records. One of the first for many years is of one being seen in the Wilkin Valley, north-western Otago, in 1958 (Chapman 1959).

S.I. PIOPIO: Just as the North Island race of the Piopio became scarce at a time too early to blame forest destruction and predation by mustelids, so too did the South Island race (Potts 1872, Buller 1888, Pascoe 1959). There have been only two reports in recent years — one from near Lake Hauroko in 1947 (Dunckley & Todd 1949), the other from north-west Nelson in 1948 (Moor 1949). Both are unconfirmed. Confirmation is necessary because the Piopio bears a strong resemblance to the wide-ranging European Song Thrush.

Stewart Island (6 species)

BROWN TEAL: This duck occurs on Stewart Island and its two largest adjacent islands: Codfish (Dell 1950) and Big South Cape (Bell, pers. comm.) but it is only rarely recorded, partly no doubt because of its retiring habits. However, Mr. R. Traill has recently informed me that it has become scarcer over the last few years. Oliver (1926) mentioned it and assumed that Cockayne's report (1909) of the New Zealand Scaup *Aythya novaeseelandiae* referred to the Brown Teal instead. This is reasonable as Cockayne remarked that the ducks he saw were in the rivers, a habitat far more characteristic of teal than scaup which are lake- or lagoon-dwellers.

STEWART I. SNIPE: Unknown from the main island itself and now found only on the South Cape Islands, this snipe once occurred on at least one other island off the east coast. Its extinction there has been attributed to the introduction of Wekas. (It is strange that snipe are virtually unknown, so far, from the two main islands of New Zealand. Fragments have been found only in three South Island localities (Scarlett, pers. comm.) and Oliver's (1955) report of an unconfirmed sight record from near Auckland early this century is probably erroneous (Turbott 1961)).

KAKAPO: A Kakapo was last seen in 1949 and feathers found in 1951 (Williams 1956). Kakapo are said to have been liberated on the island at about the end of last century but this is unconfirmed. Specimens labelled "Stewart Island" and apparently belonging to the Temminck Collection imply because of the date, early 19th century, that the birds are probably indigenous. If so, the local population may comprise a new subspecies (Williams 1960a).

STEAD'S BUSH WREN: Buller (1905) reported seeing one of these on Stewart Island itself; subsequent records are few (e.g. Dawson 1950, Tily 1951). However, the Bush Wren does still occur on the South Cape islands and is the race *variabilis*. The same race is assumed to be, or to have been, the one inhabiting the main island.

S.I. SADDLEBACK: Not officially recorded from Stewart Island proper for many years, the South Island Saddleback still exists on some of the South Cape islands. The persistence of this species, as well as the Bush Wren and Snipe, on these islands has been attributed to the absence of *R. rattus* and *R. norvegicus*. As well as this, the islands are almost unmodified by man. Taranga, upon which the N.I.

Saddleback persists, is in a similar condition; and it may well be significant that the Brown and Black Rats are the only two introduced mammals that have been established long enough in New Zealand to be regarded as possible culprits for the very early reduction or disappearance, of some species of birds (Williams 1956).

S.I. KOKAKO: The most recent record — a secondhand one (Martin 1950) — suggests the South Island Kokako was last seen on Stewart Island in the 1940's. If it still occurs it must be scarce indeed.

YELLOWHEAD *Mohoua o. ochrocephala:* Though assumed to have occurred on Stewart Island at one time (Cockayne 1909, Oliver 1955) it is unlikely that the species has ever done so. The only direct statement I can find is that of Cockayne who said: "The native canary is fairly common, flocks of six to twelve or more being met with in the higher forest or alpine scrub, but never coming to the lower country." However, as he was apparently unable to distinguish between Scaup and Brown Teal, this report cannot be accepted, especially as Yellowhammers occur on the island and were introduced about 1879 (Oliver 1926). Furthermore, there do not appear to be any specimens of Yellowheads from Stewart Island in New Zealand museums. The species should therefore be deleted from the Stewart Island list.

Chatham Islands (5 species)

C.I. SNIPE: Once occurring on other islands in the group, this snipe is now confined to South-East Island which was farmed till 1961 (Fleming 1939). In 1938 Snipe were common on the island, but in January 1953 L. C. Bell (1955) reported that there had been a marked decrease in the population and much destruction of the remaining habitat since 1938 and that the Snipe was very scarce. During his 1961 survey, B. D. Bell found it once more abundant, but obviously under continuing threat from fire or the introduction of cats or rats.

C.I. PIGEON: B. D. Bell reported this species very rare in 1961 and his party saw none during a 2½ month stay. Its greatest chance of survival appears to be in the southern forest block on the main island and on Pitt Island. However both habitats are becoming less and less favourable because of stock grazing and consequent wind damage. Bell considers this subspecies to be the most vulnerable of the Chatham Island birds at present.

FORBES PARAKEET: From a wider distribution in the group, this parakeet has now had its breeding range reduced to Little Mangare Island where there were approximately 100 birds in 1938 (Fleming 1939). The preservation of this species and the one following is precariously bound up with that of the island's tall vegetation which covers an area of between two and three acres (Bell, pers. comm.).

C.I. ROBIN: Also now occurring only on Little Mangare, this robin appears to be in even more dire straits than Forbes' Parakeet. At the time of Fleming's visit there were approximately only 20-35 pairs. Both these species appear to be threatened with extinction through the operation of the Sewall-Wright effect even if their habitats remain unaltered (Mayr 1942).

C.I. TUI: This was by no means common during Bell's visit in 1961. Only a few Tuis occurred on the main island, they were probably more abundant on Pitt, but South-East Island supported only 10 - 12 pairs. However, the subspecies does not seem to be in any immediate danger.

There are two species about which I have had considerable difficulty in deciding whether or not they should be included in this paper. They are the Black Stilt, *Himantopus novaezealandiae* and the Shore Plover, *Thinornis novaeseelandiae,* especially the former. One could argue, for example, that the two New Zealand species of stilt are in much the same category as the Brown Teal — inhabiting both fresh and salt water. Such species make it difficult to draw up consistent standards of exclusion. However, I will deal with the dilemma by giving a brief account of both birds without including them in the general discussion which follows:

The taxonomic status of the Black Stilt is in some doubt though it is officially regarded as a full species at present (Fleming *et al.* 1953). Always rarer than the pied form in European times, it has become very much rarer in recent years, especially in the North Island. Fleming (1958) has suggested that the disruptive pattern of the pied stilt now gives it a selective advantage over the melanistic form.

The Shore Plover once had a fairly widespread distribution over the main islands of New Zealand. Now it is restricted to the Chathams and is known to breed only on South-East Island in that group. Fleming (1939) estimated there to be about 70 pairs in 1937 and Bell (pers. comm.) considered the population to be holding its own in 1961 and that it may breed in small numbers on some remote islets of the Chathams.

	A Species extinct in pre-European era	B Species present at start of European era	C A as a percentage of A + B	D Species becoming extinct in European era	E Species at present threatened or in small numbers	F D + E as percentage of B	G Species* arriving & breeding in European era
North Is.	23	44	34	5	6	25	5
South Is.	31	52	37	4	8	23	7
Stewart Is.	3	34	8	0	6	18	1
Chatham Is.	12	24	33	7	5	50	1

* Waxeye, White-faced Heron, Welcome Swallow, Spur-winged Plover, Royal Spoonbill, Australian Coot, White-eyed Duck (temporarily). From Fleming *et al.* (1953), Oliver (1955), Notornis (1956-1962).

LAND AND FRESHWATER BIRDS IN NEW ZEALAND (excluding shags, stilts and shore plover throughout, see text).

DISCUSSION

If we wish to compare the degree to which extinction has gone in each island it is not enough to compare the number of species affected but rather to compare the proportions. These cannot be obtained accurately for the pre-European era because, for example, we do not know how many species were present before extinction began nor how many species from outside became newly-established between this time and beginning of European settlement about the year 1800. However the totals of species extinct before European times when added to those of species present at the start of the European era (see table) will probably give a reasonable approximation to the total land and fresh-water faunas of pre-European times. If the pre-European extinctions are calculated as percentages of these the results given in the table are obtained. With the exception of Stewart Island there is close agreement and though this may be to some extent fortuitous, it does suggest that the differences between the three islands in the extent to which extinction had gone before 1800 are small. This is in spite of the fact that the pre-European human population of New Zealand — about 250,000 — was overwhelmingly concentrated in the North Island, where it was evenly spread, instead of being peripheral and scanty as in the South (Metge *et al.* 1959). On the Chathams the population density was much closer to that of the North Island than that of the South (Buck 1949:13). As remarked earlier, we cannot at present estimate what proportion of the pre-European extinctions antedate the arrival of man in New Zealand some time before 1000 A.D.

There appear to be two alternative explanations for the low percentage of extinctions on Stewart Island. The first is that because it was the least settled and modified of the four main islands its avifauna has been the least affected. The second is that because so little is known of its early avifauna (even now the island is still only very sparsely settled and almost entirely covered with native vegetation) a number of extinct species have yet to be recorded. This appears to be the more likely explanation. Since Moas, Little Wekas and Kiwis reached Stewart Island there seems no reason why some other early species did not do so, too. Additions of this kind to the avifauna would bring not only the percentage of pre-European extinctions, but also the total number of species, more into conformity with what would be expected from size and proximity to the South Island.

When we come to compare the extent to which extinctions have occurred in New Zealand during European times our task is easier for we have a far more accurate idea of the numbers of species present initially. Once again, the difference between the North and South Island is small, though the number of actual extinctions is proportionately higher in the former than in the latter (see table).

The Chatham Islands have certainly suffered the most severely and it is likely that they have proportionately been more modified by burning and clearing since European settlement than either North, South or Stewart Islands (Bell 1955). Nearly all of the feral browsing and grazing animals found elsewhere in New Zealand are absent (except feral domestic stock) and mustelids have not been introduced though cats, "European" rats *(R. rattus* and *R. norvegicus),* Australian possums and hedgehogs are established, as in most other parts of New Zealand.

Both endemic rails soon became scarce during the period under

discussion (Oliver 1955) and very few specimens of either are known; in fact, there is only one that is complete of Dieffenbach's Rail. The waterfowl possibly could have had their extinction accelerated by human predation and Fleming (1939) considers that predation by cats has played an important role in reducing the numbers of the local Fernbird and Robin. The range of Forbes' Parakeet apparently has always been almost entirely restricted to Mangare and Little Mangare, but deforestation has now confined it to the latter for breeding, though it does visit Mangare and possibly even Pitt Island (B. D. Bell, pers. comm.). Fleming calls the extinction of the local subspecies of Bellbird "mysterious" and "difficult of explanation." He does not comment on the Bittern.

Stewart Island birds have suffered least in European times, there being no known extinctions and only 18% of the species list have been seriously reduced in range and numbers. Because it is separated from the South Island by a strait bridged to some extent by islands, there is only a small degree of isolation and this is reflected in the number of recent species present (35), most of which are only slightly different taxonomically — if at all — from the South Island forms. Five of the six diminished species are also rare in the South Island; the sixth, the Snipe has long been extinct there. The Stewart Island mainland supports a number of introduced browsing, grazing and carnivorous mammals but, as on the Chathams, mustelids are missing.

To Summarise: Approximately 40 species of land and freshwater-inhabiting birds had become extinct before the arrival of Europeans. One cannot say what proportion of these were already extinct before the arrival of man a thousand or more years previously. Three of the four major island groups suffered proportionately about equal losses. even though the amount of change of the environment consequent upon Polynesian settlement varied with each, and in spite of the fact that the density of the human population of the South Island was very small and was concentrated on the coasts. Stewart Island with only three known extinctions was on first sight, the least affected: however little is known of its earlier avifauna.

Hunting or habitat destruction do not seem adequate explanations of pre-European extinctions.

In spite of the rapid and extensive changes in New Zealand since European settlement, only five full species and five subspecies have died out. Ten more species and three subspecies are in danger and, in fact, one or two of these may have already disappeared. Once again, in spite of the differences in the degree of exploitation of the North and South Islands, the amounts of serious damage to their avifauna are approximately equal (about 24%). The Chatham Islands have suffered most with about 50% of the species present on the arrival of Europeans either extinct or in danger of extinction. Stewart Island has suffered least with no extinctions and only 18% of the species seriously reduced. However, if relict populations of certain species on offshore islands were not included, the number of extinctions occurring during the European era on the North Island and Stewart Island would be increased.

Within European times it appears that damage is least where there has been little or no settlement or modification of vegetation and

no introduction of mammals. These conditions are found on only a few small offshore islands.

Though the extinction of species is of great interest scientifically and economically and is a fate eventually almost as certain as the death of individuals (though the brevity of human history and the human lifespan masks the truth of this generalisation), its study has been greatly neglected except perhaps in laboratory populations. In the wild, as we have just seen, extinction has all too often been an accomplished fact before it has prompted attention, and as a result, the study of the phenomenon has become one that is *a posteriori* and deductive rather than *a priori* and inductive. The former approach is unlikely to yield a satisfactory answer; and as extinction is so common and so important, the need for it to be studied intensively *as a process* is obvious. There are plenty of opportunities for this:— firstly, in threatened species where admittedly the task is made difficult by the very scarcity of the animals themselves and by the time sometimes necessary for the process to go to completion; and secondly, in well-established species subject to temporary local extinctions, particularly near the limits of their range.

No all-embracing principle is likely to emerge from such studies, but any addition to the sparse archipelago of facts in what has hitherto been a gradually-widening sea of speculation should be welcome.

"To admit that species generally become rare before they become extinct, to feel no surprise at the rarity of the species, and yet to marvel greatly when the species ceases to exist, is much the same as to admit that sickness in the individual is the forerunner of death — to feel no surprise at sickness but when the sick man dies, to wonder and to suspect that he died of some deed of violence." — Charles Darwin (1895), *The Origin of Species.*

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REFERENCES

BELL, L.C., 1955: Notes on the birds of the Chatham Islands. Notornis 6: 65-68.

BELL, B. D. (in Press): Birds of Great Barrier Island.

BREEN, M. J., 1956: in Classified summarised notes. Notornis 6: 207.

BREEN, M. J., 1959: in Classified summarised notes. Notornis 8: 74.

BUCK, P., 1949: The coming of the Maori. Whitcombe & Tombs, Wellington, N.Z.

BULL, P. C., & FALLA, R. A., 1951: Observations on birds in Preliminary reports of the New Zealand-American Fiordland Expedition. edit. A. L. Poole. N.Z. Dept. Sci. Ind. Res. Bull. 103: 76-92. Govt. Printer, Wellington.

BULLER, W. L., 1873: A history of the birds of New Zealand. 1st edition. van Woorst, London.

BULLER, W. L., 1883: On some rare species of New Zealand birds. Trans. N.Z. Inst. 16: 308-318.

BULLER, W. L., 1888: A history of the birds of New Zealand. 2nd edit. Publ. by the author, London.

BULLER, W. L., 1905: Supplement to a history of the birds of New Zealand. Publ. by the author, London.

CHAPMAN, A., 1959: Kokako reported from Wilkin Valley, Lake Wanaka. Notornis 8: 177-178.

COCKAYNE, L., 1909: Report on a botanical survey of Stewart Island. Govt. Printer, Wellington, N.Z.

CUMBERLAND, K. B., 1944: Soil erosion in New Zealand. Soil Conservation & Rivers Control Council, Wellington, N.Z.

DAWSON, E. W., 1950: Bird notes from Stewart Island. Notornis **4**: 146-149.

DAWSON, E. W., 1958: Re-discoveries of the New Zealand sub-fossil birds named by H. O. Forbes. Ibis **100**: 232-237.

DAWSON, E. W., 1959: The supposed occurrence of kakapo, kaka & kea in the Chatham Islands. Notornis **8**: 106-115.

DAWSON, E. W., 1960: New evidence of the former occurrence of the kakapo (**Strigops habroptilus**) in the Chatham Islands. Notornis **9**: 65-67.

DELL, R. K., 1950: Birds of Codfish Island. New Zealand Bird Notes (= Notornis) **3**: 231-235.

DUNCKLEY, J. V., & TODD, C. M., 1949: Birds west of the Waiau River. N.Z. Bird Notes **3**: 163-164.

EDGAR, A. T., 1949: Winter notes on New Zealand birds. N.Z. Bird Notes **3**: 170-174.

FALLA, R. A., 1960: Notes on some bones collected by Dr. Watters and Mr. Lindsay at Chatham Islands. Notornis **8**: 226-227.

FLEMING, C. A., 1939: Birds of the Chatham Islands. Emu **38**: 380-413, 492-509.

FLEMING, C. A., 1953: Materials for a recent geochronology of New Zealand. Roy. Soc. N.Z., Rept. of Seventh Sci. Congr. 114-123.

FLEMING, C. A. et al., 1953: Checklist of New Zealand birds. A. H. & A. W. Reed, Wellington.

FLEMING, C. A., 1958: Darwinism in New Zealand . . . Proc. Roy. Soc. N.Z. **80**: 65-86.

GREENWAY, J. C., 1958: Extinct and vanishing birds of the world. Amer. Comm. for Internat. Wildl. Protection, N.Y.

HESSE, R., ALLEE, W. C., & SCHMIDT, K. P., 1951: Ecological animal geography. Chapman & Hall, London.

LACK, D., 1954: The natural regulation of animal numbers. O.U.P.

LINDSAY, C. J., PHILLIPPS, W. J., & WATTERS, W. A., 1959: Birds of Chatham & Pitt Islands. Notornis **8**: 99-106.

MARTIN, W., 1950: Birds on Stewart Island. N.Z. Bird Notes **3**: 230.

MAYR, E., 1942: Systematics and the origin of species. Columbia Univ. Press.

METGE, A. J., BIGGS, B. G., GOLSON, J., & LEWTHWAITE, G. R., 1959: The Maori settlement of New Zealand. in A descriptive atlas of New Zealand 1-3. Govt. Printer, Wellington.

MOORE, E. M., 1949: New Zealand thrush in Classified summarised notes. N.Z. Bird Notes **3**: 102.

MYERS, J. G., 1923: The present position of the endemic birds of New Zealand. N.Z. Jour. Sci. & Tech. **6**: 65-99.

OLIVER, W. R. B., 1926: The birds of Stewart Island. N.Z. Jour. Sci. & Tech. **8**: 321-341.

OLIVER, W. R. B., 1930: New Zealand birds. 1st edition. Fine Arts, Wellington.

OLIVER. W. R. B., 1955: New Zealand birds, 2nd edition. A. H. & A. W. Reed, Wellington.

PASCOE, JOHN, 1959: Mr. Explorer Douglas. A. H. & A. W. Reed, Wellington.

PHILLIPPS, W. J., 1959: The last (?) occurrence of **Notornis** in the North Island. Notornis **8**: 93-94.

POTTS, T. H., 1872: On the birds of New Zealand (Part III). Trans. N.Z. Inst. **5**: 171-205.

SCARLETT, R. J., 1957: Former faunal areas: some sub-fossil evidence. Proc. N.Z. Ecol. Soc. **4**: 17-18.

SMITH, W. W., 1888: On the birds of the Lake Brunner district. Trans. N.Z. Inst. **21**: 205-224.

SOPP, G. E., 1957: North Island native thrush or pio-pio. Notornis **7**: 101-102.

TURBOTT, E. G., 1940: A bird census on Taranga (The Hen). Emu **40**: 158-161.

TURBOTT, E. G., 1961: in Little Barrier Island (Hauturu), compiler W. M. Hamilton. N.Z. Dept. Sci. Ind. Res. Bull. **137**: 136-175.

TILY, I., 1949: Orange-fronted parakeet in Classified notes. N.Z. Bird Notes **3**: 100.

TILY, I., 1951: Bird notes from Stewart Island. (Dunedin Naturalists' Field Club Notes). Notornis **4**: 149-150.

VAILE, E. E., 1939: Pioneering the pumice, Whitcombe & Tombs, Wellington, 1939.

WILLIAMS, G. R., 1956: The kakapo (**Strigops habroptilus** Gray). A review and reappraisal of a near-extinct species. Notornis **7**: 29-56.

WILLIAMS, G. R., 1960a: Distribution of specimens of the kakapo in some museums throughout the world. Rec. Dominion Mus., Wellington, N.Z. **3**: 219-227.

WILLIAMS, G. R., 1960b: The takahe (**Notornis mantelli** Owen 1848). A general survey. Trans. Roy. Soc. N.Z. **88**: 235-258.

WILSON, D. C., 1877: Disappearance of the small birds of New Zealand. Trans. N.Z. Inst. **10**: 239-242.

WODZICKI, K. A., 1950: Introduced mammals of New Zealand. N.Z. Dept. Sci. Ind. Res. Bull. **98**. Govt. Printer, Wellington.