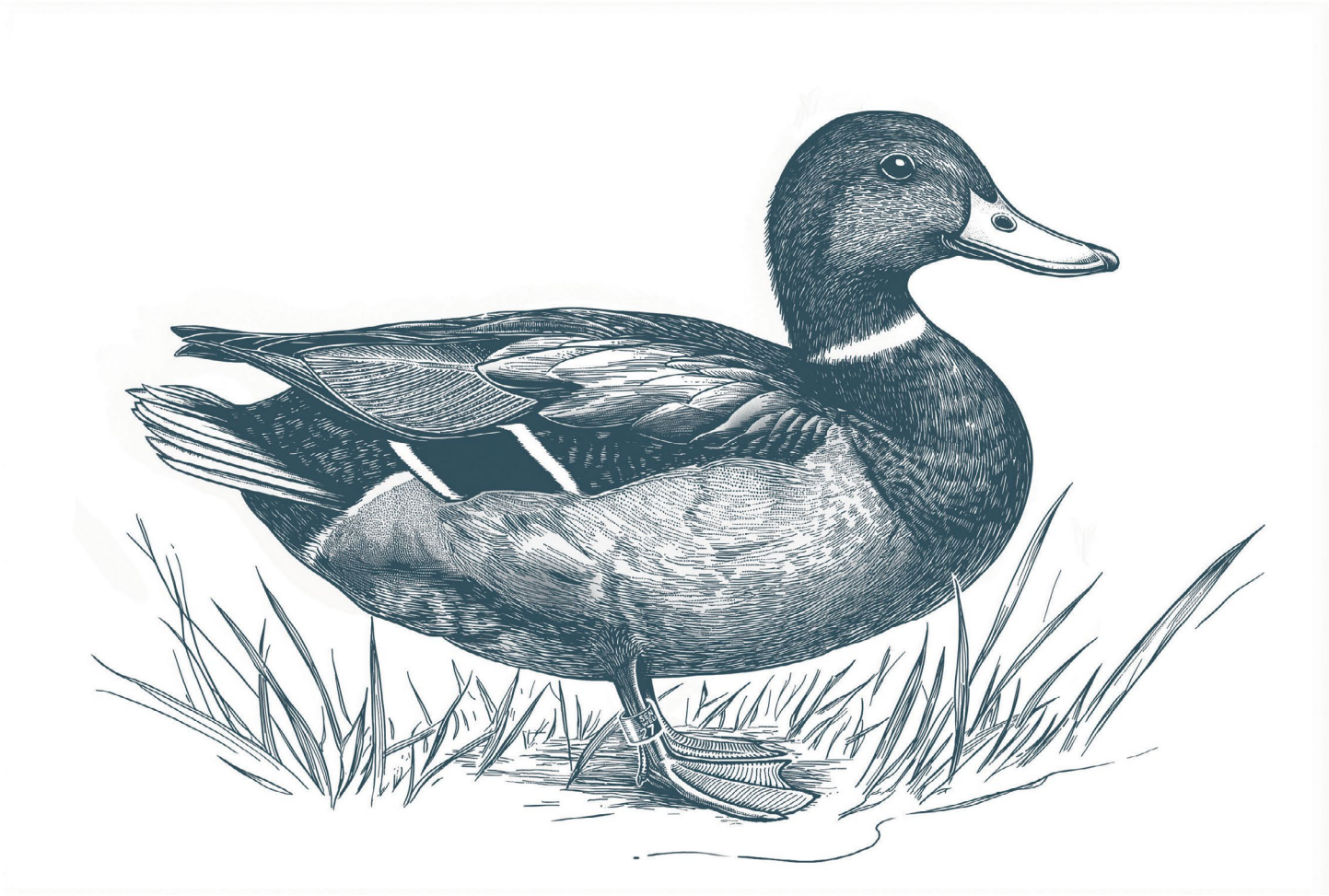
A SYNOPSIS OF GAME BIRD BANDING IN NEW ZEALAND TO YEAR 2000



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A synopsis of game bird banding in New Zealand to year 2000

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Abstract: The organised banding in New Zealand of birds that are seasonally hunted as game commenced in 1947 when wild grey ducks (*Anas superciliosa*) and mallards (*A. platyrhynchos*) were captured in Manawatu. From 1950, California quail (*Callipepla californica*) were caught and banded in central Otago and near Taupo as field studies of other game birds by Department of Internal Affairs Wildlife Branch staff commenced. At the same time, captive-raised mallards and common pheasants (*Phasianus colchicus*) were banded at release by acclimatisation societies, pre-empting a later legal requirement for banding of all released captive-raised game birds. By year 2000, approximately 150,000 of five species of introduced upland game birds (Galliformes) had been banded in New Zealand, including chukar partridge (*Alectoris chukar*), grey partridge (*Perdix perdix*), and red-legged partridge (*Alectoris rufa*), the latter two species ultimately failing to acclimatise. From this total, 7,267 were reported shot. By year 2000, approximately 370,000 of six species of wetland game birds — black swan (*Cygnus atratus*), Canada goose (*Branta canadensis*), paradise shelduck (*Tadorna variegata*), Australasian shoveler (*Spatula rhynchotis*), grey duck, and mallard (and their hybrids) — had been banded. From this total, 62,566 were reported shot.

Banding records, and details arising from the reported recoveries of banded birds, were initially administered by the Wildlife Branch, Department of Internal Affairs 1947–66, after which records were amalgamated with the nascent Ornithological Society of New Zealand's bird ringing scheme for all other species, to form the New Zealand Bird Banding Scheme. Administered 1967–87 by the Wildlife Service, the scheme has been managed thereafter by the Department of Conservation.

This narrative summarises the scales, locations, and durations of bandings of each game bird species, quantifies the recovery records for each, and reports on all published outcomes arising from the banding activities. Supplementary files provide recovery arrays (banding year by recovery year) for each of the wetland species to preserve historic records and encourage belated appraisal of much unprocessed band-recovery information.

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Keywords: banding, game birds, Galliformes, Anseriformes, New Zealand

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INTRODUCTION

Deliberate introduction of the fauna and flora of "home" was a ubiquitous accompaniment to European settlement attempts around the world, especially throughout the 19th Century (Lever 1992). New Zealand proved no exception in this regard, and the bewildering array of acclimatisation attempts by its British colonists, as individuals and as collectives, has been well chronicled (Thomson 1922; Wodzicki 1950; Druett 1983 McDowall 1994). Three groups of animals featured prominently amongst those attempts: salmonid fish, ungulates, and game birds. To be able to hunt and fish, free from constraints of a feudal landlord system, was irresistible, and a fiercely advocated right.

Acclimatisation societies, formed by enthusiasts dedicated to these introductions, were given statutory recognition in New Zealand from 1861 and, for the subsequent 130 years, were empowered under multifarious wildlife legislation, e.g. Animals Protection Act of 1907, its subsequent amendments, regulations, and replacement Acts (McDowall 1994: ch. 6), eventually to become *de facto* wildlife management agencies. Although their interests were focussed on the pursuit of freshwater salmonid fishes and game birds, for which they could sell fishing and hunting licences and retain the revenue, they were eventually delegated responsibilities for protection of native wildlife.

The term 'game bird' is popularly applied to gallinaceous species (Galliformes), and some within this group are referred to as 'upland game.' In New Zealand, birds declared to be game and able to be hunted, under license and during prescribed hunting seasons, are defined in schedules of prevailing wildlife legislation. In addition to gallinaceous species, some waterfowl (Anseriformes) and some migratory shorebirds (Charadriiformes) have been declared to be game. The Wildlife Act 1953 (1953 No. 31) broke with its predecessor legislation by removing distinction between native and imported game, and no longer designating shorebirds as game (Table 1).

Sundry Government departments shared the early administration of animal protection and wildlife legislation, but it was not until the Department of Internal Affairs established its Wildlife Branch in 1946 that an agency of Government dedicated to wildlife management operations arose (Galbreath 1993). When announcing this unit, the Department identified five operational imperatives to address "problems vitally concerning the welfare of flora and fauna of New Zealand," one of which was "the decrease of native and imported game bird populations" (DIA 1946). The Department's report to the New Zealand Parliament the following year recorded that, in January 1947, an officer of its wildlife unit had commenced investigations of ducks in the Manawatu area. The initial banding of those ducks, in March and April 1947 (Balham 1950, 1952), commenced the protracted banding of game birds in New Zealand, and established one of the strands of origin of the present-day New Zealand bird banding scheme (Cossee 1990).

Table 1. Designated game birds in 1st schedule of the Wildlife Act 1953 (1953 No. 31). Common names are those as listed in the Act, scientific names are those now recognised. Guinea fowl has not been exploited as a game bird, Virginian (Bob-white) quail is now extinct in New Zealand.

Common name	Scientific name
Black swan	*Cygnus atratus*
Canada goose	*Branta canadensis*
Grey duck	*Anas superciliosa*
Mallard duck	*Anas platyrhynchos*
Paradise duck	*Tadorna variegata*
Spoonbill duck	*Spatula* (*Anas*) *rhynchotis*
Pukeko	*Porphyrio melanotus*
Chukar	*Alectoris chukar*
Pheasant	*Phasianus colchicus*
Guinea fowl	*Numida meleagris*
Australian (brown) quail	*Synoicus ypsilophorus australis*
Californian quail	*Callipepla californica*
Virginian quail	*Colinus virginianus*

The ensuing narrative seeks to summarise the early history of game bird banding and its administration in New Zealand, and the magnitude of the banding effort to year 2000. By highlighting the scale and duration of bandings for each game bird species, the numbers of banded birds recovered, and published analyses of these band recoveries, this pioneering phase in New Zealand wildlife management is brought to the fore, and some long-forgotten contributors acknowledged. The inclusion of supplementary files containing band recovery arrays for all game waterfowl is intended to encourage analyses of long-ignored historical datasets potentially of relevance to contemporary game bird management.

ORIGINS OF GAME BIRD BANDING / RINGING IN NEW ZEALAND

The dual terminology of band and ring reported below expresses the term used at the time of reporting. Presently, 'ring' is the term in use throughout the United Kingdom, Europe, and Africa, 'band' the term applied in North and South America, Asia, and Australasia.

The 1947 ducks were not the first game birds to be banded in New Zealand. The Southland Acclimatisation Society (hereinafter all reference to acclimatisation societies will be indicated by their regional name followed by the abbreviation A.S.) then actively rearing and releasing mallards (*Anas platyrhynchos*), placed numbered leg bands on 100 ducks liberated near Thornbury, Southland in August 1911 (*Mataura Ensign 4 Sep 1911*). The bands

were marked "S" and numbered 1 to 100 (*Press 16 Nov 1911*) and were without a return address. Local hunters were encouraged to report any band retrieved, and all neighbouring acclimatisation societies advised should a banded duck be reported to them. Perhaps none was; however, "It appears that a pair of the birds have found their way back to their breeding place at Mataura" reported *Southland Times* (2 Sep 1911), adding "There is no doubt about the mallards having returned as the only birds rung by the society are those bred at Mataura."

Whether this was a singular effort is uncertain. A reporting of an October 1911 meeting of the Southland A.S. informs "The committee were writing to America for samples and quotations for leg bands and were advising other societies of the liberation of mallards" (*Southland Times 20 Oct 1911*). Later, at its February 1912 meeting, the committee advised further that "they had written to America for 100 leg bands for ducks" (*Southland Times 16 Feb 1912*). Although no reporting of subsequent banding has emerged, it is hard to imagine others not being intrigued by the Southland A.S. banding initiatives, and especially so neighbouring acclimatisation societies then also breeding and releasing mallards, e.g. Otago, South Canterbury, Waitaki-Waimate (Dyer & Williams 2010).

The early history of other bird ringing / banding initiatives in New Zealand, including that of the Ornithological Society of New Zealand's (OSNZ) ringing scheme, was chronicled by Cunningham (1949, 1950, 1951). His summaries missed inclusion of claimed 1920–22 bandings of muttonbirds (*Ardenna grisea*) by a Puysegur Point lighthouse keeper (Sutherland 1928) and two multi-year ringing projects of game birds – black swans (*Cygnus atratus*) at Lake Ellesmere by North Canterbury A.S., and captive-bred common pheasants (*Phasianus colchicus*) released by several acclimatisation societies.

"For some years past it has been the opinion of prominent sportsmen that swan migrated to other parts of New Zealand and the Chatham Islands. To arrive at some satisfactory conclusion on this subject your committee decided to mark a large number of the birds during the moulting season. Four hundred and nine black swans were ringed, the old birds with a green ring, the young birds with a blue ring on the leg" reported the Christchurch-based *Press* (17 May 1934), which, earlier (28 Feb 1934) had identified the rings as "split rings", probably of the type then widely available for ringing poultry. In May 1935, a black swan carrying a blue leg ring was shot at Lake Tuakitoto near Stirling, Otago (*Evening Star 9 May 1935*; *Press 10 May 1935*), thus providing the first published outcome of the North Canterbury A.S. swan project. Thereafter the society colour-ringed samples of swans at Lake Ellesmere annually until 1942. Numbers involved were not chronicled (other than of 409 in 1934 and 39 in 1935); however, recoveries arising from all but one of the annual cohorts dribbled in over 20 years, including a 1937-ringed swan shot at Lake Ellesmere in 1955 (North Canterbury A.S. 1955) and another there in 1958 (*Press 14 Aug 1958*). The reported locations of recovery of 32 swans extended south to Otago wetlands and north to Marlborough, Lake Wairarapa and Hawkes Bay (North Canterbury A.S. 1954; Bull 1954). Chatham Island was not one of the recovery locations.

During this era, extensive captive breeding and releases of mallard, pheasant, and California quail (*Callipepla californica*) were made by acclimatisation societies throughout New Zealand (McDowall 1994). Periodic banding of pheasants took place: Wellington A.S. used colour bands during 1937–44 (*Manawatu Evening Standard 3 Aug 1937*; Wellington A.S. 1940, 1944), and Tauranga A.S. used numbered bands lacking return addresses in 1937–40 *(Bay of Plenty Times 24 Apr 1938).* So too did Auckland A.S. during 1936–42 (*New Zealand Herald 20 Feb 1936*; Auckland A.S. 1939). "All (= 401) cock birds liberated last July (1936) were marked with a numbered leg band and a record of place of liberation kept. Hunters are particularly urged to send in any leg bands they secure with full details of the locality from which each was taken, so that the council can get authentic evidence of the spread of pheasants …and arrange increased liberations in areas which are being shot" (Auckland A.S. 1937). Thus, the banding objective was to determine hunting outcome and dispersal.

Otago A.S. banded pheasants in 1943 (155 cock birds) using numbered bands which carried the address "Return Otago Univ. Dunedin" (*Evening Star 28 Sep 1943;* Otago A.S. 1944) but this initiative was not repeated until 1947.

BANDING ADMINISTRATION

The early banding initiatives by acclimatisation societies relied on hunters reporting bands to their offices; no multi-regional projects were attempted. For game birds, that wider and more organised approach, necessitating the stamping of return addresses on the bands, had to await the 1947, and subsequent, banding projects administered by the Wildlife Branch. Meanwhile, for non-game birds, this approach had already commenced with the pioneering seabird bandings by L.E. Richdale (Peat 2011), the banding of passerines in Dunedin and elsewhere (Marples 1944), and the formal establishment of a national bird ringing scheme by the OSNZ (Cunningham 1949, 1951; Cossee 1990).

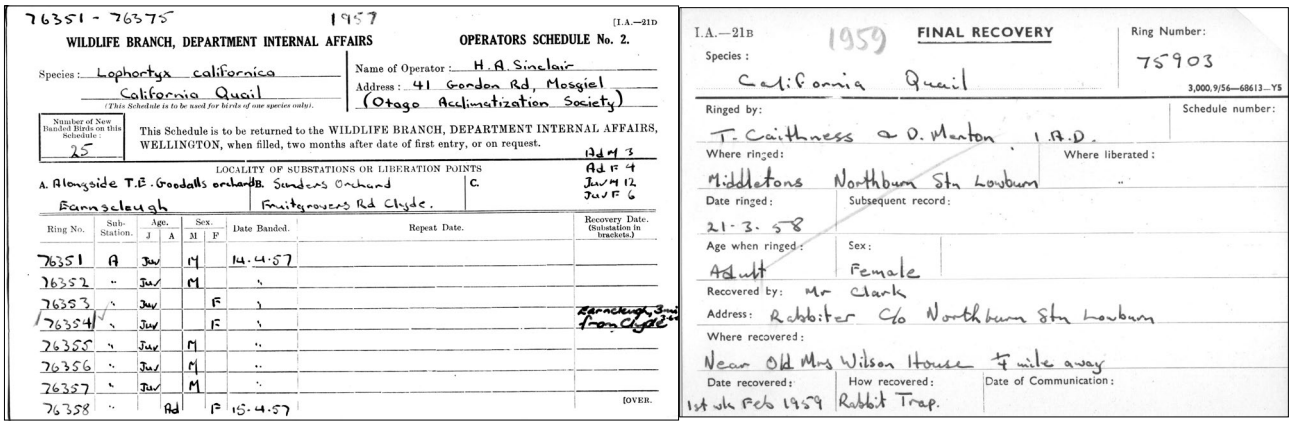
In their reporting of initial duck banding in Manawatu, Balham & Miers (1959) referred to bands being returned to "the collating office of the Wildlife Branch", a mild exaggeration given that a single entity for banding administration did not then exist. From 1947 to 1960, all game bird banding was administered

Figure 1. Wildlife Branch biologists responsible for the initial bandings of game birds in New Zealand: L to R. Kaj Westerskov, *c.*1980 (photo supplied); Gordon Williams, Ronald Balham, Ken Miers, 1956 (Photo: Wildlife Service, Archives New Zealand).

as species-specific projects, with the banding and recovery records being under direct supervision of the Wildlife Branch biologist conducting studies on that species (Fig. 1), and the administration carried out by technical staff assigned to that biologist, e.g. in 1956, California quail research by G.R. Williams was assisted by Tom Caithness, waterfowl studies by R.W. Balham and K.H. Miers were supported by Robyn Palmer, and pheasant and partridge studies by K.E. Westerskov supported by Jocelyn Danderson/ Tilley. Only post-1960 was banding administration for all game bird species combined and undertaken by a single staff member (Helen Hall; Fig. 3) and the desk she occupied referred to as "the banding office".

Banding schedule cards, developed initially to record duck banding details and to indicate a recovery made, were later used for all species (Fig. 2). The reporting of bands retrieved by hunters was promoted annually in newspapers, e.g. *NZ Sporting and Fishing Gazette*, magazines, e.g. *NZ Outdoor*, *NZ Journal of Agriculture*, in the annual reports which acclimatisation societies distributed to their members, and on hunting licences. Acclimatisation society offices were also supplied with forms on which to record recoveries for later sending to the Wildlife Branch. All band recoveries were acknowledged by letter sent directly to the contributing hunter in which details of time and place of banding were given, and should recovery data be incomplete, e.g. of recovery location or date of recovery, this was asked for. Each band recovered was marked as such on the banding schedule card and complete recovery details placed on a separate recovery card (Fig. 2). These recovery details were eventually typed on to individual machine punch cards for later machine sorting to aid analyses.

Except for pheasants 1948–56, banding was generally undertaken by staff of the Wildlife Branch, and particular emphasis was placed on accuracy of all field data, i.e. age and sex of the banded bird, location and date of banding or release. The latter was not always the case for pheasants banded by acclimatisation societies, necessitating the development of field band record booklets in which


76351 - 76375 1957 [I.A.—21D

WILDLIFE BRANCH, DEPARTMENT INTERNAL AFFAIRS OPERATORS SCHEDULE No. 2.

Species: Lophortyx californica / California Quail (This Schedule is to be used for birds of one species only).

Name of Operator: H.A. Sinclair
Address: 41 Gordon Rd, Mosgiel (Otago Acclimatization Society)

Number of New Banded Birds on this Schedule: 25

This Schedule is to be returned to the WILDLIFE BRANCH, DEPARTMENT INTERNAL AFFAIRS, WELLINGTON, when filled, two months after date of first entry, or on request.

Ad M 3
Ad F 4
Juv M 12
Juv F 6

LOCALITY OF SUBSTATIONS OR LIBERATION POINTS
A. Alongside T.E. Goodalls orchard B. Sinders Orchard C.
Bannockburn Fruitgrowers Rd Clyde.

Ring No.	Sub-Station.	Age. J	Age. A	Sex. M	Sex. F	Date Banded.	Repeat Date.	Recovery Date. (Substation in brackets.)
76351	A	Juv		M		14.4.57		
76352	"	Juv		M		"		
76353	"	Juv			F	"		
76354	"	Juv			F	"		Barracking 3 miles from Clyde
76355	"	Juv		M		"		
76356	"	Juv		M		"		
76357	"	Juv		M		"		
76358	"		Ad		F	15.4.57		

OVER.

I.A.—21B 1959 FINAL RECOVERY Ring Number: 75903
3,000.9/56—68613—YS

Species: California Quail

Ringed by: T. Caithness & D. Merton I.A.D. Schedule number:

Where ringed: Middletons Northburn Stn Lowburn Where liberated:

Date ringed: 21-3-58 Subsequent record:

Age when ringed: Adult Sex: Female

Recovered by: Mr Clark

Address: Rabbiter C/o Northburn Stn Lowburn

Where recovered: Near Old Mrs Wilson House ½ mile away

Date recovered: 1st wk Feb 1959 How recovered: Rabbit Trap. Date of Communication:

Figure 2. Left: Wildlife Branch banding card for California quail banded in central Otago, 1957. The handwriting is that of Tom Caithness. Note the typically colloquial descriptions of banding and recovery locations, and the demarcation indicating a band recovered (band 76354); Right: Band recovery card, recording the death of a banded California quail caught in a rabbit trap in central Otago, 1959.

banding details could be recorded directly and later submitted to the Wildlife Branch administrators. Large numbers of these field record sheets were retained as permanent records amongst the formal banding schedule cards and never transcribed.

Numbered bands used during the first two decades of game bird banding were of hardened aluminium and, except for 5,000 quail-sized bands obtained from a United Kingdom supplier in 1953, were sourced from Gey Band and Tag Co., Norriston, Pennsylvania, USA, and almost all were butt-bands (the ends of the band closed against each other). For pheasants being banded by acclimatisation societies, lock bands were eventually supplied (bands had a projecting flange at each end, the longer being folded over the shorter and squeezed tight to secure the band). Initially, all bands were stamped "RETURN-WILDLIFE SERVICE GOVT. BLDGS. WGTN. N.Z" but on the smaller quail bands, "SEND WILDLIFE WELLINGTON N.Z." The initial "Govt. Bldgs." address reflected the then location of the Wildlife Branch and its parent Internal Affairs Department's head office in the Government Building in downtown Wellington and before its 1962 rehousing in the Bowen State Building behind Wellington's Parliament Building. Generous use was also made of bands supplied from the OSNZ ringing scheme's stockpile. For example, bands placed on California quail 1950–53, black swan 1955–58, and Canada goose (*Branta canadensis*) 1957–59 were OSNZ-supplied with the return address "SEND DOMINION MUSEUM, NEW ZEALAND."

The game bird banding scheme was amalgamated with the OSNZ ringing scheme for all other birds in 1967. The latter was then administered at the Dominion Museum by Christopher Robertson under the direction of the museum's ornithologist and scheme convener, F.C. Kinsky. The amalgamation of the two schemes with their different recording methods, and its embedding within the (now renamed) Wildlife Service, was managed by Christopher Robertson (Fig. 3). Primarily, it involved adopting the OSNZ paper banding schedules for all banding records and transcribing all pre-1967 banding card schedules for the long-lived waterfowl (black swan, Canada goose, paradise shelduck (*Tadorna variegata*)) onto the new paper schedules, the original card schedules apparently thereafter being disposed of. Transcriptions of California quail, grey partridge (*Perdix perdix*), grey duck (*Anas superciliosa*), and mallard records were not attempted; fortunately, these card schedules were retained and remain (July 2023) in storage at Department of Conservation, Wellington.

Recovery record keeping was also redesigned; a bird's recovery information was entered, together with its original banding record, onto a triplicate paper file, one copy each for the bander, the recoverer, and the banding office, and from which details could subsequently be typed onto machine punch cards for later transfer to magnetic tape (Robertson 1972; Cossee 1990). Crucial in this process was the diligent cross-checking and validation of all band recovery records of both former schemes, undertaken principally by Les Moran, Gerry Hatzakortzian, and Shirley McKenzie. Thereafter, the unified scheme became 'the Banding Office' within the Wildlife Service and, from 1987, within the Department of Conservation. The office was managed by Christopher Robertson until 1981, and subsequently (and at year 2000) by Roderick Cossee (Fig. 3), with prolonged periods of diligent administrative assistance from Jean Llewellyn, Elizabeth Perks, Lillian Billington, Kevin Moynihan, Dawn Tofield, and Mala Neseratnum.

During the 1980s, recovery data were gradually transferred to a stand-alone desk-top computer and, during 1990–92, all recovery records were integrated into an Oracle database, the electronic transcription enabled by Ross Pickard and Geoff Patterson. During 2005–08, these recovery records were transferred to the Department of Conservation's corporate I.T. system in Microsoft Excel file format, the files becoming part of its 'Bioweb' data management system. Simultaneously, the paper banding schedules for all species were transcribed into a similar electronic format.

Another consequence of amalgamation was that all new numbered bands of all sizes were of stainless

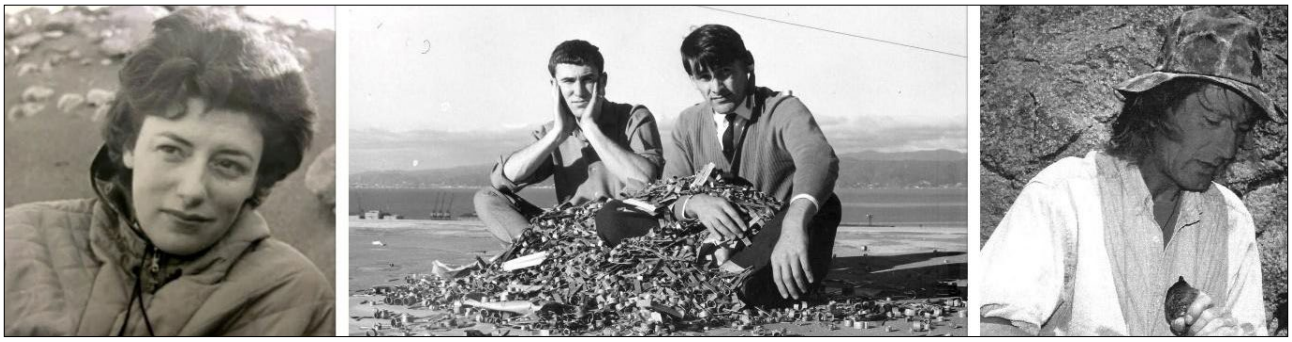


Figure 3. Banding administrators 1959–99: L to R. Helen Hall/Morrison, the initial Wildlife Branch banding officer (photo supplied); Les Moran and Christopher Robertson in a 1969 publicity photo to highlight bird banding (Photo: Wildlife Service, Archives New Zealand); Roderick Cossee (photo supplied).

steel and sourced from Sweden, a material and source used by the OSNZ scheme for much of the prior decade (Kinsky & Robertson 1964). The "SEND WILDLIFE WELLINGTON, NZ" address became standard, albeit old bands from both schemes were issued for some years until supplies were exhausted. Bands purchased post-1987 carried "SEND DEPT OF CONSERV WELLINGTON N.Z."

METHODS

The history of game bird bandings to year's end 1999 is traced, primarily, from two electronic files provided, in Microsoft Excel format, by the Bird Banding Office, Department of Conservation (May 2022). They were extracted from the Department's 'Bioweb' database, with one containing banding details for all game bird species ("Bioweb banding"), and another recording all band recoveries of game bird species ("Bioweb recovery"). Also consulted were the paper banding schedules from which the Bioweb banding file was compiled, and the Wildlife Service banding schedule cards that were never transcribed in 1967, the latter being the principal source for pre-1967 details presented in this narrative.

To complement, and in some cases, to verify, banding details, I searched archived files of the Wildlife Branch (lodged in Archives New Zealand, Wellington and referenced in this text by original file number, e.g. IAD 51/10/7, and/or Archives New Zealand item number, e.g. R12322657), and searched the National Library of New Zealand's digital archive of New Zealand newspapers and magazines (*www.paperspast.govt.nz*, the publications identified herein by title and date, e.g. *Waikato Times 22 Apr 1939*). Importantly, relevant post-1910 annual reports of acclimatisation societies were searched (accessed in National Library of New Zealand and Alexander Turnbull Library, Wellington). Specific annual reports are referenced by society name and year, e.g. Auckland A.S. 1937.

The scale of game bird banding is chronicled by listing totals of each species banded, grouped by years and locations where appropriate. Annual banding totals exclude wild birds banded and taken into captivity, or which were captive stock for breeding purposes (mostly grey partridge, red-legged partridge (*Alectoris rufa*), and chukar partridge (*A. chukar*; henceforth chukar).

Banding totals have been compiled directly from pre-1967 banding schedule cards, from the Bioweb banding file for post-1967 bandings, and reconciled with banding totals lists (a summary of numbers of each sex and age groups banded) which, after 1967, banders were required to submit with their schedules to the Banding Office. On occasion, the physical banding schedules were consulted for clarification. Entries in relevant acclimatisation society annual reports have also informed (and confused) these totals.

Totals are presented as applying to calendar years; where banding of some species occurred in November–December rather than in the usual January–March period, the total is credited to the following calendar year. Belated releases of banded captive-raised upland game birds also occurred in April and following the May–June hunting season. Where this occurred, these variations are made explicit in the species' narratives.

Band recovery totals for each species have been derived entirely from the Bioweb recovery file which was are assumed to be complete. However, there remains considerable doubt about the veracity of pre-1967 recovery records because not all indications on pre-1967 banding schedule cards denoting a recovery made (a red pencil mark alongside the band number, see Fig. 2) can be found on the Bioweb recovery file. For grey ducks and mallards, almost no pre-1967 recoveries are recorded despite those records having been curated within the Banding Office to at least 1990 (MW *pers. obs.*). There is no way to check old recovery details: when a recovery was reported, the relevant details were recorded on recovery cards, later typed onto machine punch cards, and subsequently copied to magnetic tape. Any required printed output was a multi-page computer printout with each printed line being a recovery record. Over time, most of the computer printouts, all recovery cards, and most of the machine punch cards were discarded. Therefore, any recovery total given for the pre-1967 period arises from counting the markings on the banding schedules or from a summation of listings on the Bioweb recovery file. Recovery totals for the pre-1967 period should be interpreted as "approximate".

Tabulations of banding details and of recovery distributions were derived from the two Bioweb files using the pivot table facility of Microsoft Excel.

Many of the regional locations refer to historic acclimatisation society districts (see Fig. 4) because many of the more specific geographic localities recorded in banding schedules or in recovery records are obscure or colloquial, with some names as given not recognised in any gazetteer of New Zealand place names of the era. Most pre-1967 banding schedule cards do not record a map reference of the banding location, let alone for a recovery site (see Fig. 2). For groupings of records across one or more acclimatisation society districts, existing common regional names are applied.

Reference is made to all analyses of game bird band recoveries that have been reported, primarily in the scientific literature but also in readily accessible non-scientific publications. As will become apparent, many of the species band recovery datasets have never been evaluated despite providing two obvious analytical opportunities viz., geographic distributions of recovery locations to indicate patterns of dispersal from single or multiple regional banding sites, and distributions of time between banding and recovery

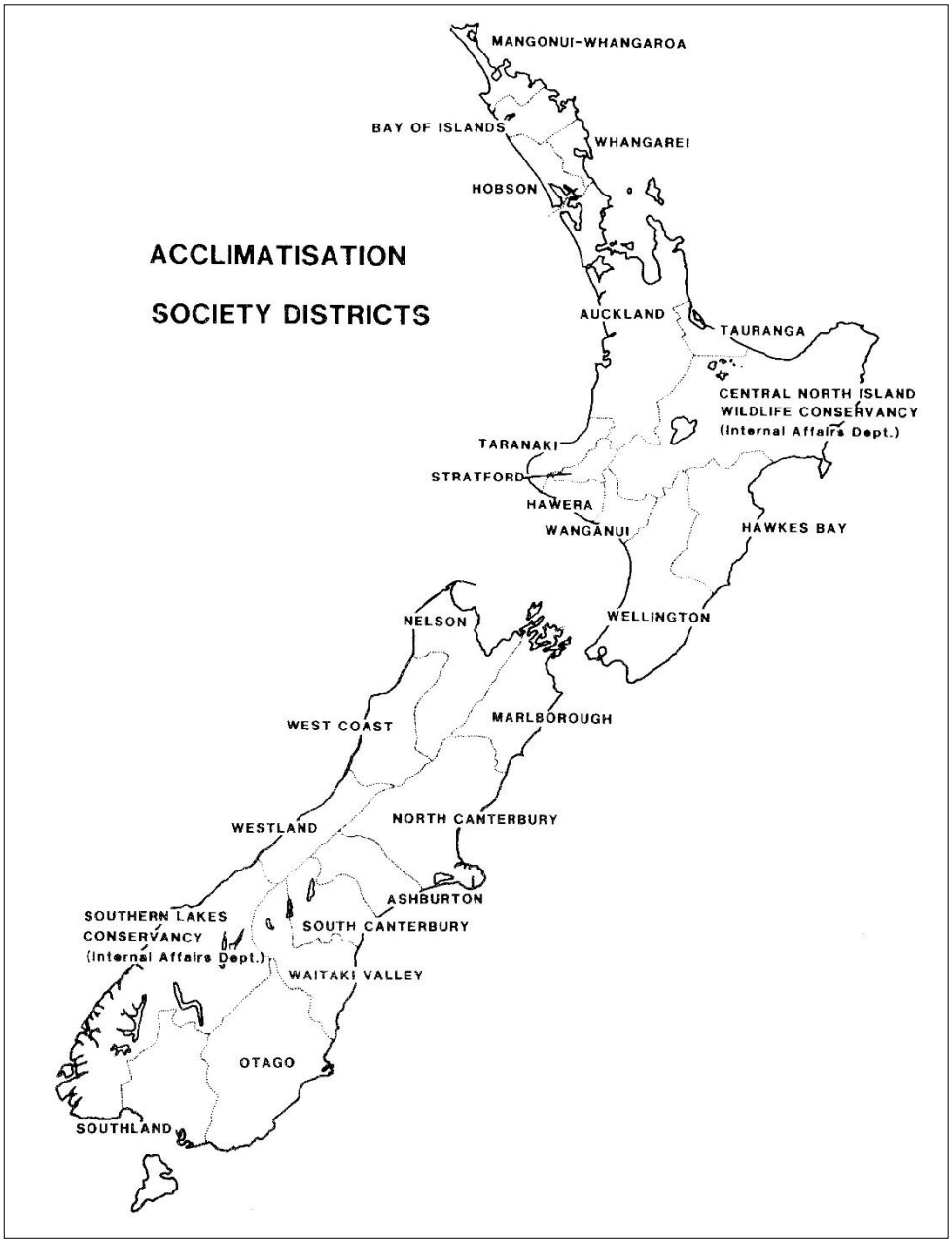


Figure 4. Acclimatisation society districts (as at 1980) referred to in the text.

to provide insights into longevity and the dynamics of banded populations.

Evaluations of geographic distributions of recoveries lie beyond the scope of this synopsis and so remain a most deserving exercise. Species and population responses to historic changes in the New Zealand environment lie embedded in these neglected datasets.

Recovery details are tabulated to indicate, for each wetland game species, totals of recoveries made overall (and the percentages of bandings from some major banding sites they comprise), and as distributions in years following banding ("time recovery distributions"), the basis for survival/mortality rate estimation as used in historic composite dynamic life table analyses (Hickey 1952; Balham & Miers 1959; Reid 1966). Because of their ease of calculation from expired band cohorts, this historic methodology has been used to derive crude mortality estimates from many of the wetland game species datasets not previously analysed. These estimates are presented as a mean percentage applying across several years, tacit recognition that analytical assumptions of composite dynamic methodology, e.g. mortality rate being age-dependant and without calendar year effect, are rarely satisfied by waterfowl datasets (Burnham & Anderson 1979), and that the methodology lacks the evaluative capability which contemporary analytical approaches, e.g. Program MARK (White & Burnham 1999) can provide. To encourage the latter, full recovery arrays for most regional bandings of each wetland game bird species

are supplied as supplementary files; https://www.birdsnz.org.nz/society-publications/occasional-publications/occ-pub-3-supplementary-files/ there is much that could add to knowledge of game bird ecology and their management should further, and more detailed, analyses be undertaken.

Longevity records are highlighted for wetland game species. Whereas mean life spans can be calculated from time recovery distributions, longevity reflects the extremes of intervals between banding and reporting dates. Cases of prolonged delay in reporting of a band recovered cannot be detected.

BANDINGS OF UPLAND GAME BIRDS

Two factors influenced the history and scale of upland game bird banding. Firstly, all game birds raised in captivity for release were required to be banded, a consequence of the Wildlife Regulations 1955 (Part VIII, section 39) which stated "No person, society, or organization shall liberate any game birds which have been reared in captivity unless the birds have been marked in accordance with such conditions as the Secretary imposes from time to time, or unless the Secretary has authorized the release of the birds without marking." This regulation arose because newly-released captive-reared mallards could not be distinguished from wild-raised mallards either in the field or when trapped, and the same conundrum applied to pheasants retrieved by hunters. The intent of this regulation was applied from about 1950 and significantly increased the numbers banded at a time when captive-raised pheasant and mallard releases were at a peak (Westerskov 1963; Dyer & Williams 2010). A requirement was thus placed on the Department of Internal Affairs (as the responsible Government department) to supply the bands and administer all records. Despite having long outlived its purpose, both regulation and requirement remained in force at year 2000.

Secondly, banding of wild-caught game birds with numbered and addressed bands was almost exclusively conducted by staff of the Wildlife Branch/Service and administered entirely by that agency. Post-1987, its successor Government agency, the Department of Conservation, administered banding records; however, its contribution as a bander of game birds ceased in 1990 when acclimatisation societies were reconstituted as regional Fish & Game Councils and given sole responsibility for the management and field investigations of game birds. Banding of captive-raised birds was always the responsibility of the relevant acclimatisation society, and once they commenced using Wildlife Branch-supplied bands, they were required to forward banding records to the Wildlife Branch. This seldom proved a smooth and timely operation and pre-1967 records, especially for pheasants, were never entirely complete (Westerskov 1963).

Missing from the species accounts below is brown quail (*Synoicus ypsilophorus*). The Wildlife Branch banding schedule cards do not record any banding of brown quail. That some must have been banded is evidenced by a divider amongst the historic cards being labelled "brown quail", and by two recovery record cards found amongst those for California quail, clearly indicating a recovery of a banded brown quail and referencing the band numbers; one was banded by Waitaki Valley A.S. in 1957, the other by Wildlife Branch at a Bay of Plenty location in 1955. Perhaps some South Island acclimatisation societies reared and released brown quail in the 1950s at a time when the species was becoming well established in Northland, Auckland, and Bay of Plenty.

California quail

Background

Most larger acclimatisation societies have a long history of attempts to acclimatise and spread various quail species throughout their districts (Thomson 1922; McDowall 1994). California quail proved the most successful and although it soon became ubiquitous, profound fluctuations in abundance were reported in many acclimatisation society records. Declines in some of the dryer landscapes, e.g. Marlborough, central Otago in the 1940s, which occurred alongside burgeoning rabbit (*Oryctolagus cuniculus*) numbers, prompted requests to the Wildlife Branch for evaluation. Biologist Gordon Williams was recruited in 1949 to appraise these declines and identify remedial responses.

Williams chose to locate his fieldwork in central Otago and, in 1950, commenced trapping and banding quail on Cairnmuir Station at Bannockburn on hillsides clothed with briar (*Rosa rubiginosa*) and matagouri (*Discaria toumatou*). The following year, trapping was extended to several other sites nearby, e.g. Luggate, Clyde, Alexandra, and a trial capture (of 15 birds) attempted in Nelson (IAD 46/132/2: Archives NZ R14986254). Bands used initially were supplied by the OSNZ before being sourced from a UK supplier (IAD 46/132/2). Low recovery rates in the first three years saw trapping shift to sites known to be popular with hunters, e.g. Poison Creek on the lower Pisa Range near Queenstown, and where quail were particularly numerous on hillsides dominated by briar, broom (*Cytisus scoparius*), matagouri, and exposed limestone outcrops. Trapping was maintained on Cairnmuir Station to provide a non-(or rarely-) hunted comparative site. A characteristic of banding in Otago was that traps were sited at similar locations each year, thus slowly increasing the number of banded birds in the area and offering the opportunity for their recapture.

From 1951, banding also occurred around the margins of central North Island *Pinus radiata* forests, mostly near Taupo and Mangakino. Here,

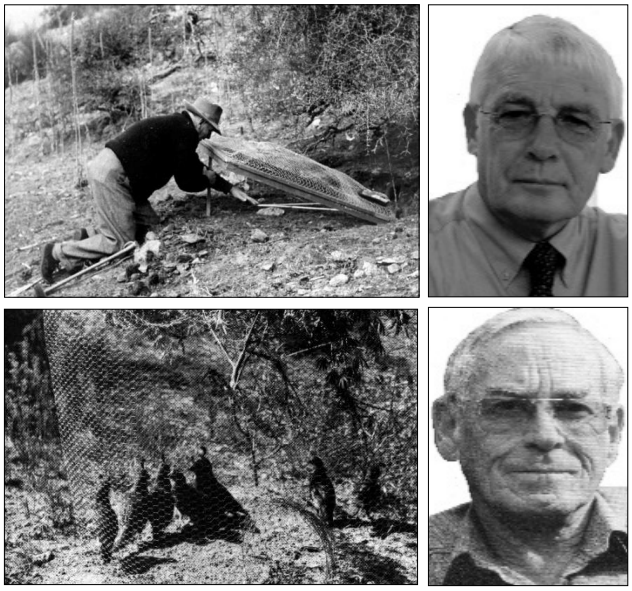


Figure 5. Left two images: Vince Barton pioneered a sensitive trigger mechanism that allowed quail to be caught in drop traps. This was the initial trapping method; California quail caught in grain-baited walk-in trap, Cairnmuir Station, Central Otago, 1953. (Photos: Wildlife Service, Archives New Zealand); Right two images: Ian Hogarth (upper) and Tom Caithness (lower) who, in their youthful years, caught quail in central Otago and central North Island before contributing, for over 30 years, to bandings of all waterfowl species (photos supplied).

quail were most common on north-facing margins of plantations, especially hillsides festooned with manuka (*Leptospermum scoparium*) and a plethora of introduced pioneer plants, e.g. blackberry (*Rubus fruticosus*), gorse (*Ulex europaeus*), and broom. Some trapping also occurred along margins of Lake Taupo and the upper Waikato River. Most banding sites were established anew annually and there was little intent to re-encounter banded quail.

Trapping targeted the multi-family coveys which established after breeding, and trappers had first to identify their presence and likely daily movements before determining where to spread bait (usually small weed seeds sourced from the cleaning of grain harvests at mills), and if the bait was taken, where to erect drop- or walk-in traps (Fig. 5). A key to this process was finding where quail had their favoured dust bathing sites, and siting traps nearby. Trappers would seek to establish and work about 10 traps at a time to target several coveys simultaneously and be prepared to shift traps regularly to target further coveys. Catches of 10 quail in a trap on any one day was a good day, and traps were sometimes left for several days at a site to capture, and recapture, more of a covey's members. Thus, trapping, generally in March–April, could extend throughout both months for total catches of 250–350 birds; annual totals up to 700 in some years reflected both additional trapping effort as well as pre-breeding trapping in August and September.

Scale and duration of banding

Between 1950 and 1965, 11,640 quail were banded to support Williams' research (Table 2). No purposeful banding took place subsequently other than of a few birds bred in captivity and released by acclimatisation societies, and others wild caught and translocated. The former included South Canterbury A.S. 89 (1968) and 74 (1973), North Canterbury A.S. 15 (1967), 33 (1968) and 78 (1969), and Southland A.S. 24 (1972) and 22 (1978). Translocations were a feature of Nelson A.S. activity 1960–62 with 740 banded quail being released into the Appleby area, an activity repeated in 1984 (44 birds). The Wildlife Service also translocated banded quail: 69 to Westland (1963), and 49 to Te Anau (1970) (IAD 46/132/2).

The banding records may be incomplete, assuming all captive-reared quail released had been banded. For example, North Canterbury A.S. annual reports record releases of captive-reared California quail as 34 (1967), 61 (1968), 85 (1969), 19 (1970), 154 (1971), 76 (1972), "some" (1974), 58 (1975), unrecorded (1976–78), and 4 (1979); however, none of these releases feature on the Bioweb banding file nor on banding card schedules of the time.

By 1985, a total of 13,006 California quail had been banded. No banding was reported thereafter.

Table 2. Numbers of wild California quail banded in central Otago, central North Island, and elsewhere, 1950–1965, numbers of banded quail recaptured alive, and percentage of banded birds recovered by hunters.

Region	Years of banding	No. banded	No. recaptured	% recovered
Central Otago	1950–51, 53–65	6,347	2,766	13.8
Central North Island	1951–52, 54–64	5,293	1,003	2.6
Nelson	1960–62	740	0	7.3
Southland	1954	144	0	2.0
Westland	1963	69	0	0

Recoveries

There were two sources of band recoveries: live recaptures of previously banded birds, and bands reported from quail shot by hunters (Table 2).

Of 3,769 live recaptures, most occurred within days of initial capture and banding. Leaving traps *in situ* for multiple days to capture most members of a covey ensured some birds were recaptured multiple times. In central Otago, 78.1% of recaptures arose from this practice, as did 85.4% of central North Island recaptures. Overall, only 6.3% of all recaptures were made two or more years after initial banding, the oldest in the sixth year.

Of 1,078 recoveries from hunters (from both regions combined), 65.0% were made in the year of banding, 23.7% from the year after banding, and

10.4% spread across the following five years; a mean annual mortality of 65–70% applied across the first four years after banding.

Reported outcomes

Acclimatisation societies and hunters were kept well informed by Williams' expansive annual reports published in society annual reports and hunter magazines, e.g. *NZ Outdoor, NZ Fishing & Shooting Gazette*. However, his major initiative was the introduction of hunting diaries wherein hunters reported the number, age, and sex of quail shot, as well as any bands recovered. Diarists received an annual newsletter in return. The administration of the hunting diary scheme, which soon had 140 regular contributors in central Otago, 40 in Nelson and Marlborough, and approximately 100 in central North Island collectively recording annual kills of 5–7,000 (IAD 46/132/3: R10764294), was tasked to his technical staff to augment their otherwise meagre banding administration duties. This diary scheme was modelled on that used in California (Sumner 1935) and previously tried by Otago A.S. (Otago A.S. 1948; Gurr 1951). The diaries became the major source of information for Williams' research and his publications.

Despite 16 years of banding, information derived directly from it contributed little to management of California quail as a game bird. Instead, the ratio of young birds killed per 100 adult hens recorded in hunters' diaries became the analytical statistic of choice, and that ratio in the annual banded samples taken as an indicator of pre-hunting season or pre-breeding population composition (Williams 1963).

Belatedly, Williams (1965) evaluated annual mortality within hunted and non-hunted populations in central Otago based on shot recoveries and recaptures. Given that neither population obviously declined during 10 years of study, he opined that the higher (10–15%) annual mortality in the hunted population may have been compensated by higher post-fledging survival as indicated by the higher proportion of young caught at banding time. No analyses of North Island data were reported, not surprising considering that band returns from hunters were minimal (Table 2), and re-trapping of banded birds likewise.

Information presented in Williams (1963, 1965) comprised a major part of his subsequent PhD thesis (Williams (1966).

Outcomes of translocations or releases of quail by acclimatisation societies were occasionally referred to in society annual reports, e.g. Nelson A.S. (1962).

Grey partridge

Background

Thomson (1922) indicates grey partridge was one of the plethora of upland game bird species imported by acclimatisation societies in the 19th Century, albeit in small numbers and, as McDowall (1994) describes, released several times in minimal numbers and without enduring effect. When Wildlife Branch biologist Kaj Westerskov suggested acclimatisation of the species should be tried again (Westerskov 1958) he found willing and enthusiastic support from both North and South Island Councils of Acclimatisation Societies, and Wildlife Branch administrators. The importation of eggs from Denmark in 1959, and the establishment of a breeding facility at Bulls, managed by the Wildlife Branch and co-funded by the island councils, resulted in partridges first being released two years later. All banding occurred within this breed-and-release programme and, in effect, banding provides a record of the duration and scale of the acclimatisation attempt.

Scale and duration of banding

The first banded partridges were released in mid-January 1961 at the Bulls game farm, Manawatu, followed the next month by 80 at Pleasant Point, South Canterbury and 60 at Southbridge, North Canterbury. A further 328 were banded and released in March 1961 near Kaiapoi, Waimate, Tapanui, and Thornbury in South Island, and at Okaiawa, Taranaki in North Island. Numbers bred annually quickly increased as several acclimatisation societies established breeding programmes at their game farms (Southland, North Canterbury, South Canterbury), and peaked in 1967.

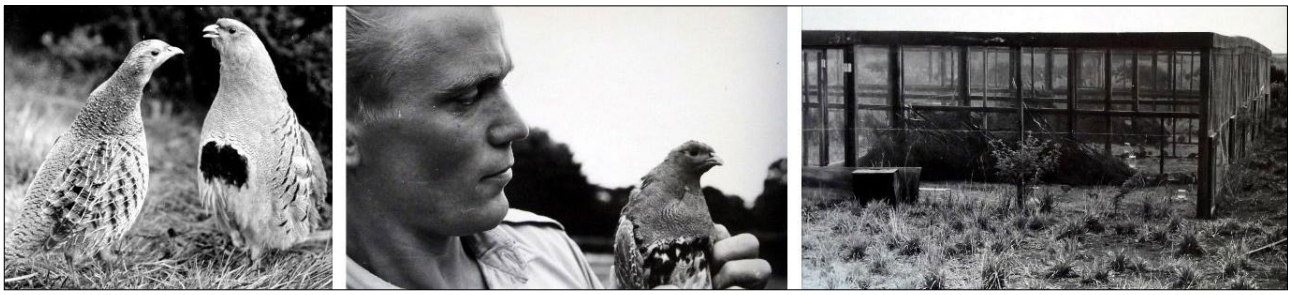


Figure 6. L to R: Hen and cock grey partridge; Danish game bird breeder, Leif Olesen, the initial breeder of partridges at the Bulls Game Farm, with the first of his partridges to be released; breeding and rearing pens for grey partridge, Bulls game farm (All photos: Wildlife Service, Archives New Zealand).

Table 3. Number of grey partridges banded and released 1961–1968.

Year	1961	1962	1963	1964	1965	1966	1967	1968	Total
Number	468	528	1,534	2,714	3,640	5,875	7,056	5,865	27,680

By the end of calendar year 1968, when the Bulls breeding facility was closed, 27,680 partridges had been banded and released (Table 3).

Many acclimatisation societies availed themselves of Bulls game farm breeding stock either to establish local breeding operations themselves or to augment those founded prior from eggs supplied from Bulls. Thus, they continued with releases, even though a developing consensus was that the species was unlikely to establish. Unbanded birds in the wild, evidence of releasees breeding, were very rarely sighted (IAD 46/7/28). Nonetheless, widespread captive breeding, banding, and releases persisted, and by 1972, a further 5,334 were added to the rural countryside across 15 regions. Post-1972, only North Canterbury A.S. persisted releasing banded partridges annually to 1986, a total of 1,271 across those 14 years. By then a grand total of 34,285 grey partridges had been banded.

Of the 21 acclimatisation societies in whose districts banded grey partridges were released, 10 released fewer than 500 birds, four released 500–1,000, four released 1,000–2,000, while three released considerably more: South Canterbury, 3,200 over 10 years; Southland, 5,500 over eight years; and North Canterbury, 13,200 over 26 years.

Recoveries

North Canterbury A.S. allowed limited hunting of partridges in 1970; 56 birds were sighted during 287 hours of hunting, of which seven were shot, one having been banded three years prior (Robertson 1970). Despite this meagre one-off hunting outcome, 1,168 recoveries of banded partridges were reported overall; for 694 (59.4%) the cause of death was "unknown", while the other main explanations of death were road and other collisions (11.1%) and predation (20.1%). "Shot" was the cause of death listed for just 21 partridges, mostly from within North Canterbury. For most (85.0%), recovery was within the year of release, and for another 10.2%, it was in their second year of freedom.

Reported outcomes

During the years of the grey partridge breed-and-release project, annual reports of all participating acclimatisation societies chronicled the scale of releases in their districts. Archived files of the Wildlife Service (especially IAD 46/7/28, 46/7/27, 46/7/3) contain records and reports about the project, including the deliberations of a Partridge Consultative Committee which provided guidance for the project. With the failure to establish a breeding population, no matter how large or persistent the releases, no considered post-mortem review was undertaken. Nevertheless, McDowall (1994) chose to offer a pithy perspective.

Red-legged partridge

Background

Failure of the grey partridge acclimatisation attempt did not entirely diminish enthusiasm for acclimatising a partridge in New Zealand's lowland pastoral and cropping landscape. In 1977, Auckland A.S. developed plans to import red-legged partridge and, with benefactor financial support, imported 1,500 eggs from United Kingdom in July 1980, and 638 eggs the following year. Hatching from both importations was extremely poor and, just 188 birds were raised in the Massey University quarantine facility to become founders for the last vertebrate acclimatisation attempted in New Zealand. McDowall (1994) provides a succinct account of the project's genesis and early tribulations.

Figure 7. Left: Captive cock red-legged partridge. (Photo: Wildlife Service, Archives New Zealand); Right: Noel Baucke who bred pheasants and all red-legged partridges for Auckland Acclimatisation Society at his Bellvue Wildlife Park, Te Aroha (photo supplied).

Table 4. Number of red-legged partridges banded and released 1984–1990. (DOC = Department of Conservation)

Agency	Calendar year							Total
	1984	1985	1986	1987	1988	1989	1990	
Auckland A.S.	822	2,948	1,591	3,356	1,560	1,467	861	12,605
Hawkes Bay A.S.	-	10	180	179	275	326	424	1,394
North Canterbury A.S.	-	-	200	209	240	44	18	711
Other A.S's combined	-	18	180	-	367	250	461	1,276
Wildlife Service/DOC	304	405	810	897	367	-	-	2,783
Total	1,126	3,381	2,961	4,641	2,809	2,087	1,764	18,769

Scale and duration of banding

By the end of the 1983 breeding season, two propagation units, the Auckland A.S.'s breeder (Bellevue Wildlife Park, Te Aroha) and a small Wildlife Service rearing facility at Pukepuke Lagoon, Himatangi, had produced over 1,000 birds. This was sufficient to fuel releases of 822 banded birds near Huntly and Te Kauwhata, Waikato, in March 1984, and 190 at Whenuakura, southern Taranaki, in August 1984. Thereafter, Auckland A.S. maintained its concerted breeding and release programme, which, by 1990, had resulted in 12,605 partridges being banded and released at 19 different locales north of Auckland city and within northern Waikato, almost all of them augmented by repeated releases (Auckland A.S. 1989; Table 4). Partridges from the Wildlife Service facility were mostly released locally or at Whenuakura and other nearby southern Taranaki sites. Hawkes Bay A.S. and North Canterbury A.S. bred partridges at their game farms for local release (their annual reports provide details).

After 1990, Auckland A.S. ceased its breeding programme, releasing its final 144 birds in 1992; however, four of the newly constituted Fish and Game Councils persisted, banding and releasing partridges during some or all of the following six years: Hawkes Bay (698), Nelson-Marlborough (2,423), South Canterbury (1,565), and Eastern (695).

Recoveries

Although no formal hunting of red-legged partridge was ever initiated, 195 recoveries of banded birds were reported by year's end 1999. For 40% of these no cause of death was recorded, whereas predation was implicated for 34% and roadkill for 16%. For 79%, recovery occurred in the year of release, 15% one year after release and just 12 birds (6%) later.

Reported outcomes

There has been no documentary account of the red-legged partridge acclimatisation attempt during which 24,294 banded birds were released; McDowall's 1994 synopsis of the project is an accounting before the project was formally abandoned. However, all participating societies gave accounts of progress in their annual reports, the most fulsome and explanatory being from Auckland A.S. in 1984 and 1989.

Chukar

Background

This partridge, which favours dry hill and montane environments, became established in central Otago and eastern Marlborough soon after its initial introductions dating from 1926 (Williams 1950, 1951; McDowall 1994).

Figure 8. Cock chukar, Tekapo (Photo: Neil Fitzgerald, NZ Birds Online), and captive chukar ready for release from field holding pens, Taieri Ridge, Otago, 1981 (Photo: Monty Wright).

No focused breed-and-release programme occurred during the period under study. However, chukar were held in captivity at several acclimatisation society game farms for public display, e.g. Southland, North Canterbury, Hawkes Bay, and occasionally surplus birds were released but not necessarily recorded as such. Three exceptions are reported below.

Scale and duration of banding

There are no records of chukar banding prior to 1981–82, and thereafter only from Hawkes Bay A.S. (492) and Otago A.S. (49). However, considerably more extensive banding by Hawkes Bay A.S. is indicated, both from its submitted banding totals lists, and from totals reported in its annual reports. For example, Hawkes Bay A.S. supplied banding totals lists reporting banding of 79 (1974) and 32, 22, 26, 80, 19 and 215 in years 1976–81, a combined total of 473. Over the subsequent 11 years, twice as many banded chukar were reported on its banding totals lists than are recorded on the Bioweb banding file. However, the latter cannot be easily matched with records of releases contained in Hawkes Bay A.S. files or annual reports (T. Winlove *pers. comm*.), e.g. its 1986 annual report specifically records 323 banded chukar released between November 1985 and October 1986, and lists all localities at which a total of 1,426 chukar had been released since September 1973. Hawkes Bay A.S. files also reference 169 chukar released in 1993/94 (T. Winlove *pers.comm*.). Perhaps as many as 2,287 chukar were bred and released in Hawkes Bay post-1973 but the number banded is most uncertain.

Southland A.S. submitted a banding total list for 1972 reporting 159 chukar banded, but nothing the following year. However, the Society reported in its 1972 annual report that, in 1971 and 1972 combined, 174 chukar bred at its Otatara game farm were released in the Hokonui hills, 169 in the Takitimu Range, and 19 at Mt Dome, 362 in all.

Otago A.S. submitted banding totals for 82 chukar in 1983 and 37 in 1985 whereas the Bioweb banding file records only 49 banded chukar being released in September 1981, on Taieri Ridge and at Oamaru. Otago A.S. annual reports have considerably more to say, with a summary of all releases, of 248 in total across 1981–85, confirming all were banded with metal numbered bands, and most colour-banded to indicate year of release (Wright 1985).

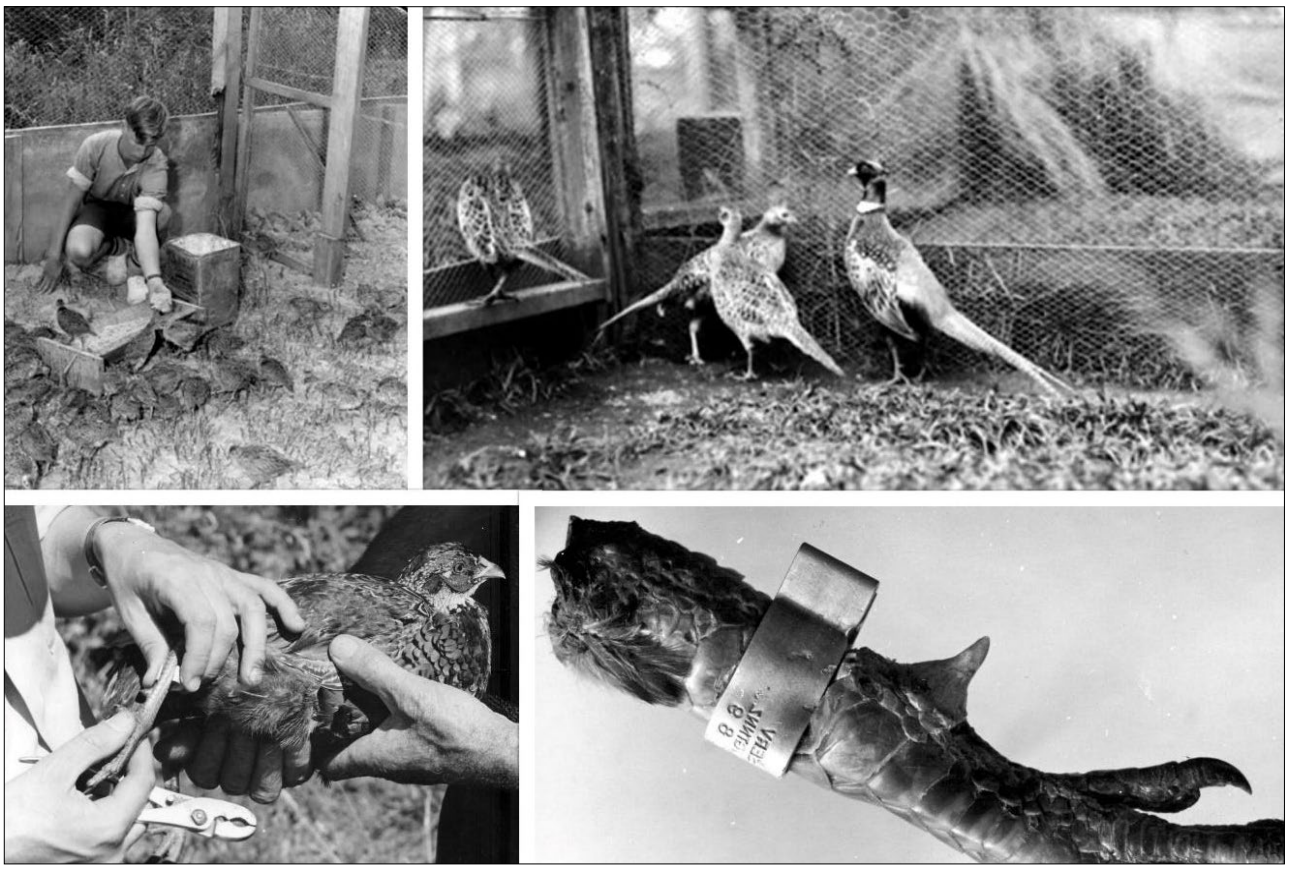


Figure 9. Upper: Pheasant rearing at Wellington A.S. game farm, Paraparaumu, 1955 (photos: *Evening Post* collection, Alexander Turnbull Library). Lower: left – a butt band being applied to a cock pheasant poult prior to release; right – a lock band, supplied to prevent misshaping of bands, shown to have been needlessly squeezed and causing injury to pheasant. (Photos: Wildlife Service, Archives New Zealand).

Recoveries
There are only 10 recovery records for chukar, all for birds released by Hawkes Bay A.S.: one in 1981, two in 1983, four in 1984, and three in 1987. Shooting is identified as the cause of death for two, predation two, roadkill three, and cause unknown three. Eight of the 10 were in the year of release.

Common pheasant
Background
The mid-1930s releases of banded pheasants, referred to in the introduction, highlight the early acceptance of banding as a means for following the fate of pheasant liberations (Auckland A.S. 1939). In 1936, and at the behest of then Minister for Internal Affairs, W.E. Parry, a fervent game bird hunter, the Department of Internal Affairs established a game farm at Ngongotaha, near Rotorua, specifically to rear pheasants for liberation in northern and central North Island. Hunters in the recipient districts were keen for birds to be banded; none was, perhaps because, as Parry, explained, "the curator was averse to placing rings on the legs of young pheasants liberated as they injured the birds." (*Otago Daily Times 28 Jun 1937*). Nevertheless, from 1948, all were, and, progressively, pheasants raised elsewhere were banded also. However, the scale and duration of these bandings were to be influenced by early analyses of recoveries and subsequent debate about the costs and rewards of pheasant releases.

Banding and recoveries to 1959
In 1947, Otago A.S. commenced three years of banding cock pheasants released immediately prior to the shooting season, an initiative overseen by its supernumerary science advisers B.J. Marples and L. Gurr and recorded as part of the OSNZ ringing scheme (Cunningham 1951). Bands carried a number and "RETURN OTAGO UNIV." address. Of 710 cock pheasants released, 197 (28%) were recovered by hunters, thus providing a first understanding of the reward and cost to hunters of the breed-and-release exercise (Gurr 1950). The society continued to breed and release pheasants, ensuring all cock birds were banded, and some hens also once they were added to the licence; 6,738 being released between 1947 and 1954 and 1,134 (16.8%) being reported shot (Otago A.S. 1954). Thereafter, their banding was part of the Wildlife Branch programme, with a further 6,832 being banded to 1959.

From 1948 to 1951, 3,485 Ngongotaha-raised pheasants were banded and released in Northland, Taranaki, Hawkes Bay, and central North Island. It was the appraisal of their band returns (117) by Westerskov (1953) that ushered in a more focused banding of all released pheasants. Westerskov identified a minimal recovery rate by hunters (4.0% for cocks, 0.4% for hens) and no recoveries beyond 24 months after release. His appraisal prompted considerable debate; however, encouraged by Westerskov, contributing acclimatisation societies agreed to four years of banding and release to validate his findings. The scale and duration of bandings henceforth were influenced by ongoing analyses by Westerskov and responses to them by the societies.

Within two years, Westerskov was able to evaluate the first of these additional bandings, now totalling 16,548 releasees (Westerskov 1956). Again, the ecological and economic folly of pheasant liberations was obvious; however, Westerskov highlighted that a 3.4% recovery for released cock pheasants could be improved to 12.7% if the birds were "hardened" with quasi-wild experiences prior to release. Unmoved, acclimatisation societies kept releasing banded young pheasants directly from breeding coops while at the same time the quality of their record keeping reached a nadir. Many simply failed to supply banding details. Wildlife Branch's game bird biologists claimed their banding administrator's inability to inform hunters about the banded pheasants they had shot was causing a noticeable reduction in bands returned from those also hunting waterfowl (IAD 51/10/7; Archives R12322657). In response, the Wildlife Branch withdrew authorisation for the banding and release of pheasants by the errant societies in 1958. This prohibition on banding did not go down well with some, e.g. Auckland, Whangarei, Hobson, still wedded to their expensive pheasant release programmes; they wanted to continue with their own local schemes, but the Wildlife Service resisted (IAD 51/10/7). However, some societies went ahead and banded their pheasants anyway, using bands previously supplied.

Westerskov (1963) established that the Wildlife Branch banding scheme contained records of 35,244 banded pheasants released between 1948 and 1959 (his Figure 1) and estimated that banding records for another 5,000 pheasants had not been supplied. Of the 20,417 cock pheasants released, 1,170 (5.7%) were reported shot, 89.9% of which were within two years of release. For the 11,034 hen pheasants released 142 (0.13%) were recovered, 82.4% of these within two years of release. Given that each released pheasant cost approximately £2 10s. to rear or to purchase, each cock bird retrieved represented a minimum expenditure of £43.

Bandings post-1960
Wildlife Branch banding schedule cards for 1960–66 record the bandings and release of 3,393 hen and cock pheasants (Table 5). There are contradictions, however; the Bioweb banding file, meant to comprise only post-1966 records, includes some for pheasants banded and released in the 1960–66 period, and earlier, perhaps indicating some records were belatedly sent to the Wildlife Branch and entered not

onto card schedules but onto OSNZ paper schedules as used to record some waterfowl records (see later). These include 125 by Waimarino A.S. (1966), 128 by Hobson A.S. (1957–58), 250 by North Canterbury A.S. (1958, 1960), and 534 by Whangarei A.S. (1958–59). Notable absences are records from Otago A.S.; its annual reports reference pheasant releases of 1,034 in 1960, 903 in 1961, and in 1963 "a record number of pheasants…." Also unrecorded were 1,529 releases by Wellington A.S. 1965–66 (Wellington A.S. 1966).

Table 5. Number of pheasants, cocks and hens combined, recorded on Wildlife Branch banding schedule cards as having been banded and released, 1960–66, and the percentage recovered shot.

Agency	Years of banding	No. banded	% recovered
Hawkes Bay A.S.	1964–66	1,034	7.0
Taranaki A.S.	1962	152	25.0
Wellington A.S.	1960, 62, 65	1,753	12.5
Wildlife Branch	1960	454	18.1

In short, figures (where given, and they were not always) in various acclimatisation society annual reports may provide a more fulsome record of pheasants banded and released in this 1960–66 period; a minimum of 8,359 were banded.

In 1967, the Wildlife Service offered a co-ordinated pheasant banding programme for North Island acclimatisation societies for the next three years on the proviso that banding and release details for the maximum 500 birds released per region were supplied immediately after the release and before the hunting season commenced. In return, the Wildlife Service would supply an annual listing of all bands returned and undertake a multi-year analysis (IAD 51/10/7). Auckland A.S. participated, releasing 4,046 banded cock pheasants between 1971 and 1977: just 264 (6.5%) were reported shot, 89% in the year of release. The all-important cost-per-cock-retrieved varied annually between $40 and $73 (Cheyne 1978).

The Bioweb banding file records that, from 1967 onwards, 22,072 pheasants were banded and released, with 1,630 of them post-1990 under the auspices of the reformatted Hawkes Bay, Auckland, and Taranaki Fish and Game Councils (Table 6). Of these, 3,306 (15.0%) were reported shot; 180 give no retrieval date, but of the remainder, 2,750 (88.0 %) were shot in the hunting season immediately following the bird's release, and 97.7% of recoveries occurred within two years of release. South Canterbury A.S. had a remarkable two-thirds of each of three annual releases (1972–74) reported shot, perhaps shot at the time and place of release in a classic English hunting estate manner.

Reported outcomes

Westerskov's (1963) appraisal of 1947–59 recoveries, and Cheyne's (1978) summary of 1971–77 Auckland-region band returns are the only reported evaluations of the approximately 60,000 pheasants banded and released between 1948 and 1999. However, post-1967, the Banding Office sometimes provided annual listings or summaries of pheasant recoveries to all contributing banders for their own evaluations.

BANDINGS OF WETLAND GAME BIRDS

Waterfowl (Anseriformes) have provided the bulk of game bird hunters' quarry in New Zealand since the introduction of seasonal bird hunting in the mid-19th Century. Prior to then, they were undoubtedly an important food resource for both Maori (Beattie 1920; Orbell 2003) and early European settlers (Potts 1869). Their widespread importance as game,

Table 6. Numbers of pheasants banded and released by various acclimatisation societies, 1967–99, as recorded in DOC's Bioweb banding file, and the percentages recovered shot.

Acclimatisation Society	Years of banding	No. banded	% recovered
Auckland	1967–69, 71–72, 74–77, 90–91	5,780	8.8
Hawkes Bay	1977–93	7,332	12.4
North Canterbury	1968–69	223	4.9
Otago	1971	599	15.2
South Canterbury	1972–74	649	63.2
Southland	1988	4	0
Taranaki	1968–69, 92–94, 96	688	18.6
Tauranga	1968–69, 77–78	1,059	15.9
Wanganui	1977	115	6.1
Wellington	1968–70	4,976	18.1
Whangarei	1967–68	534	6.7
Wildlife Service	1969, 73–75	64	7.8
Total		**22,072**	**15.0**

as perceived by acclimatisation societies, was summarised by McDowall (1994), and an apparent decline in their abundance, especially of grey duck, was a formative influence for the establishment of an operational wildlife management unit, the Wildlife Branch, within the Department of Internal Affairs in 1946 (DIA 1946).

In contrast to all but one of the upland game bird species, bandings of game waterfowl were of wild-caught birds, albeit that some captive-raised and released mallards were also. A seventh wetland-inhabiting game bird, the native gallinule, pukeko (*Porphyrio melanotus*) is not discussed; it has not been the focus of banding other than as nuisance bycatch during duck trapping, or for individual identification to aid behavioural or ecological studies, e.g. Craig (1977).

Black swan

Background

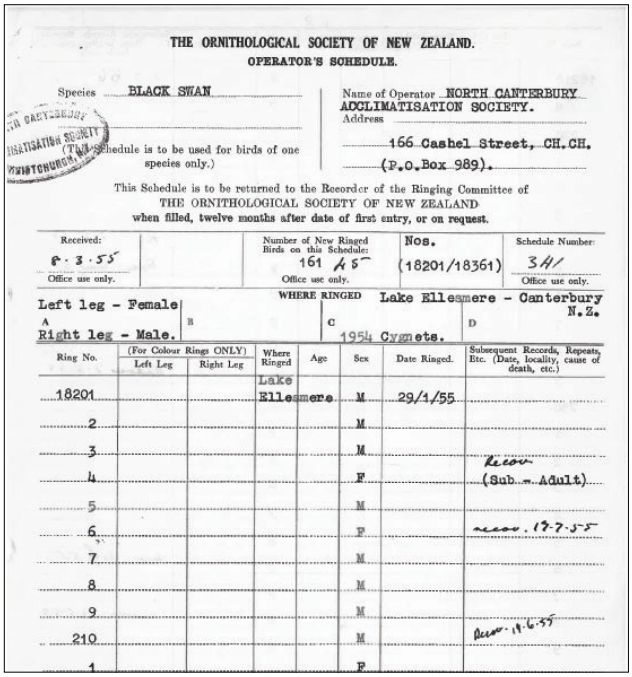
Throughout the 1950s, North Canterbury A.S. received multiple complaints about swan grazing of pastures edging Lake Ellesmere. In response, it organised "swan drives" when swans were herded to fly over lines of shooters, extended hunting seasons from four weeks to three months, and collected several thousands of eggs annually to restrict cygnet production (Lamb 1964). Swan banding commenced at the lake in January 1955 using bands supplied by OSNZ; the initial capture was of 161 swans, (78 males, 83 females), 45 identified as cygnets; however, ages of the remainder were not recorded (Fig. 10). Thereafter, at Lake Ellesmere and elsewhere, swan banding was undertaken by the Wildlife Branch.

The intent of the initial bandings at Lake Ellesmere is not reported. Most likely it sought to provide life history information of the troublesome and large swan population then at the lake. Banding at Lake Whangape, Waikato, was initiated when the Wildlife Branch seconded staff to South Auckland to conduct duck productivity surveys and banding on Waikato wetlands; again, no documentation of banding intent has been located.

The capture technique for cygnets, and for flightless adults regrowing wing feathers (moulters), was to pursue a fleeing swan in a faster-travelling boat and hook the bird around its neck using a long-handled crook, thence using the momentum of the boat to swing the swan to the boat's rear where it was hauled, somewhat unceremoniously, aboard (Fig. 11). Several swans could be held in the boat simultaneously before stopping to band each bird and return them to the water. Crude but effective for flightless adults but for cygnets, brood cohesion was invariably sundered.

Scale and duration of banding

Since those initial Lake Ellesmere bandings, 56,110 black swans were banded in 10 regions of New Zealand on 22 different wetlands (Table 7).



THE ORNITHOLOGICAL SOCIETY OF NEW ZEALAND.
OPERATOR'S SCHEDULE.

Species BLACK SWAN
(This Schedule is to be used for birds of one species only.)

Name of Operator NORTH CANTERBURY ACCLIMATISATION SOCIETY.
Address 166 Cashel Street, CH.CH. (P.O.Box 989).

This Schedule is to be returned to the Recorder of the Ringing Committee of THE ORNITHOLOGICAL SOCIETY OF NEW ZEALAND when filled, twelve months after date of first entry, or on request.

Received: 8.3.55 Office use only.
Number of New Ringed Birds on this Schedule: 161 45 Office use only.
Nos. (18201/18361)
Schedule Number: 341 Office use only.

Left leg - Female
A
Right leg - Male.
B
WHERE RINGED Lake Ellesmere - Canterbury N.Z.
C 1954 Cygnets.
D

Ring No.	(For Colour Rings ONLY) Left Leg	Right Leg	Where Ringed	Age	Sex	Date Ringed.	Subsequent Records, Repeats, Etc. (Date, locality, cause of death, etc.)
18201			Lake Ellesmere		M	29/1/55	
2					M		
3					M		
4					F		recov (Sub-Adult)
5					M		
6					F		recov. 17.7.55
7					M		
8					M		
9					M		
210					M		Recov. 19.6.55
1					F		

Figure 10. Part of the banding schedule recording the first swans banded in New Zealand with numbered rings, 1955. The template is that established by the Ornithological Society of New Zealand ringing scheme, and post-1967, used for all other bird banding to 1999.

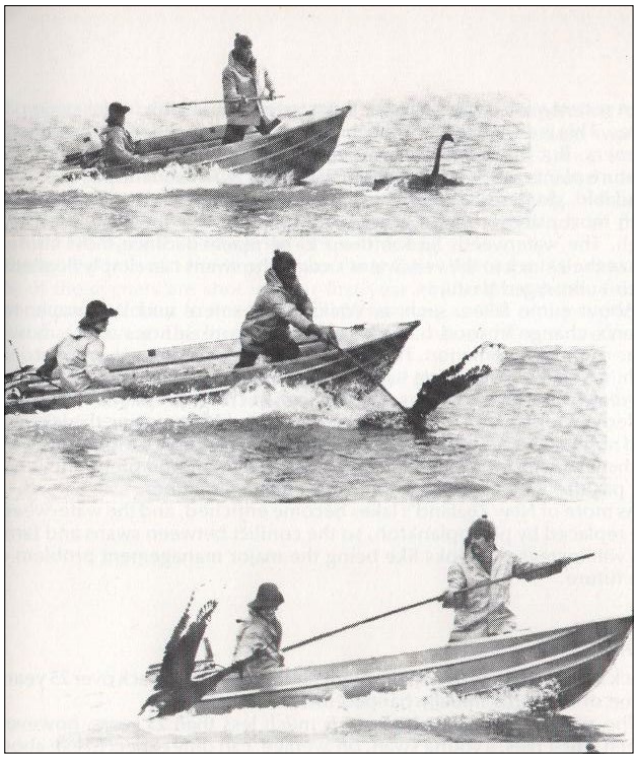


Figure 11. Method of capture of flightless juvenile and adult black swans. (Photos: J. McCombe, from Williams 1981a).

In Waikato, banding occurred consistently at Lake Whangape, at Lakes Waahi and Waikare in most years, and, in single years, on the Piako and lower Waikato Rivers, Hamilton lake, and Lake Opuatia; Hawkes Bay banding sites included Lakes Tutira, Runanga, Oingo and Horseshoe Lagoon; Rotorua banding sites included Lakes Rotomahana, Rotoehu,

Table 7. Locations, durations, and scale of black swan banding 1955–1988, and percentages of banded swans recovered shot.

Region	Principal locality	Years of banding	No. banded	% recovered
Canterbury	L. Ellesmere	1955–82, 86, 87	30,074	20.9
Waikato	L. Whangape	1962–85	10,052	18.8
West Coast	Okarito Lagoon	1964, 69, 72–79	950	16.0
Hawkes Bay	L. Runanga	1974–78	777	15.8
Wairarapa	L. Wairarapa	1974–88	6,382	24.3
Rotorua	L. Rotoehu	1974–80	1,107	17.3
Nelson	Farewell Spit	1976–82	4,411	21.5
Southland	Awarua Bay	1978, 85, 86	893	17.7
Otago	Upper Taieri R.	1984, 85	221	24.0
Northland	L. Omapere	1984–85	950	8.4
Others			289	25.6

Okareka, Rotoiti, and Rotorua; Southland bandings were restricted to coastal Awarua Bay and New River Estuary. Additionally, small numbers were banded in single years at Lake Emma (60), Lake Alexandrina (26), Lake Waihola (28), and on numerous private ponds or public gardens; a collective total of 289. In addition, 5,511 web tags were applied to newly hatched cygnets at Lake Ellesmere in 1976 (1,987), 1978 (682), and 1986 (2,842) to aid productivity estimation; 1,098 of these were subsequently recaptured and banded. During 1976–79, some swans banded at Lake Ellesmere (330), Farewell Spit (2,513), Lake Wairarapa (1,561), Hawkes Bay lakes (309), Rotorua lakes (686), and Southland estuaries (739) were adorned with coloured neck collars to aid dispersal studies.

At estuarine locations (Farewell Spit, Awarua Bay, New River Estuary), all birds caught were flightless pre-breeding or non-breeding adults. At all other (freshwater) banding sites, young of the year (cygnets) were targeted, preferably those already well feathered. Flightless adults captured there, which comprised 9.5% of the total, undoubtedly included those attending broods, but would also have included non-breeders.

At three lakes, banding extended for more than a decade: Ellesmere for 28 years, Whangape for 23 years, and Wairarapa for 14 years. These lakes, at times, supported the largest breeding populations of swans in the country and were the major contributors to wider regional populations (Williams 1980a). All suffered major ecological perturbations during the banding periods: the evisceration of aquatic macrophytes from Lake Ellesmere by the *Wahine* storm of 1968 and the consequential significant reduction in the scale of nesting at the lake for most years thereafter (Williams 1979a); reclamation of seasonally flooding margins along Lake Wairarapa's eastern shore which directly impacted the population's main nesting area and induced a relocation of breeding attempts to Vernon Lagoon in Marlborough and onto small and scattered wetlands towards Hawkes Bay (Moore *et al.* 1984); trophic changes in lakes of the lower Waikato area which resulted in Lakes Waahi and Waikare supporting considerably fewer, later no, breeding swans and, eventually, a similar change at Lake Whangape (MW *pers. obs.*). One brief consequence of the latter was the sudden and spectacular relocation of Waikato swans to Northland and their winter breeding there, which the banding at Lake Omapere in 1984 and 1985 reflects.

Recoveries

By year's end 1999, the recoveries of 13,515 banded swans had been reported, either as dead (11,618), as live recaptures (750), or as previously web-tagged cygnets (1,094). There were also 47 sight recoveries of swans marked with numbered collars, while for a further six birds no recovery details are recorded. Date of recovery is unrecorded for 133 dead recoveries.

The time recovery distributions for swans banded as cygnets and shot by hunters varied between major breeding sites sufficient to indicate significantly different hunting impacts on newly fledged swans, and similar differences also for adult swans (Table 8).

These time recovery distributions allow crude estimation of annual mortality, e.g. across all sites cygnets experienced mortality rates of 41%, 30%, and 23% during their initial three years and an average of approximately 17% annually over the subsequent five years; however, there were clearly large differences between banding sites, e.g. Lake Ellesmere *cf*. Waikato lakes (Table 8). Across all sites, adults banded while moulting experienced a mean annual mortality of approximately 19% (Table 8).

Remarkably few recoveries arising from live recaptures were recorded. For example, at Lake Ellesmere, only 179 swans banded as cygnets 1957–75 were recaptured at the lake by 1987. Of these, 111 (62%) were five or more years after banding, and 48 (26.8%) were 10 years or more after banding. The Bioweb recovery file has no recapture records for swans banded on Waikato lakes 1962–72, and just 28 recapture records for those banded there 1973–78 and recaptured alive by 1982. This paucity of recapture records suggests a systematic non-recording until about the mid-1970s. At Farewell Spit, moulting

Table 8. Time recovery distributions (the percentages of total recoveries made in years after banding) for black swans banded as cygnets or as moulting adults (>1 year old) and reported shot by hunters. ("0" = recovery in year of banding). Recovery arrays from which these distributions were derived are provided in supplementary file "Black swan."

Region	% of total recoveries in years after banding								Total
	0	1	2	3	4	5	6+	12+	
Cygnets									
Canterbury: L. Ellesmere	37.4	20.6	9.0	7.1	3.5	3.7	18.6	4.9	5,927
Waikato: all lakes	51.0	14.3	10.3	6.4	4.5	3.8	9.9	2.4	1,863
Wairarapa: L. Wairarapa	48.3	13.1	9.9	6.1	5.3	3.1	14.2	3.3	1,518
All sites	41.0	17.8	9.5	6.9	4.2	3.6	17.1	4.6	10,003
Adults									
Nelson: Farewell Spit	13.8	15.6	13.9	11.3	6.6	7.4	31.4	7.5	917
Southland: both estuaries	38.0	14.6	12.0	8.2	3.8	8.9	14.6	1.9	158
All sites	19.6	15.6	13.8	10.0	6.2	7.2	27.6	7.2	1,509

swans banded there in 1976 and 1977 were recaptured in all subsequent years to 1982, 116 in total with 23% of these occurring four and five years after banding.

Longevity records also accrued: of swans banded as cygnets at Lake Wairarapa before 1980, those 16 years or older comprised 15 (3.4%) of 443 shot recoveries (oldest 22 years), compared with seven (0.4%) of 1,758 from Waikato lakes (oldest 21 years), and 94 (1.7%) of 5,636 from Lake Ellesmere (oldest 35 years).

Reported outcomes

Williams (1973) provided estimates of annual mortality for Lake Ellesmere-banded swans from recoveries made in years 1956–1970, and later extended the recovery period to 1974 (Williams 1979a). Mean adult annual mortality was estimated to be 16% (= survival 0.84). Williams (1980a) restated these estimates and highlighted a different recovery pattern for swans banded at Lake Whangape including higher estimates of adult mortality there. However, he emphasised the uncertainty of these estimates because assumptions implicit in the analytical methods (of Seber 1971) could not be satisfied. Barker & Buchanan (1993), using a model that allowed year-specific adult survival rates to be estimated from swans banded as cygnets, examined recoveries (to 1990) of cygnets banded at Lake Wairarapa 1975–1988. Mean annual adult survival was estimated to be 0.84 se. 0.023 (= mortality 16%). No other appraisals have been reported.

Meis (1988) used recaptures of Lake Ellesmere cygnets web-tagged at hatching to estimate their survival (0.51) to age three months (≈3.4kg body weight) and to calculate population-wide productivity to that age (6,800).

Dispersal was evaluated by Williams (1977) from the locations of 4,695 recoveries by hunters of swans banded at Lake Ellesmere, and of 871 banded at Lake Whangape. Very prescribed patterns of dispersion were revealed: Ellesmere swans ranged south along coastal wetlands to Otago and Southland with fewer extending north to Marlborough and Lake Wairarapa; Whangape swans were largely confined to Waikato lakes and to Northland's lakes and estuaries. These findings prompted an extensive 1974–80 banding and collar marking of swans at multiple breeding and seasonal moulting sites, and of nation-wide annual counts (IAD 47/31/2; R14986339), the outcomes of which were reported in general terms by Williams (1980a,b; 1981a). In 1980, New Zealand's swan population was perceived as comprising seven regional populations with limited interchange.

Canada goose

Background

Within a decade of their release in New Zealand, Canada geese had established a seasonal migration between nesting sites in headwaters valleys of Canterbury rivers and coastal Lake Ellesmere where "a flock visits the lake every year" (North Canterbury A.S. 1921, 1923). They had been widely released into these valleys during 1910–22, as they had at lakes in Otago (e.g. Lake Hawea) and Southland (Lake Te Anau area) (Imber & Williams 2015). As populations established and grew, problematic relationships with pastoral farmers in these areas arose, thereafter to complicate the goose's game bird status and its management by acclimatisation societies (McDowall 1994). The banding initiative at Lake Ellesmere may have been opportunistic in that moulting geese shared the lake with black swans then being banded; however, they also happened to have game bird status there at the time, in contrast to elsewhere in Canterbury province west of the main trunk railway line. Whilst no specific aim(s) of the banding programme were declared, it is likely that the general intent of swan and duck banding (to understand movement and longevity) also applied to the geese.

To capture moulting geese, their tendency to remain in a tight flock was exploited. They were driven from the water by boats and, once on land, herded towards, and into, pens (Fig. 12). Within the flock, many of the geese were capable of flight but nevertheless remained grounded alongside those whose wing moult was not yet complete.

Figure 12. Upper: Left – Canada geese being encouraged to traverse the shores of Birdlings Flat, Lake Ellesmere and towards capture pens (Roy Cavanagh depicted); Right – geese penned at Lake Forsyth (Selwyn Bucknell depicted). Lower: banding of geese at Lake Ellesmere. Left – 1957: seated banders include Ron Balham (beret), Brian Bell (hat), Ken Miers (hatless, back left; standing handlers Marsh Small (cap) and Lou Hoff (hat). Right – 1977: participants include John Adams (leaning on bench), Ross Novis (holding bird), and banders Murray Williams (hat), Kerry Horgan, and Duncan Sutherland (Photos: Wildlife Service, Archives NZ).

Table 9. Locations, durations and scale of Canada goose banding 1953–1993, and percentages of banded geese recovered shot. * = all but 20 were goslings marked with web tags, not leg bands.

Region	Locality	Years of banding	No. banded	% recovered
Canterbury	L. Ellesmere	1953, 57–90	38,267	29.9
	L. Forsyth	1966, 68–83	5,425	29.8
	Esk/Cox River valleys	1969–80	3,644*	3.3
South Canterbury	Wainono Lagoon	1981–86	1,200	32.3
Marlborough	Bowscale Tarn	1983–86	441	51.7
Central Otago	Glenorchy area	1986–88	268	39.9
Central South Island	L. Pukaki area	1977, 83, 84, 86–88	1,967	41.1
Hawkes Bay	Wairoa lakes	1982–93	2,278	20.2
Southland	Waituna Lagoon	1962	50	0
Others, incl. transfers	various	1967–96	2,655	n.a.

Scale and duration of banding

A banding of 50 Canada geese occurred at Lake Ellesmere in January 1953. However, January 1957 marked the commencement of the Wildlife Branch's annual goose banding at the lake, continuing unabated until 1990, the most enduring game bird banding project (Table 9).

Banding extended to adjacent Lake Forsyth in 1966 to support a nesting study of resident geese; fledglings were targeted there, and extensive web tagging of goslings in Esk and Cox River valleys 1969–80 was also a complement to that nesting study (Adams & Williams 2021).

Transfers of geese to lakes near Wairoa, North Island 1969–76 established a resident population which became the focus of annual bandings for 12 years from 1982. During this period extensive transfers and liberations of banded geese occurred elsewhere throughout North Island (Imber & Williams 2015), and progeny of some resultant populations were captured annually and banded by landowners. Small scale banding programmes were undertaken in the 1980s in four central South Island locations by Wildlife Service in association with local acclimatisation societies. By 1999, a minimum of 52,573 Canada geese had been banded and 3,622 web tagged.

At banding, all geese were sexed by cloacal examination, and between 1967–72 at Lake Ellesmere and Lake Forsyth, an attempt was made to discriminate ages of moulting birds, as yearlings and older, based on depths of their bursa of Fabricius (Elder 1946; Hansen 1949). It was a problematic technique and not persisted with, nor attempted elsewhere. Colour bands were applied to some known-age geese at Lakes Ellesmere and Forsyth, and later at Lake Pukaki.

Recoveries

During 1953–99, 46,823 recoveries of banded Canada geese were reported, and a further 119 records from web tagged geese; 16,090 were derived from hunting (another 98 bands returned but with no associated recovery data), and 30,040 were from geese recaptured during annual bandings, 20,861 of them at Lake Ellesmere.

Recoveries by hunters of birds banded at Lake Ellesmere and Lake Forsyth were aided by special hunting seasons at these lakes in January–March annually 1963–72 (Miers 1964; Nelson 1964; Imber 1970). Their purpose was to "control" a perceived burgeoning goose population. An initial kill of almost 6,000 geese in 1963 was followed by annual kills of approximately 1,000; time recovery distributions of banded Lake Forsyth fledglings and Lake Ellesmere moulters during and after these hunting seasons (Table 10) indicate their consequential impacts on mortality and longevity, and the high proportion of their recoveries made in the first two years after banding highlight that newly-banded cohorts were particularly affected.

Recoveries from post-1972 bandings also indicate differences in exploitation of populations banded at different localities. For example, whereas similar year-of-banding recoveries were made at Lake Ellesmere, Wainono Lagoon, and Lake Pukaki, a mean annual mortality of 20% applying across the subsequent four years at Lake Ellesmere contrasted with the 33–39% rates at the other two sites, and Ellesmere birds were also less intensely exploited over later years (Table 10). Perhaps these reflect differences between a large and migratory population and two smaller, more sedentary ones. A similar contrast is apparent for geese banded as fledglings; at Lake Forsyth annual mortality rates of 23–25% applied across the first four years and later, whereas at Wairoa the comparable rate was 33–38% (Table 10).

Recoveries by recapture, dominate. These records are problematic for survival analyses given that geese, when initially captured and banded at moulting sites, were likely to have been either yearlings or birds of later pre-breeding age (adolescents). Once of breeding age, their likelihood of repeat capture was undoubtedly determined by their breeding status and success in any year, an annual variable. Successful breeders at distant nesting areas moulted while raising their young and only thereafter flew with their young to join a moult aggregation, thus eluding January bandings at these sites (Imber & Williams 1968).

When capturing fledglings for banding at breeding lakes e.g. Forsyth, Wairoa, moulting breeders and any adolescents present were also caught.

Table 10. Time recovery distributions (the percentage of total recoveries made in years after banding) for Canada geese banded as fledglings or as moulting adults (>1 year old) and reported shot by hunters. ("0" = recovery in year of banding). * = distribution influenced by control hunting 1986-88. Recovery arrays from which these distributions were derived are provided in supplementary file "Canada goose"

Banding locality, years, age at banding	% of total recoveries in years after banding								Total
	0	1	2	3	4	5	6+	10+	
Fledglings									
L. Forsyth, 1966–72	59.9	14.8	8.4	5.2	3.9	1.1	6.8	2.5	718
L. Forsyth, 1973–83	45.0	15.0	9.7	7.1	3.7	6.2	13.3	5.1	547
Wairoa, 1982–90	45.8	15.2	12.4	8.4	7.4	3.4	7.6	1.7	356
Adults									
L. Ellesmere, 1957–62	12.8	16.0	14.1	11.3	9.6	11.3	24.9	5.4	3,189
L. Ellesmere, 1963–72	38.1	18.9	12.1	7.0	5.7	4.1	14.0	5.6	2,990
L. Ellesmere, 1973–83	22.4	16.3	12.9	10.0	8.2	7.1	23.1	7.7	3,206
Wainono Lagoon, 1981–86	24.2	26.3	15.7	10.7	8.5	5.2	9.3	1.8	388
L. Pukaki, 1977, 83–88	19.3	26.6	24.0	12.1	6.8	2.8	8.2	1.6	809*

Table 11. Percentage distributions of ages of banded Canada geese recaptured at three long-term banding sites: Lake Ellesmere recaptures made 1958–90, Lake Forsyth 1969–84, Wairoa lakes 1984–92. * = years 6–8 only because recaptures ceased in 1992. Includes multi-annual recaptures of some individuals. Erroneous records from Lake Ellesmere (see text) excluded.

Banding locality and years, age at banding	Years after banding							Total
	1	2	3	4	5	6+	10+	
L. Ellesmere 1957–62, adult	33.7	19.7	15.6	11.7	7.5	12.0	1.2	7,779
L. Ellesmere 1974–79, adult	34.9	23.0	15.0	9.8	5.4	11.8	1.7	2,805
L. Forsyth 1968–75, fledgling	31.6	20.3	15.6	9.4	6.6	16.4	2.9	1,700
Wairoa 1983–87, fledgling	30.0	23.5	17.7	10.7	8.2	9.9*		1,855

Recapture records from Lake Ellesmere are bedevilled by obvious errors; 801 (12.3%) of 6,524 recaptures made of 1963–73 banded cohorts are recorded as being in years before they were actually banded. Whilst some or all may have arisen by a simple transposition of banding and recovery years, their resolution will require detailed scrutiny of field records (if they have been retained). Similar recording errors were not apparent in contemporaneous recapture records from nearby Lake Forsyth.

Only 119 goslings web-tagged in the Esk and Cox River valleys (Table 9) were recorded as being recaptured. However, these records offer no indication of any bands subsequently being applied. A perusal of 1974–79 Ellesmere banding records elicited no records of geese having been web-tagged. Perhaps many more tagged goslings were subsequently encountered alive.

Potential longevity is indicated by the small numbers of geese recovered (shot or recaptured) 10 or more years after banding (Tables 10, 11). At Lake Ellesmere, 28 of 14,235 recaptures of geese banded 1957–77 occurred 15 or more years after banding, two being after 19 years. Shot recoveries from these banded cohorts extended similarly, with 75 of 9,036 reaching 15 years and beyond, and the oldest 22 years after banding. Of 1,700 fledglings banded at Lake Forsyth 1968–75 and recaptured there or at Lake Ellesmere, only one reached 15 years of age; of 789 shot recoveries from these cohorts, 13 were 15 years or older, and two after 22 years. These longevity records all assume the bands were reported in the year of retrieval.

Reported outcomes

Recoveries, to 1968, of Canada geese banded at Lake Ellesmere 1957–67 were evaluated by Imber & Williams (1968). They focussed on comparing mortality rates of geese before and during a period of intensified hunting, which commenced in 1963. Band recoveries from hunters indicated mean annual mortality doubled between the two intervals, from 17% to 36% (their tables 5, 6). Annual mortality, estimated from recaptures of banded birds at the lake, indicated a lower initial rate (14%; their table 2); however, subsequent estimates were bedevilled by many birds not being present at the lake in time for recapture. This is the only published account interrogating Canada goose band recoveries or recapture information.

Locations at which 620 geese, banded at Lake Ellesmere, were shot 1970–79 were depicted in Williams (1981a), and White (1986) depicted assumed sub-population structure in South Island based on unpublished sightings and shot recoveries of marked birds from four Canterbury banding sites. No other maps or summaries of Canada goose dispersal away from banding or wintering sites in New Zealand have been reported.

Paradise shelduck

Background

Post-1930s forest clearances and pastoral development, especially in central and eastern North Island hill country, and the installation throughout of small stock watering ponds, promoted the increase and spread of paradise shelduck populations in North Island which, hitherto, had been small, localised and mostly on lowland river flats or coastal wetlands (McAllum 1965; Williams 1971). In southern and eastern South Island, the earlier and widespread replacement of native tussock grasses with finer pasture grasses also resulted in higher but localised paradise shelduck (and Canada goose) populations. Consequently, the bird became an increasing component of game bird annual harvests, albeit at an intensity which many small populations could not sustain. By the late 1950s the obvious declines in some shelduck populations prompted biological studies by Wildlife Branch, commenced by biologist Hamish McAllum (McAllum 1965). These focused initially in the Taihape-Hunterville region of Rangitikei district, and banding of moulting birds there, and near Gisborne, formed part of his field programme.

Shelducks were caught whilst aggregated in flocks for their annual wing moult. The initial technique, used on small farm ponds, involved stretching a heavily corked but lightly weighted 4-inch mesh net from shore towards the pond's centre and then herding the flock around the pond towards the cork line. The birds responded to the cork line by diving and, once entangled in the net, rose to the surface. The net of entangled birds was

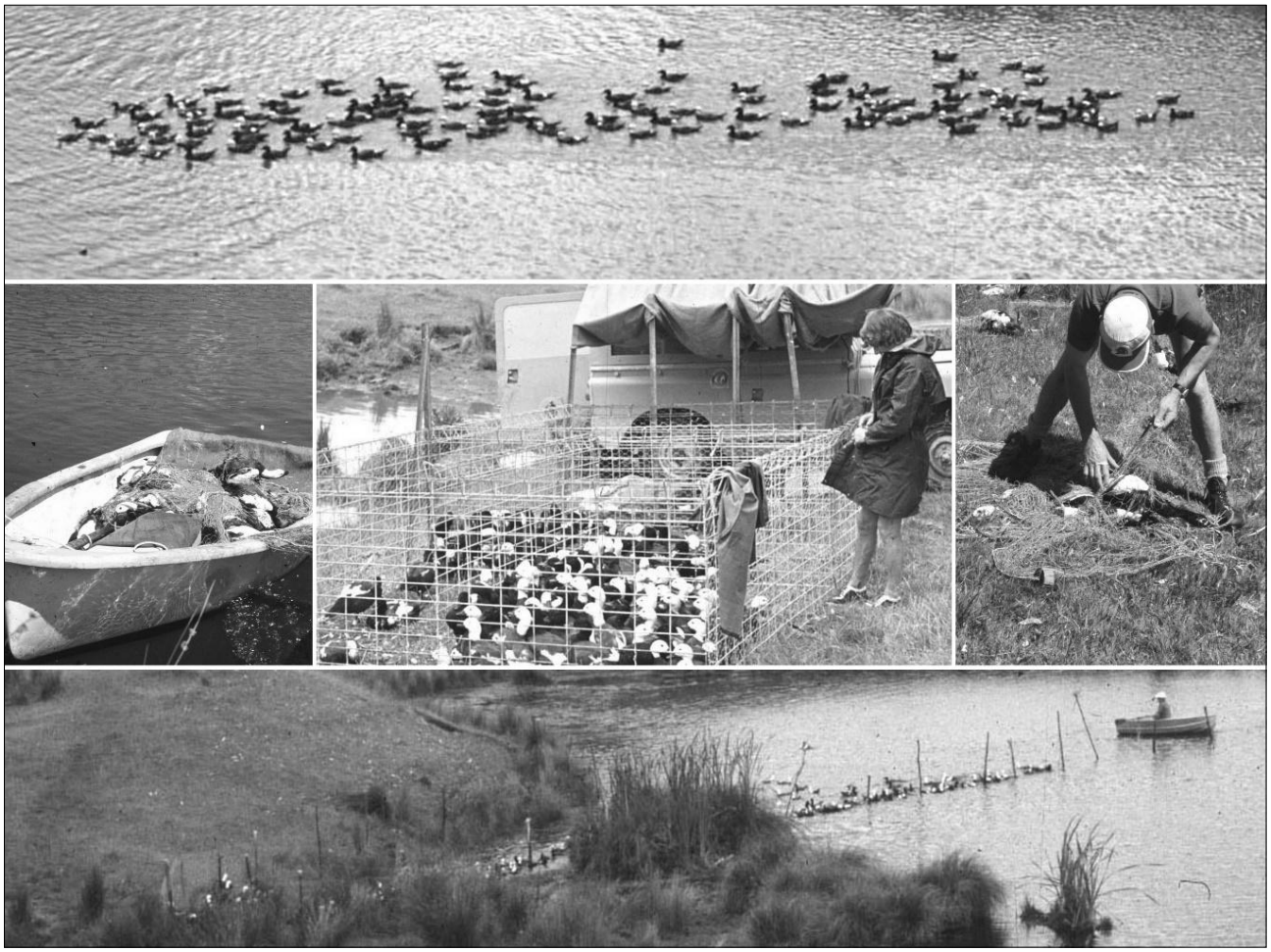


Figure 13. Centre: Stages in the capture and penning of moulting paradise shelducks using mesh nets; Lower: Manipulation of moulting shelducks towards and along a wire netting fence and into a holding pen. (Photos: M. Williams).

hauled into a boat and then laid out on the land where the birds were untangled and penned (Fig. 13). Some growing remiges would have been damaged, undoubtedly. This technique was also used to capture unfledged young on their natal ponds. On larger water bodies, a wing of wire netting was extended from holding pens constructed on the shore out into the water, the wing extending at about 60° angle to the shore. The aggregated flock was herded by boat(s) around the shoreline and towards the netting wing, along which they eventually moved towards the shore and into the pens (Fig. 13).

Banding of ducklings was usually undertaken in November–December, that of moulting birds mostly in the initial weeks of January. Moulters were mostly non-breeding birds and failed breeders, the successful breeders generally not arriving at moulting sites until late January or early February (Williams 1979c).

Scale and duration of banding

First banding of moulting shelducks occurred at Lake Repongaere, Gisborne in January 1961, and at Ruanui Station near Taihape one year later. Banding at these sites persisted for the subsequent 13 years, during which time it expanded to include other moulting sites nearby. By 1974, 4,258 moulters had been banded at Ruanui and two adjacent Taihape sites, and 7,210 at Lake Repongaere and two adjacent Gisborne sites.

Bandings at Gisborne were later extended north into East Coast to complement ecological studies conducted at Huiarua Station, Tokomaru Bay 1973–76 (Williams 1979b), and included both moulters and ducklings.

A second pulse of banding commenced in 1969 when Southland A.S., responding to a decline in their shelduck population, initiated five years of banding moulters and ducklings throughout its district, including near Te Anau, a response replicated by Wildlife Service's banding of moulters at Lake Benmore (Table 12).

The Gisborne studies identified how birds at major moulting sites could be viewed as "management units" for game bird hunting purposes, and this encouraged more widespread short-term bandings in areas where paradise shelducks were most numerous, e.g. Northland, Waikato, King Country, Taranaki, Waimarino/ Whanganui, and central Otago.

By year's end 1999, 71,404 paradise shelducks had been banded. There is considerable difficulty in trying to summarise from the Bioweb banding file because

Table 12. Locations, durations, and scale of Paradise shelduck banding 1961–1999. * = includes ducklings, see text.

Region	Principal localities	Years of banding	No. banded
Northland	Te Paki, L. Owhareiti	1976–80; 88–90	6,857*; 1,112
Waikato	L. Whangape	1983–87	2,498
King Country	Pureora/Waimiha	1978–80; 83–90	2,137; 5,548
Bay of Plenty	Omanawa/L. Rotoehu	1984–86	1,500
Hawkes Bay	L. Rotongaio	1983–86	900
Gisborne	L. Repongaere, Tiniroto	1961–76; 83–86	10,669*; 1,112
Taranaki	Opunake; Huiroa	1979–80; 87–88	420; 1,552
Waimarino	Raetihi/Ohakune	1977–81	2,475
Whanganui	various; L. Waipu	1965, 66, 69, 77; 1987–91	372; 6,554
Taihape	Ruanui,	1962–74; 82	4,258; 320
Wairarapa	L. Wairarapa	1982–83	1,582
Marlborough	Tarndale	1973–74	722
West Coast	L. Brunner, L. Haupiri	1985, 87	4,256
South Canterbury	Opuha R.	1993, 97	262
Waitaki Valley	L. Benmore; Hakataramea	1970–74; 96–98	2,316; 2,019
Otago	L. Onslow, Diamond Lake	1983–88	6,236*
Southland	Von Lake, L. Luxmore	1969–76	5,457*
various	Captive collections etc.	All years	270

moulting birds were sometimes recorded as being "1 or 1+" years of age, sometimes as "juveniles," and sometimes no age at all, while ducklings were variously recorded as "juveniles" or "pullus". Furthermore, the same banding locations are recorded with multiple names. My interpretation is that at least 48,306 moulting shelducks were banded at 121 sites in North Island and at least 18,317 at 31 sites in South Island. Banding of ducklings, a time-consuming task, was restricted to Southland (2,396) and Gisborne-East Coast districts (1,509) during 1969–76, Northland 1976–79 (69) and Otago 1984–88 (641). The regional distribution and durations of these bandings are presented in Table 12.

Table 13. Examples of recovery rates (%) of paradise shelducks banded either as ducklings or as moulters in different regions and recovered shot. * = L. Repongaere and nearby lowland sites only.

Banding region/location	Years of banding	No. banded	% recovered
Ducklings			
Gisborne-East Coast	1970–76	1,509	13.1
Otago	1983–87	641	18.9
Southland	1971–75	2,396	9.3
Moulters			
Northland	1976–80	6,788	14.5
Waikato	1983–87	2,498	17.7
Gisborne*	1961–72	5,811	32.9
Taihape	1962–74	4,258	16.5
Whanganui	1987–91	6,554	10.1
West Coast	1985–87	4,256	11.0
Waitaki Valley	1970–74	2,316	11.5
Otago	1983–88	5,591	11.2
Southland	1969–74	3,046	7.1

Recoveries

By year's end 1999, there had been 17,768 recoveries of paradise shelduck; 8,935 from having been shot, 8,702 from recaptures at banding sites, with another 131 from "other" causes.

Recoveries derived from hunting occurred at rates which differed substantially between regional populations (Table 13), presumably reflecting the scale of hunting in each, e.g. the numbers and distribution of hunters, the prevailing hunting regulations, but potentially influenced also by terrain. Hunting in dissected hill country included "pond shooting" with hunter(s) moving from pond to pond seeking pairs occupying potential breeding territories. Conversely, in lowlands and on river flats, stationary hunters attempt to decoy or intercept mobile flocks of (mostly) fledglings and yearlings. These contrasting hunting methods largely target different age classes, and will have influenced the time recovery distributions accordingly.

The time recovery distributions (Table 14) for each of three regional bandings of ducklings emphasise the vulnerability of young birds; between two-thirds to three-quarters of recoveries of ducklings were made before the birds had a chance to breed (in their second year), and this recovery excludes consideration of the unknown proportion of banded ducklings that failed to survive the period between their capture and first hunting season (a 6–7 month period). Although Southland ducklings were less intensively shot, the band recoveries indicate one-third to half of each year's survivors died in the year following.

Time recovery distributions of birds banded as moulters, mostly yearlings, also indicate a high vulnerability of pre-breeders during the subsequent hunting season when most would have still been

Table 14. Examples of time recovery distributions (the percentage of total recoveries made in years after banding) for paradise shelducks banded in different regions and recovered shot. The "0" recovery period occurs within five months of banding for "moulters" and 6-7 months for "ducklings". * = bandings 1987–91 recoveries to 1999, some cohorts not yet extinct. Recovery arrays from which these distributions were derived are provided in supplementary file "Paradise shelduck".

Banding region, age at banding	% of total recoveries in years after banding								Total
	0	1	2	3	4	5	6+	10+	
Ducklings									
Gisborne-East Coast	44.9	31.3	13.1	5.6	1.5	2.0	1.5	0	198
Otago	62.0	19.0	9.9	2.5	0.8	1.7	4.1	0.8	121
Southland	35.4	30.9	11.7	6.7	4.9	2.7	7.6	0.9	223
Moulters									
Northland	35.4	21.4	13.4	8.1	5.4	3.9	12.3	4.1	982
Gisborne:	49.2	19.1	9.7	5.3	4.9	3.9	7.9	1.3	1,087
Taihape	45.8	20.4	12.1	7.7	5.6	2.9	5.6	1.1	697
Whanganui	47.5	21.5	7.5	6.8	4.8	2.1	9.8	0.8	659*
West Coast	41.1	21.8	8.6	8.6	2.4	7.9	9.6	2.1	467
Waitaki Valley	41.0	23.3	10.5	9.8	5.6	3.0	6.8	0	266
Otago	49.4	24.5	11.4	6.4	3.1	0.6	4.5	0.6	624
Southland	41.0	19.4	13.4	7.4	3.2	4.1	11.5	4.1	217

aggregated in flocks. Northland apart, the recovery distributions for all sites show a remarkably similar proportion of banded birds were recovered within two years of banding, indicative of 41–49% and 30–40% mortality rates applying in these years. Over subsequent years, when survivors would have been established breeders, annual mortalities were mostly in the 25–30% range, albeit with some conspicuous regional differences, e.g. Northland and Southland *cf.* Taihape.

Of 7,598 shot recoveries of birds banded as moulters, 31 (0.4%) occurred 13 or more years after banding, the oldest being of a Northland bird after 20 years. Of 1,040 recoveries of birds banded as ducklings, 14 (1.3%) reached 10 years of age or older, the oldest being after 19 years.

Recaptures of previously banded birds occurred at all moulting sites where birds were banded in consecutive years. Despite these recapture records being almost as numerous as shot recoveries, data recorded in the Bioweb recovery file are generally problematic. For example, at two long-operated banding sites, recaptures are completely missing for some years in which banding occurred, and at others, recaptures are remarkably few relative to those made at other sites or in other years. The records include birds banded at one site having been recaptured at another (see below), and there are multiple recaptures of some individuals, e.g. amongst 447 recaptures at Lake Repongaere, Gisborne, of birds banded 1962–70, 89 were multiple recaptures of 43 birds; of 182 recaptures at Ruanui, Taihape, of birds banded 1963–67, 49 multiple captures were made of 20 birds; and of 74 recaptures at Lake Benmore, 1971–74 of birds banded in 1970, there were 14 multiple recoveries of seven birds. The recapture records are also compromised by few banding and recapture operations having persisted beyond five years and thus not for the likely lifetime of any banded cohort.

The oldest recaptures were of birds eight years after banding, at both Lake Repongaere and Ruanui banding sites.

Reported outcomes

Three aspects of paradise shelduck biology determined from band recoveries have been reported: survival/mortality, dispersion as revealed from locations at which birds were shot, and moulting site fidelity.

Mean annual mortality estimates of 36–40% for moulting birds banded at Taihape and Gisborne sites 1961–69 and recovered by 1970 were presented by Williams (1972). Duckworth (1986) re-analysed the same Taihape and Gisborne bandings, with recoveries extended to 1975, and Northland bandings of moulters 1976–80 with recoveries to 1985. Using the same composite dynamic methodology, he identified slightly higher annual mortality estimates from Taihape bandings (42%) compared to Gisborne (33–38%) and reported that similar mean annual mortality applied to Northland birds (41% male, 38% female).

Duckworth also applied maximum likelihood analyses (Brownie *et al.* 1978) which enabled mean annual survival (converse of mortality) estimates with associated confidence intervals to be calculated, as well as year-specific rates. These analyses highlighted extensive year-to-year variability in survival within all three populations but so wide were the associated 95% confidence intervals that the alternative possibility of a constant annual survival rate could not be rejected. His separate male and female mean

annual survival estimates for each population were: Northland (63 ± 6%, 68 ± 6%), Gisborne (61 ± 4%, 65 ± 5%), and Taihape (62 ± 7%, 64 ± 9%).

When appraising fidelity of shelducks to moulting sites, Barker *et al*. (2005a) calculated first year (after banding) survival rates of birds banded at Whanganui sites 1987–91 being 68.8% (95% CI 54.6–80.3%) in 1988 but, in 1989–91, ranging between 94.4% (CI 76.9–98.8%) and 97.4% (CI 93.8–99.0%).

Dispersal away from moulting sites was appraised from the distribution of localities at which banded birds were shot. Williams (1979c, 1981b) depicted recovery locations within a latitude-longitude grid for most of the pre-1980 banded populations, identifying greater dispersal from lowland moulting sites (medial recovery distance 41–60 km) than from those located in hill country (medial recovery distance 0–20 km). Dispersal distances for shelducks banded as ducklings in Southland and Gisborne and recovered in their first year of life indicated a similar response to landscape but with males moving more extensively than females (Williams 1979b,c). Barker (1990) reported that moulters banded at coastal Whanganui sites were more dispersive than those banded at nearby hill country sites, and that irrespective of site location, males dispersed more widely than females. Obviously, the dispersion of hunters across the landscape surrounding moulting sites will have influenced these patterns of recoveries.

Fidelity to moulting sites was appraised by Williams (1979b), Barker (1990), and Barker *et al.* (2005a). Williams' appraisal identified >90% fidelity at each of two large and isolated moulting sites and 77% at two lowland and adjacent sites in the wider Gisborne region. At a fifth site where numbers had been declining annually since banding commenced eight years prior, the return rate was 40%. Barker (1990) reported similar for Whanganui sites, with the percentage of banded shelducks recaptured at their site of initial banding varying between 39% and 97%. Birds moved among hill country moult sites, and among coastal sites, but moved little between hill country and coast. Barker *et al*. (2005a) extended this analysis to assess temporary emigration between sites and thus established an approach by which annual counts of moulting flocks could be corrected to assess regional population size.

Australasian shoveler (*Spatula rhynchotis*)

Background

This species has long been the most enigmatic of New Zealand's game birds, ranging over most of lowland New Zealand (Robertson *et al.* 2007) but

Figure 14. Significant contributors to the banding of shoveler: Upper – John Cheyne, architect of the pioneering captures at Lake Whangape, Waikato, and part of the 1981 catch; Lower, Left to Right - Murray Neilson and Roger Sutton, and his dog, Meg, were responsible for the extensive banding of ducklings in Otago and Southland respectively.

everywhere in low numbers and of infrequent occurrence. By not being attracted by grain or seed baits, shoveler never featured amongst ducks trapped at any historic duck banding site. It was the retrieval, by Roger Sutton's dog Meg (Fig. 14), of a small number of moulting shovelers from the margins of Waituna Lagoon in 1971 (Sutton 2002) that first identified shoveler moulted communally. The following year, Sutton returned to Waituna Lagoon to commence the first determined banding of shoveler in New Zealand, while John Cheyne did likewise at Ram Island Lagoon, part of the Lake Waihola-Waipori wetland complex in Otago's Taieri River basin. Sutton had, a month prior, caught and banded his first broods of shoveler ducklings in drains alongside Invercargill airport (Sutton *et al*. 2002).

Three capture techniques were eventually perfected: fyke nets when catching ducklings and attendant females in drains; a retrieving dog when extracting moulting birds or ducklings from occluded wetland margins; and at Lake Whangape, driving birds through willows on the lake's margin and into pre-constructed pens. The first two are illustrated in Sutton *et al.* (2002), the latter in Caithness *et al.* (2002), and all three in Barker & Williams (2003).

Scale and duration of banding

During 1971–85, 3,535 moulting adults and 953 ducklings were banded (Table 15). The banding of moulting adults was initially confined to Waituna and Ram Island Lagoons. Shoveler moulting sites elsewhere remained unknown until John Cheyne found shoveler moulting in the Awaroa arm of Lake Whangape in 1978. They proved difficult to herd towards pre-constructed pens and, in his first two years, Cheyne captured 112 and 180 moulters. In 1981 he managed to herd a very large flock into pens beneath flooded willows where he and his team banded 666 birds before the supply of bands was exhausted (Fig. 14). The following year 1,399 moulters were herded, a capture that then, and probably remains, the largest single capture of any shoveler species anywhere. Moulters were subsequently found by Hans Rook at two small irrigation dams, Lindsay lakes, in Hawkes Bay's Esk River valley.

The laborious capture of ducklings, brood by brood, was attempted mostly in drainage waterways on the Southland plains by Southland A.S. staff, Taieri river basin in Otago by Murray Neilson and his Wildlife Service colleagues, and Piako wetlands in eastern Waikato by Murray Crombie.

During 1971–74, 292 adults and 141 ducklings captured in Southland, Otago and Waikato, were fitted with nasal saddles (Sugden & Poston 1968; Caithness 1975) to aid field recognition of cohorts or individuals. On some birds the narrow nasal bridge of the bill became damaged when the saddle caught in vegetation and after three years of use the technique was abandoned.

Recoveries

By year's end 1999, 1,037 recoveries had been reported, 87% from hunting and 8.8% as live recaptures. Of shoveler banded as moulting adults, significantly fewer females (15.4%) were recovered from hunting than were males (22.3%; $\chi^2 = 17.4$, $p < 0.001$) and this applied also to those banded as ducklings (females 14.5%, males 20.2%; $\chi^2 = 5.3$, $p = 0.02$).

Despite their lower overall recovery rate, the proportion of total female recoveries made in the year of banding was 1.3–1.5 times that of males, and the durations over which recoveries were made more truncated (Table 16). The contrasting recovery distributions of adults banded in Southland/Otago and Waikato were not derived contemporaneously and undoubtedly reflect the climatic influences of contrasting phases of the El Nino-Southern Oscillation prevailing in the 1970s and 1980s (see Barker *et al.* 2005b; Table 17).

Of the 178 shot recoveries of Southland/Otago ducklings, 12 (6.9%) were of birds six or more years old, the oldest being 10 years; no females

Table 15. Locations and durations of Australasian shoveler banding 1971–1986, and numbers and sexes of moulting adults (Ad.) and ducklings (Juv.) banded; * = no banding in 1977, 80, 83.

Region	Principal localities	Years of banding	Age	No. banded	
				Male	Female
Waikato	L. Whangape	1974–85*	Ad.	1,963	701
	Piako R. wetlands	1974–76	Juv.	31	18
Hawkes Bay	Esk valley	1984–86	Ad.	117	40
Manawatu	Pukepuke Lagoon	1971, 77, 78	Ad.	11	5
			Juv.	9	9
Otago	Taieri R. wetlands	1972–79	Ad.	165	232
	various		Juv.	253	241
Southland	Waituna Lagoon	1972–79	Ad.	168	120
	various		Juv.	188	204
Others	Omarama	1972, 74	Ad.	11	2

Table 16. Time recovery distributions (the percentage of total recoveries made in years after banding) for Australasian shoveler banded as ducklings or as moulting adults (≥1 year old) and shot by hunters. Recovery arrays from which these distributions were derived are provided in supplementary file "Australasian shoveler".

Region/Sex	Years after banding								Total
	0	1	2	3	4	5	6+	10+	
Adults									
Waikato: males	28.9	27.1	15.1	10.1	6.1	4.6	8.1	1.5	457
Waikato: females	41.9	24.8	8.5	12.8	5.1	1.7	5.1	0.8	117
Southland/Otago males	46.3	19.5	12.2	9.8	1.2	6.1	4.9	0	82
Southland/Otago females	63.8	15.5	10.3	1.7	0	3.4	5.1	0	58
Ducklings									
Southland/Otago males	44.9	22.4	7.1	7.1	6.1	4.1	8.2	1.0	98
Southland/Otago females	60.0	11.3	11.3	7.5	5.0	2.5	2.5	0	80

were recovered beyond the sixth year. Of 807 shot recoveries of adults banded nationwide, 52 (6.4%) were from six or more years after banding, nine being after 10 or 11 years, and one after 16 years; no female was recovered beyond the ninth year.

Reported outcomes

Progress reports describing shoveler banding were presented by Cheyne (1973), Caithness (1975), and Neilson (1976), with both Cheyne and Neilson highlighting the determined catching of ducklings, brood by brood.

Three publications reported more fulsome outcomes from the 1971–1986 bandings.

Caithness *et al.* (2002) highlighted the post-moult dispersal of banded shoveler from all four main capture sites by reporting where they were shot in their year-of-banding and in later years. Nation-wide movements were described, including of birds caught when moulting or breeding in Southland later being recaptured moulting in central Waikato or shot in Northland.

Sutton *et al.* (2002) applied a similar analysis to shoveler banded as ducklings, noting that movements in the first year of life were localised before more extensive movements occurred in the second and later years. Locations of recovery for birds in their later years were distributed similarly to those of moulting adults.

Barker *et al.* (2005b) calculated survival rates for each banded population and demonstrated contrasting effects of the El Nino-Southern Oscillation weather system, not just on survival but dispersal also. El Nino conditions (predominantly SW winds, southern rains, cool temperatures) induced higher survival and decreased movements of southern-banded shoveler but decreased survival and increased movements of northern moulting birds, and the converse applied during La Nina conditions (predominantly NW winds, northern rains, warm temperatures) (Table 17).

A personal account of shoveler banding and related activity is provided by Sutton (2002).

Grey ducks, mallards, and their hybrids

Background

Following European settlement, grey ducks underpinned the establishment of New Zealand's duck hunting tradition (McDowall 1994). The mallard was an early, albeit limited, acclimatisation attempt (Thomson 1922), but the obvious reduction in grey duck numbers by the early 1900s encouraged several more determined introductions (Dyer & Williams 2010). When the Wildlife Branch was established in 1946, acclimatisation societies were responding to the concerted advocacy of Auckland's Cecil Whitney for widespread propagation of mallards at their game farms and by landholders willing to set duck eggs under bantams and release those hatched when capable of flight. The decline in native and imported game species, one of the Wildlife Branch's operational mandates to address, was focussed, initially, on grey ducks and mallards.

Table 17. Survival probabilities for Australasian shoveler in New Zealand in relation to El Nino Southern Oscillation (El Nino, SOI index = -10; La Nina, SOI index = 8). From Barker *et al.* (2005b).

Age/sex at banding	Region	El Nino years	La Nina years
Adult male	Southland, Otago, Waikato	0.81, 0.73, 0.57	0.61, 0.50, 0.82
Adult female	Southland, Otago, Waikato	0.73, 0.63, 0.49	0.49, 0.39, 0.76
Juvenile male	Southland, Otago	0.72, 0.62	0.48, 0.38
Juvenile female	Southland, Otago	0.62, 0.51	0.37, 0.28

The first banding of wild ducks, in Manawatu 1947, arose from the appointment to the Wildlife Branch of R.W. Balham as biologist and who arrived with a study brief pre-prepared by R.A. Falla (nd). This was for a broad ecological study of ducks in the Manawatu region, focussed on Lake Kaikokopu (Hunia) near Himatangi, then owned by avid hunter and ornithologist R.A. Wilson (Dawber & Haylock 2010). The study design was predicated on it being suitable as the research component of a MSc degree and which, later, Balham submitted (Balham 1950). Soon thereafter, acclimatisation societies breeding and releasing mallards at their game farms commenced banding their ducks prior to release.

Wild grey ducks and mallards were caught using grain-baited funnel traps. Erected in shallow water, or on the water's edge, the traps were constructed of wire netting supported by short poles. After about 1957, traps comprised modular wire-netting frames, a design then widely used in Australia (Fig. 15). Birds entered the traps via low funnels around and behind which the grain bait was scattered.

Sex and age (juvenile or adult) of all banded birds was assessed by cloacal inspection (Hochbaum 1942). Whilst the distinction between juvenile and adult males, based on penis size, is obvious to a trained bander, it is less so for females where discerning and probing the opening of the bursa of Fabricius is required. Banded samples with a high (>40%) proportion of adults, especially of females, may indicate inaccurate age discrimination.

Note on banding and recovery records for 1947–66

Banding records for 1947–66 were not transcribed from original Wildlife Branch banding card schedules to the paper schedules used post-1967. Banding totals and banding site details for this early period were compiled directly from the original card schedules and compared with details on archived files containing original banding field reports (e.g. IAD 46/5/32, R14985963) to ascertain their completeness.

For recoveries, a similar process was necessary. On pre-1967 banding card schedules, recoveries were denoted by a red pencil mark alongside the band number (see Fig. 2) and although these could be summed to provide totals, the year of recovery was not indicated. Those details were originally recorded separately, later transcribed onto machine punch cards, and thence recorded to magnetic tape; the original recovery records were not retained. Only a few of these recovery records are included in the Bioweb recovery file: there are 232 recoveries for grey ducks and 447 for mallards from the 1956–66 period included, whereas card markings indicate 5,295 grey duck and 3,100 mallard recoveries were received. Furthermore, all recoveries which pre-date 1956 are entirely missing from the Bioweb recovery file; some for wild grey ducks and mallards are provided in Balham & Miers (1959), and those for Southland captive-bred mallards are recorded in Reid (1966).

Recovery totals given below for the pre-1967 period were derived by counting the markings on the banding card schedules, and the Bioweb recovery file checked for recoveries not found on those schedules — none was identified. Even so, these totals should be viewed as "order of magnitude" only.

Scale and duration of banding

To partition the uncertainties of the 1947–66 period from later years, banding activity is reported and evaluated within three time-intervals, which also reflect three differing scales of banding endeavour.

1947–1966

The first bandings were of ducks captured at Hamilton's Bend (Karere Lagoon), an oxbow of the Manawatu River near Longburn; 22 grey ducks and 20 mallards were caught and banded (but neither sexed nor aged) in early 1947, and after two hunting seasons, 10 and eight respectively of these ducks had been reported shot (Balham 1950). More successful banding occurred there in the following two years

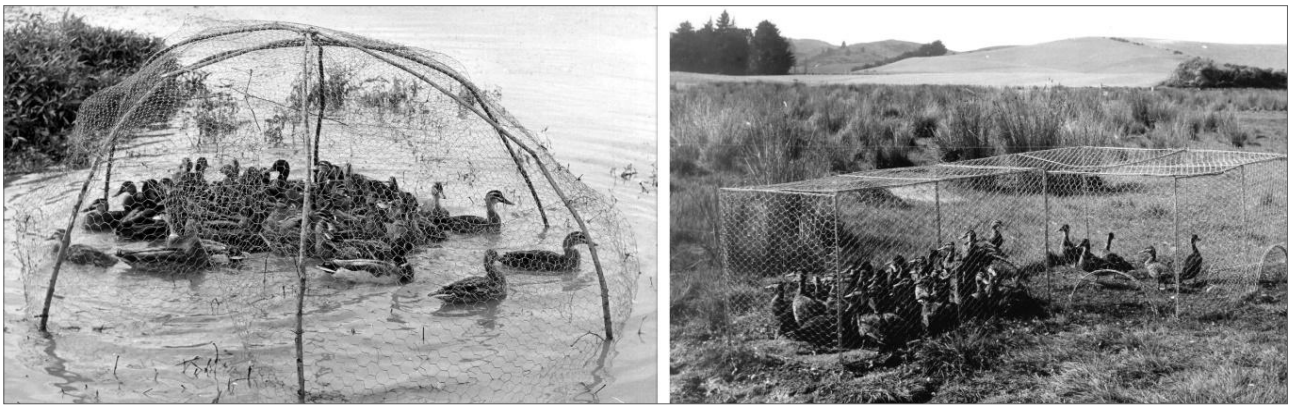


Figure 15. Grain-baited traps used to catch grey ducks and mallards 1947–56 (left) and post-1957 (right). The post-1957 trap, of Australian design, featured separate catching and holding pens and multiple funnel entrances (Photos: Wildlife Service, Archives New Zealand).

Table 18. Locations, durations, and scale of grey duck and mallard banding 1948–66.

Region	Principal locations	Years of banding	No. banded		
			Mallard	Hybrid	Grey
North Island					
Manawatu	Hamilton's Bend	1948–56	3,323	254	1,568
	Palmerston North	1963	770	0	0
Waikato	L. Waikare	1950, 51	5	5	2,074
	L. Whangape	1957–64	662	90	7,400
	L. Wāhi	1958, 59, 62–66	2,928	207	5224
	L. Karapiro	1959–61	60	14	1,838
	others (5)	1958–62	18	5	704
Northland	L. Rototuna	1951	0	0	375
Hawkes Bay	Whakaki Lagoon	1953, 54	153	8	387
Wairarapa	L. Wairarapa	1963	142	0	0
Other		1955	0	0	17
South Island					
Marlborough	Wairau Lagoon	1952	360	49	277
N. Canterbury	Woodend Lagoon	1951	52	21	60
	L. Victoria	1952	2	0	65
	Belfast	1952, 53	374	12	250
	L. Ellesmere	1964–66	1,189	2	169
S. Canterbury	Waitaki R.	1958	0	0	25
	Omarama	1965	20	0	0
Otago	Lauder	1950	52	3	23
	L. Waihola	1950, 51	771	44	659
	L. Tuakitoto	1959–65	7,147	89	2,058
West Coast	L. Ryan	1953	1	0	141

Table 19. Numbers of captive-reared mallards banded and released by various agencies/individuals 1948–1966, and percentage recovered shot.

Acclimatisation Society	Years of banding	No. banded	% recovered
Auckland	1955, 56, 58, 61	85	4.7
East Coast	1953	22	0
Hawkes Bay	1955, 56, 57, 61, 65	400	10.0
Nelson	1953–63	1,954	2.5
Southland *	1955–63	8,135	11.2
Stratford /Taranaki	1949, 1951–57	886	5.4
Tauranga	1950–56	2,107	8.6
West Coast	1954–66	984	8.8
Wellington	1951–56	1,048	14.1
Whangarei	1954	11	0
Wildlife Branch**	1949, 53, 54, 56, 57, 64–66	413	9.7
Individuals***	1950, 52, 55, 56, 61	214	9.3

* Reid (1966) listed recovery rate as 13.8%, having excluded from consideration 2,086 birds released at sites over which hunting was not immediately permitted; ** released 206 hybrids (20.9% recovered) and 44 grey ducks (20.5% recovered); *** released 24 hybrids (16% recovered).

before banding was extended to South Island (Lake Waihola, Otago 1950, Lauder, Otago 1950, Woodend Lagoon near Kaiapoi 1951, Wairau Lagoon, Marlborough 1952) and to elsewhere in North Island (Lake Waikare, Waikato 1950, Lake Rototuna near Dargaville 1951, Whakaki Lagoon, Wairoa 1953). By 1966, 41,915 wild ducks (18,029 mallards, 23,314 grey ducks, 572 apparent hybrids) had been banded at 27 locations nationwide (Table 18).

During this same period, captive-reared mallards were being released, 16,259 of which were reported as having been banded (Table 19). Six acclimatisation societies (Nelson, Southland, Stratford, Tauranga, West Coast, Wellington) undertook this task with greater determination than others and ensured their game farms or associated landowners provided a continual supply of young birds for release.

1967–1983

There was a reinvigoration of banding in the Manawatu district, motivated by the Wildlife Service's establishment of a field station at Pukepuke Lagoon near Himatangi. The initial banding site at Hamilton's Bend/Karere Lagoon was reused. Lake Wairarapa became a focus of long-term banding interest while bandings at Waikato lakes were extended, and five-year banding programmes established elsewhere in upper North Island. In South Island, banding commenced again at Lake Tuakitoto, Otago, and Southland A.S. followed its earlier mallard breeding and release programme with protracted banding of wild mallards.

Table 20. Locations, durations, and scale of grey duck and mallard banding 1967–83.

Region	Principal locations	Years of banding	No. banded		
			Mallard	Hybrid	Grey
North Island					
Manawatu	Pukepuke /Omanuka	1970–78	3,493	24	284
	Karere/Edwards	1979–83	5,035	7	50
Wairarapa	L. Wairarapa	1974–81	4,577	33	779
Waikato	L. Whangape	1967–68, 71–74, 79–83	6,421	391	3,078
	L. Wāhi /Kimihia	1967–71,74	4,744	407	1,903
	others (4)	1967, 68, 72	941	86	523
Hawkes Bay	Whakaki/Ngamotu	1969–71	827	21	279
	Horseshoe Lagoon	1972	316	9	5
Bay of Plenty	Matata	1968–71	867	17	1,115
Taupo	L. Taupo	1968–71	476	54	1,470
others (3)		1969–72, 82	89	51	152
South Island					
N. Canterbury	L. Ellesmere	1967–69	1,321	42	119
	Avon River	1977–81	124	124	43
S. Canterbury	Wainono Lagoon	1968,69, 73	1,009	15	7
	various	1968–72	1,001	10	76
Otago	L. Tuakitoto	1967–71	6,089	113	243
Southland	Te Anau	1971–73	1,136	31	333
	Waituna Lagoon/ Thompson's crossing	1968–75	7,566	36	390
Others (2)	Murchison	1968–70	171	11	65

During this 17-year interval 46,937 wild mallards, 10,961 grey ducks and 1,485 hybrids were banded nationally, with multi-year banding occurring at 17 sites. (Table 20). Mallard captures comprised 50.4% males amongst which 48.7% were adults, and amongst females 48.0% were adults. Grey duck captures comprised 53.5% males of which 23.2% were adults, and amongst females, 20.8% were adults. The differing age ratios reported for the two species is surely cause for thought. Hybrid captures were recorded as 40.1% male within which 26.5% were adults, and amongst females, 28.2% as adults; the recorded sex ratio clearly indicates uncertainty surrounding the 'hybrid' designation, further emphasised by some obvious bander-specific variances in the records.

In this era, 747 captive-reared mallards were banded and released by three acclimatisation societies (17 by Marlborough 1975; 348 by West Coast 1967–69; 74 by Southland 1967– 69) and private breeders released another 308 between 1972–82.

1984–1999

It was during these 16 years that the Wildlife Service ceased all game bird banding, and only limited bandings were undertaken by Wellington A.S. in Manawatu and Wairarapa, by Southland A.S. throughout its region, and Eastern Fish and Game Council in its Bay of Plenty and Gisborne districts. Overall, 17,564 mallards, 606 grey ducks, and 4 hybrids were banded (Table 21) at 10 multi-year sites. Mallards comprised 50.6% males of which 52.3% were adults and of females 56.6% were adults; grey ducks comprised 53.6% males of which 40.5% were adults and of females, 42.6% were adults.

Recoveries

Recoveries of banded ducks by hunters, 28,901 in total, can provide a rich source for evaluation of species, regional, and time interval analyses, and of changing patterns of dispersal. For example: a significantly higher proportion of banded grey ducks than mallards were recovered by hunters (Table 22; 1948–66, $\chi^2 = 476.5$, $p < 0.0001$; 1967–83, $\chi^2 = 83.5$, $p < 0.0001$); species band recovery rates differed significantly between regions, e.g. between Otago, Waikato, and Manawatu-banded mallards in 1948–66 (Table 22: $\chi^2 = 42.5$, $df = 2$, $p < 0.0001$), and 1967–83 ($\chi^2 = 80.0$, $df = 2$, $p < 0.0001$), undoubtedly a consequence of substantial regional differences in hunting regulations.

Banded captive-reared mallards released during 1948–66, 16,259 in total, had an overall recovery rate of 9.4% but there were considerable regional variations (see Table 19), some of which may have arisen from poor initial recordings of numbers banded, and precisely when (see Balham & Miers 1959: 36).

Balham & Miers (1959) constructed time recovery distributions (which they referred to as a "mortality series") for 2,161 grey duck and 916 mallards banded

Table 21. Locations, durations, and scale of grey duck and mallard banding 1984–99.

Region	Principal locations	Years of banding	No. banded		
			Mallard	Hybrid	Grey
North Island					
Central N. I.	Reporoa	1997–99	386		90
Bay of Plenty	Kaituna	1997–99	1,442		167
Gisborne	various	1998–99	692		73
Manawatu	Karere/Edwards Lagoons	1986–90	3,898	2	8
	Lake Alice	1986–90, 95	3,154	1	23
	Omanuka Lagoon	1986–88, 90	1,199	1	9
Wairarapa	L. Wairarapa	1988	1,144		18
	various	1994, 95	241		14
Hawkes Bay	Ohuia Lagoon	1998, 99	388		37
	other	1997	50		0
South Island					
N. Canterbury	L. Ellesmere	1985	187		5
Southland	New River	1987–91	1,422		0
	Thornbury	1987–91	1,347		0
	Roslyn Bush	1989–91	1,087		0
	others	1987–89	885		3
Various		1985, 86, 87, 91	42		33
Captive			0		126

1948–55 and recovered by 1955 (Table 23). In their analysis, possibly only the 1948–50 banded cohorts were extinct by 1955. Later recoveries from these bandings are not recorded in the Bioweb recovery file, and because most cohorts were extant, their figures are not directly comparable with data presented below from other eras.

As referred to earlier, almost all the subsequent (1956–66) recoveries are missing from the Bioweb recovery file. Recovery arrays were prepared historically, and they formed the bases for three belated survival studies (Nichols *et al.* 1990; Caithness *et al.* 1991; Barker *et al.* 1991). None of these studies published the recovery arrays; however, those used by Caithness *et al.* (1991) and Barker *et al.* (1991), of grey ducks recovered from 1957–74 bandings in Waikato, have been retrieved and these data included in summaries below (see also supplementary file for grey ducks).

Time recovery distributions for age and sex categories of grey ducks and mallards banded throughout New Zealand, and recovered by 1999, are summarised in Table 24. For this summation, regional and banding site variability were set aside, and all data combined. By so doing, the utility of band recoveries for assessing short and long-term effects of hunting on population dynamics, unfortunately, is minimised, and so scrutiny of detail in the relevant supplementary files and the application of contemporary band recovery analyses is encouraged. However, the scale of annual mortality applying in each era is starkly apparent. Irrespective of species, sex or age, between half to two-thirds of all banded ducks reported shot were retrieved within six months of banding, and of those surviving, at least half were shot the following year. These signify remarkably high mortality, and it is hard not to conclude that a substantial, even excessive, hunting impact occurred, especially on grey ducks (all age/sex categories) and on juvenile mallards. A characteristic of the 1955–66 era was of mallards rapidly gaining numerical and distributional

Table 22. Numbers of banded mallards and grey ducks recovered shot, and the percentage of those banded they comprised, 1948–99, regionally and nationally.

Era	Region	Mallard		Grey	
		No.	%	No.	%
1948–66[1]	Waikato	860	23.4	5,575	32.3
	Manawatu	807	19.2	572	36.5
	Otago	1,933	24.3	759	27.7
	NZ-wide[2]	4,016	22.3	7,456	32.0
1967–83	Waikato	2,513	20.7	1,329	24.1
	Manawatu	2,202	28.7	132	42.3
	Otago	1,302	21.4	68	28.0
	Southland	1,969	22.6	172	23.8
	NZ-wide[3]	10,556	22.1	2,911	26.6
1984–99[4]	Manawatu	2,055	24.9		
	Southland	1,039	21.9		
	NZ-wide	3,477	19.8	17	2.8

[1] Figures determined from original banding schedule cards (see text), other eras from Bioweb recovery file; [2] Plus 109 (19.1%) hybrids; [3] Plus 359 (24.2%) hybrids; [4] Recoveries to 1999 of ducks banded 1984–95 only, with some of the later cohorts possibly extant.

Table 23. Time recovery distributions (the percentage of total recoveries made in years after banding) for grey ducks and mallards banded 1948–55 and recovered shot by 1955 (From Balham & Miers 1959: tables 3, 4, 9, 10).

Category	Years after banding							Total
	0	1	2	3	4	5	6	
All grey males	72.8	15.6	6.7	3.1	0.7	0.3	0.7	1,228
All grey females	73.2	15.9	6.6	2.4	1.2	0.8		933
All mallard males	60.2	19.9	7.7	6.7	1.4	2.4	1.8	555
All mallard females	59.9	21.4	10.1	5.3	1.5	1.7		361

ascendency over grey ducks (Williams 2017) and excessive hunting clearly contributed to this (Caithness *et al*. 1991; Barker 1991).

The time recovery distributions (Tables 23, 24) provide indications of longevity, identifying small numbers of recoveries of both species made six years or longer after banding. The Bioweb recovery file for the 1967–83 era contains band recoveries of 12 grey ducks (0.4% of total recoveries) 11 or more years after banding, the oldest being 16 years. For mallards, 26 (0.2% of total recoveries) bands were returned from birds 11 or more years after banding; three from 15 years and single returns after 16, 19 and 21 years, allegedly. From the 1983–99 era, only one mallard was reported 11 years or more after banding.

Reported outcomes

Balham's (1950, 1952) reporting of results from banding of grey ducks and mallards at Hamilton's Bend, Manawatu was based on recoveries of 253 of 768 banded grey ducks and 125 of 886 banded mallards over years 1947–49. No banded cohort was considered extinct, and so he reported mean recovery rates of 30.3% for grey ducks and 11.8% for mallards in their year-of banding only.

Balham & Miers (1959), analysing recoveries of grey ducks and mallards banded at multiple sites during 1948–55, provided the first estimates of annual mortality, including of the sexes separately, and compared recovery rates and dispersal patterns of the two species. Uncertainty about accuracy of age classification of females led them to amalgamate all female recoveries. Their significant findings were: weighted mean annual mortality rate (across all age and sex classes and years) was an astonishing 70.3% for grey ducks and 55.8% for mallards; mean year-of-banding recovery rate (across all ages and sexes and years) was 25.2% for grey ducks and 12.7% for mallards; and contrasting post-banding dispersal with 48% of grey ducks but 80% of mallards recovered in their year-of-banding within 25 miles (40 km) of the banding site. Highlighted were three recoveries of grey ducks banded at Lake Waikare, Waikato, two within four months of banding from Southland

Table 24. Time recovery distributions (the percentage of total recoveries made in years after banding) for grey ducks and mallards banded throughout New Zealand 1957–66 (grey duck, Waikato only), 1967–83, and 1984–94, and recovered shot by 1999. The "0" year is the hunting season within 3–5 months of banding. Recovery arrays from which these distributions were derived are provided in supplementary files for "grey duck" and "mallard".

Era	Species	Age and sex	Years after banding							Total
			0	1	2	3	4	5	6+	
1957–66	Grey	Adult male	59.4	18.3	8.0	5.1	2.7	2.4	3.8	663
		Juvenile male	66.0	17.8	6.7	3.9	2.4	1.1	2.1	2,181
		Adult female	62.1	16.0	10.4	4.7	1.9	2.1	2.8	425
		Juvenile female	68.0	15.6	6.4	4.5	2.2	1.3	2.0	1,660
1967–83	Grey	Adult male	50.4	21.8	9.6	9.6	2.8	2.0	3.4	353
		Juvenile male	69.6	15.5	6.9	3.4	1.7	1.2	1.7	1,317
		Adult female	54.7	22.4	9.4	6.3	2.7	0.1	3.6	223
		Juvenile female	69.5	17.2	6.2	3.2	2.2	0.6	1.0	1,004
1976–83	Mallard	Adult male	48.1	20.9	12.8	7.3	4.7	2.7	3.5	2,824
		Juvenile male	57.1	21.5	8.8	5.3	2.5	1.6	3.0	3,198
		Adult female	55.4	20.7	10.7	5.7	2.8	1.9	2.8	2,019
		Juvenile female	63.7	19.2	8.4	3.9	2.0	1.2	1.7	2,489
1984–94	Mallard	Adult male	54.5	23.9	10.1	5.9	2.6	1.0	2.2	1,788
		Juvenile male	56.8	26.9	7.9	5.0	1.7	0.9	0.8	1,689
		Adult female	51.2	30.9	8.8	4.8	2.1	1.2	0.9	894
		Juvenile female	63.0	22.5	6.8	5.3	1.1	0.6	0.1	795

and Chatham Island, and another, two years after banding, also from Chatham Island. A trans-Tasman movement from Marlborough to inland New South Wales, Australia, was also reported.

Two other publications, using the analytical method of Brownie *et al.* (1985), have appraised survival rates (the converse of mortality) and band recovery rates for some post-1960 band recoveries. Caithness *et al.* (1991) appraised grey ducks and mallards banded in Waikato 1957–74 and recovered by 1980, and reported mean annual recovery rates indicating grey ducks were 1.3–1.5 times more likely to be shot than mallards. No statistically significant differences between mean annual survival rates of the two species in any sex/age class were found (adults 50–60%, juveniles 40–50%). The authors noted, however, that banded sample sizes limited the statistical power of their tests.

Nichols *et al*. (1990) evaluated mallards banded at four localities (Waikato, Manawatu, L. Wairarapa, Southland) between 1962–83 and recovered by 1988. Their Table 5 highlighted contrasting age- and sex-specific recovery and survival rates across all four localities, with Manawatu mallards returning the highest recovery rates (13–19%) and lowest annual survival rates (39–49%) while Southland mallards, despite experiencing high recovery rates of juveniles (11–16%), recorded the highest survival rates (59–76%), especially for females.

Barker *et al.* (1991) evaluated recoveries of grey ducks banded in Waikato 1957–74 to determine whether hunting mortality was entirely additive to all other forms of mortality or was compensated by changes in natural mortality. They rejected the compensatory hypothesis but not the additive hypothesis, thus implying that changes in annual hunting regulations had indeed impacted grey duck survival rates.

Recoveries from captive-reared and released mallards were also appraised. Balham & Miers (1959) reported year-of-banding recovery rates for those released by Tauranga A.S. and Wellington A.S. 1950–55 as 5.2% and 6.1% respectively. They highlighted that these recovery rates were low compared with those for newly banded wild mallards (12.7%), indicating poor immediate post-release survival of released birds. Reid (1966), in his more fulsome evaluation of Southland A.S.'s releases 1955–63, calculated that 8–10% of mallards released were recovered in the year of banding and that these represented approximately 60% of the total numbers of banded birds recovered over time, i.e. overall, 16% of released birds were reported shot. He estimated a weighted mean annual survival rate across all years and for both sexes combined of 48.3%, 10–15% lower than Nichols *et al.* (1990) found for wild Southland mallards banded 10–15 years later, and 8–10% lower than for wild Manawatu mallards appraised by Balham & Miers (1959).

Dispersal of ducks away from their banding sites, as revealed by the locations at which they were shot, was initially evaluated and illustrated by Balham & Miers (1959). Williams (1981a) compared small samples of grey ducks banded in Waikato in the 1950s and 1970s to imply more limited dispersal by 1970s birds. Conversely, a comparison of recoveries of 350 Manawatu-banded mallard from each era indicated more extensive dispersal of 1970s ducks. No subsequent evaluations of post-banding dispersal have been reported.

BANDING OVERVIEW

Of upland game birds

Approximately 150,000 upland game birds were banded prior to year 2000 to support the management of these species and the recreational hunting they provided; 7,267 (≈ 5%) bands were retrieved by hunters and reported to the Banding Office (Table 25). The primary purposes for the bandings, where stated, were to determine the numbers of released birds shot annually, and the dispersal of birds from their banding or release locations, neither objective requiring other than simple quantification or tabulation of band returns.

The legal requirement for all captive-bred birds to be banded prior to release (Wildlife Regulations 1955, Part VIII, section 39) was a driving force behind the scale and duration of most bandings.

Only for California quail was banding a field research tool; however, banding outcomes contributed little to interpreting population dynamics and the impacts of hunting; age ratios reported in hunting diaries mostly contributed that. For the attempts to acclimatise two species of partridges, compulsory banding provided a means of discriminating any field-reared individuals from those captive-reared, something for which colour bands rather than numbered metal bands may have proved equally, or more, helpful, as Otago A.S. chukar releases demonstrated (Wright 1985).

For pheasant, the most numerous of the upland game birds banded, the priority information needed to appraise the efficacy of the "put-and-take" method of

Table 25. Number of upland game birds banded and recovered shot 1947–99 as recorded on Wildlife Branch banding schedule cards (1948–66) and thereafter in Bioweb banding and recovery files.

Species	No. banded	No. recovered
California quail	13,006	1,070[1]
Grey partridge	34,285	1,168
Red-legged partridge	24,294	195
Pheasant	65,675[2]	4,824
Chukar	2,115[3]	10
Total	**139,375**	**7,267**

[1] = there were an additional 3,769 live recaptures; [2] = minimum (see pheasant text); [3] = possibly 2,897 (see chukar text).

providing sport for licensed hunters was established by 1952, after just four years of banding (Westerskov 1953). The further bandings during the 1950s simply confirmed those earlier findings, the single advance being the demonstration that pheasants released after a period of semi-wild freedom (referred to as "hardening") had conspicuously higher post-release survival (Westerskov 1956, 1963). However, new knowledge and bloody-minded intent clearly didn't meld; banding and releases persisted, the banding no longer contributing information other than to make clear that the costs to acclimatisation societies of each released bird shot by a hunter kept climbing (e.g. Cheyne 1978). The cost of administering and curating banding and recovery information, now surplus to need, was, for acclimatisation societies, a simple externality born by the administrators of the Wildlife Regulation.

The troublesome period when pheasant banding records from several acclimatisation societies were either erroneous or not forthcoming also influenced administrative procedures. A more assiduous recording of what bands were supplied to which bander, and when, was introduced and additional bands were not issued until schedules for previous bandings were returned, or short series of unused bands returned. Nevertheless, the records for 1947–66 bandings contain conspicuous gaps in sequential band numbers, as apparently do records for chukar. It is also apparent, from figures provided in some acclimatisation society annual reports, that pheasant and chukar were being released unbanded.

Of wetland game birds

Approximately 370,000 wetland game birds were banded prior to year 2000; of the 115,441 recoveries accumulated (Table 26), hunters reported 66,029 (57.2%) of these. Although the primary purposes for the bandings were rarely recorded, the default interest of how long the birds lived for, and where did they disperse to, can be viewed as a universal *raison d'être.*

Table 26. Number of wetland game birds banded and recovered (shot, recaptured, or "other") 1948–99, as recorded on Wildlife Branch banding schedule cards (1948–66) and thereafter in Bioweb banding and recovery files.

Species	No. banded	No. recovered
Black swan	61,621[1]	13,515
Canada goose	56,915[2]	46,942[3]
Paradise shelduck	71,238	17,768
Australasian shoveler	4,493	1,035
Grey duck	36,942[4]	11,076
Mallard	99,536[5]	25,105
Total	**370,745**	**115,441**

[1] = includes 5,511 web-tagged; [2] = includes 3,622 web-tagged; [3] = includes 119 web-tagged; [4] = includes 2,062 grey duck x mallard hybrids; [5] = includes 17,006 captive-raised.

Bandings of wetland game birds included prolonged annual bandings at a few sites and short-term, even single year, bandings at most. It is not entirely clear from historic archived files (e.g. IAD 46/5/23, R14985961 and others), why specific sites were chosen and what motivated establishing new sites elsewhere, and so frequently. For example, for grey duck and mallard during 1948–66 (Table 18), 17 of the 27 banding sites were used for just a single year, and another four for only two years. Potentially, requests from various acclimatisation societies for banding to be done in their regions may have influenced selection and persistence. Even so, regional representation was restricted. In the same time interval, banding programmes for black swan, Canada goose and paradise shelduck commenced and all were limited to one or two sites in one or two regions. However, during 1967–83, multi-year banding of grey ducks and mallards occurred at most sites (Table 20), and similarly for paradise shelducks (Table 12).

Widespread geographic distribution of banding sites can be viewed as a necessary part of game bird management. Hunting regulations, which as Barker *et al.* (1991) demonstrated, can influence immediate survival rates significantly, were, and remain, applied to long-established administrative districts, not as they might be to areas prescribed by dispersal patterns of well-defined and monitored (banded) populations.

The void between banding endeavour and recovery analyses

A conspicuous feature emerging from this synopsis is the paucity of analyses of band recoveries, especially relative to the scale and duration of bandings. Why so?

Given that banding is a research technique, statements of its purpose or intent have proved elusive for almost all game bird bandings considered here. Perhaps this is understandable, at least initially. The first bandings were simply part of a pioneering endeavour in New Zealand game bird management. What new knowledge might accrue if it was done? The interest of hunters when returning a band viz., "where did it come from, and how old was it" would probably have captured the intent of most initial banding programmes; published expressions at the time suggest so (e.g. DIA 1952), as did formal responses to those hunters (IAD 46/5/32, R14985963-8).

The initial duck and quail bandings were influenced by approaches then being developed overseas. For ducks, it was those being employed in North America that were being read about and tried, and these were reinforced by the Wildlife Branch's waterfowl biologist Ron Balham being funded to complete a doctoral degree (on Canada goose behaviour) 1952–54 based at the Delta Waterfowl

Research Station in Manitoba in the company of many young, and later prominent, North American waterfowl biologists. The duck banding analyses completed upon his return to New Zealand (Balham & Miers 1959) directly replicated the prevailing North American life table methodologies (Hickey 1952). Similarly, Gordon Williams' quail research was replicating approaches to animal population studies then prominent at Oxford University's Bureau of Animal Population Studies, and where Williams undertook a sabbatical sojourn. His interest became focussed on natural population cycles, not manipulative "management" of quail as sporting quarry, hence his long-running quail hunting diary scheme which recorded age and sex ratios of hunters' kills. Annual banding was simply a means of determining age ratios prior to hunting seasons. However, there was no apparent cross fertilisation of these approaches in subsequent game bird research; the expansion of duck, black swan, and Canada goose banding programmes during the late 1950s or early 1960s simply followed the prevailing North American approach. By then, however, both Balham and Williams had moved to university positions, Westerskov soon followed, and their respective research roles were left vacant for several years.

A reactivation of Canada goose research following the Wildlife Branch's recruitment of biologist Michael Imber in 1966 had, as its immediate, and only, formal outcome, an appraisal of all bandings from Lake Ellesmere to that date (Imber & Williams 1968). New bandings at Lake Forsyth, and web-tagging of goslings in the Esk and Cox River headwater valleys were intended to establish cohorts of visibly marked and known-age birds to assist productivity studies. However, these studies were abandoned in 1973 (Adams & Williams 2021), and the bandings and taggings, which continued for almost another decade, no longer had purpose.

Duck band recoveries also remained largely unevaluated. Reid's (1966) appraisal of band recoveries from Southland releases of captive-raised mallards aside, no analyses of band recoveries, neither of recovery locations to elucidate dispersal nor of survival/mortality rates to infer hunting impacts, post-dated those of Balham & Miers (1959) until, very belatedly, analyses of 1950–70s grey duck and mallard recoveries were published (Nichols *et al.* 1990; Barker *et al.* 1991; Caithness *et al.* 1991). However, for Tom Caithness, who, from 1967, was the sole biologist assigned all game duck research responsibilities, band analyses were never a priority although, irregularly, he included year-of-banding recovery rates from some bandings within narratives reporting his annual duck harvest surveys (Caithness 1968 *et seq.*, 1982a,b).

Perhaps only for paradise shelducks and black swans during part of the 1970s was there a deliberate focus on evaluating outcomes from their widespread banding (see relevant species sections above).

This brief explanatory outline of research support of banding projects for the 30 years 1950–80 indicates that the Wildlife Service's commitment to game bird banding analyses was never sufficient to cover all the species banding projects it was running. That commitment effectively ceased when a reappraisal of Wildlife Service research priorities in 1981 (Crawley 1983) saw all future game bird research and banding analyses by its scientific staff relegated to an "if time permits" category. Subsequently, no analytical commitment to game bird banding recoveries was forthcoming despite recommendations of a 1983 review of game bird research which specifically exhorted the Wildlife Service to do otherwise, especially for the then problematic Canada goose, and for the elucidation of dispersal characteristics of all other banded game birds (Williams *et al.* 1983). Wildlife Service involvement in game bird banding ceased soon thereafter. The very belated reporting of historic grey duck and mallard banding analyses referred to above, and of shoveler banding (Barker *et al*. 2005b), all arose from personal interest, not institutional commitment, and were largely achieved through the goodwill of US-based biostatisticians. In response, some staff of acclimatisation societies (and post-1990, of regional Fish and Game Councils) undertook banding and band recovery analyses, e.g. Barker (1990), Barker & Buchanan (1993), to support their organisations' game bird management activities.

By abdicating its commitment to banding analyses, the Wildlife Service's research unit left the Service's game management staff and acclimatisation societies without the science support their banding programmes had previously relied upon.

Perhaps, in conclusion, it is worth re-emphasising that banding is a research technique, a means of obtaining information about an individual bird, or cohort, which, upon scrutiny, provides new learnings about the animals in question. Ideally, banding programmes ought to have a declared purpose, or a hypothesis being tested; such statements of intent pre-determine the programme's design, the when, the where, the how many, and the timeframe. In the absence of a declared purpose, it is easy for banding to become occupational therapy, something to be done because it has always been done, something to be done because something needs to be done. But of equal importance is the evaluation phase, requiring the availability of skills to apply appropriate analytical methodologies and, thereafter, to convey outcomes in a language readily understood by non-specialist administrative and participatory audiences. For much of the game bird banding in New Zealand 1948–99, these essential requirements seem not to have all been in place.

POSTSCRIPT

The inclusion of recovery arrays (see Appendix 1 for listing) arising from most of the wetland game bird bandings is motivated by the hope that their belated analyses can shed light on the past and highlight the ways by which banding can be used to assist the sustainable exploitation of wildlife for cultural purposes. Missing from inclusion are recovery data that indicates dispersal; these data can be sourced from the NZ Bird Banding Office within the Department of Conservation.

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It is appropriate to record that the banding summarised here had many, many, contributors. Some I have managed to acknowledge by illustration or by reference in the text, but by no means the majority. With the certainty that many names will be missed, multi-year contributors identified in the Bioweb banding file were Wildlife Branch/Service staff Harry Tanfield, Marsh Small, Alan Hall, Trevor Thompson, Peter Fisher, Ralph Adams, Ken Miers, Ron Balham, Roy Cavanagh, Brian Bell, Trevor Hartley-Smith, Gordon Williams, Ian Hogarth, Selwyn Bucknell, Hamish McAllum, Peter Fisher, Michael Imber, Dave Murray, Tom Caithness, Kerry Potts, Murray Crombie, Doug Arthur, Graham Adams, John Andrew, John Adams, Murray Williams, Kerry Horgan, Duncan Sutherland, Bryan Williams, John Cheyne, Steve McGill, Murray Neilson, Gideon Anderson, Bob Simpson, Tony Roxburgh, Pat Quinn, Hans Rook, Bill Pengelly, Andy Garrick, Jim Cook, Gerard Carlin, and Matt Cook. Identified Acclimatisation Society staff were game farm managers Jim McIntosh, Laurence Piper, Les McMillan, Bill Spooner, and ranger staff Andy Russell, Stuart Sutherland, Ian Matheson, Roger Sutton, Mark Sutton, Hori Sinclair, John Bull, Graeme Hughes, Monty Wright, Brian Strange, Lou Hoff, Ross Novis, Denis Maindonald, Doug Zumbach, Ian Buchanan, Peter Taylor, Richard Barker, Peter Howard, Frank Thompson, Tony Tweed, John Dyer, and Rowan Strickland. My apologies to the unrecorded.

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On a personal note, I was recruited to the Wildlife Branch by Ken Miers in 1965. After a year back at university under the tuition of Ron Balham, I rejoined as a biologist in late 1967 with Gordon Williams as my research director who tasked me with re-establishing lapsed research on paradise shelduck and black swan. These three initial Wildlife Branch biologists (see Fig. 1) were my early science mentors, and it is a pleasure to acknowledge their support. For 20 years thereafter I found myself in the company of the Wildlife Service's many game management staff, all of whom shared an enthusiasm and remarkable work ethic for the wise management of the game bird resource, as did numerous acclimatisation society staff I was fortunate to work alongside. I hope this synopsis provides an enduring record of their field contributions.

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APPENDIX: Explanation and listings of supplementary recovery array files

The recovery arrays, provided as supplementary files, were prepared from the Bioweb recovery file provided by the Banding Office, Department of Conservation, in May 2022 and are made available with permission of the Banding Office and contributing Fish and Game Councils. Recoveries are those made before year 2000.

The arrays provide, for each species and main banding locations, the numbers of birds banded in any year and numbers reported shot later in that, and subsequent years. Banding generally occurred annually in summer (November–March) and first recoveries made during the following game bird hunting season (May–July).

The banding year, as recorded, is the calendar year at the end of each summer's banding. Birds banded in November or December (or sometimes even earlier) are invariably associated with other bandings later in the summer, in January–March. Captive-reared birds were normally released in late summer or early autumn. While the use of a "biological year" designation, e.g. 1971/72, would, strictly, be more accurate, it is replaced everywhere by the single calendar year designation, e.g. 1972. Thus, birds from each banded cohort are identified as first recorded shot in the calendar year of their banding.

The recovery arrays are "clean" in that the sex and age of the banded bird, and the year of banding and of recovery are all correct. Banding and recovery details are not always so, e.g. sex and age are not always provided in the original banding details and thus cannot always be associated with the recovery details. Birds of unknown sex and/or age are not included in arrays and are not included in the totals of birds banded. A small number of birds have been recorded as recovered in a year prior to their banding, most likely reflecting an administrative confusion of banding and recovery years; these are listed on the arrays.

Ages are occasionally problematic. The distinction between "pullus" (intended to describe young still flightless) and "juvenile" (intended to describe flying young of the year) have sometimes been misapplied. So too has the distinction between juvenile and "adults" (of one or more years of age), especially in those waterfowl caught when aggregated for moulting their wing feathers (paradise shelduck, black swan, Canada goose). In most cases, these confusions have been addressed (they applied mostly to paradise shelduck) by appraising the circumstances of the banding and making a clear distinction between those caught whilst moulting ("moulters") and those caught as flightless young or only just capable of flight ("ducklings", "cygnets", "fledglings" according to species). For all grey ducks and mallards, flighted birds caught in baited traps were discriminated as "juvenile" (young of the year) and "adults" (at least one year old), the distinction based on cloacal examination (see text).

The supplementary recovery arrays provided for each species are limited to those derived from multiple years of banding and according to location. Each species' file, in Microsoft Excel format, contains multiple sheets, identified as "location" in the table below.

Table A1. Recovery arrays provided in species supplementary files.

Species file	Location	Age at banding	Banding years
Black swan	Lake Ellesmere	Cygnets	1955–82
	Waikato lakes	Cygnets	1962–85
	Lake Wairarapa	Cygnets	1974–87
	Okarito Lagoon	cygnets	1964, 73–79
	Rotorua lakes	Cygnets	1974–79
	Lake Ellesmere	Moulters	1956–82
	Farewell Spit	Moulters	1976–82
	Southland estuaries	Moulters	1978, 85, 86
Canada goose	Lake Forsyth	fledglings	1967–83
	Wairoa lakes	fledglings	1982–93
	Lake Ellesmere	Moulters	1957–90
	Wainono Lagoon	Moulters	1981–86
	Lake Pukaki	Moulters	1977, 83–88
Paradise shelduck	Taihape area	Moulters	1962–74
	Whanganui area	Moulters	1987–91
	Northland	Moulters	1976–80, 88–90
	West Coast	Moulters	1985–87
	Lake Whangape	Moulters	1983–87

Table A1. *continued*

Species file	Location	Age at banding	Banding years
	King Country	Moulters	1978–80, 88–90
	Lake Repongaere	Moulters	1961–74
	Other Gisborne sites	moulters	1965, 69–75, 83–85
	L Benmore, Onslow	moulters	1970–74, 83–88
	Southland sites	Moulters	1969–73
	Southland	ducklings	1971–75
	Otago	ducklings	1984–88
	Gisborne/East Coast	ducklings	1970–76
Australasian shoveler	Lake Whangape	Moulters	1978–85
	Otago–Southland	Moulters	1972–79
	Otago–Southland	ducklings	1972–79
Grey duck*	Waikato	adult & juvenile	1957–74
	Waikato	adult & juvenile	1967–83
	Matata–Taupo	adult & juvenile	1968–71
	Otago–Southland	adult & juvenile	1967–74
	Manawatu	all sexes/ages comb.	1948–55
Mallard*	Manawatu	adult & juvenile	1970–90
	Manawatu	all sexes/ages comb.	1948–55
	Waikato	adult & juvenile	1967–83
	Matata-Taupo	adult & juvenile	1968–71
	L. Wairarapa	adult & juvenile	1974–81,88
	N. & S. Canterbury	adult & juvenile	1967–73
	Otago–Southland	adult & juvenile	1967–73

*As explained in the text, pre-1967 recovery data for grey duck and mallard have been lost. Balham & Miers (1959) remains the only published source of data from this era (two of their recovery arrays are reproduced in the listing above). Recovery data for grey duck 1957–66 used by Barker *et al.* (1991) and Caithness *et al.* (1991), but not published by them, have been retrieved from those authors and are provided here.

Recovery arrays for grey duck and mallards come with a strong warning. Although all are arranged within separate sex and age classes based on the information given in banding records, the aging may not always be accurate. Field discrimination of age was based on cloacal examination (Hochbaum 1942), a technique which Balham & Miers (1959) considered was especially difficult to apply to females and which led them not to discriminate between adult and juvenile females in their analyses. Alternative techniques, well known post-1970, e.g. of different terminal shapes of greater tertials, tertials and lesser covert wing feathers, or of notched tips to central tail feathers (in juveniles), were never applied.

There are substantial differences in the adult : juvenile ratio between banding sites, and between years at individual banding sites. These might reflect seasonal variability in productivity, just as they might be a consequence of bander uncertainty and/or changes of banding personnel between years. Perhaps, in any banding where adults are listed as comprising ≤20% or ≥40% of either sex category, erroneous aging may be suspected.

Supplementary files
Recovery arrays for black swan
Recovery arrays for Canada goose
Recovery arrays for paradise shelduck
Recovery arrays for Australasian shoveler
Recovery arrays for grey duck
Recovery arrays for mallard