

The native forest birds of Stewart Island/Rakiura: patterns of recent declines and extinctions

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Abstract Stewart Island/Rakiura, the third largest island in New Zealand, has not had the large-scale forest clearance and introduction of mustelids that has had deleterious impacts on populations of native forest birds on the North and South Islands. However, Stewart Island has had 3 rat species, feral cats and possums introduced, which are known bird predators. It is likely that these species have had serious consequences for the native birds there. As no review of forest birds had been done within the past 80 years, an evaluation of changes in the reported abundance of native bird species on Stewart Island over the past 100 years was carried out, which revealed relatively recent declines and extinctions. Brown teal, rifleman, mohua, South Island kokako, falcon, Stewart Island weka and probably yellow-crown parakeets, have gone extinct on Stewart Island within the past 50 years. Birds showing dramatic declines in the past 100 years include kereru, kaka, kakapo, and robin. Populations of native birds on Stewart Island showed similar patterns of extinctions and declines as the South Island despite fewer agents of decline.

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INTRODUCTION

Predation by introduced mammals is a principal cause of the decline in diversity of native species in New Zealand (Towns & Atkinson 1991). Mammalian predators have been particularly devastating for endemic birds that evolved with avian predators and have not developed effective anti-predator strategies for introduced mammals (Moors & Atkinson 1984, Holdaway 1999a). When coupled with the large-scale forest clearance and disturbance in New Zealand in the past 2 centuries, the consequences for native bird abundance and diversity has been catastrophic (Innes & Hay 1991). Currently, there is substantial debate on the relative importance of introduced mammalian predators versus habitat destruction or inbreeding and genetic effects as the principal drivers of extinctions on islands worldwide, based mainly on meta-analysis of island data sets (Blackburn *et al.* 2004, Didham *et al.* 2005, O'Grady *et al.* 2006, Duncan & Blackburn

2007). The results of these analyses can produce conflicting conclusions (Blackburn *et al.* 2005a) and further examples of islands with losses of avifauna can only improve the quality of the debate.

The 3rd largest island of the New Zealand archipelago, Stewart Is/Rakiura, has escaped the habitat destruction that occurred on North and South Is although introduced browsers have modified the vegetative cover. Several species of predators, cats *Felis catus*, rats (Pacific rat, *Rattus exulans*; Norway rat, *R. norvegicus*; Ship or black rat, *R. rattus*) and possums *Trichosurus vulpecula*, were introduced to the island; however, but no mustelids species, a particularly destructive predator guild on the North and South Is, are present. As such, Stewart Is provides an opportunity to assess the impacts of a limited group of introduced predators on native birds, relative to the South Is of New Zealand, without the confounding effects of large-scale habitat loss.

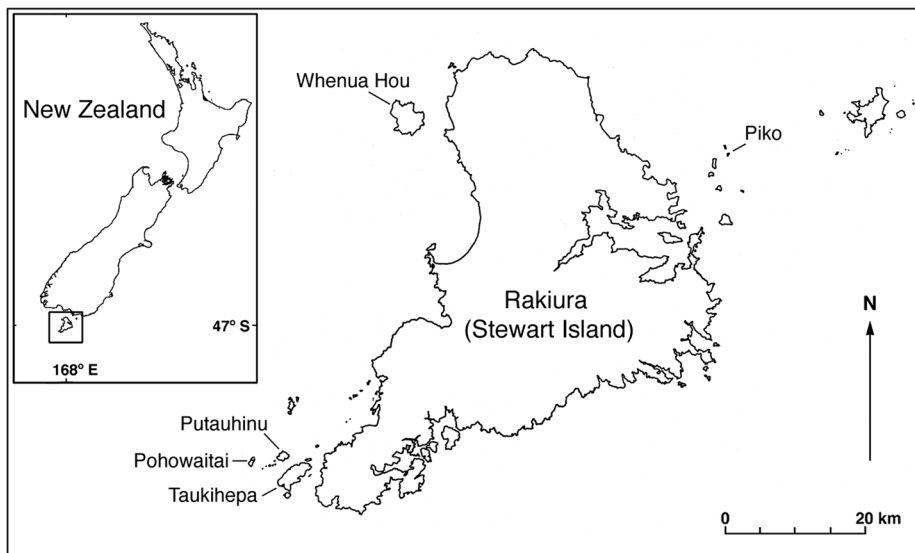
Previous reviews

There have been very few published reviews of the status of native forest birds on Stewart Is, and none in 80 years. Cockayne (1909) and Guthrie-Smith (1914) provided the first extensive bird lists from the island. Oliver published a comprehensive review

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Fig. 1. Map of New Zealand and Stewart Is, showing locations mentioned in the text.



in 1926. Since then small notes have appeared (Martin 1950, Dawson 1951, Tily 1951) and also for offshore islands (Watters 1963, Blackburn 1965, Blackburn 1968, Bell 1978). Both of the Atlases of Bird Distribution in New Zealand provide a file of birds present and their distribution at a coarse scale, but did not give an indication of status (Bull *et al.* 1985), although the comparative maps in the second atlas indicated which species' distributions have contracted (Robertson *et al.* 2007).

Stewart Is/Rakiura

Stewart Is/Rakiura (47°S, 168°E), is the smallest of the 3 main islands of New Zealand (Fig. 1). It encompasses some 1725 km² and is roughly 75 km long by 45 km wide, situated about 30 km south of the South Is (Wilson 1987). It has numerous smaller associated islands (Fig 2). The largest of these are Whenua Hou/Codfish Is (1396 ha), Taukihepa/Big South Cape (940 ha) and Pearl Is (500 ha). Ruapuke Is, to the northeast, is not included in this review as the forest cover has largely been destroyed (Wilson 1987).

Stewart Is is largely forested, and hilly, rising to over 700 m in several highlands. Extensive areas of low-lying flats exist, with permanent wetlands and small lakes. Streams, some tidal for many kilometres, are found throughout. Several drowned river valleys characterise the east coast, whereas the west coast is more exposed, and cliffs, interspersed by some sandy beaches, predominate. The largest beach, Mason Bay, is some 12 km long (Wilson 1987).

The island has a cool temperate, cloudy climate. Strong and frequent west and southwest winds predominate. Precipitation is spread evenly throughout the year (Meurk & Wilson 1989). The

township at Halfmoon Bay and Whenua Hou/Codfish Is each receive about 1500 mm per year; approximately 2265 mm per year is recorded in the Rakeahua Valley and over 3200 mm is the average for the alpine tops (Sansom 1984). Snowfall, mainly during the winter, is usually restricted to the alpine tops.

Human colonisation and habitat alteration

Stewart Is was colonised, initially intermittently, by Maori about 700 years ago (Holdaway 1999b). Europeans began working the coast for seals in the early 1800s, and small European settlements were established. The first settlement was at Whenua Hou around 1825, and the second at Port Pegasus in 1826. As the seal stocks were depleted, whaling became the dominant industry. As these industries declined, Oban at Halfmoon Bay, became the site of the main township on Stewart Is. The island was sold to the New Zealand Government in 1864 (Howard 1940) and by the early 1900s most of the island had been gazetted as scenic or nature reserves (Meurk & Wilson 1989). The poor soils meant that only small amounts of farming and logging were carried out, and by the 1930s fishing and tourism had become the main money earners (Howard 1940). In Mar 2002 Rakiura National Park was gazetted, encompassing 85% of Stewart Is and some offshore islands.

Soils are generally of low fertility (Wilson 1987). Rimu *Dacrydium cupressinum* and kamahi *Weinmannia racemosa* forest covers about 60% of the land area, co-dominant with southern rata *Metrosideros umbellata* and some miro *Podocarpus ferruginea* and totara *Podocarpus hallii* (Wilson 1987). Southern beeches *Nothofagus* spp. are absent. Low forest and scrub is found in coastal, subalpine, and alluvial sites and

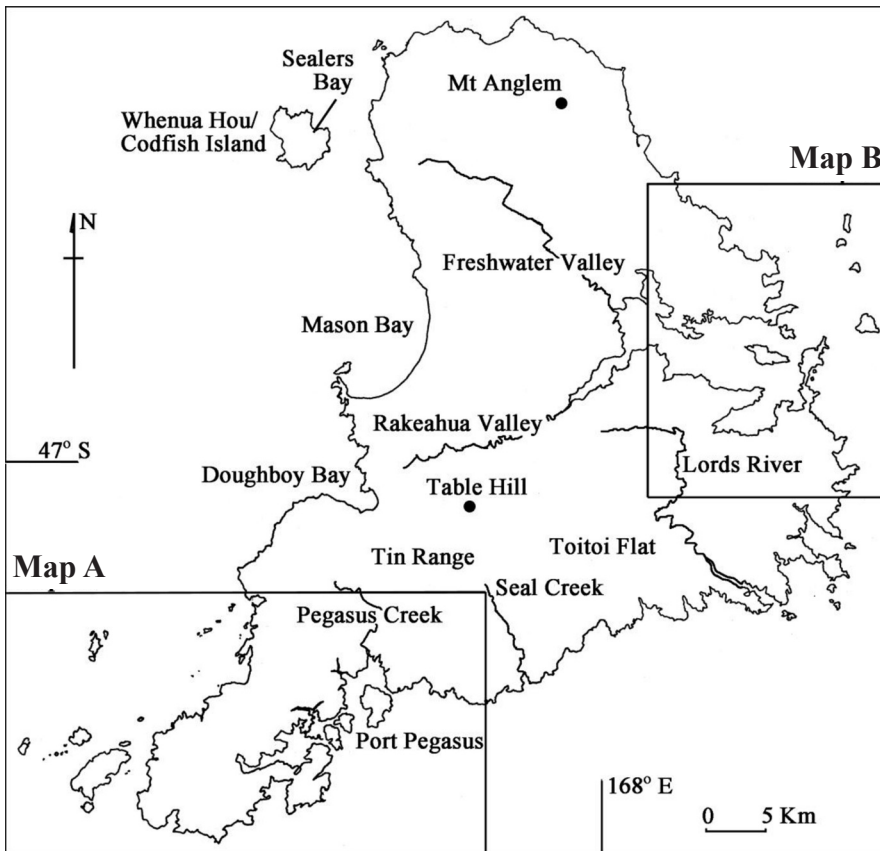


Fig. 2. Map of Stewart Is, showing locations mentioned in the text. Insets A and B continued on next page.

covers about 26% of the land area. It generally consists of various combinations of some of the following: manuka *Leptospermum scoparium*, leatherwood *Olearia colensoi*, *Dracophyllum longifolium*, *Myrsine divaricata*, *Coprosma* spp., pink pine *Halocarpus biformis*, yellow-silver pine *Lepidothamnus intermedius*, and southern rata. The remaining land area is open tall tussock grassland, alpine heath, wetlands or bare rock. Whenua Hou and some inshore islands like Pearl, Anchorage and Ulva islands have tall forest cover. Most of the smaller islands and the exposed shores of larger offshore islands are dominated by *Senecio reinholdii* or *Olearia* species.

Logging of forest was largely restricted to a small area in the vicinity of Halfmoon bay and Paterson Inlet (Howard 1940). Small areas of the vegetation cover have been burnt on Stewart Is, up to the 1920s, mainly in the Freshwater Valley and in Port Pegasus, Pegasus Creek, and Scollays Flat (Martin 1950, Fig. 2). Fire-induced shrublands are present on the upper slopes of Whenua Hou and Pearl Is.

Introduction of exotic predators

Three species of rats are present. Pacific rats were introduced to the main island about 1600AD

(Holdaway 1999b) and were found also on Mokinui/Big Moggy, Putauhinu, and Whenua Hou (Atkinson & Moller 1990, Fig. 2b). They may have reached the smaller islands relatively recently (Holdaway 1999b). For example, they may have reached Whenua Hou only 100–200 years ago as the South Georgian diving petrel *Pelecanoides georgicus* population would probably not currently exist if Pacific rats had been introduced earlier (Worthy 1998). Pacific rats were eradicated from Putauhinu, Rarotoka and Whenua Hou in the latter 1990's and Mokinui/Big Moggy in 2006.

Norway rats are likely to have arrived on Stewart Is about 1800 AD with sealers (Moors 1990). They also reached Ulva Is, Bench Is, and Pearl, Rosa and Ernest Is at Port Pegasus (Atkinson & Moller 1990). Eradication was achieved on Ulva in 1995 (Leech *et al.* 2007). Norway rats could reach plague proportions on Stewart Is. Hundreds were noted feeding on shellfish at low tide in Paterson's Inlet sometime between 1874 and 1880 (Thomson 1922).

Ship rats probably became established on Stewart Is around or after the 1890s (Atkinson 1973). Ship rats were reported at camps on Stewart Is by 1911, in addition to the Norway rat (Guthrie Smith

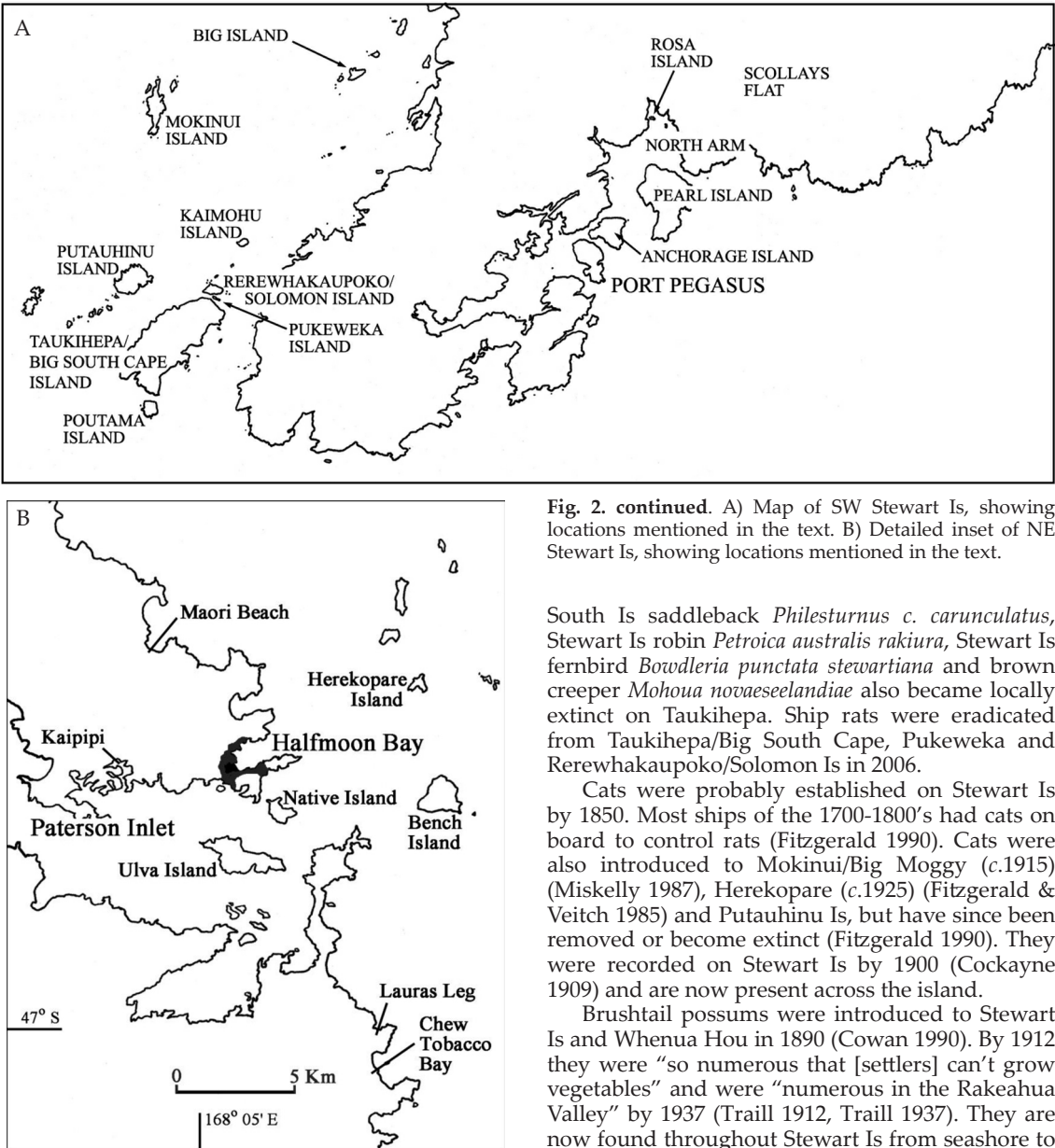


Fig. 2. continued. A) Map of SW Stewart Is, showing locations mentioned in the text. B) Detailed inset of NE Stewart Is, showing locations mentioned in the text.

South Is saddleback *Philesturnus c. carunculatus*, Stewart Is robin *Petroica australis rakiura*, Stewart Is fernbird *Bowdleria punctata stewartiana* and brown creeper *Mohoua novaeseelandiae* also became locally extinct on Taukihepa. Ship rats were eradicated from Taukihepa/Big South Cape, Pukeweka and Rerewhakaupoko/Solomon Is in 2006.

Cats were probably established on Stewart Is by 1850. Most ships of the 1700-1800's had cats on board to control rats (Fitzgerald 1990). Cats were also introduced to Mokinui/Big Moggy (c.1915) (Miskelly 1987), Herekopare (c.1925) (Fitzgerald & Veitch 1985) and Putauhinu Is, but have since been removed or become extinct (Fitzgerald 1990). They were recorded on Stewart Is by 1900 (Cockayne 1909) and are now present across the island.

Brushtail possums were introduced to Stewart Is and Whenua Hou in 1890 (Cowan 1990). By 1912 they were "so numerous that [settlers] can't grow vegetables" and were "numerous in the Rakeahua Valley" by 1937 (Traill 1912, Traill 1937). They are now found throughout Stewart Is from seashore to alpine tops (*pers. obs.*). The possums were eradicated on Whenua Hou by 1987. They are absent from inshore islands in Port Pegasus and Paterson Inlet (Cowan 1990).

Red deer *Cervus elaphus* were introduced in 1901 (Challies 1990) and whitetail deer *Odocoileus virginianus* in 1905 (Davidson & Challies 1990). The impact of deer and possums on native vegetation is substantial and well documented (Challies 1990, Cowan 1990, Davidson & Challies 1990). Other browsers once included sheep *Ovis aries*, cattle *Bos taurus*, pigs *Sus scrofa*, goats *Capra hircus* and rabbits

1914). Ship rats are now found virtually everywhere on Stewart Is, and consequently the distribution of Pacific rats and Norway rats has probably become more localised (Harper *et al.* 2005). Ship rats also established on Native Is, and Pearl and Rosa Is in Port Pegasus (Atkinson & Moller 1990, Fig. 2). A ship rat invasion of Taukihepa/Big South Cape, Pukeweka and Rerewhakaupoko/Solomon Is in 1963 resulted in the complete extinction of Stead's bush wren *Xenicus longipes variabilis* and Stewart Is snipe *Coenocorypha aucklandica iredalei*.

Oryctolagus cuniculus, which were present but have since died out or been removed.

METHODS

In addition to personal observations conducted over Stewart Is/Rakiura and the offshore islands over the past 12 years, historical books and original papers were critically reviewed for bird references relating to Stewart Is. Reports held by the Department of Conservation in Invercargill were examined. Most reports summarised searches conducted for kakapo and kokako from 1977 to 2000 by the New Zealand Wildlife Service (to 1987), the Department of Conservation (1987 onwards) and private individuals, and usually had bird lists appended. Recent records of sightings held in the Department of Conservation database in Invercargill were also reviewed. A few individuals with recent personal knowledge of native birds on Stewart Is were also interviewed.

Five-minute bird count data for some common and uncommon birds were used to provide a limited degree of rigour for broad comparisons of species' relative abundance, rather than solely relying on anecdotal information. Five-minute bird counts can be unreliable due to observer bias and varying conspicuousness of bird species through the seasons, time of day, and in differing vegetation and topography (Dawson & Bull 1975, Wilson *et al.* 1988), but were used in this study as little other data were available for comparisons between locations. Where possible, counts are derived from or undertaken in similar forest types (podocarp-broadleaf forest) to reduce variability (Moffat & Minot 1994), but seasonal variation could not be controlled in the analyses of the counts reported here.

Counts from lowland forests of Stewart Is and offshore islands as well as the South Is were used to compare relative bird abundance in forests with or without predators. Five-minute bird count surveys were conducted on Stewart Is by Department of Conservation staff in the 1998-99 and 1999-2000 summer during vegetation health surveys (386 and 321 individual counts, respectively), along 1000 m transects in podocarp-broadleaf forest. One survey of Bench Is (Fig. 2) in Apr 1999 is also included (34 counts). These data were compared with 5-minute bird counts carried out by the Department of Conservation in the Pembroke area of Fiordland in the spring of 1998 and 1999 (127 and 141 counts, respectively, Fig. 1). Data was also derived from the South Westland bird surveys of the early 1980s (O'Donnell & Dilks 1986). These data included counts from Karangarua (n=122 counts), Makawhio (n=120 counts) and Ohinemaka (n=144 counts) (Fig. 1). These forests were selected as they comprise coastal podocarp-broadleaf forest, which is similar

in structure to those on Stewart Is and Whenua Hou.

I carried out a 5-minute bird count on Whenua Hou in Aug 2001 (n = 19) (Dawson & Bull 1975). All counts were carried out in podocarp-broadleaf forest. Over 2 days, I stopped at 200 m intervals or greater and listened for 5 minutes. All counts were conducted between 10 am and 4 pm. The weather was calm and overcast on both days.

Each set of counts from Whenua Hou, Stewart Is, Bench Is, and the Pembroke were separately pooled for each season, and means and 95% confidence intervals derived from these. The assumption was made that a given bird species was equally detectable at all the counting sites. Data are presented as mean number of birds counted with 95% confidence intervals, where available. ANOVAs were used to reveal statistically significant differences between counts of bird species present at all the sites. Counts were log-transformed to normalise the data, and Tukey tests were used to show significant differences between sites (Sokal & Rohlf 1995).

RESULTS

Bird records before 1900 and now extinct

The merganser *Mergus australis*, slender moa *Dinornis struthoides*, New Zealand raven *Corvus moriorum* and laughing owl *Sceloglaux albifacies* were known to exist on Stewart Is but became extinct before 1900 (Worthy 1998). Although the piopio *Turnagra capensis* existed in rainforest in western Southland (Dunckley and Todd 1949), there are no records of piopio from Stewart Is.

Bird records 1900-2008

Stewart Is brown kiwi/tokoeka *Apteryx australis lawryi*
(Common)

Kiwi are widespread and common on Stewart Is and present on Ulva Is, and are found from the seashore to the alpine tops. Kiwi were recorded as scarce in 1916 (Meyers 1923) but this apparently referred only to the northern half of the island. They were thought to have spread from the south of the island, at one stage not being known north of the Rakeahua Valley (Cockayne 1909, Oliver 1926). Kiwi were common in the northern areas of Stewart Is by the 1950s (Dawson 1951).

O'Donnell (1984) recorded high kiwi densities in Mason Bay, compared with other parts of New Zealand. Stewart Is kiwi do not appear to be preyed upon by cats to any significant degree (Karl & Best 1982). A high chick survival rate was noted for the 1989 breeding season, possibly due to a crèche system (Colbourne 1990), that may protect the young from cats. However, possums have been recorded disturbing kiwi at nests (Morrin 1989), indicating that possum-induced nest-failure may be

a problem. Research is required on the age structure of the island's kiwi population to shed light on survivorship and recruitment.

Brown teal/pateke *Anas aucklandica chlorotis*
(Extinct)

Brown teal were very common on Stewart Is in the 1800s and apparently increased in numbers by the 1920's (Shepard 1826, Reishek 1888, Oliver 1926, Traill 1927). Over 75 were reported on one beach at the mouth of the Rakeahua River in 1933 (Traill 1933). They rapidly disappeared in the 1950's and visitors recorded none thereafter (Dawson 1951, Tily 1951). A single bird was found on Whenua Hou in 1948 (Dell 1950) but none were found there in 1965 (Blackburn 1965).

Brown teal were regarded as extinct on Stewart Is by 1972, their decline being attributed to an increase in cat abundance (Hayes & Williams 1972). The last recorded sighting was of a lone teal, possibly female, seen on Chew Tobacco Creek in Chew Tobacco Bay in early Dec 1980 (Innes 1984, Fig. 2).

Campbell Is teal *Anas nesiotis*
(Introduced/common)

Campbell Is teal were released on Whenua Hou in 1999 to provide breeding stock for re-stocking Campbell Is once Norway rats were removed. Although a large number of individuals were subsequently transferred to Campbell Is, a permanent population now remains on Whenua Hou.

Scaup/papango *Aythya novaeseelandiae*
(Uncertain status)

Scaup were recorded in the Freshwater and Rakeahua rivers by Cockayne (1909), who noted that the species was becoming scarce. However, he may have confused them with brown teal as he does not mention brown teal in his list, and no other records of scaup from the period exist. They have been recorded once near Halfmoon Bay in 1970s (Bull *et al.* 1985), although this sighting may also have confused scaup with brown teal, which were present near Halfmoon Bay until recently.

Harrier/kahu *Circus approximans*
(Common)

Recorded as uncommon in the early 1900's (Oliver 1926), the harrier is probably more common now. Harriers are now widespread but in low numbers (Pierce 1981, Powlesland 1988). Harriers are "frequently observed patrolling scrubland, swamp-land and coastal sand-dunes..." (Buckingham 1981a) and will also search above podocarp forest (*pers. obs.*). They can be abundant on offshore islands in autumn when titi *Puffinus griseus* chicks are fledging. During 3 evenings on Taukihepa in May 2004, an average of 23 (*s.e.* 4.0) were seen patrolling over approximately 2 km² of sky (*pers. obs.*).

Falcon/karearea *Falco novaeseelandiae*
(Extinct, visitor)

Reishek (1888) recorded falcons preying on tui in 1880's at Lord's River. Cockayne (1909) recorded them as common. By the 1920's falcons were not common (Oliver 1926) and were only occasionally seen (Traill 1928). They were recorded as nesting on Whenua Hou in 1934 (Stead 1935) and 1 was heard there in 1948 (Dell 1950). They were not recorded on Whenua Hou in 1965 (Blackburn 1968) and are not now breeding on Whenua Hou, although a single bird was seen in 2002 (*pers. obs.*).

Fox (1978) assumed there to be a low density of falcons on Stewart Is from previous recorded sightings. One was recorded near Halfmoon Bay during the 1970's (Bull *et al.* 1985) and at the Freshwater landing in 1979 (Buckingham 1981b). By the 1980's they were scarce. They were not recorded in Rakeahua Valley or Doughboy Bay over 13 days in May 1981 (Pierce 1981), or recorded over 222 km² grid squares in southern Stewart Is over the summer of 1984/1985 (Powlesland 1988). Traill (1981) also noted that..."I used to see them fairly often but have not seen one for a long time."

A series of 8 sightings of a falcon from points across Stewart Is were recorded from mid-1998 to early 1999 (DoC database). It was probably a single bird from the South Is and these sightings suggest that falcons are now only occasional stragglers to Stewart Is.

Stewart Is weka *Gallirallus australis scotti*

(Extinct/reintroduced, common on offshore islands)
Weka were common and widespread in the late 1800's and early 1900's (Shepard 1826, Reishek 1888, Cockayne 1909, Guthrie-Smith 1914, Philpott 1919, Oliver 1926). Weka recently became extinct on Stewart Is and are restricted to a few offshore islands.

The reduction in range and numbers of weka on Stewart Is was quite sudden. Weka were not recorded on Stewart Is at Port Pegasus in 1949 (Martin 1950), but were still common in the Rakeahua valley in 1951 (Dawson 1951). By 1963, weka, previously present in "great numbers", were "practically extinct" at Mason Bay (Lawn 1963), and they were absent from the Rakeahua Valley and the Freshwater Valley by 1975 (Anon 1975). During an eradication programme on Whenua Hou, 900 weka which had been introduced to Whenua Hou, were transferred to north-west Stewart Is in 1978 (Buckingham 1981a). They quickly disappeared from this area of Stewart Is and were down to 1978 numbers 9 years later (Powlesland 1988). None were seen or heard during a search of 222 km² grid squares in southern Stewart Is in summer of 1984-1985 (Powlesland 1988). During a survey of the northern half of Stewart Is in 1985-1986 weka were

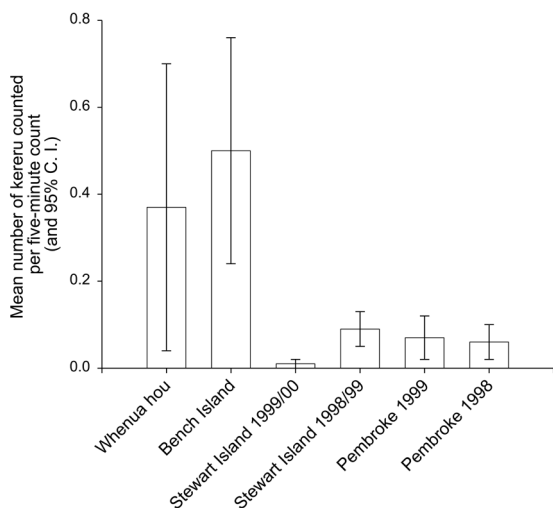


Fig. 3. The abundance of kereru in southern New Zealand 1998–2001.

only recorded around Paterson Inlet, the east coast in the vicinity of The Neck and the north coast (N. Bolton, *pers. comm.*).

They have recently (Apr 2005) been reintroduced from Bench Is, to Ackers Point, near Halfmoon Bay, after the initiation of a mammalian predator control programme there (B. Beaven, *pers. comm.*). Breeding has taken place and chicks are seen regularly. Weka have since spread out around the Halfmoon Bay township (*pers. obs.*).

Cats may have brought about the decline of weka. Cats on Macquarie Is will take weka when other preferred prey is not abundant (Jones 1977, Brothers & Skira 1984), and they have been recorded taking 'the rail' on Stewart Is (Wodzicki 1950). This suggests their decline occurred after other ground-nesting birds became extinct, possibly because weka are more difficult for cats to depredate.

Stewart Is snipe/hakawai *Coenocorypha aucklandica iredalei* (Extinct)

Snipe were previously extant on the main island and probably died out in the late 1800s (Miskelly 1987). By the turn of the century they were restricted to offshore islands, probably because of predation by cats and Norway rats. The last remaining population became extinct shortly after an invasion of Tauihepa by ship rats in 1964 (Bell 1978). Snare Is snipe (*C. aucklandica meinertzhagenae*) were introduced to Putauhinu Is in 2005.

New Zealand pigeon/kereru *Hemiphaga novaeseelandiae* (Rare, locally common)

Pigeons have almost certainly declined in abundance. Early records regularly used "plentiful" or "common" to describe pigeon numbers in forest (Guthrie-Smith 1914, Oliver 1926, Traill 1928). Pigeons were seen "in the hundreds" in Halfmoon Bay feeding on wineberry *Aristotelia serrata* berries (Oliver 1926) and a flock of 60 was recorded at Halfmoon Bay in Jan 1949 (Martin 1950). They were also very common in the North Arm of Port Pegasus, feeding on *Fuchsia excorticata* berries in Jan 1949 (Martin 1950).

Numbers of pigeons appear to have declined throughout most of northern Stewart Is by the 1950s but they were still common around Halfmoon Bay at this time (Dawson 1951). By the 1980s they were uncommon throughout most of the island, "...in the bush one hears just an occasional sound of one, whereas at one time there would be a sudden whirr of wings as 20 or 30 rose from a favourite miro tree" (Traill 1981). In the Rakeahua valley, where Guthrie-Smith had noted them as being plentiful they are now recorded as uncommon in all seasons (Garrick 1978, Buckingham 1986), or in low numbers in autumn (Buckingham 1981). I have recorded them in small numbers (1 to 3 at a time) in the Rakeahua Valley over several seasons of fieldwork. In autumn they become more conspicuous, in small groups of 3 to 4 individuals, feeding on the fruit of divaricating *Myrsine* spp. and *Coprosma* spp.

In other parts of Stewart Is, except at Halfmoon Bay and offshore islands, New Zealand pigeon show similar patterns of abundance. Recent reports from throughout Stewart Is at all seasons, describe low numbers, occasional sightings, and rarity (Cox 1978, Buckingham 1981a, Buckingham 1981b, Buckingham 1986). Pigeons were observed only in 21% of 222 km² grid squares visited over summer of 1984–1985 in southern Stewart Is, mainly in podocarp forest (Powlesland 1988). They are still conspicuous around Halfmoon Bay and on offshore islands like Ulva (*pers. obs.*).

Five-minute bird counts for New Zealand pigeons (Fig. 3) suggest that abundance of pigeons on Stewart Is is similar to that in coastal forests of the South Is. Five minute bird counts showed pigeons were significantly more abundant on islands where there are few predators (Bench Is with Pacific rats) or no predators (Whenua Hou), than on Stewart Is or the South Is ($F_{3,5,35,8} = 20.15$, $p < 0.001$). Pigeons are known to fly over Foveaux Strait (>35 km) (Harper 2003) and are quite capable of taking advantage of widely separated seasonal food sources, including flying to and from offshore islands including Whenua Hou (Macarthur 1963, *pers. obs.*). However, this behaviour does not explain the widespread scarcity of pigeons at many locations in all seasons. This suggests that predators rather than food supply may be limiting pigeon numbers on Stewart Is.

Kakapo *Strigops habroptilus*

(Transferred/present on Whenua Hou)

Kakapo were first recorded on Stewart Is in 1847 (Dawson 1962) and were seen occasionally in the early 1900's around Port Pegasus (Oliver 1926). They were re-discovered in southern Stewart Is in 1977 (Russ 1978). The majority of kakapo were found between Pegasus River and Seal Creek (Powlesland *et al.* 1995). It has been suggested that the population became established from Fiordland kakapo in the late 19th century (Williams 1956), but research shows that the Stewart Is population is genetically distinct from Fiordland kakapo (Miller *et al.* 2003).

Kakapo populations were becoming critically reduced due to predation by feral cats and rats, so in an effort to save them, 61 were transferred to Little Barrier, Maud, Whenua Hou and Mana Is by 1992 (Powlesland *et al.* 1995; Figs. 1,2). The last kakapo, a female, was discovered in 1997 (Harper 1997b) and no further sign has been seen in further extensive searches of their previous known range (Harper 2000). The main population of kakapo now resides on Whenua Hou and it is considered extinct on Stewart Is.

Kaka *Nestor m. meridionalis*

(Rare, locally common)

Kaka were once very common on Stewart Is. "Great numbers of kaka parrots" were recorded at Lords River in 1888 (Reishek 1888). Fulton (1907) noted that kaka "still swarms in the dense bush in...Stewart Island". Guthrie Smith (1914) described "during February of 1911 the kaka were in thousands in the lower slopes of the great wooded spurs that run from Table Hill into the Rakiahua[sic] Valley." Oliver (1926) regarded them as "extremely common in the forest...some days many are encountered, at other times few or none". However, kaka were scarce near settled areas at this time (Philpott 1919), probably because forest was being felled and cleared around Halfmoon Bay. Kaka have become locally common at Halfmoon Bay as native forest has regenerated and introduced trees have become established. Kaka were observed feeding on flowers of blue gums *Eucalyptus globulus* and damaging macrocarpas *Cupressus macrocarpa* in the 1920s (Traill 1928). Kaka are common on some offshore islands like Ulva, Bench and Whenua Hou. Flocks of 10 to 12 kaka were "whistled up" on Whenua Hou in the 1930s (Stead 1935) and were abundant on Whenua Hou/Codfish in 1948 (Dell 1950). Blackburn (1968) described kaka as "numerous" there in 1965, with 35 seen in a typical morning. Kaka are still very common on Whenua Hou and nests and chicks are encountered regularly (*pers. obs.*).

Numerous reports describe very small numbers or uncommon sightings of kaka throughout Stewart

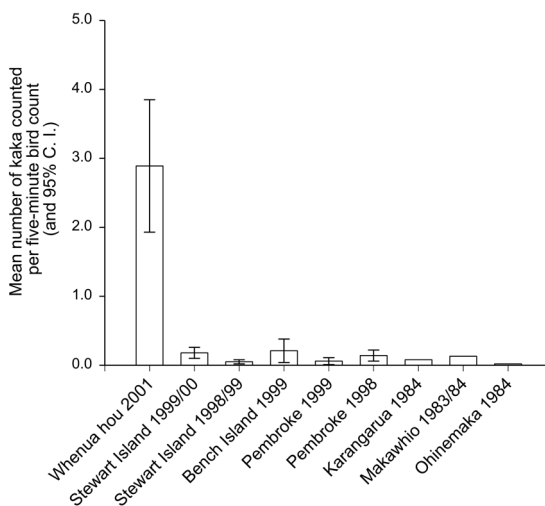


Fig. 4. The abundance of kaka in southern New Zealand 1983-2001.

Is in the past 25 years (Anderson 1977, Gray 1977, Nilsson 1977a,b, Pierce 1981, Buckingham 1981a,b, 1985, 1986, Harper 1997a, 1998, 2000). In the summer of 1984-1985, kaka were only recorded in 7% of 222 km² grid squares visited in southern Stewart Is, mainly in the North Arm of Port Pegasus and in Seal Creek (Powlesland 1988). The decline in kaka numbers appears to have begun by the 1940's. It was noted that they were becoming scarce on Stewart Is by the mid 20th century (Traill 1948), and Traill (1954) referred to a "sudden decrease" before this time.

Occasionally kaka are noted as locally common. Traill (1976) noted kaka as abundant in North Arm, Paterson Inlet in Dec 1976, while southern rata was flowering. During a rimu mast-seed year kaka were described as numerous in the North Arm of Port Pegasus (Harper 1997b). I have noted only a flock of 6 kaka in the Rakeahua Valley in the period from Mar 2000 to Sep 2001, while southern rata was flowering. Kaka can travel very large distances (Moorhouse 1991) and probably make use of widely spread, seasonally abundant food sources. Indeed, the large population at Halfmoon Bay may be flying from Ulva or Whenua Hou, to feed on food put out for kaka by humans. Kaka nests were found on Taukihepa/Big South Cape Is in early 2004 and 2005 (*pers. obs.*).

Kaka fledglings are vulnerable to cats for short periods as they spend the first 2 to 4 days after leaving the nest on the ground (Moorhouse & Greene 1995), but kaka were present on Little Barrier Is when cats were present on the island, so the impact of cats on kaka may not be severe enough to completely eliminate their population (Giradet *et al.* 2001).

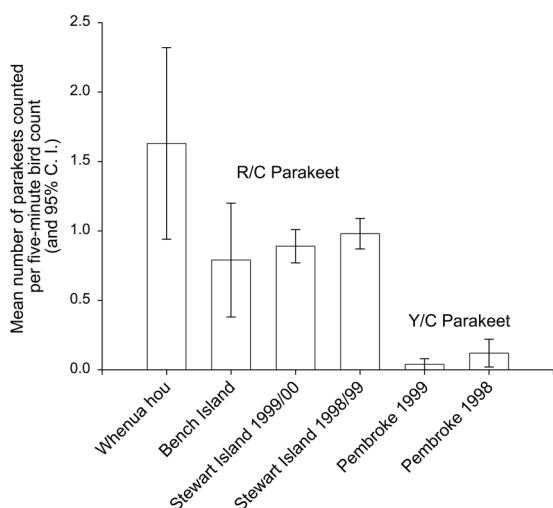


Fig. 5. The abundance of parakeets in southern New Zealand 1998–2001.

Comparisons between offshore islands and Stewart Is show a substantial disparity in numbers. Five-minute bird counts of kaka on Bench Is in 1980 recorded 0.5 kaka per 5-minute count, but at Laura's Leg on Stewart Is (Fig. 2a) in the same season the count is an order of magnitude less than 0.05 per 5-minute count (Spurr 1980). There are significantly more kaka on Whenua Hou than on Stewart Is or the South Is ($F_{25.1, 63.7} = 80.4$, $p < 0.001$). Kaka abundance on Stewart Is was as low as the western South Is sites used for comparisons (Fig. 4).

Red-crowned parakeet/kakariki *Cyanoramphus n. novaezelandiae*
(Common)

Red-crowned parakeets are seen and heard in all lowland forest despite being depredated by cats (Karl & Best 1982). Recent reports describe red-crowned parakeets as a commonly seen bird (Maunder 1966, Gray 1977, Cox 1978, Garrick 1978, Buckingham 1981b, Pierce 1981, Buckingham 1985). They were present in the early 1900s (Guthrie-Smith 1914), although not as common as yellow-crowned parakeets then widely present on Stewart Is (Cockayne 1909). Red-crowned parakeets were noted as more common than yellow-crowned parakeets by the 1950's (Dawson 1951) and red-crowned parakeets are now possibly the only parakeet species on Stewart Is. The majority of parakeet sightings on Stewart Is in the past 25 years have been of the red-crowned parakeet (Cox 1978, Garrick 1978, Buckingham 1981a, 1985), but on some offshore islands around Stewart Is both parakeet species are common.

Parakeets are more abundant on Whenua Hou than on any other sites, but these counts included both species (Fig. 5). Red-crowned parakeets are significantly more abundant in the lowland forests of Stewart Is and its offshore islands than yellow-crowned parakeets are in lowland forest in the South Is ($F =_{47.4, 232.1} = 41.7$, $p < 0.001$). Red-crowned parakeets are rarely reported from the South Is (Heather & Robertson 1996).

Yellow-crowned parakeet/kakariki *Cyanoramphus a. auriceps*
(Extinct?)

This species appears to be very rare or extinct on Stewart Is now, the last record being in the manuka shrubland of Mason Bay in 1984 (O'Donnell 1984). Yellow-crowned parakeets were exterminated from Herekopare Is after cats were introduced in 1925 (Fitzgerald & Veitch 1985). They are relatively common on Whenua Hou, Ulva Is, and other islands where predators, other than kiore, are absent. They were once very rarely seen or heard on Taukihepa/Big South Cape Is, where ship rats were present, whereas red-crowned parakeets were common. Within 18 months of the eradication of ship rats, several yellow-crowned parakeets were being seen daily, including fledglings (*pers. obs.*).

Shining cuckoo/pipiwharau *Chrysococcyx lucidus*
(Uncommon)

The population of shining cuckoo on Stewart Is/Rakiura appears to be in decline, mirroring the apparent observed trend in the South Is (Robertson *et al.* 2007). Although noted as present by Oliver (1926) and Traill (1928) there are very few recent reports (Robertson *et al.* 2007, *pers. obs.*). Buckingham heard them occasionally in 1981, but only 1 was heard over the summer of 1986 in upper Rakeahua Valley (Buckingham 1981a, Buckingham 1986). They are still heard occasionally on Stewart Is (M. Dobbins, *pers. comm.*)

Long-tailed cuckoo/koekoea *Eudynamis taitensis*
(Uncommon)

There are few recent reports of long-tailed cuckoo (Robertson *et al.* 2007, *pers. obs.*). Early records exist (Guthrie-Smith 1914, Oliver 1926, Traill 1928) and birds were heard daily in the Rakeahua Valley in 1951 (Dawson 1951). None were recorded there in the summers of 1999–2000 or 2000–2001 (*pers. obs.*) Only 1 was heard in the Freshwater Valley over 50 days in the summer of 1984–1985 (Buckingham 1985), and only 1 also in a search of 222 km² grid squares in southern Stewart Is during the same summer (Powlesland 1988). They were occasionally seen on Toitoto flat in the summer of 1978 (Cox 1978, Fig. 2), and only occasionally heard in 1981 and 1986 (Buckingham 1981b, 1986). They were heard at Ulva

Is and Halfmoon Bay in 2002 (*pers. obs.*). Adults and chicks were noted on Whenua Hou/Codfish in the summer of 2001-2002, and adults were heard daily.

Morepork/ruru *Ninox novaeseelandiae*
(Common)

Morepork are commonly heard in most lowland forest on Stewart Is and offshore islands (Gray 1977, Buckingham 1981b, Pierce 1981, Harper 1997a). They have been regularly recorded since the early 1900s (Cockayne 1909, Oliver 1926, Dawson 1951).

Kingfisher/kotare *Halcyon sancta*
(Common)

Recorded as common in 1909 and the 1920's (Cockayne 1909, Oliver 1926), kingfishers are still often seen or heard in lowland forest near rivers and coastal inlets (Buckingham 1981b, Powlesland 1988).

Rifleman/titipounamu *Acanthisitta c. chloris*
(Extinct)

Contrary to several published accounts, the rifleman appears to have gone extinct on Stewart Is by about 1990. One population remains on Whenua Hou.

Cockayne (1909) reported the rifleman on Stewart Is and noted them being particularly common in Port Pegasus. They were recorded nesting in coastal forest to sub-alpine scrub (Guthrie Smith 1914). Traill reported them becoming uncommon by the 1930's and by 1948 were described as "scarce" (Traill 1934, 1948). Dawson (1951) only mentions 2, seen near Halfmoon Bay in 1951, and the Dunedin Naturalists Field Club saw only 1 there in 1950 (Tily 1951). They were not recorded by Kikkawa (1966) during a 2-week stay in lowland forest in 1959, but 1 was noted in the upper Freshwater River in 1962 and some around Easy Harbour in 1963 (Macarthur 1962, 1963). It was noted that "they have become very rare" by the early 1980s (Traill 1981). Although rifleman were recorded in the northern portion of Stewart Is, north of the Freshwater River, in the 1970s (Bull *et al.* 1985), further searches throughout Stewart Is have failed to record them since (Buckingham 1981b, 1985 and 1986, Powlesland 1988, *pers. obs.*). Rifleman were not recorded in 5-minute bird counts on Stewart Is in 1998-2000.

Rifleman are significantly more abundant on Whenua Hou than in South Is lowland forest sites ($F_{2,284} = 46.9$, $p < 0.001$, Fig. 6). Historically they were recorded on Whenua Hou "in the thick forest on the higher levels" by Dell (1950), and were "frequently met in the forest from about 200 feet a.s.l." (Blackburn 1968). Rifleman appear to have become more abundant since the eradication of Pacific rats in 1998 and are now seen daily at the hut at Sealers Bay (*pers. obs.*). They were introduced to Ulva Is

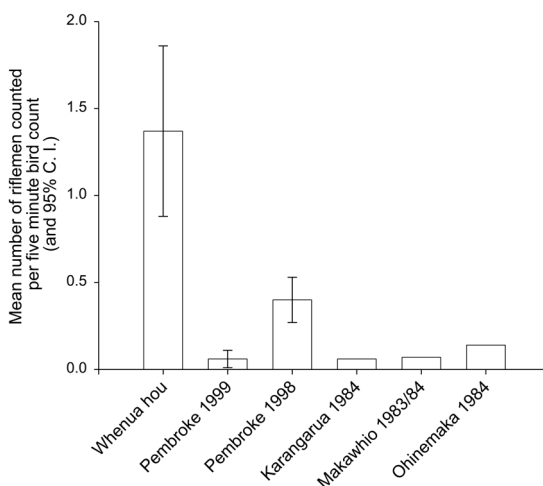


Fig. 6. The abundance of rifleman in southern New Zealand 1983-2001.

from Whenua Hou in 2003 and have established successfully (Leech *et al.* 2007).

Steads bush wren/matuhi *Xenicus longipes variabilis*
(Extinct)

The bush-wren was possibly extant on the Stewart Is up until the 1950s. "Three or four [bush-wren were] noted" near Halfmoon Bay in 1950 (Tily 1951), and again in 1951 (Dawson 1951). No further searches on Stewart Is have recorded them. The last population of Stead's bush wren became extinct on Kaimohu around 1972, after some remaining individuals were transferred from Taukihepa/Big South Cape Is during the ship rat invasion in 1964.

Pipit/pihoihoi *Anthus novaeseelandiae*
(Common)

Pipits are found in most rough open country on Stewart Is. They have been recorded in the sand dunes at Doughboy Bay (Pierce 1981), clearings in the upper Freshwater Valley (Buckingham 1985), and on the open tops (Pierce 1981, Powlesland 1988).

Fernbird/matata *Bowdleria punctata*
(Uncommon)

Cockayne (1909) regarded fernbirds as common but under threat from fire and cats. Guthrie Smith (1914) and Philpott (1914) recorded fernbirds throughout the length of the Rakeahua Valley and suitable peat flats of Mason Bay. They have not been seen or heard in the Rakeahua Valley recently although the habitat has probably changed. Comparisons with photos taken in 1911 and 1940 show that the manuka shrubland in the Rakeahua valley has grown substantially in the past 90 years. Most of the valley floor is now covered in manuka 4-5 m tall.

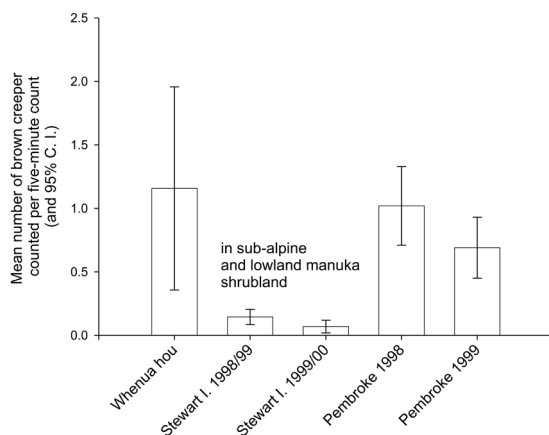


Fig. 7. The abundance of brown creeper in southern New Zealand 1998-2001.

The Freshwater River population may be in decline (O'Donnell 1984), possibly for similar reasons.

Fernbirds now live in isolated patches of suitable habitat across the island. They favour open short manuka shrubland, sub-alpine shrubland and wetlands throughout the main island (Buckingham 1981a, Cox 1981, Powlesland 1988). They are often seen on the alpine areas of the southern Tin Range and the subalpine scrub of Table Hill (*pers. obs.*). The latter sightings may be due to an increase in abundance because of cat control in the area.

Fernbirds are present on several offshore islands around Stewart Is. The population on Whenua Hou is regarded as a subspecies *Bowdleria p. wilsoni*.

Mohua/yellowhead *Mohoua ochrocephala* (Extinct)

Mohua used to be commonly seen on Stewart Is (Fulton 1907, Cockayne 1909), but by the 1920's Oliver said mohua were "rarely seen", hinting at a decline in abundance in the early 1900's. Mohua declined in coastal Southland slightly earlier, in similar forest as Philpott (1919) describes mohua disappearing "from the neighbourhood of Invercargill about ten years ago [1909]". Mohua have not been recorded on Stewart Is since the 1970's. They were introduced to Ulva Is in 2001 (Oppel and Beaven 2004), and Whenua Hou in 2003, and have established successfully.

Brown creeper/pipipi *Mohoua novaeseelandiae* (Locally common)

Most sightings of brown creeper on Stewart Is indicate a strong association with manuka and subalpine shrubland (Powlesland 1988, Kikkawa 1966, *pers. obs.*). Reports mention that they are "common in scrublands of southern Stewart Island" (Buckingham 1981a), or "seen in manuka and subalpine scrub" [of Rakeahua Valley] (Pierce 1981), and are "associated with

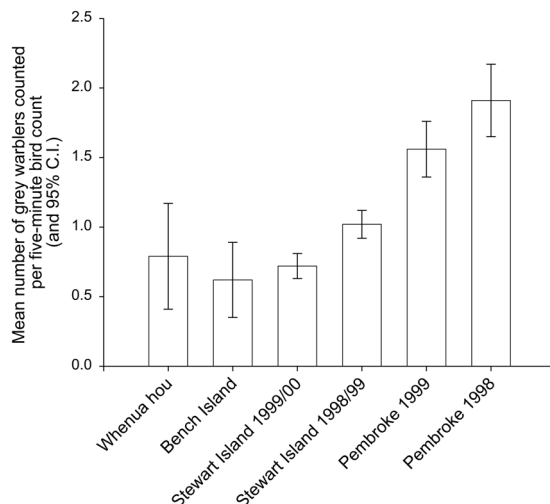


Fig. 8. The abundance of grey warbler in southern New Zealand 1998-2001.

manuka" in the Freshwater Valley (Buckingham 1985). Early reports of birds on Stewart Is had noted brown creeper in all forest types, including podocarp forest (Cockayne 1909, Guthrie-Smith 1914). On offshore islands such as Ulva and Whenua Hou however, they are commonly encountered in podocarp forest (Oliver 1926, Stead 1935, Kikkawa 1966, Dell 1950, Blackburn 1968, *pers. obs.*).

Most of the 5-minute bird counts on Stewart Is were conducted in podocarp-broadleaf forest and brown creeper were only noted in vegetation near or in manuka shrubland. This has reduced the overall mean number of brown creeper recorded (Fig. 7), and they are significantly less abundant than on Whenua Hou or the Pembroke ($F_{23.7, 156.2} = 37.6$, $p < 0.001$). Brown creeper were exterminated from Herekopare Is, probably by cats, in mid 1900's (Fitzgerald & Veitch 1985).

Grey warbler/riroriro *Gerygone igata* (Common)

Grey warblers are ubiquitous in distribution. All reports mention them as common from sea level to the tree-line (Guthrie-Smith 1914, Oliver 1926, Garrick 1978, Cox 1978, Buckingham 1981, Pierce 1981b, Powlesland 1988). Grey warblers are significantly less abundant on Stewart Is, Whenua Hou and Bench Is than in lowland forest in the South Is ($F_{5, 1022} = 28.8$, $p < 0.001$, Fig. 8).

Fantail/piwakawaka *Rhipidura fuliginosa* (Common)

As for the main islands of New Zealand, fantail are widespread and common in most forest areas, as they have been for the past century (Guthrie Smith 1914, Garrick 1978, Cox 1981, Buckingham

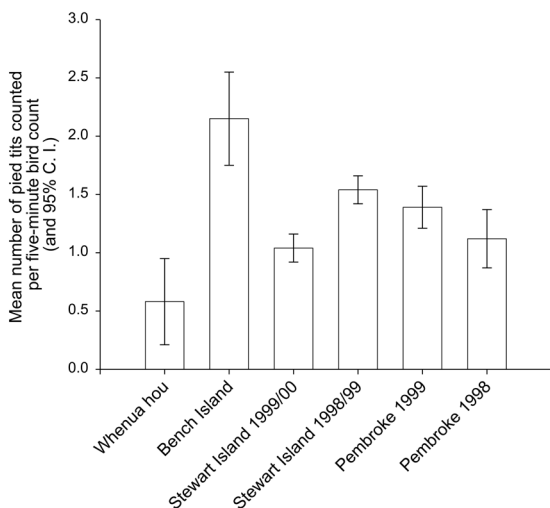


Fig. 9. The abundance of tomtit in southern New Zealand 1998-2001.

1981b). Fantails are generally found in taller forest in southern Stewart Is (Powlesland 1988).

Tomtit/miromiro *Petroica macrocephala* (Common)

Like the grey warbler, the tomtit is readily found in all forest types up to the tree-line (Oliver 1926, Cox 1978, Cox 1981, Buckingham 1981b, Powlesland 1988). Tomtits are significantly less abundant on Whenua Hou than Bench Is, Stewart Is (1998/99) and the Pembroke ($F_{5,1022} = 12.9$, $p < 0.001$, Fig. 9).

Stewart Is robin/toutouwai *Petroica australis rakiura* (Rare, locally common)

The current distribution of robins is disjunct and restricted to isolated patches of manuka shrublands and some yellow-silver pine in the Freshwater and Rakeahua Valleys, Toititi Flat, Scollay's Flat and upper Pegasus River. There is some evidence for the restriction being caused by the apparent preference for podocarp-broadleaf forest by introduced predators, notably ship rats, possums and cats (Harper 2002). A few early records hint at robins using podocarp-broadleaf forest (Shepard 1826, Black 1872, Cockayne 1909) but by the 1920's their distribution was restricted to manuka (Oliver 1926). The population may still be in slow decline in manuka shrubland, with "plentiful" robins being reported in the upper Freshwater and Rakeahua Valleys in the 1950's (Traill 1951, 1955), whereas now they could only be described as uncommon there. Robins were located in small patches of podocarp-broadleaf forest in the northern tributary of the Freshwater River in 1984 to 1986 but were very scarce (R. Buckingham, *pers. comm.*). Robins introduced

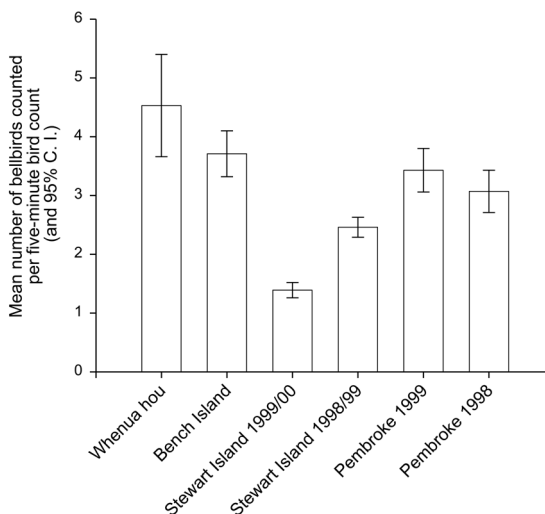


Fig. 10. The abundance of bellbirds in southern New Zealand 1998-2001.

to predator-free Ulva Is in 2 transfers from Big Is (southern titi islands) and the Freshwater Valley in 2000 (Hooson & Jamieson 2003), are now very common, and favour lower stature forest and coastal scrub with open understory and thick litter (Steffens *et al.* 2005). The preference for these forest types on Ulva is at odds with Stewart Is robin distribution in manuka forest on Stewart Is and supports the suggestion that predators are restricting Stewart Is robin to their current locations.

Robins went extinct on Taukihepa/Big South Cape when ship rats irrupted there in 1964. After the rat eradication in 2006 at least 3 robins, including a pair, were seen on the island within 18 months. As robins are present on Putauhinu and Poutama, some 300-1200 m distant, it appears they have re-established from 1 or both of these islands (Oppel and Beaven 2002). Cats extirpated robins from 28 ha Herekopare when they were introduced in 1925 (Fitzgerald and Veitch 1985).

Silvereye/tauhou *Zosterops lateralis* (Common)

The silvereye is relatively common, and is found in most forest types (*pers. obs.*, Pierce 1981). They apparently prefer lower altitude forest (Buckingham 1981b, Powlesland 1988). They seem to have become more common during the past 90 years since being 1st recorded by Cockayne (1909).

Bellbird/korimako *Anthornis melanura* (Common)

Bellbirds were common on Stewart Is early last century, where they "survive[s] in thousands...from sealine to moor land" (Guthrie Smith 1914). Little

seems to have changed and they are still common in most forest types (Garrick 1978, Buckingham 1981b, Powlesland 1988) and on offshore islands (Spurr 1980). Bellbirds are significantly less abundant on Stewart Is than on its offshore islands or the South Is ($F_{5,1022} = 28.8$, $p < 0.001$, Fig. 10).

Tui *Prosthemadera novaeseelandiae*
(Common)

Tui tend to be more restricted to podocarp forest and are not found in the subalpine zone or manuka shrubland as often as bellbirds (Buckingham 1981, Powlesland 1988). They are in small scattered populations in southern Stewart Is (Harper 1997a) but sometimes not recorded at all (Harper 1997b, 1998) or only once (Harper 2000) during several weeks. Tui were common on Whenua Hou and Ulva Is without introduced predators, and on Taukihepa/Big South Cape Is before and after the ship rat eradication.

South Is kokako/orange-wattled crow *Callaeas cinerea cinerea*
(Extinct)

The kokako was once reported as “common at Stewart Island” in 1907 (Fulton 1907), including Port Pegasus (Philpott 1914). Oliver saw kokako in 1910 at the foot of Mt Anglem, and kokako were reported on the south coast of Paterson’s Inlet, the Rakeahua Valley, and Freshwater Valley in the 1920’s (Oliver 1926). They were also seen near Kaipipi and Maori Beach in 1925 (Traill 1927), although Traill recorded them the most often in the Rakiahua [sic] Valley (Traill 1927). Guthrie-Smith (1914), who encountered kokako occasionally, noted that they inhabited the mid-story forest.

Concern was raised by the late 1920’s that they were becoming scarce (Traill 1928). Guthrie-Smith (1925) failed to find kokako in the Port Pegasus area in the early 1920s. Richdale only found 1 in Port Pegasus by Jan 1937 after a month in the area. Extensive searches suggested evidence of a few isolated kokako still present in the 1980’s, including apparent sightings in the Freshwater Valley in 1984 and 1 possible feather and sightings in the Rakeahua Valley in 1987 (Buckingham 1985, 1987). It appears the species is now extinct on Stewart Is.

South Is saddleback/tieke *Philesturnus c. carunculatus*
(Extinct. On offshore islands)

The saddleback was “...once common throughout all three main islands...but now confined...to few islands off the southwest coast of New Zealand” (Richdale, undated). They became extinct on Taukihepa when ship rats irrupted there in 1964, and 36 birds were transferred to Kaimohu and Big

Islands (Fig. 2). These populations have since been used to re-populate 15 offshore islands around Stewart Is and the South Is (Hooson & Jamieson 2003).

Other birds species of note

Bittern/matuku *Botaurus poiciloptilus*

(Locally common)

Traill recorded “solitary specimens between Mason Bay and the mouth of the Freshwater River” (Traill 1927), and they have been seen, or more often heard, occasionally since (Buckingham 1981a, Buckingham 1985). Reports of bitterns ‘booming’ are common from the Freshwater Valley and Mason Bay during the summer months.

Banded rail/moho-pereru *Rallus philippensis assimilis*

(On offshore islands)

By the 1920’s, banded rail were noted only on offshore islands (Oliver 1926) and have not been recorded on Stewart Is. They are resently extant on a few southern Titi Is (Robertson *et al.* 2007).

Spotless crake/puweto *Porzana tabuensis*
(Rare)

A very localized population was known to exist in a tributary of the Rakeahua Valley, as spotless crake were heard calling there in the 1980’s. Their preferred habitat was apparently small areas of wetland dominated by *Juncus* spp., at the bottom of old landslides in forest (Buckingham 1981a).

Southern New Zealand dotterel/tuturiwhatu *Charadrius o. obscurus*

(Population recovering)

Southern New Zealand dotterels currently only nest on the alpine tops of Stewart Is. They used to nest in the sand dunes of Mason Bay up until 1981 (O’Donnell 1984). The decline of the southern New Zealand dotterel has been described by Dowding and Murphy (1993) and is attributed largely to feral cats. The population declined to around 65 individuals by 1992. A cat control programme was initiated and the numbers have increased to over 300 birds (M. Dobbins, *pers. comm.*).

DISCUSSION

A combination of anecdotal information supported by limited objective data has provided an overview of the status of native forest birds on Stewart Is, its offshore islands and the southern South Is. The 5-minute bird counts were restricted in application by the problems discussed previously, and in the case of Whenua Hou and Bench Is, by the small sample size. Despite these constraints the 5-minute count data still supported the anecdotal reports on Stewart Is for both common and rare species.

Brown teal, rifleman, mohua, kokako, falcon, weka and probably yellow-crowned parakeets, have gone extinct on Stewart Is within the past 50 years. Birds showing dramatic declines in the past 100 years include kereru, kaka, kakapo, robin and New Zealand dotterel. Bird populations on Stewart Is therefore exhibit similar patterns of extinctions and declines as found on the South Is despite the absence of mustelids and little forest clearance. The decline of birds such as kaka has often been attributed to stoats (Wilson *et al.* 1998), but it appears that predators other than stoats have caused similar declines in kaka and other native forest bird species on Stewart Is.

The timing of extinctions and contractions can give some idea of the relative impact of the various predators present at the time. For example, the South Is saddleback and New Zealand snipe did not survive with Norway rats or cats, and were extinct on the Stewart Is by 1900 (Heather & Robertson 1996). They may have been able to survive with the Pacific rat however, as they have existed on New Zealand offshore islands where Pacific rats are present (Miskelly 1987). Several species declined sharply on Stewart Is during the 1st half of the 20th century. This suggests that the predators introduced around 1900, namely ship rats and possums, were responsible for their demise, or that conditions changed that improved conditions for existing predators, such as cats.

Cats are known bird predators on Stewart Is (Karl & Best 1982) and probably extirpated several of the ground-living birds, including brown teal and weka. In the case of weka, their decline occurred over at least 50 years, which suggests predation may have shifted from the 'easy' prey to weka relatively late in the period. If cats were killing slightly more weka than were being recruited during the last 50 years then the weka population would have declined relatively quickly. There appears to have been a wave of weka extirpation, beginning in southern Stewart Is around the 1950's, and finishing with the last birds being seen in the vicinity of the north coast sometime around the late 1980's or early 1990's. Disease is also a possible reason for the weka extinction, but evidence of diseased birds is lacking and the apparent south-north infection spread, over several decades, appears inordinately attenuated. The continued existence of kiwi is puzzling, as cats are predators of young kiwi in the North Is (McLennan *et al.* 1996). Cats did not eradicate North Is Kiwi on Little Barrier Is for the 100 or so years that both were present however, and cats are in low densities on Stewart Is (Harper 2007). Survival of kiwi young is high on the island and the absence of stoats as an additional predator may help kiwi to maintain their abundance.

Although cats are predators of ground nesting birds (Sanders & Maloney 2002), the role of cats in the extinction or reduction in abundance of extant volant forest birds is less likely. The eradication of cats from Little Barrier Is by 1980 appears to have had little effect on the abundance of tree-nesting birds there, although ground nesting petrels were severely affected (Giradet *et al.* 2001). As cats hunt on or near the ground their impact on Stewart Is is now restricted to flying birds that forage on or near the ground, such that birds constitute about 14% of feral cat diet by weight (Karl & Best 1982, Harper 2005a). Similarly, cats preferentially prey on rats, rather than birds, even when rat numbers are very low, and cats are in very low densities (Harper 2007), so encounters with birds are probably infrequent.

The adept climbing abilities of ship rats make them ideal predators of tree-nesting birds that would have been previously largely safe from the Norway rat, or cats. The Pacific rat, although arboreal, may have had a less severe impact on tree-nesting birds due to its smaller size. Ship rats have largely displaced the Pacific rat and Norway rats on Stewart Is (Harper *et al.* 2005) as they have on the South Is. Ship rats were conspicuous around bush camps by 1910 (Guthrie-Smith 1914) and were probably the dominant rat in the podocarp forest by the early 1900's.

Podocarp-broadleaf forest probably provides a less variable food supply for ship rats and consequently supports higher rat abundances than southern beech *Nothofagus* spp. forest on the South Is (Innes 1990, Harper 2005b). This has probably kept ship rat numbers relatively constant compared with the boom and bust population cycle in pure *Nothofagus* forest (King & Moller 1997). Like *Nothofagus* forest, podocarp-broadleaf forest has mast species, such as rimu, and consequently does have associated rat plagues (Harper 2005b). Plagues of ship rats, associated with recent rimu mast seed events, were noted on Stewart Is in various years; late spring and summer 1974-75 (Traill 1981, Buckingham 1981b), in subalpine scrub in Aug 1978 (Garrick 1978), summer 1978-79 (Wilson 1987, Powlesland *et al.* 1992), summer 1981 (Powlesland 1992), summer and autumn 1985 (Powlesland *et al.* 1992), and spring 2002 (Harper 2005b.). Ship rat plagues on the South Is doubtlessly add to the constant predation pressure on nesting mohua, yellow-crowned parakeets and other hole-nesting birds (Elliott *et al.* 1996). Mohua are likely to quickly become extinct under continuously high levels of predation (Elliott 1996). Although extinct now, mohua, riflemen and both species of parakeets were once common in podocarp forest near Lake Brunner (Smith 1888), on Stewart Is (Cockayne 1909, Guthrie-Smith 1914), and mohua were also

common in lowland forest around Invercargill (Philpott 1914), despite the presence of Norway rats and cats (Thompson 1922).

The densest populations of mohua, yellow-crowned parakeets and rifleman are now largely restricted to high altitude *Nothofagus* forest on the South Is (O'Donnell & Dilks 1986). This suggests that the current distribution of these birds may be restricted by the distribution of ship rats. In contrast to their densities in podocarp-broadleaf forest, ship rats are generally in extremely low numbers in high-altitude *Nothofagus* forest due to the cold climate and irregular food supply (Innes 1990). However, a recent seed-mast of *Nothofagus* 2 years in succession and a mild winter during 1999-2000 resulted in high ship rat numbers on Mt Stokes, Marlborough Sounds, and the probable extinction of mohua there (Studholme 2000). The distribution of the brown creeper, may also be affected by ship rat distribution. On Stewart Is, brown creeper are now generally only found in sub-alpine and manuka shrubland, forest types with low abundances of ship rats. On islands without ship rats however, they are common in podocarp-broadleaf forest (Whenua hou, Ulva, Chalky/Te Kakahu [Fiordland], *pers. obs.*) and are more common in high altitude forest than lowland forest on the South Is (O'Donnell & Dilks 1986, Wilson *et al.* 1988). As they are not an obligate hole-nester like mohua, brown creepers probably survive on Stewart Is as they nest in shrubland, with few ship rats. Predation rates also seem to be affected by the habitat preferences of the predators. The difference in habitat use by robin and brown creeper between Stewart Is and adjacent predator-free islands suggests that the robin and brown creeper are restricted to forest types that introduced predators do not prefer.

Possums are predators of nests, chicks and adults of kaka (Moorhouse *et al.* 2003), kokako, kereru, kiwi (Sadleir 2000), and small introduced passerines (McLeod & Thompson 2002). They probably also compete for nest sites with hole nesting birds (Cowan 1990) and may act as a significant nest-disturbance factor. They are probably not as destructive as ship rats, however. Kaka densities on Kapiti Is in the North Is and on Whenua Hou remained relatively high despite the presence of possums and Pacific rat and/or Norway rats (Blackburn 1965, Wilson *et al.* 1998), although on Kapiti Is, kaka numbers did increase after eradication of possums (Heather & Robertson 1996).

Yellow-crowned parakeets are likely extinct on Stewart Is, whereas red-crowned parakeets are common. On the South Is the reverse is true, with yellow-crowned parakeets the predominate species. Both species are vulnerable to predation; they both declined in abundance on Taukihepa after the ship rat irruption there in 1964 (Atkinson

1984). As red-crowned parakeets are more common than yellow-crowned parakeets on islands with kiore or ship rats (*pers. obs.*), it appears yellow-crowned parakeets are particularly impacted by rats. The dramatic recovery of yellow-crowned parakeet numbers on Taukihepa/Big South Cape and Whenua Hou after the eradication of ship rats and kiore respectively, supports this conclusion. However, rats did not eliminate the yellow-crowned parakeet populations on either island, which suggests additional predators, cats or possums, had to have been present to cause their extinction, as is the case on Stewart Is. This marked contrast in species composition between Stewart Is and the South Is suggests species-specific vulnerabilities to different predators, possibly during the nesting stage, and deserves further investigation.

Both species of cuckoo are now uncommon on Stewart Is, but common on islands like Whenua Hou. This apparent decline may be due to deleterious changes within their winter ranges in the South Pacific, however the discrepancy in abundance between New Zealand offshore islands with few/no mammalian predators and Stewart Is suggests a role for introduced predators. Declines in the brood parasites of each cuckoo species is likely to coincide with declines in their hosts. In the case of long-tailed cuckoo, the extinction of mohua and decline in brown creeper on Stewart Is would have severely restricted the availability of suitable nests.

Current distributions of native forest bird species, including rifleman, robin, kakariki, and mohua, on Stewart Is and probably on the South Is, appear to be restricted by the habitat preferences of introduced mammalian predators. Strongholds for these species on the South Is are montane beech forest, or dry shrubland, where predator numbers are generally the lowest (O'Donnell & Dilks 1986, Innes 1990, Clout & Gaze 1984), which have implications for the positioning of 'mainland islands' on the South Is. The 2 current mainland islands, Rotoiti and Hurunui, are in montane beech forest (Saunders 2000), in which several vulnerable native passerines (e.g.: mohua, parakeets, rifleman) are largely restricted as relict populations. This forest type is probably sub-optimal habitat for small passerines due to the cooler climate, poor fertility, lower plant diversity and more simple forest structure. This would suggest that mainland islands in lowland forest would sustain higher densities of various bird species that are now missing in these more diverse, fertile and climatically benign forest types.

The consequence of having a guild of 5 mammalian bird predators on Stewart Is is a similar pattern of declines and extinctions as has occurred on the South Is, despite the lack of mustelids on the

former. Predation by rats and feral cats coupled with opportunistic predation and nest disturbance by possums probably caused the recent declines of many bird species on Stewart Is, especially in podocarp forest. Possum abundance, like that of ship rats, is generally low on Stewart Is, but they are ubiquitous and in higher densities than feral cats (Harper 2002), so encounter rates with birds and nests are probably more frequent than for cats. Competition for food with these omnivores, and associated changes in forest structure and diversity caused by possums and deer, probably also contributes to declines in forest birds, by reducing food availability and quality (Allombert *et al.* 2005).

The conclusions of this review are relevant to the recent debate on agents of decline in birds on islands worldwide (Blackburn *et al.* 2005a, Didham *et al.* 2005). Although habitat loss has not occurred to any significant degree on Stewart Is, there have been numerous extinctions, mainly driven by introduced mammalian predators. However, damage to forest caused by introduced browsers has probably exacerbated the effects of introduced predators. So although habitat destruction *per se* has not occurred, the habitat is in poor condition and unlikely to support pre-browser densities of at least some birds (Allombert *et al.* 2005). Reduced populations of birds would then, in turn, be more susceptible to losses caused by introduced predators, although it is unlikely habitat damage alone would cause extinctions (Allombert *et al.* 2005). As population sizes reduce, additional extinction drivers related to losses of genetic diversity, Allee effects and stochastic events like storm events and predator irruptions would provide additive effects to hasten declines. On a large island like Stewart Is, these latter effects would have had little impact on large populations of birds on their own (Duncan & Blackburn 2007). Similarly, there is an additive effect of having several predator species present, as some (rats) are also the principal prey for others (cats) and maintain higher densities of the top predator than would be present without rats (Harper 2005a). This would result in more intense and diverse predation pressure than would occur with fewer predator species present (Blackburn *et al.* 2005b). Luckily, the suite of predators extant on Stewart Is does not include mustelids, or the list of extinctions would likely be larger.

Although interacting drivers of extinction have caused losses of bird species on islands elsewhere (Didham *et al.* 2005), the principal driver for extinctions on Stewart Is appears to have been the introduction of a limited suite of mammalian predators, as the habitat is largely intact, albeit damaged. In any case, several extinctions of forest birds on Stewart Is have occurred relatively recently, and for some species, like kaka, kereru and robin,

their precipitous decline may portend the same outcome.

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