Review of Canada Goose Population Trends, Damage, and Control in New Zealand

Eric B. Spurr

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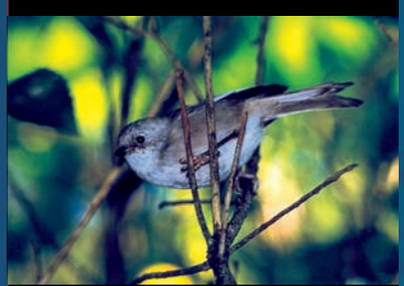
Landcare Research



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Contents

Summary

The history and management of the Canada goose (*Branta canadensis* L.) in New Zealand are briefly reviewed. The species was introduced to New Zealand as a recreational hunting resource, and while it remains so it has also become an agricultural and urban pest. It is currently listed as a game bird in the First Schedule to the Wildlife Act 1953, but this classification is currently being reviewed by the Minister of Conservation. Population trend counts in the South Island, where the species first became established in 1905, have been relatively stable over the last decade, after about 80 years of rapid increase. However, they are expanding their range outside trend count areas. Population trends in the North Island, where the species was first introduced in 1970, indicate rapidly increasing numbers. Most geese breed around inland high-country lakes and rivers and then move to coastal lakes and rivers to moult and feed for the remainder of the year. Damage by geese is multifaceted, but their economic impacts are largely unknown. In rural areas, they show a strong preference for pasture, especially newly sown grass, and compete for it directly with stock. They also foul pasture with their droppings, and these deter grazing by sheep and cattle. In urban areas, goose droppings foul parks and sports fields, and may constitute a public disease risk, while their presence around airports increases the risk of bird strikes. In the light of these impacts, numbers are considered too high by both farming interests and urban authorities. Goose management both within New Zealand and overseas is discussed. Lethal control through recreational hunting is the management option preferred by local Fish & Game councils. However, because recreational hunting alone is insufficient to control goose numbers, official culling operations are recognised as necessary to supplement hunting. Egg destruction is no longer widely practised. Various physical scaring devices have generally little long-term benefit, and toxic baits and chemical repellents have limited local application. Further research is needed to quantify the costs of goose damage, develop cost-effective methods of goose control, and improve the monitoring of goose population trends.

Introduction

The Canada goose (*Branta canadensis* L.) was introduced to New Zealand from North America by the Government and regional acclimatisation societies (now Fish and Game New Zealand) as a recreational hunting resource (Fish & Game 1995). The first introduction was in 1876, but geese became established only after the liberation of 50 birds, spread around various parts of the country, in 1905 (Thomson 1922; Imber 1971a, 1971b, 1985; Williams 1981; McDowall 1994; Appendix 1). The species flourished in the South Island, but died out in the North Island by 1930, and was only reintroduced there from the South Island in 1970. In the South Island, Canada geese are now abundant in eastern districts, from Marlborough to North Otago, and common in the drier tussock country of eastern Fiordland. In the North Island they are now well established around Lake Wairarapa, coastal Manawatu, northern Hawke's Bay, the Taupo–Ohakune area, and the Waikato (Heather & Robertson 1996). They are still expanding their range in both islands.

Canada geese have become a problem in New Zealand because they inhabit, almost exclusively, privately owned or leased farmland (Imber & Williams 1968). During the breeding season most geese nest on high-country farmland, at least in the South Island, but some also nest in coastal areas. During the non-breeding season they congregate on inland or coastal waterways, such as Te Waihora (Lake Ellesmere) in the South Island and Lake Wairarapa in the North Island, and graze on adjacent developed farmland. They eat mainly pasture plants such as grass, clover, and lucerne, and also crops such as brassicas, peas, and grain (Heather & Robertson 1996). These feeding habits bring them into conflict with farmers (Leathers & Costello 1986; White 1986; Harris et al. 1987; Costello et al. 1988; Potts & Andrew 1991; Holloway et al. 1997, 1998; Win & Hickling 2000, 2001; Win 2001). Other problems arising from Canada geese include defecation (fouling) on pasture, public parks, golf courses, and sewage treatment ponds, the potential to transmit diseases to other animals and humans, the threat to aircraft safety around airports, and a general nuisance simply from their presence in urban areas.

Canada geese were totally protected until 1931, apart from brief hunting seasons in May 1925 and May 1926, when a few geese were shot (Lamb 1964; Imber & Williams 1968; McDowall 1994; Holloway et al. 1997). Legal protection was reduced in 1931 as a result of increasing goose numbers and complaints from farmers of increasing goose damage. Following the change in legal status, geese could be killed anywhere and anyhow except that (a) they could not be shot during the month (April) preceding the winter open season for waterfowl, (b) they could be shot only by persons holding a waterfowl hunting licence and in compliance with waterfowl shooting regulations during the winter open season, and (c) they remained protected in certain coastal areas, including Te Waihora, except during special hunting seasons (Imber & Williams 1968).

When the Wildlife Act 1953 was enacted, the Canada goose was included in the Fourth Schedule (wildlife not protected except in areas and during periods specified by a Ministerial notice published in the Gazette) (DOC 1991; McDowall 1994). This allowed unrestricted goose control by farmers and others as considered necessary, using whatever methods were deemed appropriate, except where specifically limited by the Minister. In 1959, the Canada goose was transferred to the Third Schedule to the Wildlife Act (wildlife that may be hunted or killed, subject to Ministerial notice). This gave the bird partial protection, and the Wildlife Service of the Department of Internal Affairs became the agency directly responsible for the management of the species. Control operations by farmers were allowed, including moult culls and bird drives using fixed-wing aircraft (DOC 1991). However, after a number of incidents involving aircraft and harassment of the native paradise shelduck (*Tadorna variegata*) in the period 1959 to 1973, the Wildlife Service and various regional acclimatisation societies pushed for increased protection of the Canada goose.

In 1966, the Canada goose was declared a game bird, under the First Schedule to the Wildlife Act, in coastal Canterbury and Otago, where most recreational hunting occurred, but remained in the Third Schedule elsewhere. In 1973, it was included in the First Schedule as a game bird throughout New Zealand. The Wildlife Service (now Department of Conservation or DOC) assumed responsibility for authorising hunting seasons and permits to hunt or destroy birds causing damage outside hunting seasons or using methods not legally allowed, and Fish and Game New Zealand (Fish & Game) assumed responsibility for issuing hunting licences and enforcing the regulations of the Wildlife Act (Costello et al. 1988; DOC 1991).

In the early 1990s the Minister of Conservation asked Fish & Game to prepare a management plan for the species under sections 17L and 17M of the Conservation Act 1987. A 5-year Canada goose management plan for the South Island (excluding the West Coast Fish & Game region) was implemented in March 1995. It set target levels for Canada goose numbers, assessed by annual aerial surveys (known as June trend counts) in 20 management areas within five Fish & Game regions. These target levels added up to a total of 20,350 geese (Fish & Game 1995). A subsequent 5-year plan (Fish & Game 2000) was drafted for 32 management areas, with a total upper target level of 37,700 and a lower target level of 23,150 geese. A new 5-year plan is currently being drafted (as at June 2005), with an upper target level of 38,100 and a lower target level of 23,350 geese. The overall goal of the South Island Canada goose management plan is to maximise the recreational harvest and minimise the adverse effects of Canada geese. Specific objectives include (a) monitoring trends in the population and recreational harvest, and (b) managing the population to the defined levels in individual management areas. Surprisingly, there is no specific monitoring to determine whether any management action is minimising the adverse effects of Canada geese. The cost to Fish & Game of operating the management plan is approximately $100,000 per annum (M. Webb, Fish & Game, pers. comm. 2005). Government funding for Canada goose control ceased in 1990, and currently Fish & Game is funded entirely from licence fees from anglers and hunters (Fish & Game 1995).

Regional councils currently have no legal jurisdiction over Canada geese because, although they can normally declare introduced harmful animals as pests in their regional pest management strategies under the Biosecurity Act 1993, the provisions of the Wildlife Act are retained in the Biosecurity Act and regional councils must comply with these provisions (R. Phillips, Convenor, Biosecurity Managers Group, pers. comm. 2005). However, this situation may change. The Minister of Conservation has initiated a review of the status of various species, including the Canada goose, listed on schedules to the Wildlife Act (M. Gee, DOC, pers. comm. 2005). If the Canada goose ceases to be listed as a game bird, regional councils may have to take over management of the species wherever it is deemed to be a pest. This will require the development of improved and publicly acceptable methods of controlling goose numbers.

Below we briefly review Canada goose management issues in relation to population trends, damage, and methods of control.

Methods

Information on Canada geese was obtained from the authors' own databases and by conducting a literature search using the Internet search engine Google™ and the Internet version of CAB Abstracts® (1973–present) and Current Contents® (1998–present), for the terms "Canada goose" and "Canada geese", by searching the Fish & Game website (www.fishandgame.org.nz), and by contacting staff from Fish & Game (B. Abernethy, J. Graybill, B. Johnson, R. Millichamp, M. Rodway, M. Webb), regional councils (W. O'Donnell, R. Phillips), Christchurch International Airport Ltd (O. Stewart), Federated Farmers (C. Pederson, A. Mitchell), a local farmer (R. Grigg, Barrosa Station, Mt Somers), and other researchers (R. Barker, University of Otago; C. Pennell, AgResearch).

Results

Breeding biology

In the South Island, most Canada geese breed near high-country lakes and rivers, but some breed near coastal waterways, such as Te Waihora and Lake Forsyth (Waiwera), where they remain year round (Imber 1971b, 1985; Williams 1981; Potts 1984; White 1986; Heather & Robertson 1996). In the northern South Island, many non-breeders and unsuccessful breeders fly from the high country to coastal lakes and estuaries in November–December for the autumn moult, where they may form flocks of up to 2,000 birds. The moult occurs in late December to early January. Successful breeders moult in nesting areas while attending their young. Many successful breeders and their young leave the high country in late January to early February after the moult and join the flocks on coastal lakes and estuaries. Geese usually then remain on the coastal waterways throughout the winter, feeding on adjacent pastures and crops. They fly back to the high country in late August or early September to breed. However, some successful breeders remain in the high country all year round, feeding on pastures adjacent to inland waterways. In the southern South Island, moulting geese tend to move to inland waterways (e.g. upper Waitaki, upper Clutha, and the Southern Lakes) rather than to coastal waterways (M. Webb, Fish & Game, pers. comm. 2005). Similar patterns occur in the North Island, where most birds breed in the hill country and move to coastal lakes (e.g. Whakaki Lagoons and Lake Wairarapa) to moult (B. Abernethy, Fish & Game, pers. comm. 2005). However, as in the South Island, some birds breed in coastal areas, where they remain year round. At least one bird marked in Marlborough has crossed Cook Strait and was resighted in the Wairarapa (B. Abernethy, Fish & Game, pers. comm. 2005).

Egg-laying occurs from mid-September to late October, though replacement clutches may be laid in November (Williams 1981; Imber 1985; Heather & Robertson 1996). The clutch size is most commonly 4–5, but may be up to 10 eggs. Incubation is about 28 days (by the female only), and the eggs hatch synchronously. Fledging occurs after about 80 days. Birds tend to nest in the same site each year. They typically nest in loose colonies in lowland areas, but in a more dispersed manner in the high country (Holloway et al. 1997). Males weigh about 5.4 kg, females 4.5 kg (Williams 1981; Heather & Robertson 1996). About 20% of males start breeding when 2 years old, and almost all males are breeding when 3 years old (Imber 1971b). Practically no females breed when 2 years old, more than half breed when 3 years old, but some do not start breeding until 4 years or older (Imber 1971b). They may continue to breed for 25 years. The average life expectancy is 2.8 years, and the maximum is over 30 years (Heather & Robertson 1996). Mortality is 45% in the first year and 30% annually thereafter (Williams 1981); 20% from hunting, 10% natural (Heather & Robertson 1996).

Population trends – qualitative data

Total counts of the Canada goose population in New Zealand have never been made, but some idea of the population trend since introduction of the species may be gained from qualitative anecdotal historical data (Appendix 1). These have been used to construct Fig. 1.

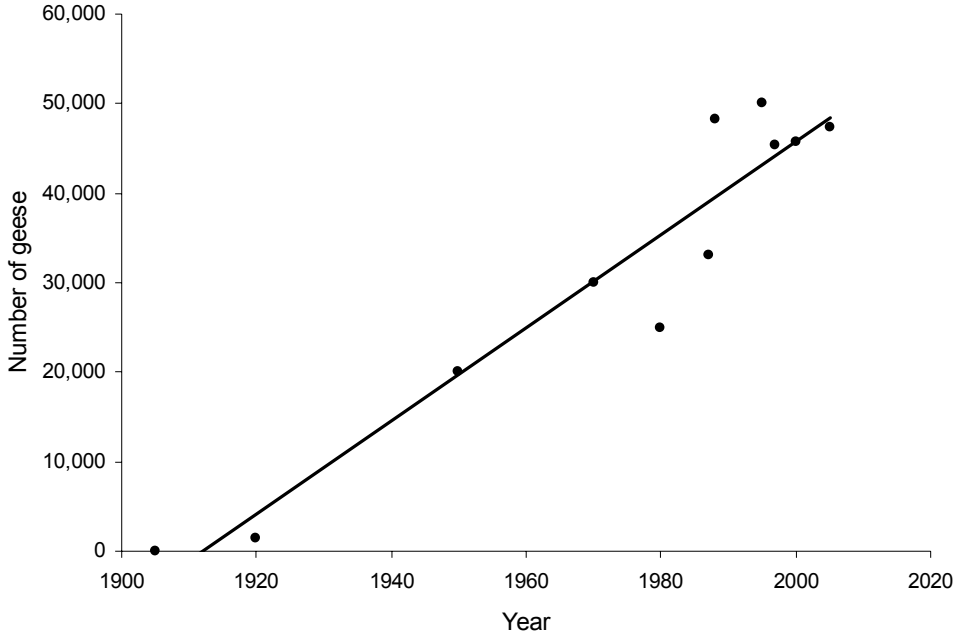

Fig. 1 Canada goose population trend in New Zealand since establishment, based on anecdotal historical data (see text and Appendix 1).

The Canada goose population in New Zealand is considered to have originated from fewer than 43 birds, because some of the 50 birds introduced in 1905 died without breeding (Imber 1971a, 1985). By 1915, the species was "doing well" in several parts of New Zealand (Thomson 1922; Long 1981). By 1920, the population had increased to flocks of up to 300 birds in several places (Imber 1971a). For the purposes of constructing Fig. 1, the total population in 1920 is assumed to have been 1,500. Despite the increasing population, 10 additional geese were liberated in North Canterbury in 1920, and an unknown (small) number in Otago in 1923 (McDowall 1994). By 1924, the species was reported to be increasing rapidly in Canterbury (Lamb 1964). By the 1930s, goose numbers in the South Island had increased to the extent that farmers complained about damage to their pastures and crops (Lamb 1964; Imber & Williams 1968; Holloway et al. 1997). However, the species is reported to have died out in the North Island (Long 1981). By the late 1940s to early 1950s, the goose population was estimated to have been more than 20,000 (Williams 1981; Imber 1985). As a result of continued complaints from farmers, more than 3,000 geese were killed in North Canterbury in 1950–51, and another 1,700 geese and 1,150 eggs were destroyed in 1951–52 (Imber & Williams 1968). These actions may have at least temporarily halted the presumed exponential rate of increase in the population. However, the population continued to increase from 1957 to 1962 (Imber & Williams 1968). In January 1963, in the first special hunting season, almost 6,000 geese were shot on Te Waihora (Williams 1981). If this represented 20% of the geese present in the South Island, as suggested by Imber & Williams (1968), then the population at that time must have been about 30,000. Certainly by the late 1960s, there were an estimated 30,000 geese in the South Island (de Lacy 1984). In 1970, about 200 geese were introduced from the South Island to Lake Wairarapa in the North Island, but the population increase there has not been as rapid as in the South Island (see below).

From 1976 to 1980, some 8,979 eggs and more than 105 adult geese were destroyed in South Island operations (Holloway et al. 1997). In 1980–81, the number of geese in New Zealand was estimated as 20,000 (18,000 in the South Island, which is lower than in the 1940s, and at least 800 in the North Island) (Williams 1981). However, the South Island figure is likely to be an underestimate, because an aerial survey over part of the South Island produced a count of more than 19,000 geese in April 1980 (Potts 1984). Assuming 80% of the birds present were counted (see below), the New Zealand population at that time is more likely to have been about 25,000 geese (perhaps 24,000 in the South Island and 1,000 in the North Island). In the early 1980s, pastoral development in the South Island high country, including pasture improvement, irrigation, and fertilisation of large tracts of tussock grassland and semi-developed pasture, enhanced the food supplies and increased the breeding success of geese (Caithness 1982; Potts 1984; White 1986; Holloway et al. 1997). As a consequence, further egg destruction and goose culling operations were initiated. Some 14,141 eggs, 622 flappers, and more than 30,271 adult geese were destroyed between 1981 and 1989 (Holloway et al. 1997). Despite these culls, the population increased rapidly during the 1980s. In 1988, an aerial survey over part of the South Island produced a count of 37,000 geese (extrapolated from Holloway et al. 1997), which, based on the assumptions above, would indicate a New Zealand population of about 48,000 geese. In the mid-1990s, there were an estimated 40,000 geese in the South Island and 10,000 in the North Island (Heather & Robertson 1996). In 1997, the total New Zealand population was estimated as 36,000–43,000 geese, of which 28,000–35,000 (approximately 80%) were in the east coast of the South Island, a few in the west coast, and 8,000 in the North Island (Holloway et al. 1997). Although recent aerial surveys in the South Island indicate that population along the survey lines has not changed since the mid-1990s, it is likely to be still increasing nationally because of an expanding distribution (see below).

We have fitted a linear line to the historical and anecdotal data of Canada goose population increase in New Zealand, to indicate how much it has increased since introduction (Fig. 1). It was not realistic to fit the traditional logistic (sigmoid) population growth curve to the data. Both hunting/culling pressure and environmental changes have impacted upon the goose population, and it is likely that there have been two or more sigmoid trends. Thus, the population probably increased relatively slowly until about the 1930s, then increased rapidly in the 1940s and 1950s, but tapered off in the 1960s with the imposition of special hunting seasons. It increased rapidly again in the 1980s with irrigation, fertilisation, and improvement of high country pasture, but may have tapered off again in the 1990s with the imposition of organised culling operations under the South Island goose management plan.

Population trends – quantitative data

Canada goose population trends in the South Island are currently monitored annually by Fish & Game, in two ways:

- Aerial counts of geese, originally in April now in June (known as the trend count)
- Game hunter surveys, in June or July (at the end of the hunting season).

The only North Island population trend data we have obtained are aerial counts of moulting geese in January on Lake Wairarapa (B. Abernethy, Fish & Game, pers. comm. 2005) and ground counts of moulting geese in January–February on the Rotorua Lakes (Innes et al. 1999; Griffiths & Owen 2001).

Trend counts

Goose-population trend counts in the South Island began in 1975, from a light aircraft following a set flight path, covering most of the major high-country valleys within the then Canada goose range (see map in Potts 1984). Until 1985 they were undertaken in April each year. In 1985 and 1986, counts were made in both April and June, and from 1987 onwards only in June (Holloway et al. 1997)[1]. June counts were expected to provide a better index of the population than April counts (J. Andrew, DOC, Christchurch, pers. comm., in Holloway et al. 1997). June counts were up to 40% higher than April counts, as a consequence of snowfall forcing birds to congregate where they could be counted more easily and the addition of a new flight path to include a number of areas where goose usage had recently increased (Holloway et al. 1997). Initially, June counts were made only in the Nelson/Marlborough, North Canterbury, and Central South Island regions, and it was not until 1993 that they were made in all South Island regions. Since then, the counts have been made in the same areas each year. They are made over a period of only a few days, thus limiting double counting or missing birds that fly between areas. The survey methodology was designed to provide an index of the goose population. It was not designed to determine the absolute size of the population (i.e. it was not a census of Canada geese) because flights do not occur over all areas where geese occur. However, even as a population index the counts may be biased because the trend count survey lines are not randomly distributed. Also, geese have become wary of aircraft (both fixed-wing and helicopter) and so the counts may underestimate the numbers present on the flight paths. This was demonstrated by ground-based observations of geese flying off before the survey aircraft arrived, and a comparison of aerial and ground counts of the same areas (de Lacy 1984). Thus, counts may represent anywhere from 50 to 90% of the total population, with an average of perhaps 80% (M. Webb, Fish & Game, pers. comm. 2005). Counting error cannot be assumed to be constant from year to year (e.g. because of variations in weather conditions, and late or early seasons affecting the dispersion of geese), and so counts should not be compared from one year to the next (Potts 1984). However, trends in goose numbers over time can be determined validly from a series of counts (Fig. 2).

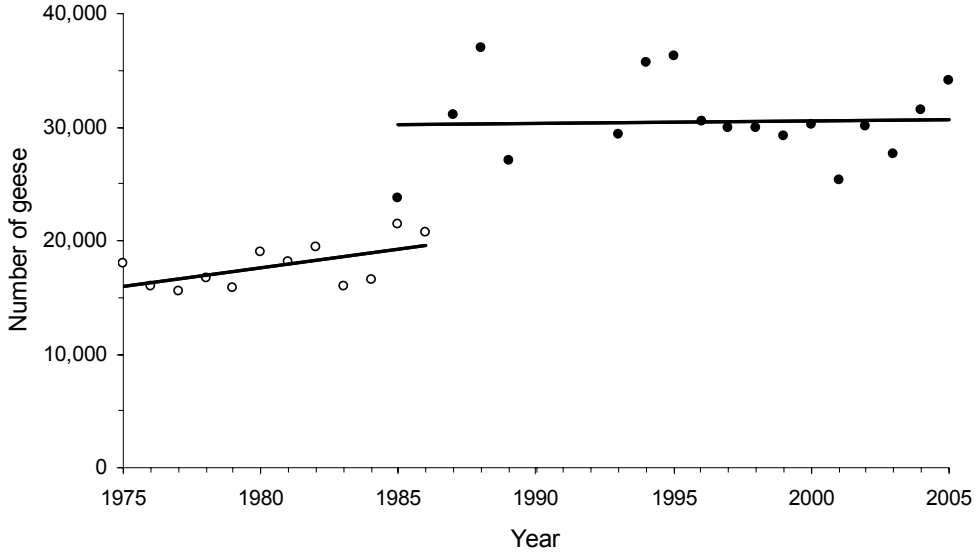

Fig. 2 South Island Canada goose population trend from counts in April 1975–1986 (○), and June 1985–2005 (●) (from Potts 1984; Holloway et al. 1997; M. Webb, Fish & Game, unpubl. data 2005).

[1] There is some confusion over the years in which double counts were made, because Holloway et al. (1997, p.4) said there were double counts in 1984 and 1985, but their graph (Fig. 4) shows double counts in 1985 and 1987.

A regression analysis of April aerial trend counts from 1975 to 1983 indicated no significant change in the South Island Canada goose population over that period, although numbers increased in the Upper Wairau-Hurunui and Upper Waitaki/Mackenzie Basin and decreased in coastal North Canterbury (Potts 1984). Population control measures (including egg-pricking and culling of moulting birds – see below) commenced in 1980, and Potts (1984) suggested that these may have caused the reduction in Canada goose numbers recorded in 1983. However, subsequent counts did not support that interpretation (Holloway et al. 1997). A regression analysis of April aerial trend counts for an extended period (1975 to 1986) indicated a marginally significant increase in the Canada goose population ($t_{10} = 2.28$, $P = 0.046$, $r^2 = 0.342$) (Fig. 2). However, as can be seen from the graph, numbers counted have fluctuated considerably from year to year.

A regression analysis of June aerial trend counts from 1985 to 2005 indicated no significant change in the South Island Canada goose population over that period ($t_{15} = 0.15$, $P = 0.886$, $r^2 = 0.001$) (Fig. 2). Again, there were large fluctuations in the population from year to year. However, the data indicate that the goose population has changed little since the implementation of the goose management plan in 1995. The number counted in 1995 (36,287) was similar to that counted in 2005 (34,144), indicating little real change over the intervening period. The average number counted from 1995 to 2005 was 30,420 (M. Webb, Fish & Game, unpubl. data).

Population trend counts in the South Island have varied regionally and over time (M. Webb, Fish & Game, unpubl. data). In Nelson/Marlborough, numbers counted at the start of the goose management plan in 1995 (1,241) were similar to those 9 years later in 2004 (1,102). In North Canterbury, counts declined from 22,503 in 1995 to 14,468 in 2004 (see also Ross in Rodway 2003a). In the Central South Island, counts declined from 8,832 in 1995 to 6,191 in 2004, and to 4,921 in 2005. However, the decreases in the North Canterbury and Central South Island regions have been offset by increases elsewhere. For example, numbers have increased in Christchurch City where birds usually cannot be shot (A. Crossland, Christchurch City Council, pers. comm. 2005). Numbers have also increased in Otago, from 1,340 in 1995 to 4,169 in 2004 (see also Fitzpatrick in Rodway 2003a), and in Southland from 1,971 in 1995 to 3,355 in 2004 (see also Moss in Rodway 2003a). Even in management areas where numbers have increased, they have seldom exceeded the target upper population levels set in the management plan (Ottmann 2000; M. Webb, Fish & Game, unpubl. data). However, geese have appeared in previously unoccupied areas, possibly as a consequence of enhancement of the habitat (e.g. the creation of new lakes such as Opuha and Ruataniwha, and associated agricultural development adjacent to these lakes) and hunting/culling pressure causing dispersal of birds (M. Webb, Fish & Game, pers. comm. 2005).

In the North Island, the number of moulting Canada geese has increased significantly in the last 20 years on both Lake Wairarapa ($t_{16} = 8.34$, $P < 0.001$, $r^2 = 0.813$) and on the Rotorua Lakes ($t_2 = 6.51$, $P = 0.023$, $r^2 = 0.955$) (Fig. 3). In the Rotorua Lakes district, the number of lakes occupied by Canada geese increased from two in 1985 to seven in 2001. We do not know whether this increase in abundance and distribution is typical of other North Island locations.

Hunter returns

A national game hunter survey has been carried out by Fish & Game annually since 1992. It records the numbers of each game bird species (including the Canada goose) harvested during the waterfowl hunting season (May to July). There was no evidence of any change in the annual hunter harvest of Canada geese nationally over the 5-year period from 1998 to 2002 (Barker in Rodway 2003b).

In the South Island, the number of Canada geese shot by recreational hunters over the period July to June each year has been recorded for some Fish & Game regions since 1985, and for all regions since 1993. There was no evidence of any change in the annual hunter harvest of Canada geese over the 12-year period from 1993 to 2004 inclusive ($t_{10} = 0.71$, $P = 0.493$, $r^2 = 0.048$), although there were

considerable fluctuations from year to year (Fig. 4). The average annual South Island harvest from 1993–2004 was 13,656 geese (M. Webb, Fish & Game, unpubl. data).

In addition to recreational hunter returns, Fish & Game also records the number of geese removed in organised culling operations. From 1993 to 2004, the average annual cull was 7,255 birds, ranging from 14,784 in 1995 to 3,183 in 2002 (Fig. 4). The total number of geese removed from the population annually by hunting plus culling (average 20,911) did not differ significantly over the 12 years ($t_{10} = –0.23$, $P = 0.826$, $r^2 = 0.005$), although there were obvious fluctuations from year to year.

There was no significant correlation between the number of geese removed by hunting and culling combined in the previous year and the population trend count in June, from 1993 to 2005 (Spearman rank correlation, t_{11} approximation = 0.367, $P = 0.721$) (Fig. 5). Furthermore, there was no correlation between the number of geese removed by either hunting alone or culling alone in the previous year and the population trend count in June (Appendix 2). However, there was a strong positive correlation between the population trend count in June and the total number removed from the population in the following year (Spearman rank correlation, t_{10} approximation = 2.864, $P = 0.017$) (Fig. 6). This correlation was due entirely to the number culled not the number shot by recreational hunters (Appendix 3). That is, a high trend count in June prompted a high number to be killed in subsequent organised culling operations (mainly moult culls in the following January), but had no effect on the number shot by recreational hunters the following May–June. However, as noted above, the number culled in January had no effect on the subsequent trend count in June. This implies that when an increased number was culled in January there was a compensatory increase in survival of the remaining juveniles and/or adults. Inter-compensation between hunting mortality and natural survival was also suggested by Imber & Williams (1968, p. 264).

Canada goose damage

Canada geese, because of their feeding habits, compete directly with livestock for pasture and crops. Complaints from South Island high country farmers of goose damage to pasture occurred as early as 1925, and continue to this day. Late summer/early autumn damage is of particular concern, because at that time farmers are trying to maintain autumn pasture for overwintering stock. In spring, geese may eat growing pasture and crops. Preliminary attempts to quantify the agricultural damage caused by geese in the high country were made by Leathers & Costello (1986), White (1986), and Harris et al. (1987). Leathers & Costello (1986) calculated a weighted average annual loss per goose of about $7 (range approximately $2–$14) in 1986 values, based on surveys of farmers. White (1986) obtained a similar figure, and calculated that four geese consume the equivalent of one stock unit. Farmer estimates of goose damage per farm ranged from $1,375 to $47,500. However, losses estimated by a computer-based feed budgeting model were substantially lower, for unexplained reasons (Leathers & Costello 1986; White 1986).

In a more recent study, Canada geese significantly reduced pasture production adjacent to Lake Grassmere, inland Canterbury (Win 2001; Win & Hickling 2001). Daily pasture intake by geese in a 69-ha study area ranged from 90 kg in spring to 490 kg in autumn. The difference in monthly dry-matter production in goose-grazed and ungrazed pasture ranged from less than 100 kg/ha in winter to 900 kg/ha in late summer to early autumn, and was positively correlated with the number of geese present. Densities of grazing geese ranged from 3.7/ha in spring to 20.2/ha in autumn (Win & Hickling 2000).

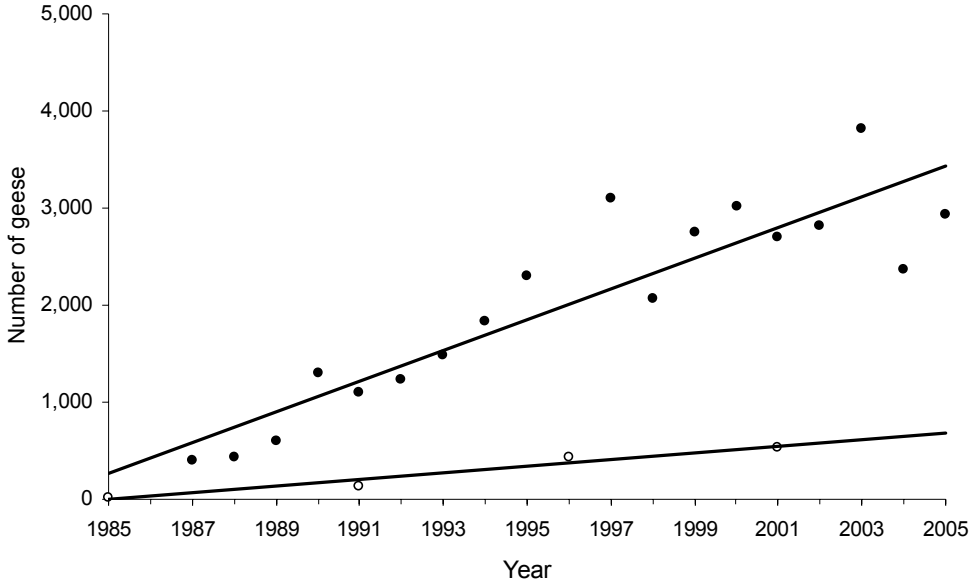

Fig. 3 Canada goose population trends, from counts of moulting birds in January–February, on Lake Wairarapa (●) and the Rotorua Lakes (○) (B. Abernethy, Fish & Game, unpubl. data 2005; Innes et al. 1999; Griffiths & Owen 2001).

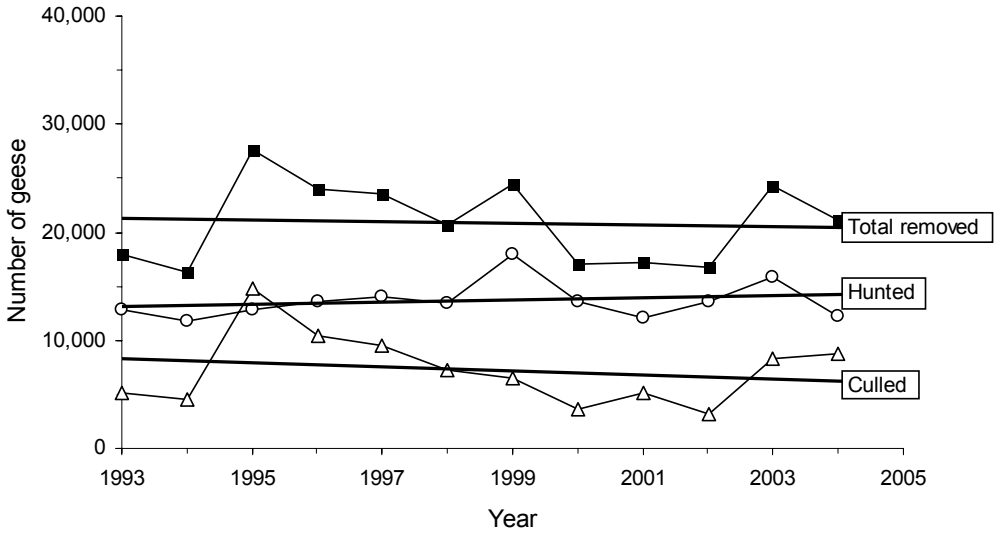

Fig. 4 South Island Canada goose numbers hunted, culled, and hunted plus culled (total removed), 1993–2004 (M. Webb, Fish & Game, unpubl. data 2005).

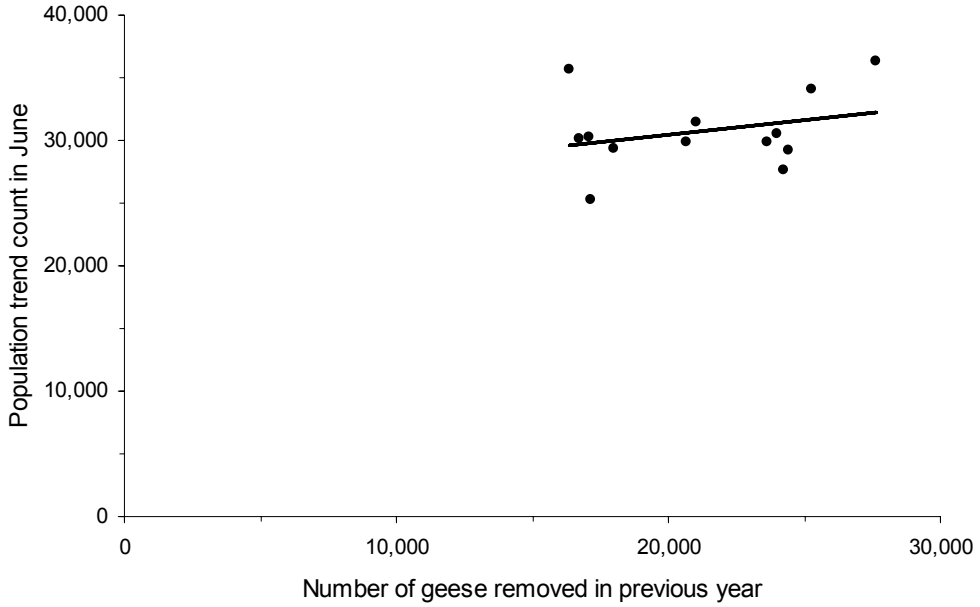

Fig. 5 South Island Canada goose population trend counts in June 1993–2005 (n = 13) in relation to the total numbers removed by hunting plus culling in the previous year (see Appendix 2 for hunting and culling separately) (M. Webb, Fish & Game, unpubl. data 2005).

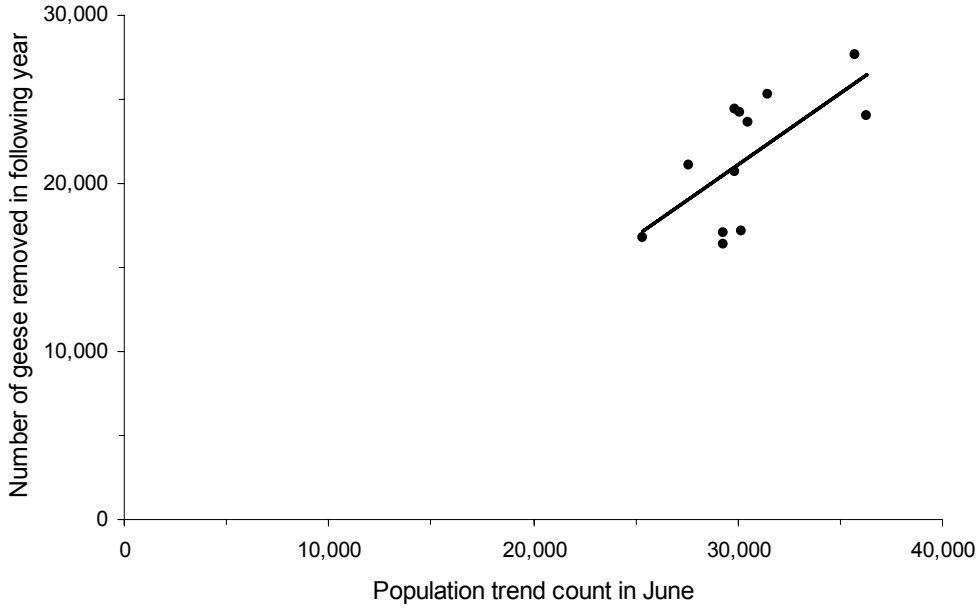

Fig. 6 Numbers of Canada geese in the South Island removed by hunting plus culling in the year following the June population trend count, 1993–2004 (n = 12), in relation to the June population trend count (see Appendix 3 for hunting and culling separately) (M. Webb, Fish & Game, unpubl. data 2005).

Although there have been few studies of the economic impacts of geese, anecdotal accounts of goose damage to pasture and crops abound (e.g. Lamb 1964; de Lacy 1984; Ward 1984; Costello et al. 1988; McDowall 1994; B. Abernethy, Fish & Game; R. Grigg, Barrosa Station, Mt Somers; C. Pedersen, Federated Farmers; and W. O'Donnell, Greater Wellington Regional Council, pers. comm. 2005). Geese in areas of dryland grazing appear to favour fields adjacent to lakes, irrigated pasture, and emergent re-sown pasture, and are most damaging on annual compared with perennial pasture. These feeding preferences result in a small percentage of farmers "hosting" most geese and incurring most goose damage, while many farmers rarely if ever see geese on their property. For example, only 15–20 of 300 farm properties in the South Island high country in the mid 1980s reported unacceptable levels of goose damage (White 1986). However, this pattern of goose dispersion may be influenced by weather patterns, with geese being widely distributed during wet years and more localised on damper or irrigated pastures during dry years. A dramatic example of this occurred in the Wairarapa in 2005, when many new pastures were sown following widespread flooding, providing unique local grazing opportunities for geese, and goose damage reached record levels (W. O'Donnell, Greater Wellington Regional Council, pers. comm. 2005).

As well as damaging pasture, Canada geese may also damage crops; e.g. turnip crops sown for winter fodder (Leathers & Costello 1986; White 1986; Potts & Andrew 1991). Large numbers of geese have also been seen feeding on spilled grain in stubble fields (White 1986; Potts & Andrew 1991; Holloway et al. 1997), and on emergent autumn-sown cereals (C. Pedersen, Federated Farmers, pers. comm. 2005). However, goose damage to crops is generally minor. Only 2% of 100 arable farmers surveyed in Canterbury in summer 2000 reported damage by Canada geese (Coleman & Spurr 2001), with both observations involving geese grazing on emergent peas.

Canada geese foul pasture with their droppings, and stock may avoid fouled areas (Leathers & Costello 1986; White 1986). However, forage around fresh droppings remains edible to stock despite preferences for non-fouled forage (White 1986). Furthermore, goose droppings may encourage compensatory pasture growth later in the year (Brazely & Jefferies 1985).

Canada geese are carriers of a number of significant diseases, including avian influenza, *Campylobacter*, *Escherichia coli*, and *Salmonella* (Clark 2003). They have the potential to transmit these diseases to humans and livestock, although definitive data are lacking. Canada geese also carry some of the same parasites carried by native waterfowl such as paradise shelduck, grey duck (*Anas superciliosa*), shoveler (*Anas rhynchotis*), and scaup (*Aythya novaeseelandiae*), and could be acting as alternative hosts from which potentially deleterious 'spillback' of infection to native hosts could occur (Tompkins & Poulin in press).

Canada geese have caused nuisance problems within urban areas of Christchurch (e.g. in city sports fields, around Horseshoe Lake, and around the Bromley sewage treatment ponds and adjacent Travis Reserve wetlands). This has led to limited culling, carried out against some public opposition (G. Ottmann, pers. comm., in Win 2001).

Canada geese have not been reported yet as a problem species in bird strikes at New Zealand airports (e.g. Chilvers et al. 1997) but are a serious threat to aircraft overseas (e.g. Cooper 1996; York et al. 2000). However, Christchurch International Airport Ltd (CIAL) has become concerned recently about high and increasing numbers of geese in the vicinity of the airport, resulting in one "near miss" in 2004 (O. Stewart, CIAL, pers. comm. 2005). The company has sought action from the Christchurch City Council to reduce goose numbers in and about the city. The concerns of the airport authority have been aggravated by proposals for a new pond system for Olympic-grade rowing facilities near the airport and by the Council's move towards creating additional wetlands favouring waterfowl habitat within the city limits. These concerns are currently being addressed by a working party established by the Council (Christchurch City Council Media Release, 6 July 2005).

Control methods used in New Zealand

The primary method of goose control that Fish & Game is obliged to use, because of its funding source, is recreational hunting (shooting) by licensed hunters (Fish & Game 1995). Hunting is allowed for 10 or 11 months of the year, with no bag limit (Ottmann 2000). However, geese are actively hunted by only about 5% of licensed game bird hunters in the Wellington region and 10% in Central South Island region, apparently because of the high set-up costs (c. $5,000) and difficulty of hunting (B. Abernethy, M. Webb, Fish & Game, pers. comm. 2005). As noted above, an average of 13,656 geese were shot per year by recreational hunters in the South Island between 1993 and 2004, and the annual hunter harvest has not changed significantly over the last 12 years (Fig. 4).

Before 1963, about 9% of geese were shot annually (Williams 1981). From 1963 to 1966, after the initiation of special hunting seasons, 20% of geese over 1 year old were shot annually (Imber & Williams 1968). The annual harvest in the mid 1980s was estimated as 7–10% of all birds (White 1986). In the mid-1990s, Heather & Robertson (1996) stated that about 20% of geese were shot annually.

If recreational hunting is insufficient to stop the adverse effects of geese, as appears to be the case, then control is undertaken by non-recreational means. Non-recreational control often occurs in response to demand (e.g. from farmers reporting damage to their pasture). According to the current Fish & Game management plan, the following non-recreational methods of control should be used, in order of priority:

- Fish & Game-organised shoots using recreational hunters and traditional hunting methods
- Dispersal by scare guns or other approved dispersal devices operated by land occupiers
- Other control methods authorised or undertaken by Fish & Game (e.g. egg destruction, moult culls).

Dispersal of geese by scare guns or other approved dispersal devices was occasionally carried out between the 1930s and 1960s (Lamb 1964), but is rarely done now because it simply shifts geese from one farm to another.

Few major non-recreational control operations were undertaken before 1980 (Holloway et al. 1997). As noted above, perhaps the first major control operation was in North Canterbury in 1950–51, when more than 3,000 geese were shot, and again in 1951–52 when another 1,700 geese were shot (Imber & Williams 1968). In the first special hunting season at Te Waihora, in January 1963, almost 6,000 geese were shot (Williams 1981), and 7,000 were shot over the whole summer (Lamb 1964). Simulation modelling of Canada goose populations has indicated that lethal control (shooting) of adult geese is four times more effective at reducing their numbers than egg destruction (Hughes et al. 1999). It is also the least costly goose population management technique (Cooper & Keefe 1997).

Egg destruction has been undertaken since about 1976. This involves injecting eggs with formalin (and is often called egg-pricking). In most of the early control operations all eggs in most discovered nests were destroyed because it was assumed that eggs in undiscovered nests would be sufficient to maintain the population (Holloway et al. 1997). This tactic was flawed because Canada geese tend to nest elsewhere if unsuccessful (White 1986). As a result, instead of nesting colonially, geese now tend to nest in isolation, often retreating to steep slopes (Holloway et al. 1997). These days, one or two eggs per nest are not injected but left to develop and hatch, to encourage geese to continue incubation and re-nest in the same area in subsequent years, rather than abandon the nest and re-nest elsewhere. Some 8,979 eggs were destroyed in 1976–1980, 12,421 eggs in 1981–1985, and 1,720 eggs in 1986–1989 (Holloway et al. 1997). However, a problem with egg destruction as a method of control is the

difficulty (and hence cost) of finding enough nests for the method to have an impact on subsequent goose population levels.

According to Ottmann (2000), the main non-recreational control methods used from 1995 to 2000 were organised culls of moulting birds (also known as flapper drives), shooting nesting birds from the ground, and shooting birds from helicopters. Leathers & Costello (1986) calculated that culling geese at moult would appear to be a commercially viable method of control (and less costly than egg-pricking or shooting from aircraft). Major culling operations in 1983–85 removed 6,500–7,500 birds (White 1986). As noted above, the average annual South Island cull from 1993 to 2004 was 7,255 birds (Fig. 4). Moult culls occur in late December to early January when birds are unable to fly (DOC 1991; Fish & Game 1995; Ottmann 2000). Moulting geese are rounded up into holding pens, stunned, and beheaded. This is considered the most humane method available to kill captured geese, and is approved by the Ministry of Agriculture (MAF) and Society for Prevention of Cruelty to Animals (SPCA). However, although moult culls are often very successful they are unacceptable to some sections of the public, and may not be an acceptable control tool long term.

Shooting from helicopters has been used by several Fish & Game regions. There is some evidence that birds rapidly learn of the dangers associated with helicopters, causing hunting effectiveness to decline over time (DOC 1991; B. Abernethy, Fish & Game, pers. comm. 2005). However, the Central South Island region has developed a national Standard Operating Procedure that minimises learned avoidance behaviour by geese, and thus minimises the risk of failure (M. Webb, Fish & Game, pers. comm. 2005). Shooting from helicopters is currently being used by CIAL to control geese in the Waimakariri River bed and is thought to be very effective (O. Stewart, CIAL, pers. comm. 2005).

Sedation and killing of birds using alphachloralose mixed with grain such as barley is another approved method of goose control (Fish & Game 2000; Ottmann 2000). The successful use of alphachloralose is dependent upon getting the correct dose into the geese. If geese eat sufficient they will fall into a stupor and die from exposure. However, on occasions the technique has failed because some geese flew off before eating a sufficient dose when they observed other geese succumbing to the effects of active ingredient (R. Millichamp, Fish & Game, pers. comm. 2005; G. Hickling, Lincoln University, pers. comm. 2000). Also, non-target species, especially paradise shelducks, may feed on the bait and suffer the same fate as geese.

Control methods used overseas or under development

Canada geese cause problems in Europe and North America (e.g. grazing on winter cereal crops, fouling in urban areas and on golf courses, and disrupting air traffic at airports). In the UK, current research on the management of several goose species is based largely on the development of scaring techniques and on the avoidance of bird damage, rather than on the destruction of the birds per se (Peter Robertson, Central Science Laboratory (CSL), York, pers. comm. 2001). Recent studies also include documenting the numbers of geese feeding in fields (either by direct counts or by counts of their droppings), and attempts to limit crop losses by excluding marauding geese through the application of tapes and streamers (McKay et al. 2001).

Physical scaring

Plastic tapes, plastic streamers, and plastic bags on stakes above crops have been shown to deter incoming geese from feeding in emergent cereals and oilseed rape in the UK, provided there are fields free from such deterrents nearby for geese to go to (Summers & Hillman 1990). Using these techniques, reductions of up to 10% in the losses of final yields sustained during attacks by Brent geese (*Branta bernicla*) have been reported (McKay et al. 1993). Tapes and streamers have shown potential for reducing grazing by mute swans (*Cygnus olor*), and have potential to protect cereals planted alongside lakes and rivers from grazing by Canada geese. However, the costs of installation

and management of tapes, streamers, and plastic bags are significant, i.e. $150/ha for plastic strips on stakes at 25-m spacing, and $140/ha for plastic bags at similar spacing, and the techniques are practical only over small areas (2–3 ha). As with most visual scaring devices, displaced birds generally move to the nearest adjacent safe feeding areas. Wire traces stretched across crops to exclude foraging geese have been trialled (H. McKay, CSL, pers. comm. 2001), and although successful in excluding birds, are not considered acceptable due to the risk of physical injuries to incoming or outgoing birds.

Plastic tapes and bags set out in rigid geometric patterns on short stakes have been trialled with great success to control/disperse feeding geese in northern USA, with birds being successfully excluded for c. 6 weeks from favoured feeding sites (Coleman 2001). Such techniques offer hope for the reduction of Canada geese feeding and fouling New Zealand high-country pasture, but do not, however, provide an easy option for the protection of crops, because the presence of stakes limits crop management.

A variety of non-lethal methods including vehicle horns, sirens, crackers, screamer shells, propane canons, coyote effigies, and scarecrows wearing the same orange vests as dispersal personnel failed to reduce Canada goose numbers below the level identified as a threat to aircraft at Elmendorf Air Force base in Alaska (York et al. 2000). The geese became habituated to the scare tactics.

Border collie dogs were effective in scaring away Canada geese and reducing the problems associated with their presence in the Dow Jones corporate complex in New Jersey (Castelli & Sleggs 2000), and on golf courses in North America (Temby 1999).

Laser beams have shown promise as a method of dispersing Canada geese from grass plots (Blackwell et al. 2002). Similar equipment used in the USA, said to be less powerful than that tested in the UK, is apparently as successful at dispersing birds as more traditional scaring techniques, yet does not offer the same physical threat (ocular damage within 50 m) to targeted birds or users as British laser guns apparently do (Glahn & Blackwell 2001). The technique is silent and target-specific and, with care, able to be used in urban areas. Laser guns are being trialled in New Zealand, and have proved effective at temporarily dispersing geese from Akaroa Domain and Clearwater Golf Course (C. Pennell, AgResearch, Lincoln, pers. comm. 2005).

In the USA, the National Wildlife Research Center (NWRC) is investigating Demand Performance Scaring Devices (DPSD's), i.e. scaring systems activated by radar, which identify incoming flocks of birds and, by staggered use, avoid habituation by birds (Larry Clark, NWRC, pers. comm. 2001).

These scaring techniques may offer short-term protection from goose activities, but all merely shift the birds to other areas (e.g. other fields, crops, airports, golf courses) and, as such, do not provide any long-term or widespread solution.

Sacrificial crops

Sacrificial crops are being used in the UK and mainland Europe to limit crop losses and provide cost-effective control of Brent and Canada geese (ADAS 1994; McKay et al. 1996a, 1996b, 2001). The technique involves the planting of foods favoured by geese alongside fields of at-risk cereals. The most suitable low-cost crops appear to be well-fertilised white clover or grass, provided both crops are located near water, away from hedgerows, and in areas rarely disturbed by humans. Modifications to this technique include other alternative crops such as thinly sown oilseed rape grown alongside vertical netting erected on the edge of establishing/emerging cereals. In this example, the sacrificial crop draws in the birds and the netting apparently limits their movements to the adjacent cereals (I. Inglis, CSL, pers. comm. 2001). The downside of the use of sacrificial crops includes concerns over *Salmonella* passed by geese to humans using such areas for recreational purposes and the fouling of pasture subsequently available for stock, although these problems are probably very limited

(J. Vickery, University of East Anglia, pers. comm. 2001). The costs and benefits of sacrificial crops have not been determined, but the technique receives support in the EU from the practice of setting aside 10% of all farmland for non-productive activities. Costs of sacrificial crops will be higher in New Zealand as no similar land-use strategy is practised.

Diversionary feeding
The use of diversionary feeding areas for Canada geese to minimise crop damage is practised overseas, especially in North America. In New Zealand, a trial diversionary feeding area for geese was established on about 8 ha of land bordering the shore of Lake Pukaki in autumn 1987 (DOC 1991). The land was cleared and oversown with grass seed, with the expectation that when geese were disturbed on farmland they would disperse to this area rather than other farms where they may cause damage. Initial observations of goose utilisation of this area were encouraging (DOC 1991). However, the concept was regarded by both Fish & Game and high-country farmers as too expensive and unlikely to succeed.

Habitat manipulation
In the UK, the Department for Environment, Food and Rural Affairs (formerly Ministry of Agriculture, Fisheries and Food) advises farmers to limit grazing by geese on emergent cereals by planting these crops as far from the sea as possible, close to hedges, and in areas regularly disturbed by humans. The development of integrated management strategies to alleviate damage to crops by diverting Canada geese to amenity grasslands is being investigated (B. Hughes, Wildfowl and Wetlands Trust, pers. comm. 2001), but the results of this work are confidential. In the USA, overabundant geese on airports, golf courses and parklands are being managed at some sites by the oversowing of swards dominated by highly palatable grasses with grasses of low palatability. This strategy may be a better option than physical scaring or lethal control, because it leads to the permanent avoidance of formerly favoured feeding areas.

In New Zealand, Chris Pennell (AgResearch, Lincoln) has produced endophyte-laden grasses that cause learned feeding aversion in Canada geese; i.e. geese generally refused to eat the grasses after the first feeding because the grasses caused the geese to feel ill (Pennell & Rolston 2003; Pennell 2004). This work is currently being trialled at Christchurch Airport and shows great promise, but because of the coarseness of the grasses used, is apparently a less suitable option for high-use public areas.

Chemical repellents
In the US, two chemical repellents are used for Canada goose control: anthraquinone (registered as Flight Control™) and methyl anthranilate (registered as Rejex-it® and Bird Shield®). Anthraquinone is registered in New Zealand (as Avex™) for use on emergent seedlings and non-food crops to protect them from a range of agricultural bird pests. Methyl anthranilate is not registered in New Zealand.

Flight Control™ has been shown to reduce Canada goose numbers and/or damage to turf by 95% (Devers et al. 1998; see also Dolbeer et al. 1998; Blackwell et al. 1999), and thus may have some application where geese graze in areas of high public use. However, it is unlikely to be cost-effective on crops or extensive high-country pastures (Spurr & Coleman 2005).

Rejex-it® has also been shown to significantly reduce the number of Canada geese grazing on treated plots (Cummings et al. 1991, 1992a, 1992b, 1995). However, the active ingredient, methyl anthranilate, is highly volatile, dissipates rapidly, and is broken down by ultraviolet light (Avery 2003). Thus, it is effective for less than 1 week, and requires regular application (Cummings et al. 1991, 1992a, 1992b, 1995). Unless economic losses are high, repeat applications are unlikely to be cost-effective (Spurr & Coleman 2005).

Methiocarb (registered as Mesurol®) was previously registered for Canada goose control in the USA, but the registration has now lapsed because the manufacturers declined to meet additional data requirements specified by the EPA (Avery 2003). Like Flight Control™ and Rejex-it®, it has been shown to be highly effective in deterring geese from grazing on grass (Conover 1985; Cummings et al. 1992b). Mesurol® is registered in New Zealand for use on emergent seedlings and non-food crops to protect them from a range of agricultural bird pests but not, to our knowledge, geese.

Chemical feeding repellents (e.g. Flight Control™, Rejex-it®, and Mesurol®) may deter geese from grazing on grass, but will not prevent geese from standing on grass (Clark 1998). Thus, chemical feeding repellents will not prevent geese using a public park, golf course, or airport for loafing or roosting, and so will not reduce nuisance, fouling, or bird strike problems arising from these activities.

Egg-oiling
Egg-oiling (e.g. with white mineral oil or corn oil) is a well-established technique for control of goose populations (Cummings et al. 1991b; Christens et al. 1995; Blackwell et al. 2000). The oil may be sprayed onto the eggs in the nest, or the eggs may be temporarily removed, immersed in oil, and then returned to the nest. Such action has resulted in the total failure of all treated clutches (Christens et al. 1995). However, critical to its success is the extension of incubation of addled eggs, so that birds on treated nests continue to incubate and do not have the opportunity to re-breed. Best results are obtained with eggs oiled late rather than early in incubation (Blackwell et al. 2000). Because geese lay at different times, it may be most cost-effective to spray eggs twice, early and late in the season (J. Dawes, Pestat, Australia, pers. comm. 2005). However, as with egg-pricking, a problem with egg-oiling as a method of control is the difficulty (and hence cost) of finding enough nests for the method to have an impact on subsequent goose population levels.

Reproductive control
In the USA, research is being undertaken by the NWRC on the use of nicarbazin as a reproductive inhibitor for control of non-migratory Canada goose populations where they come into conflict with humans, such as in urban areas where they cannot be shot (VerCauteren et al. 2001; Stahl et al. 2003). Nicarbazin is an anticoccidial agent used in broiler poultry food, and has been documented to reduce egg production and viability. However, it needs to be fed to geese daily throughout egg-laying. It is also distasteful, so geese tend to avoid eating it. Azocosterol, a cholesterol inhibitor reducing ovulation, has also been investigated as a reproductive inhibitor. It was originally registered as Ornitrol® for control of rock pigeons (*Columba livia*) (Spurr 2002). It needs to be applied to bait and fed to birds daily for 10–15 days before egg-laying to work effectively. It is no longer commercially available, but is being re-evaluated (L. Miller, NWRC, pers. comm. 2001).

Potential problems with bait-delivered reproductive inhibitors include target specificity and delayed action. Thus, ways will need to be developed to prevent birds of other species (e.g. ducks) eating the baits. Also, when geese are a problem, they often need to be controlled immediately. A useful strategy might be to reduce goose numbers by a method such as lethal control (e.g. moult culls), and then keep them down with fertility control.

Management issues

In reviewing the management and control of Canada geese in the South Island, DOC (1991) identified six principles that should be kept in mind when considering a possible change in the legal status of Canada geese to improve the balance in management between the desires of hunters and others affected by the geese; viz.:

- Game status should be retained only if hunters are prepared to assume responsibility for the costs that this status imposes on others who suffer damage.
- Game status should be considered only if there is sufficient recreational harvest, in conjunction with control operations, to adequately exploit the species to a level that minimises externality costs to other interests.
- The status chosen must provide mechanisms to resolve conflicts in management between Canada geese as a recreational resource and as a pest.
- Management of the bird must be consistent and coordinated so that management actions in different areas do not conflict.
- As recreational hunting alone is unable to control goose numbers, the status chosen should not preclude the adoption of the most efficient control methods where control is warranted.
- Both hunting and farming interests should have input to the management of the species because both parties are directly affected by it.

DOC (1991) then outlined five options for changing the status of the Canada goose:

(a) The status quo – retain the Canada goose as a game bird across its full South Island range under the First Schedule to the Wildlife Act 1953, but in addition require a coordinated goose management plan and allow a greater range of control methods (than in the current South Island goose management plan).
(b) Partly or fully remove the bird's game status but still provide a degree of protection for recreational hunting by either:
    (i) Moving the Canada goose to the Third Schedule to the Wildlife Act 1953 (wildlife that may be hunted or killed subject to a Ministerial notice published in the Gazette) in part of its range (i.e. the upper plains hill and high country west of the South Island main trunk railway line)
    (ii) Moving the Canada goose to the Third Schedule to the Wildlife Act 1953 (wildlife that may be hunted or killed subject to a Ministerial notice published in the Gazette) in its entire range
    (iii) Moving the Canada goose to the Fourth Schedule to the Wildlife Act 1953 (wildlife not protected except in areas and during periods specified in a Ministerial notice published in the Gazette)
(c) Remove all protection for the Canada goose by moving it to the Fifth Schedule to the Wildlife Act 1953 (wildlife not protected) across its entire range.

After discussing the advantages and disadvantages of each option, DOC (1991) recommended that the status quo be retained for 4 years, and then if the Canada goose population was not controlled to the satisfaction of the Minister of Conservation and in accordance with an approved management plan, the species should be transferred without further review to the Fourth Schedule to the Wildlife Act 1953. The retention of the status quo recommendation was conditional upon consideration of allowing the use of improved methods to increase the effectiveness of control; e.g. use of poisons, commercial farming, guided goose-hunting, sale of hunting rights, and diversionary feeding of geese.

Costello et al. (1988) disagreed with any proposal to alter the classification of Canada geese under the Wildlife Act 1953, or to declare Canada geese a pest of national or local importance under the Agricultural Pests Destruction Act 1967 (now Biosecurity Act 1993). Instead, they recommended that the Director-General of Conservation authorise, under various sections of the Wildlife Act 1953 and as a matter of course, the destruction of Canada geese on private land by the landowners or occupiers, the commercial farming of Canada geese on private land, and the sale of rights to hunt Canada geese on private land. They also recommended that responsibility for the management of Canada geese be transferred to Fish & Game because they are in the best position to judge the special circumstances of when and where to hunt, whereas farmers (and other landowners/occupiers) are in the best position to judge the damage that geese cause, the costs and benefits of goose control on their properties, and the value of geese as game or farm animals.

Despite these recommendations, to date the Canada goose has been retained in the First Schedule to the Wildlife Act 1953, and only now (2005) is the Minister of Conservation initiating a public review of its legal status (M. Gee, DOC, pers. comm. 2005). Fish & Game's current position is that it would prefer retention of the status quo for management of the Canada goose; i.e. that the species remains a game bird in the First Schedule to the Wildlife Act 1953 (B. Johnson, Fish & Game, pers. comm. 2005). It does not agree with the concept of split responsibility in law for goose management, as recommended by Costello et al. (1988), because of potential governance and accountability problems. It believes that goose management needs to be integrated through one agency with sole responsibility so that the actions of one party do not compromise achievement of the overall goal (B. Johnson, Fish & Game, pers. comm. 2005).

Federated Farmers consider that total goose numbers in the South Island continue to exceed those agreed to in the management plan (A. Mitchell, Federated Farmers, pers. comm. 2005). Although Fish & Game is making some progress in reducing goose numbers and keeping them close to target levels in some areas, goose numbers continue to exceed agreed totals in other areas. In the North Island, farmers consider goose numbers are too high overall, and in the Wairarapa goose numbers exceed the agreed levels (A. Mitchell, Federated Farmers, pers. comm. 2005).

Discussion

The aerial trend counts of Canada geese in the South Island have remained relatively stable for at least the last 12 years. We stress the term "relatively stable" because there have been considerable fluctuations in counts from year to year. Furthermore, relative stability in trend counts does not necessarily mean that the Canada goose population itself has remained stable. As noted above, when the trend count survey lines were established they were not randomly distributed, and geese have continued to spread to previously unoccupied and unmonitored areas. Recent monitoring in these areas has shown massive increases in goose numbers (M. Webb, Fish & Game, pers. comm. 2005). As a consequence, the total South Island Canada goose population is apparently still increasing. The available evidence indicates that the North Island population is also still increasing.

The Canada goose population continues to increase partly because of continued enhancement of the environment for geese, e.g. by farmers improving pasture, electricity generating companies creating new lakes, and local authorities restoring or creating new wetlands. Goose numbers can be reduced locally by intensive culling operations, as evident in parts of the North Canterbury and Central South Island regions. However, as noted above, goose numbers have increased elsewhere and this has led to continued problems with geese.

Canada goose damage to pastures and crops continues to occur at certain times (not necessarily coincident with high numbers of geese) and in certain areas, despite the current control effort. As noted in the South Island Canada goose management plan, the capacity of an area to cope with goose numbers varies considerably from year to year. Geese may have a greater effect on pasture during a season when pasture growth is limited (e.g. by drought). In such years there may be more justification for active goose management than in years with the same number of geese and strong pasture growth. Thus, managing populations to an exact number of geese may not be appropriate. Management needs to be able to take account of the changing nature of the environment and goose numbers when setting limits on the goose population. Currently, the Canada goose population is well above the levels agreed to by farming interests (A. Mitchell, Federated Farmers, pers. comm. 2005). However, as noted above, farmers are contributing to increasing goose numbers by enhancing the habitat for geese. They

carry the costs of goose damage, but because of current legislation are unable to actively control geese on their own properties, and are not contributing to the costs of goose control (Costello et al. 1988). However, authorisation of actions such as allowing the destruction of Canada geese on private land by the landowners or occupiers and the sale of rights to hunt Canada geese on private land, as recommended by Costello et al. (1988), or the transferral of Canada geese to the Fourth Schedule to the Wildlife Act 1953, as recommend by DOC (1991), is not the preferred position of Fish & Game. As noted above, it would prefer retention of the status quo for Canada goose legislation; viz. that the species remains a game bird in the First Schedule to the Wildlife Act 1953 (B. Johnson, Fish & Game, pers. comm. 2005). It believes that goose management needs to be integrated through one agency, with sole responsibility, so that the actions of one party do not compromise achievement of the overall goal. One-off or ad hoc control efforts could be counter-productive. However, it also believes there should be official recognition that farmers (and others) are increasing the goose problem and should therefore contribute to the costs of goose control.

There have been calls in the past for further research on the impacts of geese on agricultural values, and on the cost-effectiveness of alternative methods of goose control (Leathers & Costello 1986; Holloway et al. 1997). These calls are still valid. There is also a need for improved monitoring of Canada goose population trends, for example by adding additional, randomly distributed, trend count survey lines in both the South Island and North Island. The direction which further research on goose management issues should take will be clearer when, or if, the Minister of Conservation clarifies the legal status of geese.

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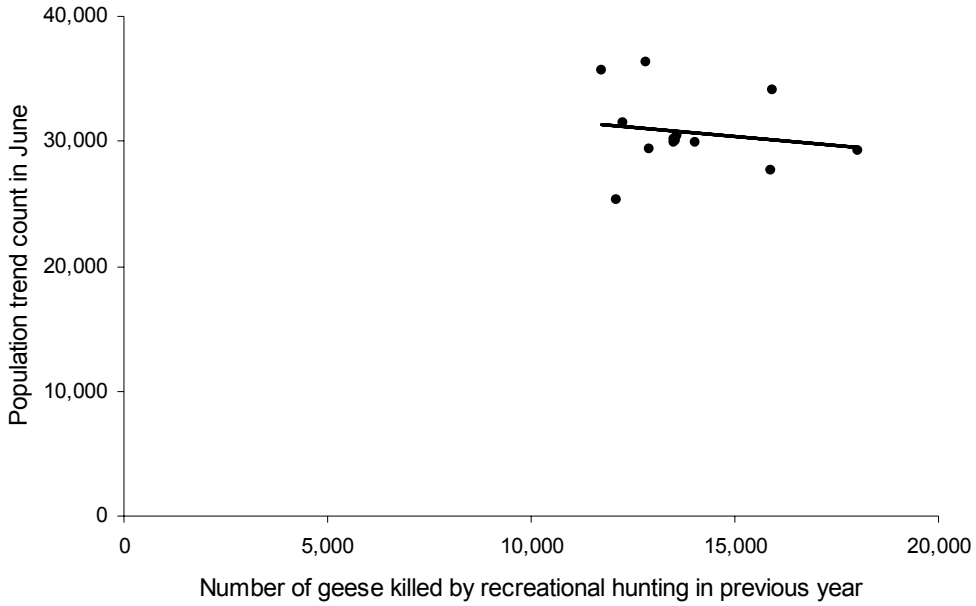
Appendices

Appendix 1. Significant events following introduction of the Canada goose to New Zealand

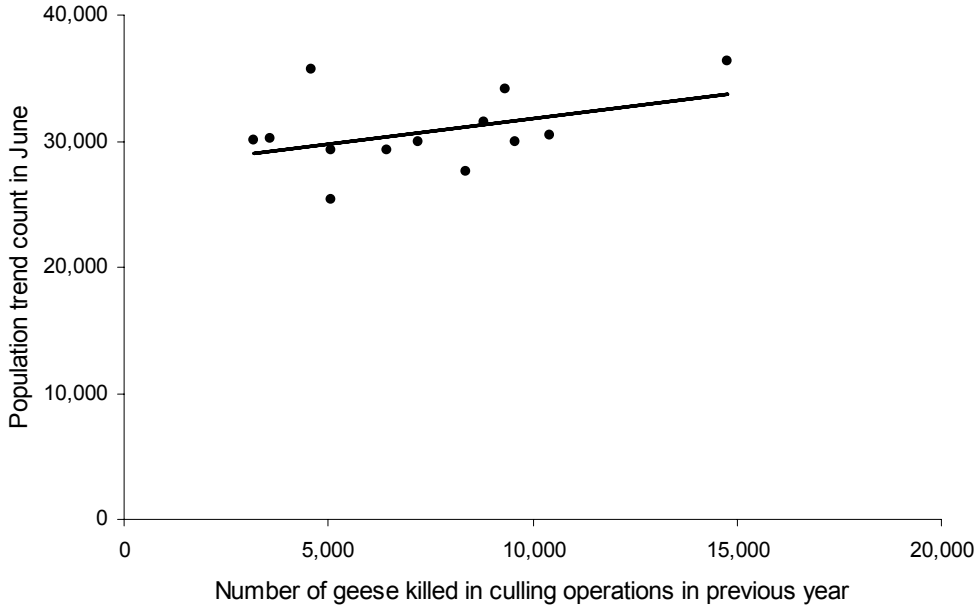
Year	Event
1905	50 Canada geese liberated in New Zealand, totally protected (Thomson 1922; Imber 1971a).
1915	The species was "doing well" (Thomson 1922; Long 1981).
1920	Several flocks of up to 300, another 10 birds liberated in Canterbury (Lamb 1964; Imber 1971a).
1924	Goose numbers increasing rapidly in Canterbury (Lamb 1964).
1925	Brief shooting season declared, but few geese shot (Imber & Williams 1968).
1931	Legal protection reduced, following complaints from farmers of goose damage.
Late 1940s	Population estimated to be more than 20,000 (Williams 1981; Imber 1985).
–early 50s	Selective culling operations undertaken (Leathers & Costello 1986).
1950–1952	Further culling operations following complaints from farmers of goose damage. More than 4,700 geese and 1,150 eggs destroyed (Imber & Williams 1968).
1953	Placed in Fourth Schedule to Wildlife Act 1953 (not protected except by Ministerial notice).
1957–1962	Population continued to increase (Imber & Williams 1968).
1959	Transferred to Third Schedule to Wildlife Act 1953 (may be hunted or killed).
1963	Special post-moult shooting seasons started at Te Waihora, 6,000 shot in 1963.
1963–1967	Population not decreasing (Imber & Williams 1968), probably continued to increase.
1970	Estimated 30,000 geese in South Island (de Lacy 1984). c. 200 birds from South Island introduced to North Island (Williams 1981).
1973	Declared game bird throughout New Zealand under First Schedule to Wildlife Act 1953.
1975	April population trend counts started, minimum 18,000 geese in South Island (Potts 1984).
1975–1983	No significant change in April population trend counts (Potts 1984).
1976–1980	8,979 eggs and >105 adults destroyed in South Island (Holloway et al. 1997).
1980	Estimated 18,000 geese in South Island, >800 in North Island (Williams 1981), likely to be underestimate because minimum 19,000 counted in April trend count (Potts 1984).
1981–1985	At least 12,421 eggs, 252 flappers, and 20,029 adults destroyed in South Island (Holloway et al. 1997).
1984	Population more than 20,000 in South Island (Ward 1984).
1985	Population approaching 20,000 in South Island, few in North Island (Imber 1985). June population trend counts started, minimum 19,801 in three South Island regions (Fish & Game, unpubl. data), 23,774 in whole South Island (Holloway et al. 1997).
1986–1989	At least 1,720 eggs, 372 flappers, and 10,242 adults destroyed in South Island (Holloway et al. 1997).
1987	Population reached 31,000 in South Island (McDowall 1994).
1988	Minimum 32,607 geese counted in June trend counts in three South Island regions (Fish & Game, unpubl. data), 36,981 in whole South Island (Holloway et al. 1997).
1995	Minimum 36,287 geese counted in South Island June trend count. South Island Canada goose management plan implemented under Conservation Act 1987.
1996	Estimated 40,000 geese in South Island, 10,000 in North Island (Heather & Robertson 1996).
1997	Estimated 28,000–35,000 geese in the east of the South Island, few in the west, and 8,000 in the North Island (Holloway et al. 1997). West Coast trend count minimum 500.
1995–2005	No significant change in South Island goose population June trend counts (Fig. 2).
2005	Minimum 34,144 geese counted in South Island June trend count (Fish & Game, unpubl. data).

Appendix 2. South Island Canada goose population trend counts in June in relation to the number of geese removed from the population in the previous year, 1993–2005 (n = 13) (M. Webb, Fish & Game unpubl. data)

(a) Recreational hunting (Spearman rank correlation t_{11} approximation = −0.846, $P = 0.415$)

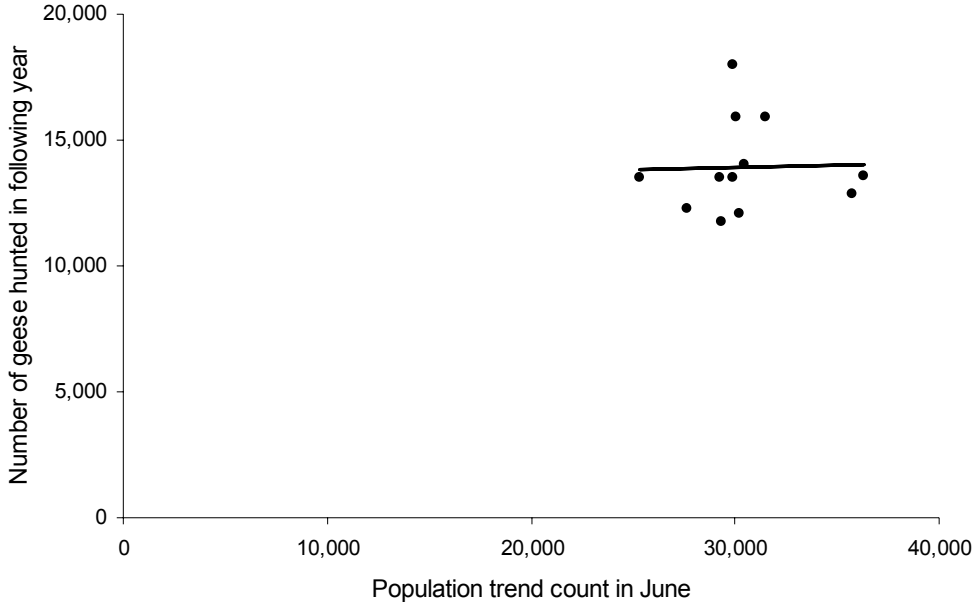


(b) Organised culling operations (Spearman rank correlation t_{11} approximation = 1.115, $P = 0.289$)

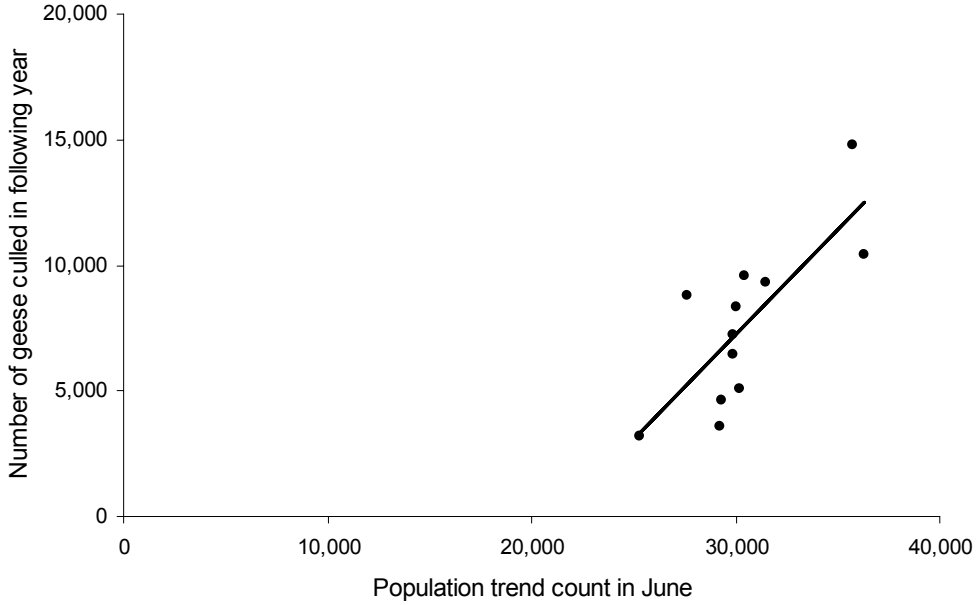


Appendix 3. Numbers of Canada geese in the South Island removed in the year following the June population trend count, in relation to the June population trend count, 1993–2004 (n = 12) (M. Webb, Fish & Game unpubl. data)

(a) Recreational hunting (Spearman rank correlation t_{10} approximation = 0.798, P = 0.443)



(b) Organised culling operations (Spearman rank correlation t_{10} approximation = 4.176, P = 0.002)



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