# Recovery of the Aleutian Cackling Goose *Branta hutchinsii leucopareia*: 10-year review and future prospects

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**Abstract**

Aleutian Cackling Geese *Branta hutchinsii leucopareia* were feared extinct until a remnant population was discovered on Buldir Island by Robert "Sea Otter" Jones in 1962. Population declines, primarily due to predation by Arctic Foxes *Alopex lagopus* introduced to the breeding islands, resulted in the listing of Aleutian Cackling Geese as endangered in 1967. Fox removal, translocation of captive birds and captive breeding programmes boosted the remarkable recovery of this sub-species from 790 individuals in 1967 to > 30,000 in 2001, when it was removed from the United States' Endangered Species List. Population estimates currently exceed 100,000 birds. However, the population recovery has brought complex management issues, including the harvest of a once-endangered sub-species and conflict with agricultural interests. This review comes 50 years following rediscovery of the remnant population, 20 years after initial reclassification from endangered to threatened, and 10 years after formal delisting from the United States' Endangered Species Act. This review describes the events leading up to the bird's recovery, details management actions taken on behalf of the sub-species, and recommends strategies for ensuring that this conservation success story continues into the future.

**Key words:** Aleutian Cackling Goose, endangered species, habitat, hazing, hunting, recovery.

 

Maintaining habitat to support species biodiversity is a hallmark of conservation biology (Carroll & Fox 2008), yet single species initiatives are emphasised when populations are critically endangered (Mills 2007). Species recovery begins with identifying population size and status through monitoring programmes, followed by the development and testing of hypotheses regarding limiting ecological or bio-political factors (*e.g.* habitat needs or the strength of wildlife protection laws) that may hinder recovery. Stepwise recovery initiatives and actions are then required, beginning with strategies to address the root cause for the species' decline, and continuing through to protective legislation and sometimes the establishment of refuges (Black 1998a). In the United States, these actions are carried out under the authority of the Endangered Species Act (ESA). Should a population fail to respond, increasingly intensive actions may be required. Proactive strategies on behalf of avian species include managing habitat or supplying food, reducing predators and competitors, providing nest sites, and translocating/reintroducing eggs or birds from other wild or captive stocks (Black 1991; Cade & Temple 1995). If the species is both endangered and a game species, which is not common in the U.S., actions on its behalf are especially important. The Aleutian Cackling Goose *Branta hutchinsii leucopareia* (formerly the Aleutian Canada Goose and hereafter Aleutian Goose) is an example of a once-endangered sub-species, successfully recovered to favourable conservation status, but now considered a problem by affected farmers and ranchers, which is harvested by wildfowlers throughout its non-breeding range. This paper summarises some of the steps taken to promote the bird's recovery and describes post-recovery management issues.

## From the brink of extinction: persistence of an imperilled population

After his extensive surveys of the Aleutian Islands (Fig. 1) in 1936–1937, Murie (1959) reported that Aleutian Geese "had disappeared on most of the islands, and our total observations indicated that only a few pairs remained in the Aleutians. In fact, these geese are so scarce that the migration is no longer noticeable." This small white-cheeked goose, characterised by a distinct white neck ring, formerly bred on most of the Aleutian, Commander, and Kuril Islands (Springer *et al.* 1978; Byrd & Woolington 1983), but the widespread introduction of Arctic Foxes *Alopex lagopus* for fur farming (reviewed in Williams *et al.* 2003), together with hunting in the non-breeding season, caused major reductions in population size and distribution (Murie 1959; Byrd & Springer 1976; Springer *et al.* 1978; Byrd *et al.* 1991). In the late 1940s, a resident refuge manager, Robert "Sea Otter" Jones, was hired for the U.S. Fish and Wildlife Service (USFWS) Aleutian Islands National Wildlife Refuge (NWR) and began a fox removal programme (Spencer 1980). Over the next 20 years, foxes were eliminated from Amchitka and significantly reduced on Agattu Island (Byrd & Springer 1976). By 1991, foxes were eradicated from nine other islands (Byrd *et al.* 1991). Two additional non-native mammals

– Brown Rats *Rattus norvegicus* (introduced in 1780) and Ground Squirrels *Spermophilus parryii* (introduced *c.* 1819) – may have impacted breeding populations, both directly through egg predation and indirectly as an additional prey for foxes (Bailey 1993; Ebbert & Byrd 2002).

Fortunately, Aleutian Geese persisted on islands where foxes were never introduced; *c.* 60 adults and at least seven goslings were observed at Buldir Island in 1962 and 156 were counted there the following year (Jones 1963; Fig. 1). This record of the continued existence of Aleutian Geese and its imperilled status led to it being listed as an endangered species in 1967 under the Endangered Species Preservation Act (USFWS 1967) and under the formal legislation of the ESA in 1973 (Public Law 93–205). Aleutian Geese were placed on the International Union for Conservation of Nature and Natural Resources (IUCN) Red List as "rare" in 1986 (IUCN Conservation Monitoring Centre 1986). Meanwhile, additional surveys in the east Aleutian Islands led to the discovery of another remnant colony on Kiliktagik Island in 1979 (Hatch & Hatch 1983) and on Chagulak in 1982 (Bailey & Trapp 1984; Fig. 1), both in the Semidi Island Chain. The Semidi Island birds, which migrate to the northern Oregon coast in autumn and remain there until returning to the breeding grounds (Stephenson 2010; Fig. 1), are considered to be distinct from the western-most population, with potential for separate listing status (Pierson *et al.* 2000). This review focuses primarily on the west Aleutian breeding population, rather than on the Semidi Island birds.

## Recovery and delisting years: from success to concern

### Recovery: 1975–2000

An Aleutian Goose Recovery Team was formed in 1975 led by six biologists (Byrd & Springer 1976), who developed the Aleutian Goose Recovery Plan to guide sub-species management following listing under the ESA (USFWS 1991; Byrd 1998). The initial goals were to restore breeding habitat and re-establish breeding populations. Early attempts to re-establish the geese in the Aleutian Islands included re-introduction of captive-bred birds and translocation of wild-caught birds from the remnant Buldir population (Byrd 1998). By 1991, nearly 2,500 geese had been released on four fox-free islands, though the success of these early efforts was limited due to Bald Eagle *Haliaeetus leucocephalus* predation (Byrd 1998). A few wild birds from Buldir served as migration guides (Byrd 1998), but re-sighting rates (5–15% of the released birds, marked with coloured rings) were low in wintering areas (P. Springer, unpubl. data). Byrd (1998) suggested that lack of migratory tradition and the physical capabilities of captive-reared birds might have affected their survival. Pairing captive-bred geese with wild geese from Buldir Island and the translocation of groups of wild geese from Buldir proved more successful. Eventually breeding attempts were recorded on or adjacent to release sites, especially on Agattu and Nizki-Alaid (Byrd 1998; Fig. 1).

Aleutian Geese were first documented migrating south of the Aleutian Islands during the mid-1970s (Woolington *et al.*

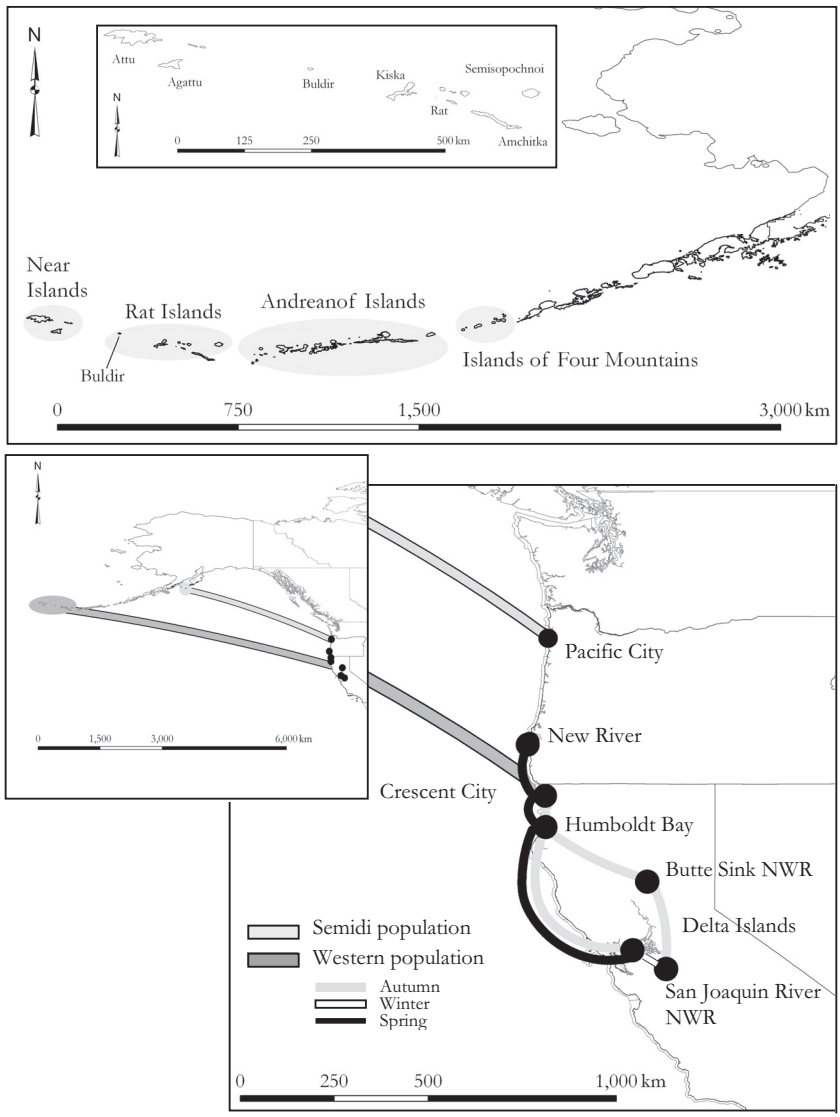


**Figure 1**. Aleutian Goose distribution map, from the birds' breeding grounds in the Aleutian Islands to autumn, winter, and spring migration areas in Oregon and California. The Semidi Island population migrates from the Semidi Island group to Pacific City in Tillamook County, Oregon. The remainder of the western-most Aleutian population migrates from the Near Island and Rat Island groups to autumn and wintering areas in California. Original autumn and wintering areas were primarily in central California; however, Aleutian Geese have recently migrated to Humboldt Bay in the autumn. During spring migration, Aleutian Geese originally migrated to the Crescent City area, but now also migrate to the Humboldt Bay area and to New River, Oregon.

1979) after 8 years of being listed under the ESA. They were sighted during the autumn of 1975 in Crescent City, California (Woolington *et al.* 1979; Fig. 1), roosting on Castle Rock, a 5.7 ha offshore island, and foraging in nearby pastures. Some Aleutian Geese remained in Crescent City through late autumn, while others migrated directly to the Sacramento Valley (near Butte Sink; Woolington *et al.* 1979; Springer & Lowe 1998; Fig. 1) or further south to the San Joaquin Valley (near San Joaquin River NWR; Woolington *et al.* 1979; Fig. 1). In subsequent years, Aleutian Geese were observed in the San Joaquin Valley through mid-March and later in spring back at Castle Rock and the Crescent City area before returning to the breeding grounds (Fig. 1). In the late 1970s, nearly the entire population staged near Crescent City, California during spring migration (Woolington *et al.* 1979).

Once the migration route was identified, securing and managing habitat in migration and wintering areas for feeding and roosting, together with closure of hunting in these areas, became priorities (Byrd *et al.* 1991). The Butte Sink, as part of the Sacramento NWR Complex, has served as a key roost and sanctuary for wintering Aleutian Geese since the birds were first detected there in the late 1970s, but use of this site has declined in recent years (Griggs 2005). In the southern end of their range, the San Joaquin River NWR was established in 1987 (USFWS 2006), and refuge staff subsequently created roost ponds and began farming crops (Maize *Zea mays* and Winter Wheat *Triticum aestivum*) to provide nutrient-dense forage. In 1980, Castle Rock NWR was established to protect the critical roost (USFWS 2009) and the Lake Earl Wildlife Area, managed by the California Department of Fish and Game (CDFG), was established just north of Crescent City to provide pasture and wetland habitat for foraging geese and other wildlife. Private land at each stop-over site also provided and continue to provide food, roost sites, and some sanctuary for geese. In the San Joaquin Valley, the USFWS entered into cooperative agreements with landowners to flood wetlands and provide Maize on their property (USFWS 2006). All hunting of "white-cheeked" geese was curtailed in closure zones in California (on the north coast and areas surrounding Butte Sink and San Joaquin River NWR) from 1975 and in Oregon from 1982 (Tillamook and Langlois County; Gregg *et al.* 1988), to minimise the possibility of harvesting Aleutian Geese.

The Aleutian Goose population responded rapidly to fox removal on breeding islands, translocations of birds to islands cleared of foxes, and protection afforded on the wintering grounds, rebounding from the original 790 individuals counted in 1979 to 7,000 in 1990, at which time it was down-listed in the ESA to "threatened" status (USFWS 2001; Fig. 2). It was removed from the IUCN Red List by 1988 (IUCN Conservation Monitoring Centre 1988). By 1996, the population reached *c.* 20,000 and was recommended for delisting by the Aleutian Goose Recovery Team and Pacific Flyway Council (hereafter PFC; PFC 1998). In accordance with the Aleutian Goose Recovery Plan (Byrd *et al.* 1991), a flyway-wide management plan was created in 1999,

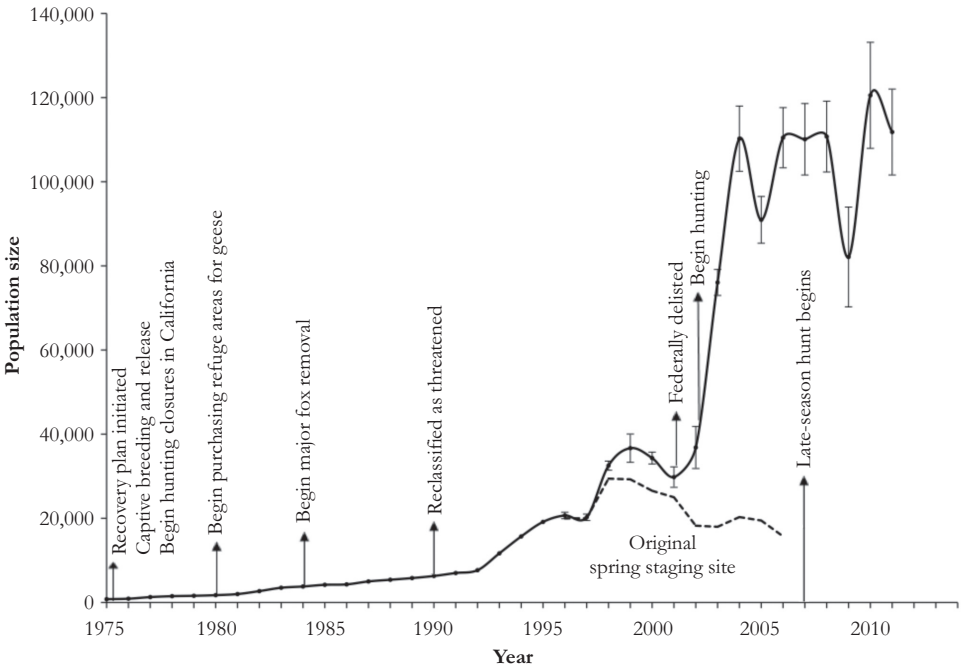


**Figure 2.** Aleutian Goose population size and management actions from 1973–2011, with important milestones noted. Data sources: 1975–1995 were direct counts (Collins & Trost 2011); 1996–2011 shown with standard errors from indirect (mark-recapture) estimates (Collins & Trost 2011); 2001–2002 indirect estimates from Drut & Trost (2004); 1996–2006 peak direct counts for Crescent City (USFWS 2010a).

as a guideline for responsible management over a 5-year period up until 2004. The goal was to provide "optimal aesthetic, educational, scientific, and hunting uses" throughout the migratory range of the geese (PFC 1999, p. 3).

The 1999 Aleutian Goose Management Plan identified current and future management problems and relevant management actions to address those problems including: 1) no long-term population goal; 2) limited public land available; 3) changing agricultural practices; 4) lack of funding; 5) disease; 6) climate issues on wintering grounds; and, on the breeding grounds: 7) predation by Bald Eagles; 8) predation by foxes; and 9) introduced rats and squirrels (PFC 1999). Recommended management actions were to: 1) protect breeding habitat through terrestrial predator removal; 2) acquire adequate funding to protect migration habitat; 3) manage depredation (*i.e.* crop loss) by better management of public land or acquisition; 4) conduct annual winter population indices through direct counts and neck collar monitoring; 5) continue marking and banding of geese in California;

6) conduct a breeding population estimate at least once during the five year post-delisting period; 7) set a population objective; 8) develop a harvest strategy; 9) continue translocations; and 10) control disease (PFC 1999).

## Delisting to current status: 2001–2011

Delisting was to be considered when the first two (of three) recovery objectives were satisfied: 1) an overall population of at least 7,500 geese and an upward long-term trend; 2) at least 50 breeding pairs of geese nesting in each of three geographic parts of the historic range for three or more consecutive years; and 3) a total of 10,125–14,175 ha of feeding and roosting habitat for migration and wintering, secured and managed for Aleutian geese (PFC 1999, p. 5). Byrd (1998) outlined other factors that would support delisting Aleutian Geese, including a programme to re-establish the geese in the far western part of their range in cooperation with Japan and Russia, a plan to reduce crop depredation in the Crescent City area, and new procedures to monitor geese wintering in California to allow early detection of, and response to, population declines.

The Aleutian Goose was formally delisted in 2001 when the population exceeded 30,000 birds (Fig. 2). The reasons for delisting at that time included: 1) the estimated Aleutian Goose population was approximately five times the recovery goal; 2) the population trend was increasing annually by *c.* 20% from 1990; 3) the population of geese nesting in the western Aleutian Islands was self-sustaining and exceeded the delisting objective (although the ≥ 50 pairs nesting in each of three geographic parts of the historic range criterion was not met); and 4) foxes had been removed from islands in the central Aleutian Islands and translocations had been successful (USFWS 2001). When the Federal Register (USFWS 2001) document delisting Aleutian Geese was written, authors stated that "the recovery objective of conserving and managing 10,125–14,175 ha of migration and wintering habitat" had not been achieved; "however, the recovery team allowed that not attaining this acreage target would not preclude delisting" if otherwise warranted (USFWS 2001, p. 15647). Several large-scale conservation easements were being pursued with landowners adjacent to San Joaquin River NWR in the wintering area at the time, so it was considered "that not all the lands utilised by the Aleutian Goose must be held in the public trust to ensure the long-term survival of the species" (USFWS 2001, p. 15647).

Five years of monitoring were required following delisting from the ESA and the 1999 management plan covered three of these years. In 2004, the PFC revised the 1999 management plan for the next five years (2005–2009) and solicited public input. The updated plan sought "to improve monitoring surveys, develop a progressive harvest strategy, and address agricultural depredation complaints in the context of habitat management efforts" (PFC 2004, p. 1). The population goal was set at 60,000 geese, based on a three-year average of indirect population estimates from 2002–2005 (PFC 2006). Updated management issues included: 1) the first occasion for regulating the size of a recently

delisted population of migratory game birds; 2) "the high rate of population growth and lack of experience in development of hunting regimes" limiting "the precision of managing the population"; 3) "the capacity of public lands to support these geese" being limited, "especially along the northwest coast of California, but also potentially in other migration and wintering areas"; 4) "additional funding needed for management of public lands…to provide optimum feeding conditions…and to reduce depredations"; 5) "changing agricultural practices… negatively affect[ing] current migration and wintering areas"; 6) "public land managers need[ing] goose habitat treatments that are cost-effective and balance[d] for other wildlife"; 7) avian cholera as a source of mortality; 8) Bald Eagle predation preventing sustainable nesting in the central Aleutians; 9) introduced rats and ground squirrels indirectly limiting expansion of nesting geese to other fox-free islands; and 10) potential effects on seabird habitat from the population using offshore roosting islands along the northwest California and Oregon coasts (PFC 2006, p. 16–17). The 2006 Aleutian Goose Management Plan suggested monitoring distribution and habitat use on spring staging areas, using an aerial inventory for population assessment, removing translocations as a priority, and expanding research to include public pasture management and spring staging habitat carrying capacity (PFC 2006).

When the 2006 management plan was written, the Aleutian Goose population was estimated at 94,034 ± 5,071 (mean ± s.e.), based on a three-year average of mark-recapture data (2003–2005; estimated from Collins & Trost 2011). From 1975–1998 direct counts in winter were sufficient when the population was small and used only a few areas. However, as the population grew and spread out among areas, managers began using indirect methods (mark-recapture) of estimating population size from 1996 to the present (Collins & Trost 2011). By 2011, the population was estimated at 111,809 ± 10,212 (95% confidence intervals = 91,793–113,824; Fig. 2), which was *c.* 11.5% lower than the previous year. The three-year average from 2008–2011 is estimated at 107,158 ± 12,174 birds (from Collins & Trost 2011).

## Expanding population creates depredation and seabird habitat concerns

### Concern regarding crop depredation

As Aleutian Geese recovered and increased in numbers, so did private landowner concerns regarding crop depredation in the original spring staging area (Crescent City, near Castle Rock NWR). Based on conversations with landowners, some ranches and farms on the north coast during spring months were either reducing livestock herd size, providing supplemental feed, moving stock to inland sites, or converting pasture to flower bulb production. Crop depredation concerns surfaced in 1986 while the population was still considered threatened under the ESA (Mini & LeValley 2006; PFC 2006). The Aleutian population had reached 5,000 geese and landowners in the Crescent City

area voiced displeasure with goose grazing that occurred on private land from February through April (PFC 2006). Although the population was small, the timing of the birds' grazing pressure and local crop phenology were incompatible, as is common in many depredation situations across the globe (Moser & Kalden 1991).

Goose-landowner conflicts appear to be less serious on the wintering grounds, for four main reasons identified through interviews with landowners, discussions at public meetings, complaints to public land managers, and published reports (Griggs 2005; Mini & LeValley 2006; USFWS 2010a; D. Woolington, pers. comm.). First, the majority of geese in this region use the San Joaquin River NWR, which produces Maize and Winter Wheat for the geese, manages wetlands for roosting/loafing, and prohibits hunting within its boundaries. Second, adjacent private landowners have established conservation easements with the USFWS that prevent development/habitat degradation, support producing wildlife-friendly crops, and promote conserving and enhancing wetlands, while allowing the landowner to receive income through farming and grazing. Third, the timing of bird migration and crop phenology and distribution is not a problem. Geese arrive in October–November, when Maize is harvested on private land, and feeding by geese on the residual waste grain is tolerated. As depredation of newly-planted winter wheat occurs in late autumn, the hunting season opens for geese in adjacent areas and hunting pressure pushes birds to other fields and back to NWR lands. This is in contrast to the spring staging grounds, where large concentrations of geese coincide with the emergence of new, sought-after pasture vegetation. Lastly, there is a long tradition of historic waterfowl use in the Sacramento and San Joaquin Valleys, where landowners are accustomed to thousands of geese and ducks using public and private land. This is in significant contrast to the north coast of California and coastal Oregon, where large populations of waterfowl (especially grazing species) did not exist before the Aleutian Geese arrived, although traditional migration routes likely encompassed this region.

### Concern regarding conflict with other species

Nocturnal use of Castle Rock NWR has been documented since birds were first discovered in the area. As the number of Aleutian Geese increased, the potential for conflict with nesting seabirds and habitat degradation became a concern (USFWS 2009). Castle Rock NWR is the second largest breeding seabird colony in California, supporting eleven species of burrow and above-ground nesting birds (Jaques & Strong 2001). Numbers of many species (especially burrow nesters) have declined here in recent decades (Carter *et al.* 1992; Jacques & Strong 2001). There is evidence that the vegetative composition has changed significantly since the 1970s, and concern that large numbers of geese (as many as 30,000) using the island may damage the thin soil layer present and remove most of the vegetation, resulting in burrow collapse, erosion, and increased predation due to cover loss (Jacques & Strong 2001).

## Cooperative strategies to address spring-time crop depredation concerns

### Establishment of working groups

Concern over depredation of grass pastures in northern California led to the formation of a working group of landowners and agency personnel in 1990, the "Lake Earl Working Group," with the aim of finding solutions to reduce springtime goose grazing on private land (USFWS 2001). When the Aleutian Goose was first listed as endangered (1967–1991), the geese foraged on lands immediately adjacent to the Castle Rock roost site (Woolington *et al.* 1979). However, as numbers increased and the birds became more widespread, landowners wished to commence hazing (*i.e.* scaring). Cooperatively, landowners and agencies began to identify a "corridor" of 375 ha of public land (some of which needed improvement) that could be used for Aleutian Geese, plus an additional 28 ha if the original Point Saint George area were once again managed as short-grass habitat with livestock grazing (potential total = 403 ha; Mini & LeValley 2006). Goose hazing by landowners was planned on the remainder of the area (private land). The strategy included splitting the area into four hazing quadrants, and each quadrant was managed by an individual landowner or hazing group consisting of private individuals (Mini & LeValley 2006). Unfortunately, the management "corridor" was fragmented and few landowners coordinated with each other, so hazing was not entirely effective although it accelerated a landscape-level redistribution of Aleutian Geese.

A second group, with some overlap in participants, began to meet in 2003 when goose numbers rose to appreciable levels at Crescent City farms (*c.* 20,000) and newly discovered pastures adjacent to Humboldt Bay (*c.* 40,000; Black *et al.* 2004). The Aleutian Goose Working Group's project goal was to "work cooperatively to develop and implement management strategies acceptable on public and private lands on the spring staging area so that the Aleutian Goose is an asset to the community" (Aleutian Goose Working Group 2005). Five subcommittees were formed: mapping, habitat, hunting/hazing, education/documentation, and other solutions/hope. An important proposed "roadmap" of tasks (D. Lancaster, *in litt.* 2004) included: 1) determine habitat required to meet the flyway objective; 2) identify available public land and improve attractiveness to geese; 3) augment with private land via easements; 4) if a shortfall still exists, implement coordinated hazing and hunting on private land to rotate geese among landowners; 5) establish goose-safe areas first, including designated public land, land under easement for Aleutian Geese, and land provided in the hazing/hunting rotation; 6) seek increased bag limits and season duration; and 7) pursue grants and identify research needs for efficient implementation of the project. The hazing/hunting subcommittee made progress faster than others, so the concept of ensuring that high-quality goose-safe habitat was in place prior to efforts to shift the birds was not fully achieved.

## Habitat improvements on public land

In the late 1980s to early 1990s, many state lands in the original spring staging area had ceased grazing programmes (Mini & LeValley 2006). Much of the pasture formerly used by geese became fallow and there was insufficient high-quality pasture that could be used by geese. Other public areas in the Humboldt Bay region lacked established grazing programmes because Aleutian Geese were not known to use these areas before 1997. Nutritional analysis in 2003 and 2004 indicated that the sward on some of the public land differed in protein or fibre content than that on some private land (Mini 2005). Based on the cooperative efforts of the Aleutian Goose Working Group, habitat enhancement became a higher priority from 2004 onwards. Public land managers in coastal northwest California used livestock grazing, mowing, field replanting, and fertiliser treatments to lure Aleutian Geese away from private pasture (Bachman 2008). Thus, following a few years of sward management, forage quality on some public land was similar to that found on some private cattle pastures (Spragens 2010).

Public land managers, especially in the San Joaquin Valley, Sacramento Valley, and Humboldt Bay area, and in the surrounding communities, have made significant progress in providing foraging habitat for Aleutian Geese. On National Wildlife Refuges (Sacramento and San Joaquin NWR Complexes) and easement lands in the wintering areas, 15,854 ha of habitat are available for goose grazing (M. Hamman, pers. comm.; M. Lloyd, pers. comm.; K. Griggs, unpubl. data). These include irrigated and native pasture grazed by cattle and agricultural crops (*e.g.* Maize and Winter Wheat). As of 2011, the total area in the Humboldt Bay region in public ownership (local government, state, and federal) managed as short-grass habitat for geese is estimated at 825 ha, with an additional 284 ha in protected non-profit ownership (K. Spragens & J. Black, unpubl. data); 375 ha in Crescent City (Mini & LeValley 2006), and 81 ha in Oregon (PFC 2006). This amounts to a total of 1,565 ha in protected short-grass habitat for foraging Aleutian Geese on the spring staging grounds.

## Hazing and hunting during spring staging period

Hazing of Aleutian Geese in the Crescent City area began in the mid-1990s (*c.* 1995–1997) as the geese extended their foraging areas (Mini & LeValley 2006). Hazing activities by private landowners were concentrated from late February, when the staging population reached *c.* 10,000, through to April when the geese migrated north (Mini & LeValley 2006). Firecrackers and less forceful means, such as deploying ribbons, mirrors and other objects on the land, or landowners walking into fields, were the original methods used to displace the geese (Mini & LeValley 2006). As the population grew, hazing became more intense, including the use of all-terrain vehicles, pick-up trucks, and non-lethal shotgun rounds (Mini & LeValley 2006). By 2001, coordinated and aggressive hazing was initiated using an ultra-light aircraft to drive geese off private land

and back to public land (Mini & LeValley 2006).

Geese began to arrive in the Humboldt Bay area in 1997 (direct count: 600 geese in 1997; Black *et al.* 2004). By 2002, 19,750 geese were counted on pastures adjacent to Humboldt Bay (Black *et al.* 2004). Geese that remained at the Crescent City area experienced reduced foraging opportunity, resulting in elevated energy expenditure and poorer body condition (Mini & Black 2009). As numbers increased on the pastures near Humboldt Bay, some landowners there also began a hazing programme (Spragens 2010).

Hunting was added to the repertoire of tools used to manage geese when protection was removed on the north coast in 2002 and all areas of California in 2003. Harvest strategies for all geese are set by a federal framework, the PFC and individual states; however, managing and assessing harvest for one sub-species is difficult due to other sub-species of Branta geese in the Pacific Flyway. Beginning in 2007, Aleutian Geese were hunted solely on private land for 14 days in February–March, in an effort to push birds on to agency owned pastures (Table 1). Hunting could not extend past 10 March due to the Migratory Bird Treaty Act. By 2008, hunters could take up to six Aleutian Geese per day during a *c.* 100 day waterfowl season and during the 17-day late-season hunt on private lands (Table 1). Additionally, a well-coordinated SHARE (Shared Habitat Alliance for Recreational Enhancement) hunt programme was established in cooperation between the California Waterfowl Association and the CDFG, to assist with access to private fields. The state of Oregon initiated a "Fertiliser for Access Programme" in which farmers and ranchers in southwest Oregon, who allowed access during the hunting season, were compensated with fertiliser for grasslands impacted by Aleutian Geese (USFWS 2010a). Fortunately, areas supporting geese along the north coast had some public land adjacent to private lands, but these areas varied in total size and quality (Spragens 2010).

A decrease in the number of grass depredation complaints was observed as soon as the late-season hunt was initiated in 2007 (USFWS 2010a). In the northern portion of Humboldt Bay, geese used public land in greater numbers than had previously been recorded (Spragens 2010). However, following the hunt, Aleutian Geese immediately returned to using private land, albeit at lower densities across a greater extent of the landscape (Spragens 2010). In the southern portion of Humboldt Bay in 2007, and in subsequent years, geese used public land more intensively during the late-season hunt (USFWS 2008; USFWS 2010a), indicating that hunting is an effective means of shifting birds to public land at this time of year.

## Landscape distributional changes

Aleutian Goose use of the San Joaquin River NWR during winter has remained consistent over the years, due to consistent production of high-quality forage, the no hunting policy, and undisturbed roost areas, whereas winter use of Butte Sink has

**Table 1**. History of Aleutian Goose hunting regulations from 1973–2010.

| Year | Bag limit | Timing | Action |
|---|---|---|---|
| 1973 | No Season | No Season | Alaska hunting moratorium[a] |
| 1975 | No Season | No Season | California hunting moratorium[a] |
| 1982 | No Season | No Season | Oregon hunting moratorium[a] |
| 1984 | No Season | No Season | Aleutian Goose & all small Canada Goose hunting moratorium for Pacific Flyway[a] |
| 1994 | No Season | No Season | Small Canada Goose moratorium lifted in California in areas outside special closure areas[a] |
| 2001 | 2 geese per day | Nov.–Jan. | Aleutian Goose federally delisted. California & Alaska limited hunt outside of special closure areas[a] |
| 2002 | 2 geese per day | Nov.<br>Nov.–Jan. | California: 5 day hunt in coastal areas<br>86 day hunt in wintering areas with special closure areas[b] |
| 2003 | 2 geese per day | Nov.<br>Nov.–Jan. | California: 16 day hunt in coastal areas<br>86 day hunt in wintering areas with special closure areas opened[b] |
| 2004 | 2 geese per day<br>3 geese per day | Oct.–Jan.<br>Oct.–Jan. | California: 93 day hunt in coastal areas[b]<br>California: 93 day hunt in wintering areas[b] |
| 2005 | 4 geese per day | Oct.–Jan. | California & Oregon: 100 day hunt, Oregon removes special closure areas[b,c] |
| 2006 | 4 geese per day | Oct.–Jan. | California & Oregon: *c.* 100 day hunt. Washington state removes Aleutian Goose from state ESA listing[a,b] |
| 2007 | 4 geese per day | Oct.–Jan. &<br>Feb.–March | California & Oregon: 86 day season, 16 day late season hunt on private lands in coastal areas,<br>100 day season in inland areas[b] |
| 2008 | 6 geese per day | Oct.–Jan. &<br>Feb.–March | California & Oregon: 87 day season, 19 day late season hunt on private lands in coastal areas,<br>100 day season in inland areas[b] |
| 2009 | 6 geese per day | Oct.–Jan. &<br>Feb.–March | California & Oregon: 85 day season, 18 day late season hunt on private lands in coastal areas,<br>100 day season in inland areas[b] |
| 2010 | 6 geese per day | Oct.–Jan. &<br>Feb.–March | California & Oregon: 85 day season, 18 day late season hunt on private lands in coastal areas,<br>100 day season in inland areas[b] |

[a] 2006 Pacific Flyway Management Plan for Aleutian Canada Geese.
[b] California Department of Fish and Game & Oregon Department of Fish and Wildlife annual hunting regulation booklets.
[c] A portion of Tillamook County, Oregon remains closed to hunting to protect the Semidi Island Aleutian Goose population segment.

recently declined (Fig. 3). In 2001, geese began to occur in the San Joaquin-Sacramento River Delta and use of this area had increased substantially (Delta Islands; Fig. 3). Approximately 2,000–4,000 Aleutian Geese also have been observed in the Humboldt Bay area throughout winter (USFWS 2010a).

During the 1970s to 1990s, most Aleutian Geese passed through the Humboldt Bay area on spring migration without stopping (Woolington *et al.* 1979; Springer & Lowe 1998). Hazing efforts in the Crescent City area, coupled with increasing population size, led to shifts in geese from Crescent City, 150 km south to the Humboldt Bay

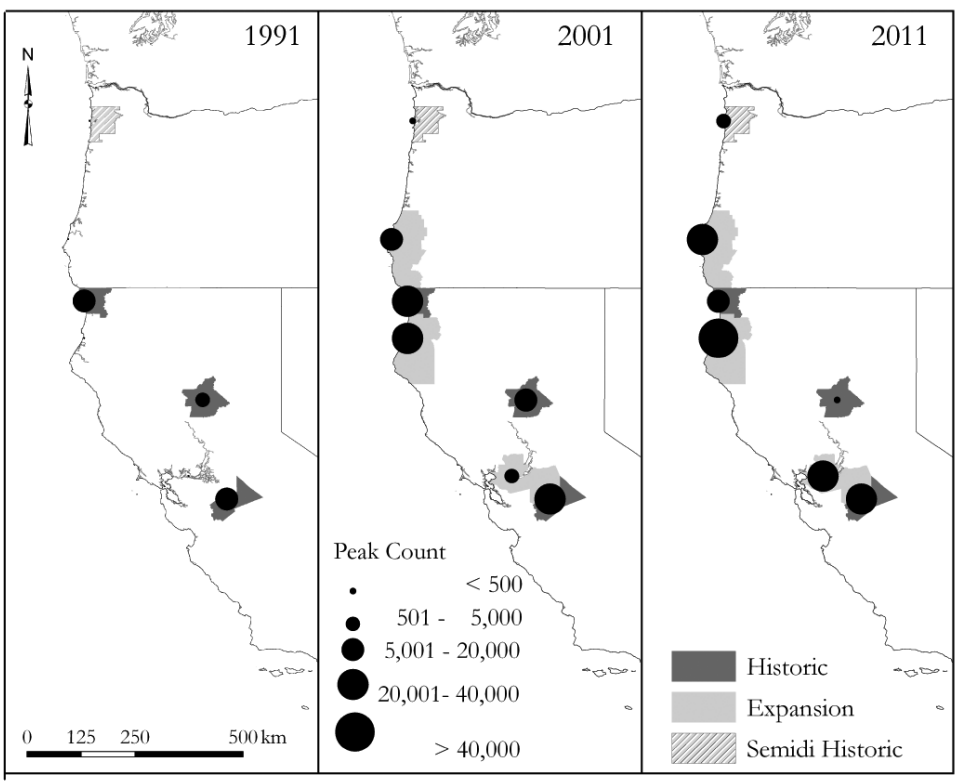


**Figure 3.** Landscape distributional changes of Aleutian Geese in 10-year increments from 1991–2011, including all known counties used for wintering and migration. Circles in central California are autumn and wintering grounds (October–February). Circles along the north coast of California and coast of Oregon represent counts in spring staging areas (February–April), although autumn and wintering use of Aleutian Geese now occurs on the north coast of California. The southern Oregon coast circle represents a two-week window at the end of spring staging before return to the Aleutian Islands; the northern Oregon coast (cross-hatched) area is where Semidi Island birds migrate, and have recently mixed with the other Aleutian Geese in the spring.

area, which has a greater area for accommodating birds (Mini & Black 2009). The period of greatest Aleutian Goose population growth occurred from 1998–2004 (Fig. 2), and major range expansions occurred between 1997–2000 and 2007–2010 (Fig. 3). Following the start of late-season hunts in 2007, the population as a whole expanded and changed foraging sites to other regions along the entire northern California and Oregon coasts. During 2003–2007, as many as 25,000 Aleutian Geese used the New River area for 1–2 weeks in April before heading north (Fig. 3). However, since 2007 there has been a drastic decrease in the number of birds using this area and small groups of Aleutian Geese have been pioneering new staging and wintering areas in several locations along the Oregon coast (Stephenson 2010). This change in distribution from southwest Oregon to the north-central coast in Tillamook County concerns land managers and owners because western Aleutian and Semidi Island populations now intermingle in this area (Fig. 3).

## Recommendations and research needs

A set of monitoring and research priorities for the Aleutian Geese have recently been outlined by the Arctic Goose Joint Venture (AGJV Technical Committee 2008), including: 1) continued special management for Semidi Island birds, such as hunting closures; 2) continued surveys to re-sight birds marked with neck collars; 3) aerial surveys of spring staging areas; 4) direct counts of Aleutian Geese on the Oregon coast; 5) surveys to provide an index of Semidi Island birds; 6) continued marking of birds to evaluate harvest distribution and survival rates; 7) an assessment of whether post-season banding would be useful; 8) research into what prevents an increase in numbers for birds breeding on Semidi Island; 9) continuation of the 2006 harvest strategy to meet the population objective of 60,000 birds; 10) continued fox removal; 11) provision of funding to protect and manage goose-use areas; 12) determination of the amount and timing of use on staging areas to detect shifts in distribution, changes in foraging patterns and response to habitat management; and 13) encouragement of optimal management of public land for goose forage to relieve agricultural damage. Some of the above priorities were also in the 1999 and 2006 Aleutian Goose Management Plans (PFC 1999; PFC 2006).

Black *et al.* (2004) echoed the need to meet these priorities, added the importance of using mark-recapture methods for assessing survival, site fidelity, migration chronology and movements among staging areas, and emphasised determining the carrying capacity of goose habitat and the response of grasses to varying amounts of grazing. In addition to the Black *et al.* (2004) recommendations, we suggest that the safeguarding of sufficient high-quality goose-safe habitat in spring staging areas for at least 60,000 geese (*i.e.* the population goal) should be considered, to reduce private land depredation. This may require further habitat improvements on public pasture, initiating agreements for adjacent land with private landowners (easements),

and calculation of the carrying capacity of land already used by the birds.

## Improving habitat

In an agricultural setting, livestock grazing is the preferred management tool for creating a short grass habitat to attract migratory geese (Owen 1990; Vickery & Gill 1999). Public land managers on the north coast have worked with ranchers to graze public land pasture to provide quality habitat. For example, the Humboldt Bay NWR, which began to be used by geese in 2001, arranges agreements with ranchers to graze refuge pasture in exchange for in-kind services (*e.g.* addition of fertilisers/lime, weed management, and pasture mowing). In one study, Aleutian Geese spent twice the amount of time feeding on cattle-grazed pastures on the refuge compared to mechanically mown pastures (Bachman 2005). Aleutian Geese spent most time in refuge pastures that were 3–5 cm in height and discontinued use as average sward height reached > 10 cm (Bachman 2005). Public land managers, treating pasture for prolonged use by the geese, should aim for grass heights of > 3 cm to increase available biomass of vegetation for the geese (Bachman 2005), but should also aim for swards of < 9 cm based on other studies of Aleutian Geese (Dahl *et al.* 1999) and other similar sized geese (Lang & Black 2001; Durant *et al.* 2003; Heuermann *et al.* 2011). In refuge pastures, mowing after grazing removed weeds and less palatable grass species and created a uniform pasture height preferred by Aleutian Geese (Bachman 2005). Fertilised grasslands on refuges received 42% more Aleutian Goose grazing pressure compared to unfertilised pasture (Bachman 2008) and planting clover *Trifolium* sp. may be another effective way of attracting geese to a site (Owen 1975; McKay *et al.* 2001). Mini (2005) and Bachman (2008) both found evidence that Aleutian Geese select clover while foraging on pasture in spring.

## Safeguarding habitat

A common feature of international action plans for species of concern, including those conflicting with other species or humans, is to set aside habitat that is used by ≥ 1% of the population (Scott 1980; Black 1998b; Taylor *et al.* 2005). Acquiring enough well-managed habitat or securing it through agreements with landowners (*i.e.* safeguarding) can encourage current use and subsequent return of wildlife (Hunter & Gibbs 2007). In the San Joaquin Valley, the USFWS has a proactive easement programme to protect land for wildlife, which has also provided geese a place to forage. Additionally, Butte Sink has one conservation easement for Aleutian Geese. However, on the spring staging grounds of northwest California and southwest Oregon, few viable easement programmes exist specifically for geese. Several long-term or permanent easement programmes in the "Farm Bill" (formally the Food, Conservation, and Energy Act of 2008; Public Law 110–246) may be valuable, including the Wetland Reserve Programme, the Conservation Reserve Programme and the Grassland Reserve Programme (Gray & Teels 2006). In the most recent Farm Bill, there is a new pilot easement programme (Wetland Reserve Enhancement Programme) that may apply to the spring staging areas.

Management of grassland for geese has been widely discussed in Europe (Owen 1979, 1990; McKay *et al.* 1996; Vickery & Gill 1999; Vickery *et al.* 2001). Owen (1977, 1990) suggested that establishing well-managed refuges to accommodate as many geese as possible would reduce the "goose burden" on farmland. Similarly, Vickery *et al.* (1994) suggested that the optimal financial solution to crop depredation for taxpayers was the establishment of goose refuges. The use of alternative feeding areas for geese has worked well in the U.K. and the Netherlands (Owen 1977, 1990; Van Eerden 1990; Vickery *et al.* 1994; Vickery & Gill 1999; Cope *et al.* 2003; MacMillan *et al.* 2004) and is similar to how some NWRs and state-run Wildlife Areas are managed in the U.S. (USFWS 2009; USFWS 2010a). Intensive management of alternative feeding areas is timed so that the optimal quality and quantity of forage is available when the geese arrive (Owen 1977, 1990; Owen *et al.* 1987; Cope *et al.* 2003). With this strategy, geese may redistribute across the landscape, thus reducing the depletion of crops. We emphasise that high-quality habitat must be in place before disturbance schemes are undertaken, if they are to be effective.

## Calculating carrying capacity

Determining the amount of habitat necessary to "service" a particular number of individuals (essentially, carrying capacity) requires detailed knowledge regarding a study population's demography, social structure, annual energy needs, food availability, true metabolisable energy (TME) of food items, and migration chronology (*sensu* Belovsky *et al.* 1994; Central Valley Joint Venture 2006). For Aleutian Geese, the amount of suitable publicly owned habitat for foraging geese on the north coast is currently being determined, but better assessment is needed. Numbers, distribution, movement, return rates, diet, disturbances, and change in body condition are understood, but may need further study.

The next step required for an evaluation of carrying capacity for Aleutian Geese is to quantify intake rates, energy value and availability of food resources in a range of habitats (high-quality, moderate, and marginal), and how body mass patterns change over the annual cycle. Within seasons and from one season to the next, geese determine whether to return or go elsewhere by the deficit or surplus in daily energy budgets and ability to build body stores (Black *et al.* 2007). Fat and nutrients can be stored when energy intake exceeds energy expenditure (including flights from roosts and between foraging patches), when food is abundant, available, readily digestible, and nutritious, and when the geese have ample time to feed without disturbance from humans, predators, or competitors (Black *et al.* 2007). A carrying capacity model would include a sliding threshold, achieved by individuals over time after a certain date, taking into account that all birds must leave at the end of the spring season even if they do not achieve the threshold. It is assumed that the site has served (enabled) breeding birds that meet the threshold and partly served others who are non-breeders (Goss-Custard *et al.* 2002, 2003; Goss-Custard 2003; Prop *et al.* 2003; Black *et al.* 2007). Such models can

determine, for example, how many geese are able to maintain body mass on a daily basis, or the energy threshold needed to trigger migration and subsequent breeding.

### Prospects for expansion of breeding colonies in Aleutian Island Chain

Further research in the Aleutian Islands is required to assess current nesting and colony distribution in relation to fox removal (Byrd 1998; *sensu* Byrd *et al.* 2005). Nesting densities are thought to be increasing and Aleutian Geese may be approaching carrying capacity in some breeding areas. Following Woolington & Early (1977) and Byrd & Woolington (1983), researchers revisited 30 plots in 2009 to quantify changes in distribution of geese on Buldir (J. Cocke, unpubl. data). Aleutian Geese have extended their nesting distribution into all habitats on the island, including occurring in vegetation communities not previously occupied (J. Cocke, unpubl. data). Thirty-five years on from the initial studies, there is now preliminary evidence to suggest that geese on Buldir are at higher nesting densities, have smaller clutch sizes, and that post-breeding female body mass is reduced (J. Cocke, unpubl. data), which may suggest nearing or exceeding island nesting capacity.

Since 1970, USFWS has removed foxes from 40 islands, for an area of > 4,000 km$^2$ (Byrd *et al.* 2005) and the region is returning to historic fox-free conditions (Ebbert 2000). In the western Aleutians, where there are no predatory Bald Eagles, Attu Island (90,320 ha) now provides a substantial amount of available nesting habitat (USFWS 2001), and geese have recently established a nesting population there, probably from reintroduced populations nearby (V. Byrd & J. Williams, pers. comm.). On islands east of Buldir (*e.g.* at Amchitka Island and Rat Island; Fig. 1), where Bald Eagles are present, there is evidence of at least a few pairs of nesting geese (J. Williams, pers. comm.). Expansion to unoccupied islands east of Buldir is not expected to occur as rapidly as the Near Island group. Quantifying future breeding densities could be undertaken with available information on suitable habitat characteristics of fox-free islands.

## Discussion

The recovery of Aleutian Geese is a remarkable achievement in the conservation of a once endangered population. The success of the population is a testament to the patience, perseverance, and collaborative efforts of federal and state agencies, landowners and private individuals. The geese have recovered to healthy population levels and many people can once again view and harvest these geese. A successful Aleutian Goose Festival, celebrating the recovery of the geese, took place in the Crescent City area from 1999–2010. The Humboldt Bay NWR holds an annual fly-off weekend to highlight benefits to the public provided by the Aleutian Goose, and this has gained in popularity with the local community. The SHARE programme is growing and is well-liked by landowners (USFWS 2010a). Other landowners gain economic benefit from leasing their lands as hunting clubs (USFWS 2010a).

Nevertheless, the recovery of this population and its continued growth leave

managers and biologists with several pressing issues. Questions arise regarding the flyway population objective of 60,000 and whether it is reasonable, because there is a lack of precise estimates of harvest levels and carrying capacity on breeding areas. Furthermore, depredation that is occurring is difficult to quantify, and whether it could or should be mitigated needs to be assessed. Carrying capacity of spring staging areas has yet to be calculated. Lastly, it is difficult to address whether the majority of geese would still be using the original spring staging haunt if more high-quality habitat had been made available prior to hazing in the spring staging areas. Drent *et al.* (2003, 2006, 2007) developed a compelling argument about the importance of traditional migration sites that underpin the timing of goose migration and subsequent breeding success, where natural selection favours site-faithful individuals (Black *et al.* 2007). Some of these questions are especially challenging due to a lack of historic population or distribution data.

Perhaps the most contentious issue is whether or not the current population size is too large and at what size it will be managed, because the current population size is already giving rise to complaints of crop damage in northern California and coastal Oregon. North American wildlife managers in several flyways are increasingly dealing with the issue of "too many geese" (Ankney 1996). However, compared to other defined goose populations in North America, the Aleutian Goose population is one of the smallest, ranking 6 out of 20 in estimated population size, excluding Hawaiian Geese *Branta sandvicensis* (from Arctic Goose Joint Venture 2008). In contrast, there are several million mid-continent Lesser Snow Geese *Chen caerulescens caerulescens* and Ross's Geese *C. rossii* making use of a network of NWR, state, and non-profit wetland complexes and massive areas of agricultural land along their migration corridors (Ankney 1996; Abraham *et al.* 2005; Alisauskas *et al.* 2011). Managers are challenged with attempting to reduce numbers through liberal hunting regulations. A problem associated with too many Lesser Snow Geese is their feeding habits and trampling of the fragile tundra ecosystem (Williams *et al.* 1993). The original issue with Aleutian Geese in spring was their impact on some dairy and beef production operations near Crescent City, but complaints have spread to include areas adjacent to Humboldt Bay in winter and spring, as well as coastal counties in Oregon in spring. The coordinated hazing programme, and having fewer geese at the population's original spring staging area (near Crescent City), has the benefit of reducing concerns about possible impacts to nesting seabirds on the Castle Rock NWR and fewer reports of crop depredation received from landowners. However, ironically Béchet *et al.* (2003) suggested that more crop damage may have resulted from spring hunting when more Greater Snow Geese *C. c. atlantica* were pushed to previously unused areas. It would be informative to conduct an economic and taxpayer satisfaction study (*sensu* Vickery *et al.* 1994) to determine the total cost of geese remaining at few (original) sites compared to when they spread out across multiple sites and communities. In the meantime, the agricultural communities on the north coast of California and coastal Oregon are

adjusting to the impacts of large numbers of geese that previously never occurred in these areas.

How North American wildlife managers cope with the problem of over-abundant goose populations and, in particular, the once-endangered Aleutian Goose, are of great interest to the scientific, management, and public communities. From a global perspective it might seem aggressive to allow hunting on a once-endangered species, and to permit late-season hunts which may break pair bonds (Owen *et al.* 1988) and reduce the birds' body condition (Féret *et al.* 2003; Mainguy *et al.* 2003). However, in North America, a bag of six birds per day seems rather limited compared to bag limits for light geese, such as 20 in the Central and Mississippi Flyways and 25 in the Atlantic Flyway (USFWS 2010b). Additionally, under the 1999 Conservation Order, the harvest of light geese includes new methods (*e.g.* unplugged shotguns, electronic calls, and no daily harvest or possession limits) and a hunting period extending beyond the 10 March deadline set in the Migratory Bird Treaty Act (Alisauskas *et al.* 2011). Some would commend the Pacific Flyway for acting quickly on what was perceived as a situation with Aleutian Geese that might have spiralled out of control. As it stands, the Aleutian Goose population has remained at around 100,000 for the past few years (Collins & Trost 2011; Fig. 2).

As wild goose and human populations continue to overlap in proximity, wildlife managers will have increasing opportunities to foster a positive image for geese through outreach programmes and habitat management that, in the end, attract geese and other wildlife for public viewing. More emphasis should be placed on increasing an understanding of population dynamics, habitat needs, and management issues while highlighting the benefits of geese to communities (*e.g.* increased revenues from hunting, bird watching and local festivals, and the wilderness values that wild geese engender). Focus should continue to be on the management of sufficient high-quality habitat for at least the flyway population objective (60,000 geese) and on collaborative research for determining the amount of goose-safe habitat such an objective would require. Safeguarded habitat must be in every way "suitable" to attract and hold geese, with the aim of reducing the negative connotations that some farmers and ranchers may have of geese as burdens. It is rare that an endangered species once thought extinct is rediscovered or that it recovers as well as the Aleutian Goose. Biologists and managers certainly need to do everything possible to alleviate impacts Aleutian Geese may cause, but all should celebrate this remarkable conservation success.

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## References

Abraham, K.F., Jeffries, R.L. & Alisauskas, R.T. 2005. The dynamics of landscape change and Snow Geese in mid-continent North America. *Global Change Biology* 11: 841–855.

Aleutian Goose Working Group. 2005. *Living with Aleutian Geese on the Pacific north coast*. http://www.humboldtfarmbureau.org/livingwithAleutianGeese.pdf (accessed June 2011).

Alisauskas, R.T., Rockwell, R.F., Dufour, K.W., Cooch, E.G., Zimmerman, G., Drake, K.L., Leafloor, J.O., Moser, T.J. & Reed, E.T. 2011. Harvest, survival, and abundance of mid continent Lesser Snow Geese relative to population reduction. *Wildlife Monographs* 179: 1–42.

Ankney, C.D. 1996. An embarrassment of riches: too many geese. *Journal of Wildlife Management* 60: 217–223.

Arctic Goose Joint Venture Technical Committee. 2008. *Arctic Goose Joint Venture strategic plan: 2008–2012*. Unpublished report, Arctic Goose Joint Venture Coordination Office, Canadian Wildlife Service, Edmonton, Alberta, Canada.

Bachman, D.C. 2005. *Aleutian Canada Geese field selection in relation to grass quality and quantity during spring staging*. Unpublished report, U. S. Fish and Wildlife Service, Humboldt Bay National Wildlife Refuge, Loleta, California, USA.

Bachman, D.C. 2008. *Managing grassland pastures at Humboldt Bay National Wildlife Refuge for Aleutian Geese*. M.Sc. Thesis, Humboldt State University, Arcata, California, USA.

Bailey, E.P. 1993. *Introduction of foxes to Alaskan islands – history, effects on avifauna, and eradication*. U.S. Fish and Wildlife Service Research Publication No. 193. U.S. Fish and Wildlife Service, Washington, D.C., USA.

Bailey, E.P. & Trapp, E.P. 1984. A second wild breeding population of the Aleutian Canada Goose. *American Birds* 38: 284–286.

Béchet, A., Giroux, J.-F., Gauthier, G., Nichols, J.D. & Hines, J.E. 2003. A spring hunt changes the regional movements of migrating greater snow geese in southern Québec. *Journal of Applied Ecology* 40: 553–564.

Belovsky, G.E., Bissonette, J.A., Dueser, R.D., Edwards, T.C., Jr., Luecke, C.M., Ritchie,

M.E., Slade, J.B. & Wagner, F.H. 1994. Management of small populations: concepts affecting the recovery of endangered species. *Wildlife Society Bulletin* 22: 307–316.

Black, J.M. 1991. Guidelines for bird recovery programmes: re-introduction and re-stocking. *Bird Conservation International* 1: 329–334.

Black, J.M. 1998a. Threatened waterfowl: recovery priorities and reintroduction potential with special reference to the Hawaiian Goose. *In* J.M. Marzluff & R. Shallabanks (eds.), *Avian conservation: research and management*, pp. 125–140. Academic Press, New York, USA.

Black, J.M. 1998b. Flyway plan for the Svalbard population of Barnacle Geese: a summary. *Norsk Polarinstitutt Skrifter* 200: 29–40.

Black, J.M., Prop, J. & Larsson, K. 2007. *Wild Goose Dilemmas: Population Consequences of Individual Decisions in Barnacle Geese*. Branta Books, Groningen, The Netherlands.

Black, J.M., Springer, P.F., Nelson, E.T., Griggs, K.M., Taylor, T.D., Thompson, Z.D., Maguire, A. & Jacobs, J. 2004. Site selection and foraging behavior of Aleutian Canada Geese in a newly colonized spring staging area. *In* T.J. Moser, K.C. VerCauteren, R.D. Lien, K.F. Abraham, D.E. Andersen, J.G. Bruggink, J.M. Coluccy, D.A. Graber, J. Leafloor, D.R. Luukkonen, & R.E. Trost (eds.), *Proceedings of the 2003 International Canada Goose Symposium*, pp. 106–113. 2003 International Canada Goose Symposium, Madison, Wisconsin, USA.

Byrd, G.V. 1998. Current breeding status of the Aleutian Canada goose, a recovering endangered species. *In* D.H. Rusch, M.D. Samuel, D.D. Humburg & B.D. Sullivan (eds.), *Biology and management of Canada Geese*, pp. 21–28. 1998 International Canada Goose Symposium, Milwaukee, Wisconsin, USA.

Byrd, G.V., Durbin, K., Lee, F., Rothe, T., Springer, P., Yparraguirre, D. & Zeillermaker, F. 1991. *Aleutian Canada Goose (*Branta canadensis leucopareia*) recovery plan. Second revision*. Unpublished document, U.S. Fish and Wildlife Service, Anchorage, Alaska, USA.

Byrd G.V., Renner, H.M. & Renner, M. 2005. Distribution patterns and population trends of breeding seabirds in the Aleutian Islands. *Fisheries Oceanography* 14: 139–159.

Byrd, G.V. & Springer, P.F. 1976. Recovery program for the endangered Aleutian Canada Goose. *Cal-Neva Wildlife Transactions* 1976: 65–73.

Byrd, G.V. & Woolington, D.W. 1983. *Ecology of Aleutian Canada Geese at Buldir Island, Alaska*. U.S. Fish and Wildlife Service Special Scientific Report. *Wildlife* 253: 1–18. U.S. Fish and Wildlife Service, Washington, D.C., USA.

Cade, T.J. & Temple, S.A. 1995. Management of threatened bird species: evaluation of the hands-on approach. *Ibis* 137: 161–172.

Carroll, S.P. & Fox, C.W. 2008. *Conservation Biology: Evolution in Action*. Oxford University Press, New York, USA.

Carter, H.R., McChesney, G.J., Jaques, D.L., Strong, C.S., Parker, M.W., Takekawa, J.E., Jory, D.L. & Whitworth, D.L. 1992. *Breeding populations of seabirds in California, 1989–1991*. Unpublished report, U.S. Fish and Wildlife Service, Northern Prairie Wildlife Research Centre, Dixon, California, USA.

Central Valley Joint Venture. 2006. *Central Valley Joint Venture Implementation Plan–Conserving Bird Habitat*. U.S. Fish and Wildlife Service, Sacramento, California, USA.

Collins, D.F. & Trost, R.E. 2011. *Waterfowl harvest and status, hunter participation and success in the Pacific flyway and United States*. Unpublished report, U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Portland, Oregon, USA.

Cope, D.R., Pettifor, R.A., Griffin, L.R. & Rowcliffe, J.M. 2003. Integrating farming and wildlife conservation: the barnacle goose management scheme. *Biological Conservation* 110: 113–122.

Dahl, A.L., Stabins, H.C., Grue, C.E. & Manuwal, D.A. 1999. *Management of Migratory and Wintering Habitat for Aleutian Canada Geese*. U.S. Fish and Wildlife Service, Ecological Services, Anchorage, Alaska. USA.

Drent, R.H., Both, C., Green, M., Madsen, J. & Piersma, T. 2003. Pay-offs and penalties of competing migratory schedules. *Oikos* 103: 274–292.

Drent, R.H., Eichhorn, G., Flagstad, A., Van der Graaf, J., Litvin, K.T. & Stahl, J. 2007. Migratory connectivity in Arctic geese: spring stopovers are the weak links in meeting targets for breeding. *Journal of Ornithology* 148: 501–514.

Drent, R.H., Fox, A.D. & Stahl, J. 2006. Travelling to breed. *Journal of Ornithology* 147: 122–134.

Drut, M.S. & Trost, R.E. 2004. *Summary of goose population monitoring programs [Pacific Flyway], 2003–2004*. Unpublished report, U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Portland, Oregon, USA.

Durant, D., Fritz, H., Blais, S. & Duncan, P. 2003. Functional response in three species of herbivorous Anatidae: effects of sward height, body mass, and bill size. *Journal of Animal Ecology* 72: 220–231.

Ebbert, S. 2000. Successful eradication of introduced Arctic Foxes from large Aleutian Islands. *In* T.P. Salmon & A.C. Crabb (eds.), *Proceedings of the 19th Vertebrate Pest Conference*, pp. 127–132. University of California, Davis, Davis, California, USA.

Ebbert, S.E. & Byrd, G.V. 2002. Eradications of invasive species to restore natural biological diversity on Alaska Maritime National Wildlife Refuge. *In* C.R. Veitch & M.N. Clout (eds.), *Turning the tide: the eradication of invasive species*, pp. 102–109. Proceedings of the International Conference on Eradication of Island Invasives, IUCN SSC Invasive Species Specialist Group, IUCN, Gland, Switzerland and Cambridge, UK.

Féret, M., Gauthier, G., Béchet, A., Giroux, J.-F. & Hobson, K. 2003. Effect of a spring hunt on nutrient storage by greater snow geese in southern Québec. *Journal of Wildlife Management* 67: 796–807.

Goss-Custard, J.D. 2003. Fitness, demographic rates and managing the coast for wader populations. *Wader Study Group Bulletin* 100: 183–191.

Goss-Custard, J.D., Stillman, R.A., Caldow, R.W.G., West, A.D. & Guillemain, M. 2003. Carrying capacity in overwintering birds: when are spatial models needed? *Journal of Applied Ecology* 40: 176–187.

Goss-Custard, J.D., Stillman, R.A., West, A.D., Caldow, R.W.G. & McGrorty, S. 2002. Carrying capacity in overwintering migratory birds. *Biological Conservation* 105: 27–41.

Gray, R.L. & Teels, B.L. 2006. Contributions of the farm bill on fish and wildlife. *Wildlife Society Bulletin*: 905–905.

Gregg, M.A., Eckhardt, T.M., & Springer, P.F. 1988. *Population, distribution, and ecology of Aleutian Canada Geese on their migration and wintering areas, 1986–87*. Unpublished document, State of California, Department

of Fish and Game, Wildlife Management, Sacramento, California, USA.

Griggs, K.M. 2005. *Aleutian cackling goose monitoring program: summary of reports from the Sacramento Valley, San Joaquin Valley, and coast of northern California and southern Oregon, 2004–2005*. Unpublished document, U.S. Fish and Wildlife Service, San Luis National Wildlife Refuge Complex, Los Banos, California, USA.

Hatch, S.A. & Hatch, M.A. 1983. An isolated population of small Canada Geese on Kiliktagik Island, Alaska. *Wildfowl* 34: 130–136.

Heuermann, N., van Langevelde, F., van Wieren, S.E. & Prins, H.H.T. 2011. Increased searching and handling effort in tall swards lead to a Type IV functional response in small grazing herbivores. *Oecologia* 166: 659–669.

Hunter, M.L., Jr. & Gibbs, J. 2007. *Fundamentals of Conservation Biology, 3rd edition*. Blackwell Publishing, Malden, Massachusetts, USA.

International Union for Conservation of Nature and Natural Resources Conservation (IUCN) Monitoring Centre, Cambridge U.K. 1986. *1986 IUCN Red List of Threatened Animals*. IUCN, Gland, Switzerland and Cambridge, UK.

International Union for Conservation of Nature and Natural Resources Conservation (IUCN) Monitoring Centre, Cambridge U.K. 1986. *1988 IUCN Red List of Threatened Animals*. IUCN, Gland, Switzerland and Cambridge, UK.

Jaques, D.L. & Strong, C.S. 2001. *Seabird status at Castle Rock National Wildlife Refuge, 1997–1999*. Unpublished document, Crescent Coastal Research for the U.S. Fish and Wildlife Service, Humboldt Bay National Wildlife Refuge, Loleta, California, USA.

Jones, R.D. Jr. 1963. Buldir Island, site of a remnant breeding population of Aleutian Canada Geese. *Wildfowl Trust Annual Report* 14: 80–83.

Lang, A. & Black, J.M. 2001. Foraging efficiency in Barnacle Geese *Branta leucopsis*: a functional response to sward height and an analysis of sources of individual variation. *Wildfowl* 52: 7–20.

MacMillan, D., Hanley, N. & Daw, M. 2004. Costs and benefits of wild goose conservation in Scotland. *Biological Conservation* 119: 475–485.

Mainguy, J., Béty, J., Gauthier, G. & Giroux, J.-F. 2002. Are body condition and reproductive effort of laying greater snow geese affected by the spring hunt? *Condor* 104: 156–162.

McKay, H.V., Milsom, T.P., Feare, C.J., Ennis, D.C., O'Connell, P. & Haskell, D.J. 2001. Selection of forage species and the creation of alternate feeding areas for Dark-bellied Brent Geese *Branta bernicla bernicla* in southern UK coastal areas. *Agriculture, Ecosystems and Environment* 84: 99–113.

Mills, L.S. 2007. *Conservation of Wildlife Populations: Demographics, Genetics, and Management*. Blackwell Publishing, Malden, Massachusetts, USA.

Mini, A.E. 2005. *Energy expenditure and body reserves of Aleutian Cackling Geese utilizing three spring staging areas in northwestern California*. M.Sc. Thesis, Humboldt State University, Arcata, California, USA.

Mini, A.E. & Black, J.M. 2009. Expensive traditions: energy expenditure of Aleutian Geese in traditional and recently colonized habitats. *Journal of Wildlife Management* 73: 385–391.

Mini, A.E. & LeValley, R. 2006. *Aleutian Cackling Goose Agricultural Depredation Plan for Del Norte County, California*. California Coastal Conservancy, San Francisco, California, USA.

Moser, M. & Kalden, C. 1991. Farmers and waterfowl: conflicts or co-existence – an introductory overview. *In* M.V. Roomen & J. Madsen (eds.), *Waterfowl and agriculture: review and future perspective of the crop damage conflict in Europe,* pp. 13–19. Proceedings of the international workshop "Farmers and waterfowl: conflict or coexistence," Lelystad, The Netherlands, 6–9 October 1991. IWRB Special Publication No. 21, International Waterfowl & Wetlands Research Bureau, Slimbridge, UK.

Murie, O.J. 1959. Fauna of the Aleutian Islands and Alaska peninsula. *North American Fauna* 61: 1–134.

Owen, M. 1975. Cutting and fertilizing grassland for winter goose management. *Journal of Wildlife Management* 39: 163–167.

Owen, M. 1977. The role of wildlife refuges on agricultural land in lessening the conflict between farmers and geese in Britain. *Biological Conservation* 11: 209–222.

Owen, M. 1979. The role of refuges in wildfowl management. *In* E.N. Wright, I.R. Inglis & C.J. Feare (eds.), *Bird Problems in Agriculture BCPC Monograph 23,* pp. 144–156. Lavenham Press, Lavenham, UK.

Owen, M. 1990. The damage-conservation interface illustrated by geese. *Ibis* 132: 238–252.

Owen, M., Black, J.M., Agger, M.C. & Campbell, C.R. 1987. The use of the Solway Firth by an increasing population of Barnacle Geese in relation to changes in refuge management. *Biological Conservation* 39: 63–81.

Owen, M., Black, J.M. & Liber, H. 1988. Pair bond duration and timing of its formation in Barnacle Geese (*Branta leucopsis*). *In* M.W. Weller (ed.), *Waterfowl in winter*, pp. 23–57. University of Minnesota Press, Minneapolis, Minnesota, USA.

Pacific Flyway Council. 1998. *Pacific Flyway management plan for Northwest Oregon–Southwest Washington Canada Goose agricultural depredation control*. Unpublished report, Pacific Flyway Study Committee, [c/o] U.S. Fish and Wildlife Service, Portland, Oregon, USA.

Pacific Flyway Council. 1999. *Pacific Flyway management plan for the Aleutian Canada Goose*. Unpublished report, Aleutian Goose Subcommittee, Pacific Flyway Study Committee, [c/o] U.S. Fish and Wildlife Service, Portland, Oregon, USA.

Pacific Flyway Council. 2004. *Pacific Flyway management plan for the Aleutian goose*. Unpublished report (draft for public review), Aleutian Goose Subcommittee, Pacific Flyway Study Committee, [c/o] U.S. Fish and Wildlife Service, Portland, Oregon, USA.

Pacific Flyway Council. 2006. *Pacific Flyway management plan for the Aleutian goose*. Unpublished report, Aleutian Goose Subcommittee, Pacific Flyway Study Committee, [c/o] U.S. Fish and Wildlife Service, Portland, Oregon, USA.

Pierson, B.J., Pearce, J.M., Talbot, S.L., Shields, G.F. & K.T. Scribner. 2000. Molecular genetic status of Aleutian Canada Geese from Buldir and the Semidi Islands, Alaska. *Condor* 102: 172–180.

Prop, J., Black, J.M. & Shimmings, P. 2003. Travel schedules to the high arctic: barnacle geese trade-off the timing of migration with accumulation of fat deposits. *Oikos* 103: 403–414.

Riddington, R., Hassall, M. & Lane, S.J. 1997. The selection of grass swards by Brent Geese *Branta bernicla bernicla*: Interactions between food quality and quantity. *Biological Conservation* 81: 153–160.

Scott, D.A. 1980. *A Preliminary Inventory of Wetlands of International Importance for Waterfowl in West Europe and Northwest Africa*. International Waterfowl and Wetlands Research Bureau Special Publication No. 2, IWRB, Slimbridge, UK.

Spencer, D.L. 1980. *Aleutian Islands National Wildlife Refuge*. U.S. Fish and Wildlife Service Report, Alaska Maritime National Wildlife Refuge, Homer, Alaska, USA.

Spragens, K.A. 2010. *The fight for forage: distribution and abundance patterns of Aleutian Cackling Geese during spring staging*. M.Sc. Thesis, Humboldt State University, Arcata, California, USA.

Springer, P.F., Byrd, G.V. & Woolington, D.W. 1978. Re-establishing Aleutian Canada Geese. *In* S.A. Temple (ed.), *Endangered birds: management techniques for preserving threatened species*, pp. 331–338. University of Wisconsin Press, Madison, Wisconsin, USA.

Springer, P.F. & Lowe, R.W. 1998. Population, distribution, and ecology of migrating and wintering Aleutian Canada Geese. *In* D.H. Rusch, M.D. Samuel, D.D. Humburg & B.D. Sullivan (eds.), *Biology and management of Canada Geese,* pp. 425–434. 1998 International Canada Goose Symposium, Milwaukee, Wisconsin, USA.

Stephensen, S.W. 2010. *White-cheeked geese surveys at Nestucca, Nehalem, and Tillamook Bays, Oregon 2009–10*. Unpublished report, U.S. Fish and Wildlife Service, Oregon Coast National Wildlife Refuge Complex, Newport, Oregon, USA.

Taylor, D., Diémé, E., Bracke, A. & Schneider-von Deimling, K. 2005. *Ramsar Sites: Directory and Overview*. Wetlands International (compact disc), Wageningen, The Netherlands. Available at: http://www.wetlands.org/RSIS/_COP9Directory/ENG/Default.htm (accessed on 18 June 2011).

U.S. Fish and Wildlife Service. 1967. Endangered Species. *Federal Register* 32(48): 4001.

U. S. Fish and Wildlife Service. 2001. Endangered and threatened wildlife and plants; final rule to remove the Aleutian Canada Goose from the federal list of endangered and threatened wildlife. *Federal Register* 50 *CFR Part 17* 66(54): 15643–15656.

U.S. Fish and Wildlife Service. 2006. *San Joaquin River National Wildlife Refuge final comprehensive conservation plan and final environmental assessment*. Unpublished report, U.S. Fish and Wildlife Service, Sacramento, California, USA.

U.S. Fish and Wildlife Service. 2008. *Aleutian Canada Goose monitoring program annual progress report for California and Oregon 1996–2008 summary report*. Unpublished report, U.S. Fish and Wildlife Service, Humboldt Bay National Wildlife Refuge, Loleta, California, USA.

U.S. Fish and Wildlife Service. 2009. *Humboldt Bay National Wildlife Refuge complex comprehensive conservation plan and final environmental assessment*. Unpublished report, U.S. Fish and Wildlife Service, Sacramento, California, USA.

U.S. Fish and Wildlife Service. 2010a. *Aleutian Canada Goose monitoring program annual progress report for California and Oregon 1996–2010 summary report*. Unpublished report, U.S. Fish and Wildlife Service, Humboldt Bay National Wildlife Refuge, Loleta, California, USA.

U.S. Fish and Wildlife Service. 2010b. www.fws.gov/cno/press/release.cfm?rid=110 (accessed in June 2011).

van Eerden, M.R. 1990. The solution of goose damage problems in the Netherlands, with special reference to compensation schemes. *Ibis* 132: 253–261.

Vickery, J.A. & Gill, J.A. 1999. Managing grassland for wild geese in Britain: a review. *Biological Conservation* 89: 93–106.

Vickery, J.A., Tallowin, J.R., Feber, R.E., Asteraki, E.J., Atkinson, P.W., Fuller, R.J. & Brown, V.K. 2001. The management of lowland neutral grasslands in Britain: effects of agricultural practices on birds and their food resources. *Journal of Applied Ecology* 38: 647–664.

Vickery, J.A., Watkinson, A.R. & Sutherland, W.J. 1994. The solutions to the Brent Goose problem: an economic analysis. *Journal of Applied Ecology* 31: 371–382.

Williams, J.C., Byrd, G.V. & Konyukhov, N.B. 2003. Whiskered Auklets *Aethia pygmaea*, foxes, humans and how to right a wrong. *Marine Ornithology* 31: 175–180.

Williams, T.D., Cooch, E.G., Jeffries, R.L. & Cooke, F. 1993. Environmental degradation, food limitation and reproductive output: juvenile survival in Lesser Snow Geese. *Journal of Animal Ecology* 62: 766–777.

Woolington, D.W. & Early, T.J. 1977. *Progress report on the study of Aleutian Canada Geese at Buldir Island*. Unpublished report, U.S. Fish and Wildlife Service, Aleutian Islands National Wildlife Refuge, Adak, Alaska, USA.

Woolington, D.W., Springer, P.F. & Yparraguirre, D.R. 1979. Migration and wintering distribution of Aleutian Canada Geese. *In* R. L. Jarvis & J. C. Bartonek (eds.), *Management and biology of Pacific Flyway geese: a symposium*, pp. 299–309. Oregon State University Book Stores, Inc., Corvallis, Oregon, USA.

**Photograph:** Aleutian Geese on pasture at Arcata, California, USA, by Leslie Scopes Anderson.