ASSESSMENT OF A WESTERN CANADA GOOSE TRANSLOCATION: LANDSCAPE USE, MOVEMENT PATTERNS, AND POPULATION VIABILITY

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Abstract: To provide new hunting opportunities in California and reduce nuisance and damage complaints in Nevada, 645 western Canada geese (*Branta canadensis moffitti*) were trapped near Reno, Nevada, and released on state wildlife areas around Humboldt Bay, California, 1987–1992. Numbers increased to about 3,200 by 1997 and an annual September sport hunt was initiated in 1998. The flock numbered about 1,500 individuals, 1999-2001. Farms used by the geese in recent years had more water bodies and were closer to roost sites than unused farms. Other landscape variables such as area/size and roads around farms were not significantly different between used and unused farms. Sixty-eight of 630 (11%) banded birds were encountered outside the study area; 70% of the 68 emigrants were goslings (<1 year old) or yearlings (<2 years old). Twenty-one of 23 birds not killed when they were known to be outside the area returned to Humboldt Bay. Movements were in the north, northeast direction and were as far as British Columbia and Alberta, Canada, indicating that the small, resident Humboldt Bay flock is a part of the Pacific population of western Canada geese. A population viability analysis modeling the response of this small flock to harvest indicated stable numbers can be maintained with an annual harvest of ~200 birds. The model also predicts a rapid decline when harvests exceed 300 birds and a rapid increase in numbers when harvest levels were reduced. This study presents 1 of the few post-translocation assessments of a wildlife population.

Key words: *Branta canadensis moffitti*, emigration, Humboldt Bay, landscape use, population viability analysis, translocation, western Canada goose.

Translocation of animals from 1 location to another is a common wildlife management practice. Griffith et al. (1989) estimated that approximately 700 annual translocations were conducted in North America in the 1980s, with 90% involving game species. Reasons for translocations include restoration of animals to historic habitats, establishment of new populations, relocation of nuisance animals, provision of additional consumptive and nonconsumptive use, and perpetuation of endangered species (Boyer and Brown 1988, Dodd and Seigel 1991, Cade and Temple 1995, Wolf et al. 1996). However, the practice of translocation of wild animals and the reintroduction of captive-bred animals has been challenged by those concerned with the possibility that newly released animals may be susceptible to increased mortality and that augmented populations may experience increased competition and possibly suffer from the spread of novel diseases and deleterious genes (Reinert 1991, Case 1996, Wolf et al. 1996). Translocation programs are often expensive and may disproportionately consume wildlife funding (Boyer and Brown 1988). Translocation and reintroduction programs may have negative economic, social, and political impacts to local human communities (Booth 1988, Dodd and Seigel 1991, Kleiman et al. 1994).

It is important to conduct detailed feasibility studies before and during translocation programs (Black 1991, 1995; Kleiman et al. 1994; Engelhardt et al. 2000), and to evaluate the success of the program (Scott and Carpenter 1986; Dodd and Seigel 1991; Black and Banko 1994; Black et al. 1994, 1997; Cade and Temple 1995). To assess the merits of a translocation program, it is useful to (1) quantify population demographics after the releases have taken place, (2) determine post-release distribution and movements in relation to habitats that were originally targeted, and (3) evaluate biosocial implications (Black 1991, Kleiman et al. 1994). These findings should be documented and disseminated to provide information for others contemplating the translocation management option (Szymczak 1975, Scott and Carpenter 1986, Black 1991).

In 1987, the California Department of Fish and Game, Nevada Division of Wildlife, and California

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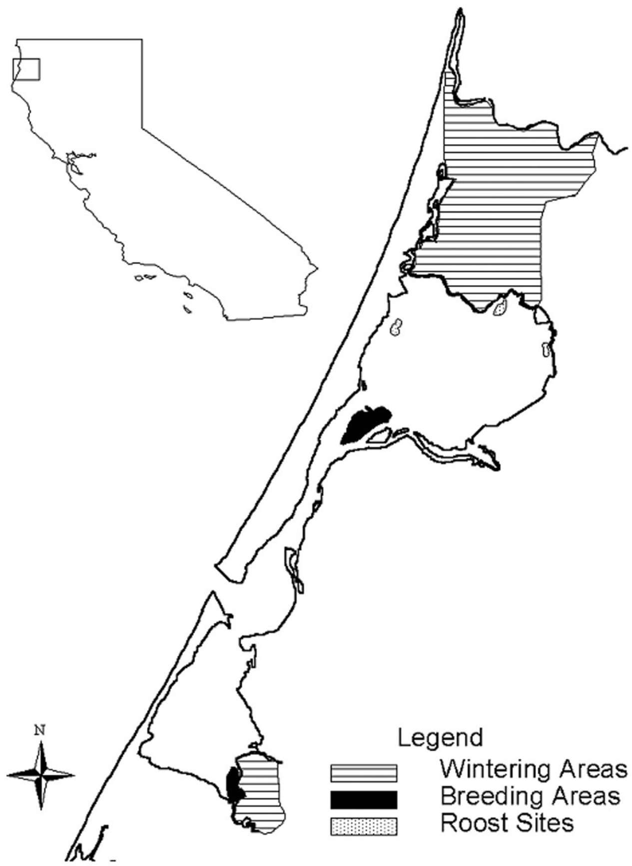

Fig. 1. Map of Humboldt Bay study area, highlighted with areas used by western Canada geese throughout their annual cycle.

Table 1. Number of birds translocated from the Reno, Nevada area to Humboldt County, California 1987–1992.

Year	Number released
1987	102
1988	117
1989	136
1990	99
1991	80
1992	111
Total	645

Waterfowl Association began a program to move western Canada geese to the Humboldt Bay area to establish a flock large enough to support local hunting opportunities while attempting to reduce nuisance/damage concerns in the Reno, Nevada area. Over a 6-year period 645 adult and juvenile geese were trapped near Reno, Nevada, and released on state wildlife areas around Humboldt Bay (Table 1 and Fig. 1). The geese established nesting territories in 1990 and have successfully bred in each subsequent year (Harris 1996). The habitats around Humboldt Bay support numerous species of other waterfowl and shorebirds (Colwell 1994) and in recent years have become a major spring staging area for Aleutian Canada geese (*B. c. leucopareia*) (Black et al. 2004). The pastures around Humboldt Bay are also used intensively for dairy farming. Hunting of the flock, which began in 1998, was limited to between 200–400 applicants for a 9-day period in September. Fewer than 300 birds were estimated to have been harvested each year (H. Pierce, California Fish and Game, unpublished data). Changes in 2002–2003 hunting regulations permit a short open season on all races of Canada geese in the Humboldt Bay area (D. Yparraguirre, California Fish and Game, personal communication).

In the recent draft environmental impact statement regarding resident Canada geese (U.S. Fish and Wildlife Service 2002), translocations are included as an option for reducing conflicts in urban and suburban settings and a number of state wildlife agencies identified areas where they could establish new goose flocks. Our study objectives were to (1) document the change in flock size and distribution, (2) describe habitat/landscape features where the birds became established, (3) generate a measure of fidelity of birds to the area in which they were released, and (4) explore the use of a population viability model to predict the affects of different harvest rates on the flock.

STUDY AREA

The study of goose landscape use was conducted in the bottomland pastures north of Humboldt Bay (40° 53' N, 124° 06' W), on the coast of northwestern California (Fig. 1). The study area consists of 92 farms totaling 2,147 ha. During this study, 96% of these farms were pastureland used primarily to support dairy cattle, with the other 4% being unmanaged. Throughout the study area were sloughs, ponds, irrigation channels, and smaller permanent and semi-permanent bodies of water. Pastures were dominated by a mixture of grasses and forbs. Major species include velvet grass (*Holcus lanatus*), bent grass (*Agrostis* sp.), Italian rye grass (*Colium mulliforum*), orchard grass (*Dalylis glomerata*), clover (*Trifolium* sp.), and buttercup (*Ranunculus* sp.) (Long 1993).

METHODS

Population Parameters, Distribution, and Landscape Use

We conducted annual ground counts over a period of 2 days in late August before the September hunt, 1999–2001. The entire survey area was viewable from vantage points along rural roads totaling 400 km. Counts of nonbreeders (in Apr/May) and broods (in Jun) were conducted annually within the main study area on the Arcata Bottoms (Fig. 1). We refer to unpublished documents and personal communications with original researchers involved in the translocations for information on population numbers before 1999.

From August 2000 through July 2001 we drove the survey route through the area holding the most geese (Arcata Bottoms) every 3–4 days. Each farm (n = 92) was scanned from the road with a spotting scope (Leica® Televid 77, 20-60x) and the number of birds was recorded. Observations were conducted during morning (0700–1100) and afternoon (1400–1700) hours when geese were actively feeding.

Individual farms, bodies of water, roost sites, and roads were digitized from a digital orthophoto image using ARCVIEW (Environmental Systems Research Institute, Redlands, California, USA). Only permanent bodies of water, determined from ground checks, were used in the analysis to provide consistency throughout the study period. Farm area and perimeter, water surface area and perimeter, number of bodies of water, distance to roost sites and nearest body of water, and length of road adjacent to a farm were calculated using ARCVIEW for each parcel in the study area. We calculated the ratio of farm area to perimeter, proportion of a farm covered by water, and the average size of bodies of water within a farm. Distance between the roost and a farm is also an indication of its distance to Humboldt Bay, where birds roost on the mudflats during the nonbreeding months.

In the analysis, we divided the year into 3 periods based on the goose annual cycle, wintering (Aug–Jan), breeding (Feb–Apr), and brood rearing (May–Jul). Because surveys were frequent, we assumed numbers of birds were the same on each farm between surveys. Goose use was measured as average goose days (total birds/number of days in the period, e.g., 184 days for the wintering period) for each farm, in each seasonal period and year. We used logistic regression with landscape characteristics as predictor variables, to describe differences between used and unused (goose days = 0) farms. We conducted forward stepwise selection procedures using likelihood-ratio tests to derive variable combinations that best differentiate used from unused farms (Hosmer and Lemeshow 1989).

Movement Patterns

During the summers of 1998–2001 we captured flightless Canada goose families in the Humboldt Bay area using a corral trap (Cooch 1953). Birds were aged, sexed through cloacal examination, and fitted with U.S. Geological Survey bands and beginning in 1999, alpha-coded plastic neck collars. An intensive, year-round observation effort took place to track individual attendance at Humboldt Bay. We used hunter band returns and observations and recaptures of Humboldt Bay birds from outside the area to determine where geese were emigrating. Using both sources of data we estimated when different classes of birds (i.e., age and sex) left the area and which classes returned. To describe movements of we relied on observation and band recovery data provided by D. Yparraguirre (California Department of Fish and Game, personal communication) in early 1999. Using this data we provided a general index of the number of geese banded in the Humboldt Bay area that remained there, returned to Nevada, and moved to new areas outside of Humboldt County.

Population Viability Models

We used Vortex®, a population viability analysis program designed to model changes for small populations (Lacy 2000). We used the model to describe the response of the Humboldt Bay flock to various levels of harvest. We employed demographic data from other goose studies for model parameters where we did not have information, and assumed such data was relevant to our study. We conducted 500 iterations for each model and simulated changes in population levels for 100 years. We assumed a carrying capacity of 10,000 individuals for our study area. We used the mean of pre-hunt censuses conducted in Septembers during 1999–2001 as the initial population size for the model. Using data generated from territory and brood surveys, the proportion of adult females producing broods was estimated by dividing the number of successful females by the total number of territorial and nonbreeding females. The model required an estimate of natural mortality as well as the number harvested. We used published demographic data from a protected barnacle goose (*Branta leucopsis*) population as our estimate of natural mortality rates, because most studies of Canada goose mortality rates combine natural and harvest mortality into 1 rate. Owen (1982) estimated a rate of ~7.5% natural mortality in barnacle geese. We assumed pre-hunt mortality rates of 35% for goslings (0-1 yrs) (Drent et al. 1998), 7.5% for yearlings (1-2 yrs), and 7.5% for adults (>2 yrs) (Owen 1982). Hunting mortality was included in the model in addition to natural mortality. Levels of harvest from each age and sex class were included as separate parameters. Data from hunter band returns and check station surveys in 1999 were used to determine the proportion of each sex and age class harvested (H. Pierce, California Fish and Game, unpublished data); the sex ratio of harvested birds was equal, while goslings, yearlings, and adults made up 60%, 24%, and 16% of the harvest, respectively. To examine the effects of various harvest levels on flock viability, all other model parameters were held constant.

RESULTS

Numbers of Canada geese in the Humboldt Bay study area rose to 3,200 individuals in 1997 (J. Smith, County Supervisors Office, unpublished data), following the end of translocations in 1992. This initial increase coincided with the initiation of breeding attempts in the area. The 1997 count, however, included estimates

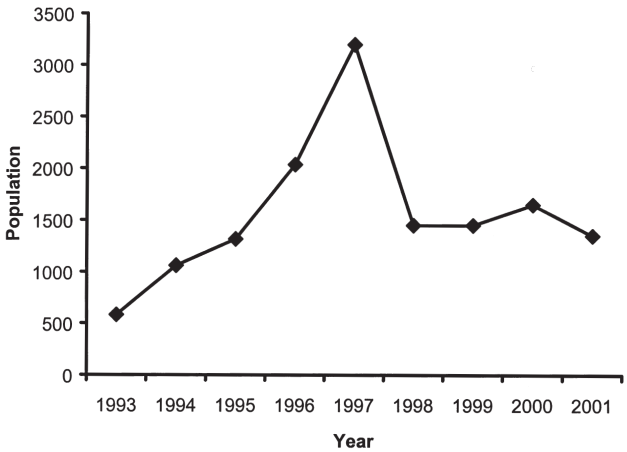

Fig. 2. Fall population numbers of western Canada geese translocated to the Humboldt Bay area, 1993–2001. Data from 1993–1996 and 1997 are from J. Smith (unpublished report) and California Fish and Game (unpublished report), respectively.

Table 2. Average flock sizes of western Canada geese in the Humboldt Bay area, August 2000–March 2001.

Month	Mean Flock Size
Aug	135.8
Sep	55.7
Oct	113.0
Nov	156.1
Dec	127.0
Jan	63.0
Feb	28.9
Mar	34.6

taken from aerial surveys conducted later in the fall rather than earlier ground counts, which may have inflated the estimate for that year by possibly including cackling Canada geese (*B. c. minima*) and/or Aleutian Canada geese (*B. c. leucopareia*) (J. Smith, County Supervisors Office, personal communication). The highest prior count was 2,037 individuals in 1996.

September sport hunting was initiated in 1998. Two tags were allocated to each hunter amounting to 400 tags in 1998 and 2001, and 800 tags in 1999–2000 (H. Pierce, California Fish and Game, personal communication). The population size declined by half after the first year of hunting, presumably through a combination of mortality and emigration (Fig. 2).

Flocks visiting farmers' fields in the study area varied in size through the annual cycle, peaking in size in November (Table 2). The largest flock size observed (1999–2001) on any single farm was 700 birds while the average flock size in winter was about 125 individuals.

Distribution and Habitat Use

Western Canada geese in the Humboldt Bay area were concentrated on 2 sites: the bottomland pastures north of Humboldt Bay and Humboldt Bay National

Table 3. Average goose days per farm during 3 periods in the western Canada goose annual cycle in the Arcata Bottoms, California, August 2000–July 2001.

All farms	Mean	SE	n
Winter	4.04	1.08	92
Breeding	1.16	0.37	92
Brood rearing	1.56	0.92	92
Used farms			
Winter	10.34	2.42	36
Breeding	3.45	0.99	31
Brood rearing	11.96	6.55	12

Wildlife Refuge (HBNWR) southeast of Humboldt Bay (Fig. 1). The current northern concentration is near to the original release area, however, the southern concentration is a few kilometers to the north of the site of original release. There was little mixing between the south and north bay flocks based on observations of marked birds between 1999–2001 (J. M. Black, Humboldt State University, unpublished data).

During the wintering, breeding, and brood-rearing periods birds used 39%, 34%, and 13% of available farms, respectively. However, the average use of these farms amounted to less than 12 geese per day (Table 3). During all 3 seasonal periods, farms that were used by the geese had a greater percent cover of water and were closer to roost sites than unused farms (Table 4). Other landscape variables such as area/size and roads around farms were not significantly different between used and unused farms.

Emigration Patterns

After mass emigrations in the first years of the translocation efforts, improved techniques may have resulted in approximately 85% of the birds remaining in the area. Adult birds made up most of the geese moved in the first 2 years and few of these remained in the release area, presumably returning to the source population in Reno, Nevada (J. Smith, County Supervisors Office, personal communication). However, since few of these birds were banded it is not possible to verify this belief. In subsequent years, birds were banded before release and the majority of these were goslings (< 1-yr old) and parent birds. Of the 595 banded birds banded at Humboldt Bay (1989–1990), an average of 15% (range 10–19%) were relocated outside the Humboldt Bay release areas with only 2–3% observed back in Reno (Table 5).

Eleven percent of 630 birds banded at Humboldt Bay from 1999–2001 were encountered outside Humboldt County; none back in the Reno area. Ninety-one percent (n = 68) of these wintered in Humboldt County before leaving in spring as flock sizes decreased and pairs began establishing breeding territories (Table 6). Goslings (0-1 yrs), yearlings (1-2 yrs), and adults (>2 yrs) accounted for 38%, 32%, and 29% (n = 68) of the

Table 4. Variables used in a multiple logistic regression analysis that best differentiated used farms from unused farms during 3 periods of the goose annual cycle, in the Arcata Bottoms, California, August 2000–July 2001.

Period	Predictor variables[a]	Used fields mean	Used fields SE	Unused fields mean	Unused fields SE	Model x^2	Model P	Model Correctly classified (%)
Winter	WTCV**[b]	0.049	0.009	0.014	0.029			
	DSRT**	3761	215	5260	248	27.27	<0.001	72
Breeding	WTCV**	0.053	0.010	0.015	0.003			
	DSRT*	3687	242	5151	232	25.63	<0.001	73
Brood rearing	WTCV*	0.063	0.015	0.020	0.004			
	DSRT*	3142	240	4903	202	16.99	<0.001	88

[a] DSRT = average distance to 3 roost sites (m), WTCV = proportion of farm covered by water.
[b] significance in the multiple logistic regression model, *P<0.05, **P<0.01, ***P<0.001.

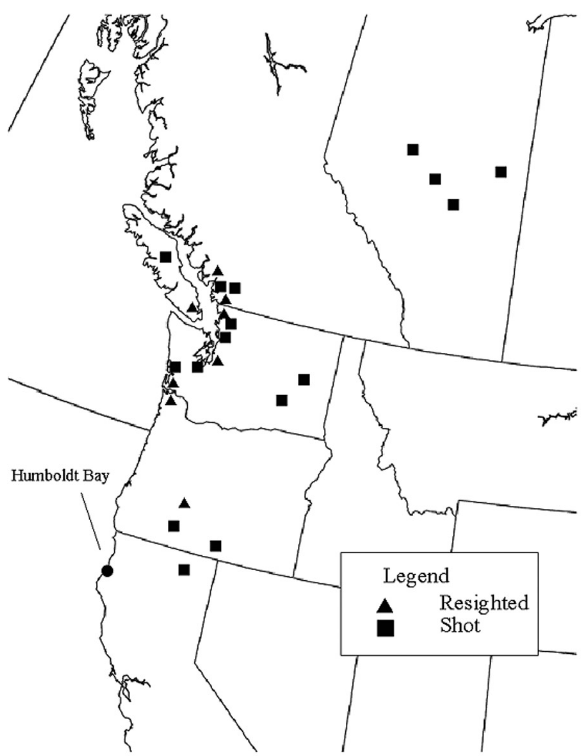

Fig. 3. Encounter locations and fate of birds banded in the Humboldt Bay area.

birds known to emigrate from the Humboldt Bay area, respectively. Return rates were high for birds not killed when they were outside the area; 21 of 23 birds (91%) observed elsewhere were subsequently observed back in the Humboldt Bay study area. The direction of all movements was north or northeast. Observations and band recoveries indicated that emigrating birds were encountered within the range of the Pacific population of western Canada geese (Subcommittee on the Pacific Population of Western Canada Geese 2000) (Fig. 3).

Table 5. Number of translocated western Canada geese resighted/harvested in Humboldt County and outside Humboldt County, 1989–1992. If the same individual was resighted multiple times in the same area it was only counted once.

	1989	1990	1991	1992
Total birds banded	216	100	73	206
Total encounters (%)	22 (10)	22 (22)	14 (19)	46 (22)
Number resighted in Humboldt Bay area (%)	1 (0.5)	1 (1)	3 (4)	1 (0.5)
Number shot in Humboldt Bay area (%)	0 (0)	2 (2)	2 (3)	6 (3)
Number resighted outside Humboldt Bay area (%)	8 (4)	6 (6)	7 (9)	18 (9)
Number shot outside Humboldt Bay area (%)	6 (2)	11 (2)	2 (3)	21 (10)
Number returning to Reno (%)	7 (3)	2 (2)	0 (0)	0 (0)
Total number of encounters outside the Humboldt Bay area (%)	21 (10)	19 (10)	9 (12)	39 (19)

Population Viability Models

The initial population size used in the models was 1,500 birds. In addition, it was estimated that 33% of adult females produced broods. This estimate was based on brood surveys that also found the average brood size of successful females was 4.4 (range 1–8; n = 86).

Changes in population size estimated under various levels of harvest are presented in Fig. 4. A harvest level of 200 birds approximates the situation experienced in 1999–2001. The model suggests that small deviations in harvest of as little as 50 birds can result in large increases or declines. The model suggests that the population will grow exponentially and quickly reach carrying capacity in the absence of harvest.

Table 6. Migration patterns of western Canada geese using the Humboldt Bay area 2000–2002.

Number of birds (%)	When birds left Humboldt Bay area	Number of birds returning to Humboldt Bay area (%)[1]	Number of birds shot (%)[1]	Comment
62 (91)	Spring, as pairs establish breeding territories	19 (56)	15 (44)	Contained a family of 8
4(6)	Sep hunt	2 (50)	0 (0)	A single family; only 2 returned to HB
2 (3)	Jul, after gosling fledge	0 (0)	2 (100)	Adult Female and 1 gosling

[1] 28 of the 62 birds left the area in June 2002. Their fate (return/shot) is yet to be determined. These figures represent birds with known fates.

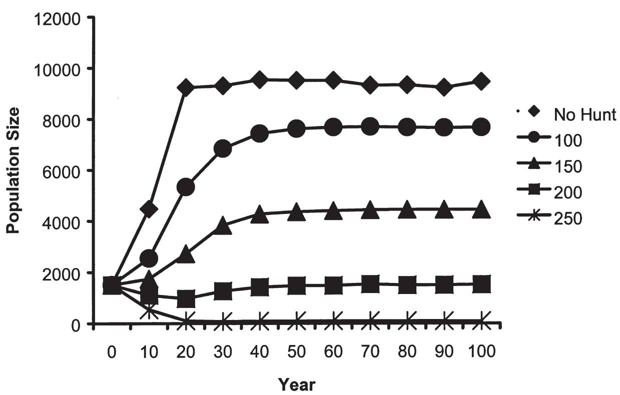

Fig. 4. Changes in population size under various harvest levels in western Canada geese using the Humboldt Bay area, based on program VORTEX and assumptions presented in the text.

DISCUSSION AND MANAGEMENT IMPLICATIONS

Population Size and Habitat Use

The number of geese in our study area rose to at most, 3,200 in 1997, after the final translocation in 1992. The first sport hunt took place in 1998, after which numbers declined to about 1,500. Numbers remained at about this level during 1999–2001.

During winter, wild geese are known to use habitats that enable them to efficiently acquire nutrient reserves needed for the coming breeding season (Owen 1980). In our study the geese were attracted to farms with a greater percent cover of water and those that were closer to roost sites on Humboldt Bay. Farms with a greater percent cover of water create mosaics of pasture and water, which provide geese with adequate food, while enabling them to drink, bathe, and safely rest near feeding sites. By using farms closer to roosts, geese are able to better exploit feeding areas (Raveling 1969) and limit daily flights, which are energetically expensive (Mooij 1992).

Previous research has shown that geese establish nest sites close to open water (Reese et al. 1987, Petersen 1990, Kaminski and Weller 1992) where nests can be situated to reduce the risk of predation (Anderson and Titman 1992, Kristiansen 1998) and territorial confrontations (Reese et al. 1987). Although we did not directly measure distances of individual nests to open water, breeding geese may choose to use farms with greater percent cover of water because these farms provide more suitable areas to establish nest sites. Geese in the Humboldt Bay area establish breeding territories and nests on the slough edges and levees bordering the bay. Nesting on elevated surfaces may better enable pairs to detect and defend against approaching predators; raccoons (*Procyon lotor*) are the main predator in our study area. Farms near the bay have numerous sloughs and backwaters that increase the percent cover of water. While moist soils may enhance the attractiveness and diversity of forage, the link between goose use and percent cover of water on farms may simply be a consequence of the proximity of farms to the bay rather than a characteristic associated with vegetation that geese are attracted to.

After hatching, developing goslings require habitats that offer escape and protection from predators and high quality food (Owen 1980, Stahl and Loonen 1998). Areas with a high percent cover of water are more likely to meet these requirements (Hughes et al. 1994). Farms with higher percent cover of water also provided adults, both breeders and nonbreeders, with refuge from predators and disturbance during their wing molt. Due to the lack of summer rainfall in our study area (approximately 1.15 cm per month) and the phenology of grass and forb species, the vegetation at this time of year is dry and fibrous. However, we suspect that the vegetation immediately adjacent to wet areas is more nutritious, enabling goslings and molting adults to meet high energetic demands of development and feather growth (Sedinger 1992). A more detailed analysis of water and vegetation characteristics would address these concerns. Eberhardt et al. (1989) found that Canada goose broods were found most often within 5 m of the shoreline. They believed this was due to lush forage near the waterline and predation pressure from coyotes (*Canis latrans*). In our study area the most heavily used farms were closer to Humboldt Bay and its tributaries. The bay provided an excellent refuge for flightless birds to escape approaching predators.

Emigration Patterns

A likely cause of slow population growth is emigration from the area. Twenty percent of the birds fitted with alpha-coded plastic neck collars and legbands were reported as encounters from Washington, Oregon, central California, and Canada. Based on the timing and age distribution of encounters, we concluded that most of the birds leaving the area were molt migrants (Zicus 1981). Juveniles and yearlings leaving Humboldt Bay during the breeding season made up the bulk of emigrants. On 3 occasions researchers captured Humboldt Bay birds during molt round-ups in northern locations. These birds were observed back in Humboldt Bay the following winter.

Through this translocation effort a better understanding of successful techniques and potential pitfalls has been gained. The migratory nature of geese has presented the most significant problems, avoidable by translocating young birds that have not established migratory traditions in certain areas (also see Szymczak 1975, Zenner and LaGrange 1998, Aldrich et al. 1998).

Population Model

A local flock of Canada geese at Humboldt Bay has been established and is currently sustaining a limited sport harvest as originally desired. However, the model we employed suggests that the level of harvest that this population can withstand may be limited to a small number of birds. We believe this is due to relatively high rates of emigration and low nest success. Band return data are currently too limited to provide accurate estimates of emigration rates, due to a combination of factors that include limited numbers of birds in the flock and thus numbers of banded birds, relatively low and possibly variable rates of reporting of banded birds in different geographic areas, and the limited time frame in which the flock has been studied. However, we have generated estimates of nest success in the Humboldt Bay area. In 1999–2001, predation rates on western Canada goose nests were 50-60%, with mammalian predators taking most eggs (J. Black and K. Griggs, unpublished data). These are higher than the rate (39%) shown by Stolley et al. (1999) where avian species were the main predators, but similar to the average rate (57%) in dusky Canada geese (*B. c. occidentalis*) shown by Campbell (1990) where mammalian species were the primary predators.

Our model suggests that this flock may be sensitive to relatively small changes in harvest level. The model we used predicted that the flock will remain at its current level if harvest is maintained at current levels. However, based on the assumptions and model we used, changes in harvest of 50 birds in either direction could result in the flock approximately tripling in size or significantly decreasing within 30 years.

Impacts of the Translocation

The impacts of this flock of introduced western Canada geese on the habitats, native species, and socioeconomics of the Humboldt Bay area may be negligible due to the small flock size and use of just a few areas bordering the bay. This limited impact is in contrast to other areas supporting larger goose flocks where such problems have become commonplace. We did not conduct a survey of attitudes among members of the community but wildlife authorities experienced an initial increase in complaints from farmers about depredation in the years after the translocations (H. Pierce, California Fish and Game, personal communication).

The new flock has provided additional hunting opportunities for between 200–400 hunters annually, some of whom are known to have traveled long distances to the county. The flock is also the focus of many Humboldt State University undergraduate student projects to meet requirements for the wildlife major. Each year since 1999, over 100 students contributed observations of collared geese while practicing wildlife observation techniques. Members of the community also join students for annual summer efforts to capture, mark, and measure a sample of the population as part of the long-term monitoring program.

Goose hunting has long been closed on the Pacific north coast to enable the recovery of the Aleutian Canada goose population. Numbers of Aleutians have been increasing in recent years and the new flock of western Canada geese may have decoyed them to the area. In 2001, there were 19,570 Aleutian Canada geese counted in the Humboldt Bay area (Black et al. 2004). A similar resident goose decoying effect on migratory Canada geese was reported in the Colorado foothills by Szymczak (1975), emphasizing the need to consider habitat requirements, impacts to other species, and the socio-economics of local communities before translocations projects are initiated (Black 1991, Kleiman et al. 1994).

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