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Movements and Distribution of Radio-Collared Canada Geese in Anchorage, Alaska

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ABSTRACT—We monitored radio-equipped (n = 50) and neck-collared (n = 205) lesser Canada geese (*Branta canadensis parvipes*) during August through October 1996 in Anchorage, Alaska, to ascertain local patterns of movement and post-molt dispersal; to identify geese from molting sites that frequent Elmendorf Air Force Base (EAFB); and to evaluate the effectiveness of hazing at EAFB. Telemetry data and visual observations of collared geese indicated 59% of geese observed at EAFB were from molting sites ≤10 km from EAFB. We observed 93 marked geese from 11 molting sites 1 or more times in the EAFB airdrome, and 63% of geese observed >2 times on EAFB were from molting sites ≤10 km from EAFB. A significant direct relationship was found between proportion of geese invading the EAFB airdrome and the distance molting sites were located from EAFB. After attaining flight, geese from the northeast and northwest quadrants of Anchorage initially moved greater distances from molt sites to feeding sites than geese from other parts of Anchorage. Intensive hazing proved effective in preventing 67% of marked geese from returning to the exclusion zone. However, hazed geese dispersed only 3.53 ± 0.2 km from the exclusion zone. Most observations of marked geese at EAFB occurred during afternoon from 1200 through 1759 hr. Although hazing efforts provided an increased measure of flying safety, we suggest that managing geese at the spatial level of the entire city will be more successful at reducing danger to aircraft.

Key words: *Branta canadensis parvipes*, Canada goose, airports, hazing, movements, radiotelemetry, urban wildlife, Anchorage, Alaska

Bird strikes to aircraft are a serious safety and economic problem in the United States, annually causing millions of dollars in damage to civilian and military aircraft and the occasional loss of human life. The U.S. Air Force reported 13,427 bird or other wildlife strikes to aircraft world-wide between 1989 and 1993 (Arrington 1994). These strikes resulted in the loss of 8 aircraft, 1 pilot fatality, and 1 permanently disabled pilot. Damage estimates exceeded $85 million. Also, bird strikes to approximately 2200 U.S. and 1000 Canadian civilian aircraft are reported annually (Forbes 1996), and result in an estimated annual cost of >$150 million to the U.S. civil aviation industry (Cleary and others 1997). One of the most tragic military aircraft disasters in the U.S. occurred 22 September 1995 at Elmendorf Air Force Base (EAFB) in Anchorage, Alaska, when an E-3 Sentry Airborne Warning and Control System (AWACS) aircraft ingested several Canada geese on takeoff and crashed, killing 24 people.

The majority of bird strikes in North America involve 33 different bird species with gulls (*Larus* spp.) accounting for more than half of all bird strikes worldwide (Forbes 1996). In recent years, Canada geese have become permanent residents throughout the U.S., and populations have increased as a result of exploiting anthropogenic food resources in urban and suburban settings (Conover and Chasko 1985). In addition to the disaster at EAFB, Canada geese were involved in a number of bird strikes to aircraft in the U.S. during 1995 including a Cessna Citation which hit 4 Canada geese on takeoff from Mackinac Island, Michigan, resulting in both an ingestion and a strike causing a 14-inch hole in the wing; Dulles International Airport in Washington, D.C., reported an incident involving a Boeing 757 that hit 10 geese, damaging the engines, wings, and radome; and an Air France Concorde landing at John F. Kennedy International Airport ingested Canada geese into 2 engines, resulting in >$4 million in damages (Forbes 1996). Canada geese may soon become the most common bird species involved in bird strikes to aircraft as a result of population increase and propensity to become permanent residents in urban environments (Forbes 1996; Cleary and others 1997). The number of Canada geese nesting and residing over summer in Anchorage has increased more than 10-fold during the past 2 decades (USFWS 1998). This trend is likely to continue until control efforts are implemented to slow the population growth rate of geese in Anchorage.

Lesser Canada geese nest in Cook Inlet and throughout river drainages from western and interior Alaska to the Yukon Territory. These geese migrate south along the Gulf of Alaska coast or up the Tanana River through British Columbia to their wintering grounds in western Oregon (Rothe 1994). During the spring and fall migration, urban geese attract geese migrating to and from breeding grounds elsewhere in Cook Inlet and western Alaska. During the last half of September and early October, tens of thousands of Canada geese pass through Anchorage, stopping briefly to feed when they see other geese already there (USFWS 1998). Because geese nest in the location where they learned to fly, these migrants do not remain in Anchorage to nest and are a concern to aircraft only during migration (USFWS 1998).

Information on movements of urban geese will aid in the identification of source populations of geese which move into areas where they negatively impact aircraft safety, and these geese can subsequently be targeted for management activities that reduce the risk of bird strikes to aircraft. Our objectives were to ascertain local patterns of movement during post-molt dispersal, to identify geese from molting sites that frequent EAFB, and to evaluate the effectiveness of hazing at EAFB.

Study Area and Methods

This study was conducted in Anchorage, Alaska, which occupies a triangular promontory between Cook Inlet's Knik Arm to the north, the Turnagain Arm to the south, and the Chugach Mountain range to the northeast (Miller and Dobrovolny 1959; Fig. 1). Since the establishment of Anchorage in the early part of the 20th century, local vegetation has been highly modified including the conversion of forested and bog habitats into residential and commercial developments (USFWS 1998). The varied terrain and hydrology of the local area has created a variety of freshwater wetlands as well as brackish pools and marshes on coastal tidelands. Anchorage's deepwater wetlands include approximately 20 glacial kettle lakes and another 11 artificial lakes (USFWS 1993). From 1950 to 1990, increased construction of artificial lakes doubled the area in lakes from 125 to 268 ha, while lawns and other grassy areas associated with new housing development increased at the expense of natural wetlands (USFWS 1993). During the past 20 years, excellent nesting and brood-rearing goose habitat has been created by urbanization in Anchorage by the juxtaposition of mowed lawns, ballfields, and numerous lakes (USFWS 1998).

In Anchorage, Alaska, lesser Canada goose numbers increased rapidly in the 1980s and through the early 1990s (12 to 15% annually), but since have slowed to an annual increase of approximately 6%. An estimated 4650 ± 183 geese returned to Anchorage in spring 1998 (Crowley 1998). The primary reasons for the increase in this urban goose population are the habitat and food conditions, which have enhanced their productivity in the city, and low rates of harvest and natural mortality (USFWS 1998).

We captured 74 adult, molting lesser Canada geese at 13 sites throughout Anchorage (Table 1, Fig. 1) during 4 through 18 July 1996. Geese were captured by round-up, cannon nets and alpha-chloralose bait. Each goose was weighed, sexed and banded with a U.S. Fish and Wildlife Service leg band. Twenty-four adult (10 male, 14 female) geese were fitted with a blue plastic neck collar coded with a white numeric sequence. The remaining 50 geese (26 male, 24 female) were equipped with a neck collar with an attached transmitter (Advanced Telemetry Systems, Inc., Isanti, MN) weighing approximately 30 grams (Samuel and Fuller 1994). Alaska Department of Fish and Game (ADFG) captured by round-up an additional 181 geese at 5 of the same molting sites and also fitted geese with blue plastic neck collars.

We used 2 vehicles equipped with 4-element,

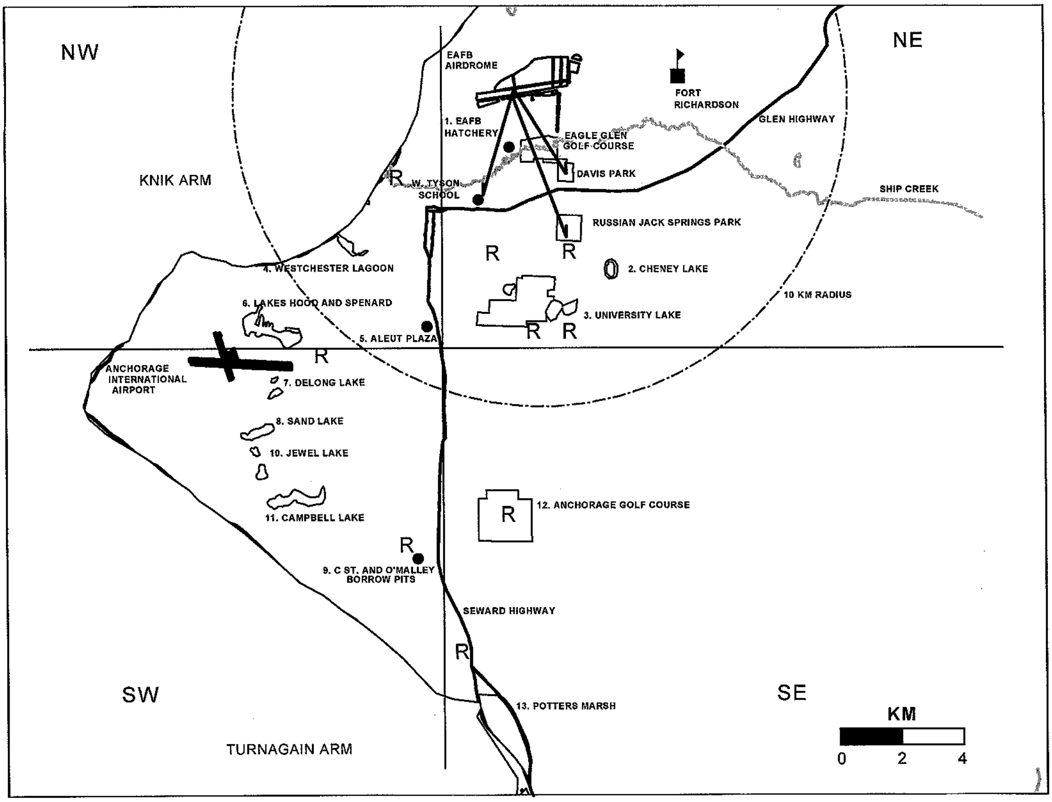

FIGURE 1. Location of the goose movement study area in the greater Anchorage, Alaska, metropolitan area. Labeled are capture sites 1 through 13 and quadrants. All identified roost sites (R) are indicated except Eagle River Flats north of Elmendorf Air Force Base airdrome. Arrows indicate dispersal routes of hazed geese from EAFB.

dual-yagi antennas and receivers (Lotek Engineering Inc., Newmarket, Ontario, Canada) to track radio-equipped geese throughout Anchorage and surrounding areas. Using 2-way communication, geese were located simultaneously from elevated locations throughout Anchorage. We attempted to obtain bearings at 90° angles and minimize distance from radioed geese. Geese that moved out of ground telemetry range were located from a UH-1 Army National Guard helicopter.

Because of molt, movements of marked geese were restricted until the 1st week of August. Once geese attained flight, we located each twice daily (Monday through Friday) from 0700 through 0900 hr and 1400 through 1600 hr. Each Tuesday and Thursday, roost locations were determined from 2000 to 2400 hr. In addition, EAFB personnel conducted a bird hazing program 24 hr/day in the EAFB airdrome; all goose collar codes were recorded and used in this study to document goose movements. Tracking continued from 1 August until a snowstorm hit Anchorage on 14 October 1996 and forced geese to migrate to their winter range.

Frequently, signal interference prevented locating all radio-equipped geese during a tracking session. Consequently, visual observations of marked geese were obtained daily to provide additional information on movements. Prior to hazing, marked geese on EAFB were identified by Air Force personnel using spotting scopes and binoculars.

We used a linear regression analysis (SAS Institute, Inc. 1988) relating the proportions of marked geese from each molting site that were observed on EAFB to the distances of the molting sites from EAFB. To facilitate analysis of flock movements and dispersal, we divided a

TABLE 1. Marked geese observed on Elmendorf Air Force Base from Anchorage, Alaska, molting sites where the geese were captured.

Quad-rant	Molting site	Distance[a]	n^b	n^c	n^d	%[e]	$\bar{x}^f$	%[g]
NE	1—EAFB Fish Hatchery	2.40	42	15	11	73.0	4.6	49.0
	2—Cheney Lake	6.30	343	34	13	38.0	2.1	
	3—University Lake	8.10	33	4	2	50.0	2.0	
NW	4—Westchester Lagoon	8.40	386	32	13	41.0	2.5	41.0
	5—Aleut Plaza	8.80	79	26	12	46.0	2.3	
	6—Lakes Hood & Spenard	12.10	153	13	4	31.0	2.3	
SW	7—Delong Lake	13.40	72	2	1	50.0	3.0	29.0
	8—Sand Lake	14.70	192	26	2	8.0	0.0[h]	
	9—Minn / C St-Borrow Pits	15.60	44	12	3	25.0	0.0[h]	
	10—Jewel Lake	15.60	58	2	1	50.0	0.0[h]	
	11—Campbell Lake	15.60	495	81	31	38.0	2.5	
SE	12—Anchorage Golf Course	14.00	111	5	0	0.0	0.0[h]	0.0
	13—Potter Marsh	20.60	43	3	0	0.0	0.0[h]	

[a] Distance (km) of capture site from EAFB runways.
[b] Number of geese available for marking at molting sites.
[c] Number of geese radioed and / or collared at molting sites.
[d] Number of initial sightings of marked geese at EAFB.
[e] Percentage observed at EAFB by molting site.
[f] Mean number of multiple visits onto EAFB by marked geese.
[g] Percentage observed at EAFB within quadrant.
[h] No multiple visits by marked geese.

map of the Anchorage area into 4 quadrants (NE, NW, SW, SE; Fig. 1). Chi-square tests were used to determine if proportions of geese observed on EAFB, grouped by quadrants, were statistically different. In addition, geese grouped by separate molting locations were analyzed separately using Fisher's exact test to determine if they demonstrated different movements onto EAFB. Locations of radio-equipped geese were plotted in Locate II (Pacer, Truro, NS, Canada) using Universal Transverse Mercator Coordinates, and later mapped using Atlas GIS (Environmental Systems Research Institute, Inc., Redlands, CA).

EAFB personnel implemented a no-tolerance policy for the EAFB airdrome. This exclusion zone was monitored 24 hr / day; all birds were immediately hazed when clearance was granted from the control tower, and geese collar codes were recorded. Hazing techniques included propane exploders, predator effigies, and pyrotechnics. Radio communication between hazing and radio-tracking crews was maintained to track movements of radio-equipped geese hazed from EAFB. These data were used to document dispersal routes and immediate post-hazing locations and to evaluate the effectiveness of hazing operations on EAFB. Hazed geese were monitored for 1 hr post-hazing to document additional movements.

RESULTS

Movements of Radio-Equipped and Collared Geese

A significant difference existed between the frequency of movements onto EAFB by geese from the 4 quadrants ($\chi^2 = 11.58$, 3 df, $P = 0.009$) and from the 13 capture locations (Table 1) when analyzed separately (Fisher's exact test: $P < 0.0001$). In addition, following molting, 21 of 25 radio-equipped geese in northern quadrants and only 5 of 25 in southern quadrants moved >1 km to their 1st intensively used feeding area ($\chi^2 = 20.51$, 1 df, $P < 0.001$).

Geese from the NE quadrant frequented EAFB, Fort Richardson, and Eagle River Flats (about 8.0 km north of Anchorage), and 49% (26 of 53) of marked geese from this quadrant were located at least once on EAFB (Table 1). The mean (±SE) of 79 recorded movements for these geese was 5.18 ± 0.4 km.

Generally, geese from the NW quadrant dispersed southeast toward the Anchorage Golf Course, the mud flats at the mouth of Ship Creek, and EAFB ($\bar{x} \pm SE = 4.74 \pm 0.4$ km, $n = 72$ recorded movements). Forty-one percent (29 of 71) of marked geese from the NW quadrant were located on EAFB (Table 1).

Geese from the SW quadrant typically remained in south Anchorage ($\bar{x} \pm SE = 3.97 \pm 0.3$ km, $n = 41$ recorded movements). However, geese from Campbell Lake were frequently observed at EAFB (Table 1).

Geese from the SE quadrant were not observed on EAFB (Table 1). These geese were most often observed feeding and resting at a sod farm, golf courses and ball fields in south Anchorage ($\bar{x} \pm SE = 3.52 \pm 0.4$ km, $n = 62$ recorded movements).

Of marked geese observed on the airdrome by EAFB personnel, 35%, 46%, and 19% of observations occurred during 0600 to 1159 hr, 1200 to 1759 hr, and after 1800 hr, respectively. Daily flight patterns of radio-equipped geese between roost and feeding sites would vary on occasion such as geese abandoning feeding sites on ball fields when these fields were used recreationally. Identified roost locations were used on a regular basis but not always by the same geese. We identified 11 roost locations throughout Anchorage in habitats including coastal mud-flats, parks, golf courses, lakes, and wetlands. During nocturnal monitoring in September and October, we observed geese moving to roost sites as late as 2300 hr.

Observations of Collared Geese in the EAFB Exclusion Zone

The majority (51 of 93; 55%) of geese observed at EAFB were from molt sites ≤10 km from EAFB (Table 1). Marked geese captured within this 10 km range of EAFB invaded the airdrome in greater proportion (51 of 111) than geese captured >10 km to the south (42 of 144) ($\chi^2 = 7.62$, 1 df, $P = 0.006$). In addition, results of the linear regression between proportion of geese observed and distance captured from EAFB was highly significant ($r^2 = 0.49$; 1, 11 df; $P = 0.0076$).

We observed 93 marked geese from 11 molting sites at least once on EAFB, and the majority (24 of 38) of geese observed >2 times on EAFB were from sites ≤10 km of EAFB. The EAFB Fish Hatchery capture site is located nearest EAFB runways (2.40 km) and contributed the largest percentage (73%), from any 1 site, of invading geese observed at least once on EAFB (Table 1).

An exception to our observations were geese from Campbell Lake. This lake is located in south Anchorage, 15.64 km from EAFB, where geese tended to restrict movements to nearby feeding sites. However, 38% (31 of 81) of geese collared at Campbell Lake were observed at EAFB during our study. Unfortunately, the only goose radioed at Campbell Lake either left Anchorage shortly after molting or had a malfunctioning transmitter. Consequently, no telemetry data are available from geese at this lake.

Hazing Efforts at EAFB

EAFB personnel hazed 18 radioed-equipped geese at least once from the airdrome; 11, 4, and 3 of these geese originated from the NE, NW, and SW quadrants, respectively. When hazed, these geese dispersed from EAFB in a southerly direction to Davis Park (2.50 km, n = 9 radio-collared geese), William Tyson Elementary School soccer field (3.40 km, n = 4 radio-collared geese), and Russian Jack Springs Park (4.70 km, n = 5 radio-collared geese) ($\bar{x} \pm SE = 3.53 \pm 0.2$ km) (Fig. 1). Six of 18 hazed geese returned to EAFB at least twice (range = 1 to 37 days, $\bar{x} = 15.31$ days).

DISCUSSION

Geese captured and marked in northern quadrants of Anchorage moved onto EAFB in significantly greater proportions than geese from southern quadrants. However, geese from south Anchorage joined flocks that traveled onto EAFB in numbers that could also pose threats to aircraft safety. The regression analysis indicated distance may be the single most important factor explaining use of EAFB.

The comparison of initial, post-molt movements between northern and southern quadrants of Anchorage indicated geese in the north moved longer distances. These movements may indicate a contrast in quality and / or availability of foraging sites near molt locations. Also, these movements make it probable that geese molting in the NW and NE quadrants will eventually come in contact with the abundant grassy lawns, parade grounds, and runways on EAFB.

These results are complicated by the fact that 31 of 81 marked geese from Campbell Lake traveled >15 km to EAFB while by-passing available forage at parks, golf courses, and a sod farm that were much closer. Movement away from Campbell Lake may be related to human disturbance on this lake that also serves as a busy floatplane base. In addition, Campbell

Lake is surrounded by private housing development that provides little foraging opportunity when compared to city parks. These characteristics probably contributed to the abandonment of this site by large numbers of geese. Geese which learn to avoid 1 site commonly redistribute to other areas within the urban area (Aguilera and others 1991). Also, the possibility remains that some of the parks, golf courses and ball fields in south Anchorage are currently so overcrowded that foraging geese are attracted to less crowded areas such as EAFB and adjacent Fort Richardson (Fig. 1). Observations of 73% (11 of 15) of EAFB Fish Hatchery geese in the EAFB exclusion zone reinforced the previously held suspicion that direct movements were common between this molting site and EAFB, and they make a strong case for direct removal of these geese and modification of habitat around the hatchery to reduce risks to aircraft.

We believe that hazing efforts prevented geese from congregating at EAFB, which prevented attracting migrants onto the airdrome as the season progressed. However, these hazed geese only dispersed short distances to adjacent parks, which presents the threat of future movements onto EAFB. Our findings indicated peak movements onto EAFB occurred from 1200 through 1800 hr. Hazing operations at EAFB should be designed to intensify efforts during this time period. In addition, observed after-dark movements indicate 24-hr hazing will be required to ensure geese do not move onto EAFB in evening hours.

Although EAFB hazing efforts provided guidance for short-term goose manipulation strategies that appear to be effective, we suggest that the larger issue of managing geese at the spatial level of the entire city needs to be addressed. Results from this study have identified suspected populations of geese that have created management problems at EAFB. Targeting these populations, which are ≤10 km of EAFB, for translocation or removal during molt, would potentially eliminate some bird hazards. In addition, hazed geese can be targeted for removal at dispersal sites by using collar codes to identify geese that habitually enter EAFB.

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