Survival and Recovery of Normal Wild vs. Relocated Adult Resident Canada Geese in Georgia, 2000–2009

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Abstract: Georgia's growing resident (non-migratory) Canada goose (*Branta canadensis*) population often causes nuisance problems in urban areas. One method of reducing nuisance goose problems is capture and relocation, especially if geese are relocated to rural areas where hunting may occur. To determine if relocated geese have different survival or band recovery rates than normal wild geese, I estimated probabilities of survival and recovery for adult, resident Canada geese between 2000 and 2009 using banding and dead recovery data from normal wild geese and from relocated geese in Georgia. Survival and recovery varied by group and time. Average annual adult survival rates were higher for normal wild geese ($\bar{x} = 0.759$, SE = 0.028, $n = 10$) than for relocated geese ($\bar{x} = 0.624$, SE = 0.032, $n = 10$). Recovery rates for normal wild geese ($\bar{x} = 0.084$ SE = 0.004, $n = 10$) were very similar to relocated geese ($\bar{x} = 0.082$, SE = 0.004, $n = 10$). These data indicate that relocated geese have similar harvest rates and lower survival rates than normal wild geese which could reduce the number of nuisance birds returning to problem areas.

Key words: Canada geese, *Branta canadensis*, Georgia, survival, recovery, relocation

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Georgia's resident Canada geese (*Branta canadensis*) often inhabit urban locations and cause nuisance problems such as threats to human health and safety (e.g., aggressive behavior, accumulation of feces, aircraft/car collisions) and private property damage (Stephens et al. 2007). Urban, nuisance geese have high survival rates and low harvest rates (Balkcom 2010). Capture and relocation of nuisance geese has been an accepted technique for reducing nuisance problems, especially when the geese are released at least 160 km from the capture site and released in areas where hunting can occur (Fritzell and Soulliere 2004, Powell et al. 2004*a*, Holevinski et al. 2006, Stephens et al. 2007). In Ontario, North et al. (2004) concluded that direct recovery rates of bands for geese moved to rural areas were greater than band recovery rates of birds not relocated, indicating that relocation may increase band recovery rates. Powell et al. (2004*a*) and Holevinski et al. (2006) reported that band recoveries from relocated geese were typically within 50 km of the release site, and Stephens et al. (2007) reported that 85% of band recoveries from relocated geese were within 80 km of the release site. These studies indicated that relocations seemed to alleviate nuisance geese problems and speculated that hunting may be an important mortality factor for relocated geese.

In Georgia, the USDA APHIS Wildlife Services (USDA) staff have captured and relocated numerous nuisance Canada geese in the past in response to nuisance calls received from the public. These geese were moved at least 160 km, and release sites were coordinated with Georgia Department of Natural Resources (GDNR) staff to reduce the opportunity for relocated geese to cause more nuisance problems. Geese were released on private property in rural areas where hunting could occur or on Wildlife Management Areas where hunting did occur. Between 1993 and 2002, Stephens et al. (2007) determined that only 3% of relocated geese were recaptured in their original capture county suggesting that relocation efforts were successful. My hypothesis for this banding analysis was that relocated geese would have lower survival and higher harvest rates than their normal wild counterparts. The relocation effort would solve the local nuisance problem and the presumed higher harvest rates and lower annual survival rates would slow population growth. Therefore, I analyzed banding and recovery data from 2000 through 2009 to determine if survival rates or band recovery rates for relocated geese differed from normal wild geese that were captured, banded, and released on-site.

Methods

Resident Canada geese from across the state of Georgia were captured and banded annually during the June–July molting period. USDA staff captured and removed geese from office complexes, private subdivisions, apartment complexes, golf courses, and similar locations in response to complaints received from the public, and the GDNR staff caught and banded geese on Wildlife Management Areas and selected private properties where the landowner had an interest in conservation. Agency staff, both GDNR and USDA independently, herded flightless geese into corral traps (Cooch 1953). Age, sex, date, and location of banding were recorded, and a standard numbered U.S. Fish and Wildlife Service alu-

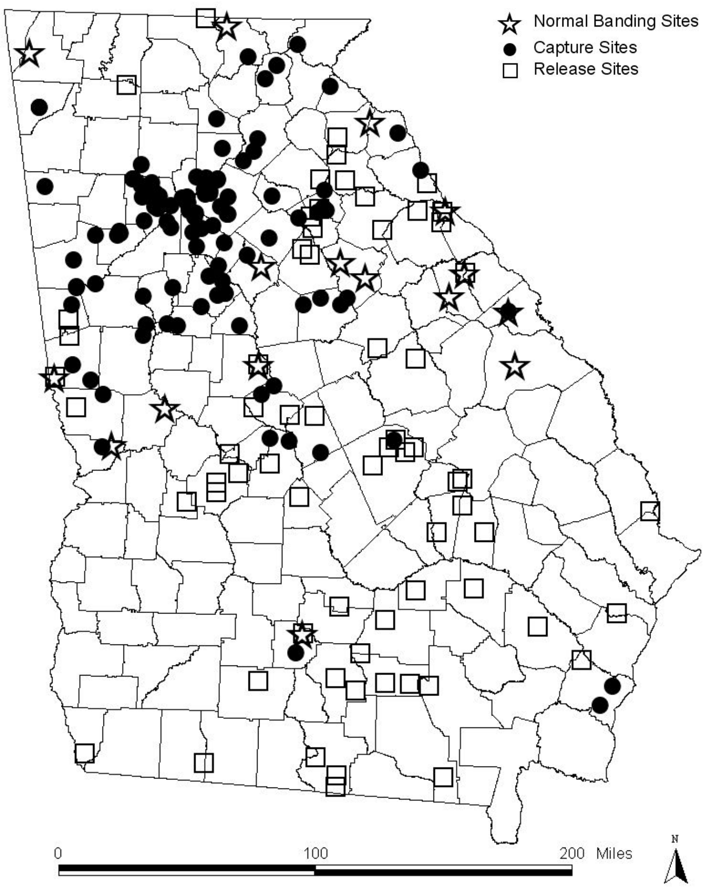

Figure 1. Banding sites for normal wild geese (stars) and capture sites (solid circles) and release sites (open squares) for relocated geese in Georgia, 2000–2009.

minum leg band was applied (Dimmick and Pelton 1994). Using standard USGS Bird Banding Laboratory terminology, geese that were released on the same site as they were captured were classified as normal wild birds and were recorded as status 300. Relocated birds were recorded as status 200. Normal wild birds were immediately released on site following the banding activity. Relocated birds were loaded into cages and driven to their release sites at least 160 km away. All relocated geese were held less than 24h and were released on private property where owners had requested geese or on state-operated Wildlife Management Areas (Figure 1).

Using banding data gathered from the USGS Bird Banding Laboratory, I created capture histories using new bandings and dead recoveries from geese that were shot or found dead during hunting seasons from 2000–2009. I only used adult (after-hatch year) geese for this analysis because there were low numbers of juvenile geese in the sample.

I used Program MARK to estimate survival (S) and recovery (f) according to the Brownie model (Brownie et al. 1985, White and Burnham 1999). I allowed both parameters to vary by group (g), time (t), group and time (g * t), or group and time with an interaction (g + t), or to be constant (.), which resulted in 25 (5^2) potential models to explain variation in the estimates. I ranked models using quasi-Akaike's Information Criterion ($\Delta QAIC_c$) scores adjusted for sample size and a calculated variance inflation factor ($\hat{c} = 1.26029$) generated from Program ESTIMATE as χ^2 / df from the goodness of fit tests for Model 1 (Burnham and Anderson 2002, Cooch and White 2007). I averaged parameter estimates over the 10-yr period and calculated standard errors using the delta method (Powell 2007).

Harvest and kill rates can be calculated using the current resident Canada goose reporting rate of 0.73 (M. Koneff, U.S. Fish and Wildlife Service, unpublished data) and the standard crippling loss estimate of 0.2 (Anderson and Burnham 1976, Martin and Carney 1977) in the following formula: harvest rate $= f / \lambda = K(1 - c)$ where f = Brownie recovery rate, λ = reporting rate, K = kill rate, and c = crippling loss (Williams et al. 2002). Once estimates of S and K have been calculated, it is possible to estimate natural mortality by using the relationship natural mortality $= 1 - K - S$, assuming additive harvest mortality (Williams et al. 2002). Finally, I assumed that either no band loss occurred during the study period or band loss was equal between groups; therefore, I did not include any estimates of band loss into my calculations.

Results

From 2000–2009, GDNR and USDA staff banded a total of 11,224 adult resident Canada geese. Of these, 3704 were normal wild geese and 7520 were relocated geese (Table 1). Normal wild geese were captured and banded at 16 different locations, and relocated geese were captured at 106 different sites and released at 68 different locations (Figure 1). Over the 10-year period, 2282 bands were recovered by hunters and reported to the USGS Bird Banding Laboratory.

Using these data, Program MARK indicated good model-selec-

Table 1. Number of normal wild and relocated adult, resident Canada geese banded in Georgia, 2000–2009.

Year	Normal wild	Relocated	Total
2000	331	857	1188
2001	295	1383	1678
2002	567	783	1350
2003	721	764	1485
2004	354	975	1329
2005	253	200	453
2006	378	945	1323
2007	312	626	938
2008	346	274	620
2009	147	713	860
Sum	3704	7520	11,224

tion certainty with one model accounting for 93.7% of the weight, and the second-ranked model having $\Delta QAIC_c = 6.52$ and only 3.6% of the weight from the 25 *a priori* models (Table 2). The top model indicated that survival differed by group and time. Survival estimates ranged from 0.478 to 0.999 for normal wild geese with an average of 0.759 (SE = 0.028) and ranged from 0.425 to 0.999 for relocated geese with an average of 0.624 (SE = 0.032) (Table 3).

Also, recovery estimates differed by group and time in the top model. Recovery rate estimates ranged from 0.047 to 0.105 for normal wild geese with an average of 0.084 (SE = 0.004) and ranged from 0.051 to 0.127 for relocated geese with an average of 0.082 (SE = 0.004; Table 4). Mean harvest rate for normal wild geese was 0.115 and 0.113 for relocated geese. Mean kill rate for normal wild geese was 0.144 and 0.141 for relocated geese. Assuming additive harvest mortality, natural mortality for the normal wild geese was 0.097 and 0.235 for relocated geese.

Discussion

Managing nuisance Canada goose problems in urban areas often requires an integrated program of short-term and long-term techniques that include discontinuance of feeding, habitat modification, hazing and scaring, chemical repellents, control of reproduction, and removal (Smith et al. 1999). Relocation can be effective for removing geese from problem areas but requires permits, trained personnel, and specialized equipment (Smith et al. 1999, Stephens et al. 2007). Relocation of nuisance resident Canada geese out of urban areas may be a successful management technique because nuisance geese are removed from the problem area and generally do not return (Powell et al. 2004*a*, Stephens et al. 2007), hunting opportunity is provided in rural areas on both public and private properties, and annual survival of geese is reduced as a means to reducing population growth. In my study, top model in Program MARK indicated that survival and recovery rates varied by group and time. Annual variation could be due to several factors such as number of bandings, differing hunting regulations across years as opportunity increased, different banding sites among years, and different release sites among years. Nevertheless, my objective was to evaluate the overall, long-term impact of relocation on survival and recovery rates; therefore, I averaged across years within group to generate an average survival and recovery rate.

My estimated average survival rate of 0.759 for the normal wild geese was nearly identical to the pooled average survival rate of 0.762 for Georgia resident Canada geese between 1990 and 1996 (Conroy and Powell 2001) and was similar to survival rates reported for other hunted populations of geese such as 0.773 and 0.709 in the Atlantic Flyway (Hestbeck and Malecki 1989) and 0.688 and 0.727 in Nebraska (Powell et al. 2004*b*).

Table 2. Top five models with highest $QAIC_c$ (Akaike's Information Criterion adjusted for sample size and lack of fit) values ($\Delta QAIC_c$ <11) that explain variation in survival and recovery rates of adult, resident Canada geese banded in Georgia, 2000–2009, with number of parameters (K), model weight (w_i), and deviance (Qdev).

Model[a]	K	$\Delta QAIC_c$	w_i	Qdev
S(g*t) *f*(g*t)	34	0.00	0.937	128.221
S(g*t) *f*(t)	26	6.52	0.036	150.824
S(g*t) *f*(g+t)	27	8.38	0.014	150.678
S(g+t) *f*(g*t)	30	9.66	0.008	145.927
S(g+t) *f*(g+t)	21	10.64	0.005	164.992

a. Model notation follows Program MARK (White and Burnham 1999), where *S* indicates survival, *f* indicates recovery rate, g indicates group (normal wild or relocated), and t indicates time. The best approximating model had $QAIC_c$ = 14,135.839.

Table 3. Survival rates for normal wild and relocated adult, resident Canada geese in Georgia, 2000–2009.

	Normal wild		*Relocated*	
Year	*S*	SE	*S*	SE
2000–01	0.751	0.093	0.683	0.072
2001–02	0.999	0.003	0.685	0.072
2002–03	0.628	0.068	0.459	0.048
2003–04	0.625	0.075	0.999	0.000
2004–05	0.999	0.000	0.665	0.146
2005–06	0.478	0.078	0.425	0.096
2006–07	0.541	0.099	0.647	0.094
2007–08	0.810	0.161	0.560	0.123
2008–09	0.999	0.014	0.489	0.130
Avg	0.759	0.028	0.624	0.032

Table 4. Recovery rates for normal wild and relocated adult, resident Canada geese in Georgia, 2000–2009.

	Normal wild		*Relocated*	
Year	*f*	SE	*f*	SE
2000	0.079	0.017	0.085	0.011
2001	0.105	0.016	0.085	0.008
2002	0.082	0.010	0.078	0.008
2003	0.088	0.010	0.127	0.011
2004	0.105	0.013	0.063	0.006
2005	0.070	0.009	0.051	0.011
2006	0.073	0.011	0.090	0.009
2007	0.094	0.014	0.075	0.010
2008	0.098	0.015	0.089	0.017
2009	0.047	0.008	0.079	0.011
Avg	0.084	0.004	0.082	0.004

In a previous analysis comparing survival rates of geese banded in an urban area to geese banded in a rural area in Georgia between 2001 and 2006, normal wild geese banded at a rural site had a survival rate of 0.682 (Balkcom 2010) similar to my survival estimate of 0.624. These data indicate that geese moved to rural areas may behave similarly and face the same threats as geese that naturally inhabit rural sites. Lower survival rates may help meet management objectives by reducing the number of nuisance geese returning to problem areas and potentially slowing resident goose population growth because survival estimates in this range are similar to those of a declining population (Hestbeck 1994).

I hypothesized there would be differences in vulnerability following relocation, and that recovery rates for relocated geese would be higher (North et al. 2004, Powell et al. 2004*a*, Stephens et al. 2007). Surprisingly, there was no biological difference in recovery rate between the two groups. The Brownie recovery rates of 0.082 and 0.084 for the two groups are slightly lower than other published estimates of 0.089 to 0.128 in southwestern Idaho (Harris et al. 1998) and 0.17 in Michigan geese translocated to Iowa (Fritzell and Soulliere 2004), indicating that harvest pressure may be lower in rural Georgia than in other areas of the country. Because of similar recovery rates, there are apparently no differences in vulnerability to hunting between relocated geese and normal wild geese in rural areas; therefore, natural mortality must be different between the two groups. Relocated geese suffer higher natural mortality (0.235) than normal wild geese (0.097). This study did not address differences in natural mortality and suggesting possible causes would be speculative.

Management Implications

For state agencies looking for ways to reduce nuisance geese in urban areas, relocation may be a valid option as long as suitable relocation sites are available. Management objectives of providing opportunities for hunting and wildlife observation, reducing the number of resident Canada geese returning to problem areas, and reducing resident goose population growth may be met through capture and relocation activities as long as the following conditions are met: 1) geese are relocated at least 160 km from the nuisance capture site (Powell et al. 2004*a*, Stephens et al. 2007), 2) both adult and juvenile geese are released together to increase the chance that adults will stay at the release site with their juvenile offspring (Holevinski et al. 2006), and 3) hunting is allowed at or near the release site. Future research could identify causes of increased natural mortality in relocated geese.

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