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Evaluation of the effects of September hunting seasons on Canada geese in Nebraska

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Abstract

Populations of temperate-nesting Canada geese (*Branta canadensis*) have increased in Nebraska, USA, resulting in an increased number of nuisance and damage complaints. September hunting seasons were initiated in southeastern Nebraska in 2004 to reduce populations of Canada geese. We analyzed band recoveries from Canada geese banded in southeastern Nebraska during their hatch-year (HY) or after-hatch-year (AHY) to determine whether September hunting seasons affected survival, harvest, and recovery rates. Survival analyses revealed that HY geese had higher survival than AHY geese (S_{AHY} = 0.696, 95% CI = 0.679–0.713; S_{HY} = 0.896, 95% CI = 0.786–0.953) and September seasons did not affect survival of geese in southeastern Nebraska. Geese banded in the geographic zone with the September seasons (southeastern Nebraska) had the same survival as did geese outside the hunt zone (northeastern Nebraska; S = 0.711, 95% CI = 0.666–0.752). September hunting seasons affected timing of band recovery; 23–49% of annual band recoveries occurred during the month of September. Prior to the initiation of the September seasons, the highest percent of recoveries occurred during November. The September seasons appeared to temporally redistribute harvest but did not reduce survival for populations of Canada geese in southeastern Nebraska. Continuation of the season may not be warranted, because management does not appear to be affecting AHY survival, which is needed to reduce the population. Additional or new methods are likely needed to control populations of temperate-nesting Canada geese in Nebraska and managers should evaluate the effectiveness of these methods as they are implemented.

Keywords: band analysis, *Branta canadensis*, Canada goose, harvest, recovery, September hunting seasons, survival

Restoration of Canada geese (*Branta canadensis*) is considered a success story of 20th Century wildlife management in North America. Populations in the United States have increased an average of 6.2%/year since the mid-1970s (Schmidt 2004). Canada geese have become common inhabitants of urban areas due to abundant and stable nesting habitat, plentiful food sources, few predators, and habituation to humans (Groepper et al. 2008). Canada geese provide recreational opportunities for numerous stakeholders and most residents approve of the presence of Canada geese in their communities, but damage and nuisance problems have become more common as populations increase (Coluccy et al. 2001, Powell et al. 2004*a*).

Populations of Canada geese have exceeded management objectives in the Atlantic, Mississippi, and Central Flyways and the increasing populations have resulted in nuisance problems (Gabig 2000). Incidents involving nuisance geese have increased; these include depredation of agricultural crops, airport hazards, fecal contamination of water, and damage to lawns, parks, beaches, and golf courses (Gosser et al. 1997, Coluccy et al. 2004). Reducing population growth of temperate-nesting Canada geese where they have exceeded public tolerance continues to be a focus of managers (Moser and Caswell 2004).

Hunting is the primary cause of mortality in Canada geese (Krohn and Bizeau 1980, Trost and Malecki 1985) and state agencies have implemented September hunting seasons to reduce populations of temperate-nesting Canada geese while causing little or no impact to populations of migratory geese (Gabig 2000, Coluccy et al. 2004, Vrtiska et al. 2004, Sheaffer et al. 2005). In the Central Flyway, South Dakota was the first state to initiate a September season in 1996, followed by North Dakota and Kansas (1999), Oklahoma (2000), and Nebraska (2004, Vrtiska et al. 2004). However, relatively few studies have been conducted to determine effects of special hunting seasons on temperate-nesting Canada geese (Heusmann 1999, Sheaffer et al. 2005, Dieter et al. 2010). Current survival and harvest parameters associated with September seasons are important for management decisions (Gabig 2000, Vrtiska et al. 2004).

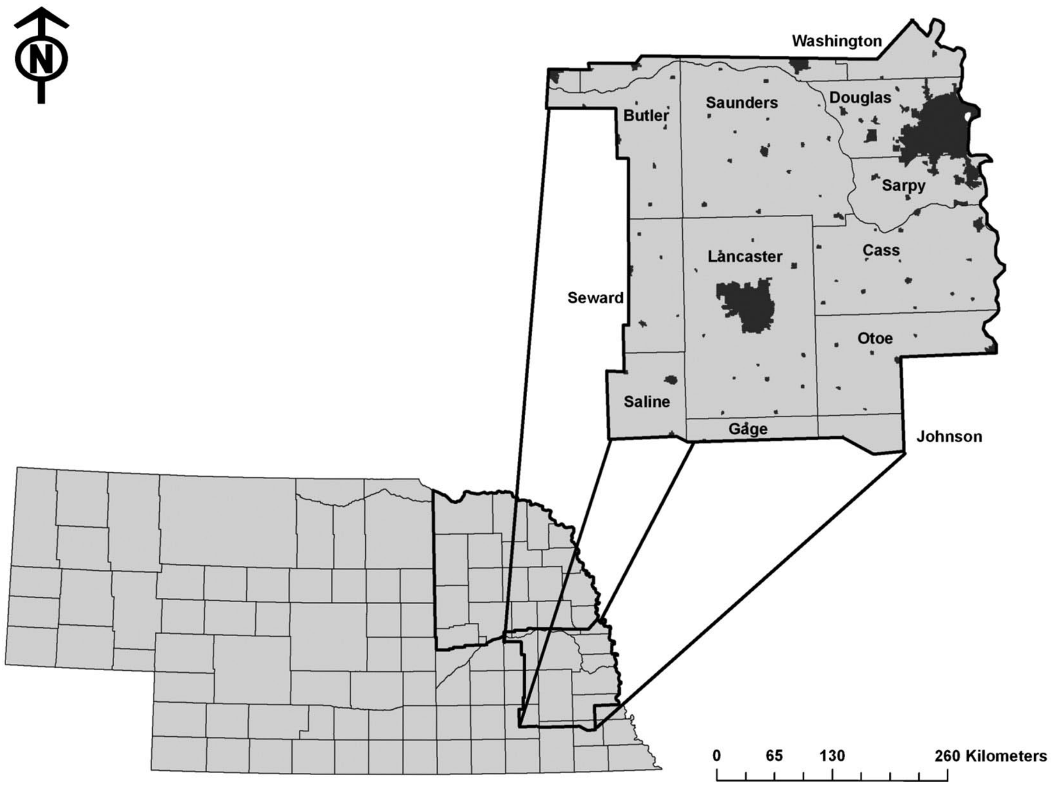

Figure 1. The southeastern and northeastern study areas (bold lines) in Nebraska, USA, including the southeastern September Canada goose hunting zone (inset), 2004–2010.

In 2004, the Nebraska Game and Parks Commission (NGPC) initiated an early September hunting season in southeastern Nebraska to reduce populations of Canada geese. Although September seasons have continued through 2010, no assessment has been made concerning changes in population and harvest demographics in relation to September seasons. Our goal was to determine whether the early hunting seasons affected survival, recovery, and harvest rates of temperate-nesting Canada geese banded in Nebraska. We also determined chronology of recoveries of geese banded in southeastern Nebraska.

Study area

September Canada goose seasons were conducted in 16 counties in southeastern Nebraska, USA (Fig. 1) from 2004 to 2010. The metropolitan areas of Omaha and Lincoln, located in Douglas and Sarpy, and Lancaster counties, respectively, were within the bounds of the September seasons. We banded geese at 21 locations in southeastern Nebraska, including 8 locations around the Omaha area and 13 locations around the Lincoln area. The City of Omaha and associated suburbs covered 380 km^2 with a population of 865,350 and the City of Lincoln covered 195 km^2 with a population of 258,379 (U.S. Census Bureau 2010). The study area of northeastern Nebraska included 18 counties (Fig. 1) and was a more rural area. We banded geese at 19 locations in northeastern Nebraska beginning in 2006. The largest city in the northeastern study area was Norfolk, which covered 26 km^2 with a population of 24,210 (U.S. Census Bureau 2010). The greater Sioux City metropolitan area lay in portions of Nebraska, Iowa, and South Dakota (USA), and it covered 164 km^2 with a population of 97,139, primarily in Iowa (U.S. Census Bureau 2010).

Methods

We attempted to band Canada geese at locations where adults were present with young and where ≥15 geese were present. Although we did not band geese at all sites in all years, geese were banded at most locations in most years. Geese banded for this study likely represented the same local populations present prior to and after implementation of September seasons. We captured geese at molting locations by drive-trapping them during their flightless period of late June and early July (1999–2010). We used plumage characteristics to determine age (hatch-year [HY] or after hatch-year [AHY]) and cloacal examination to determine sex. We fitted all geese with a U.S. Geological Survey band unless geese were previously banded. The length of the early September hunting season was 9 days in 2004 and 2007–2010, 10 days in 2005, and 11 days in 2006. In 2009 and 2010, the early September hunting seasons opened on Labor Day weekend (5 and 4 Sep, respectively), and prior to 2009 the season opened the weekend following Labor Day. From 2004 to 2009, the daily bag limit was 5 geese. In 2010, the daily bag was increased to 8 geese/hunter. In 2000–2002, regular hunting-season dates included 1–3 days of hunting in late September.

We obtained Canada goose banding and recovery data (1999–2010) from the Bird Banding Laboratory in Laurel, Maryland, USA. We queried about only shot birds, and we categorized recoveries that occurred during the same hunting season as "direct" and recoveries from after the first hunting season as "indirect." If geese were translocated, we removed them from our sample. Translocated geese were not leg-banded. We used the Brownie et al. (1985) model in Program MARK (White and Burnham 1999) to estimate survival (S) and recovery (f) rates. We used Akaike's information criterion (AIC; Akaike 1973) to compare models that considered age, sex, location, and year-specific survival and recovery rates for time periods and study areas. We used 2 time periods, pre-initiation of September hunting seasons (1999–2003) and post-initiation of September hunting seasons (2004–2010) for the analysis of impact of September hunting seasons (h) on survival. We constructed 36 models to assess variation in survival and recovery rates of Canada geese banded in southeastern Nebraska. The global model for the analysis included age (a) and year ([t], $S(a \times t)\ f(a \times t)$).

We constructed a second set of models that compared survival between 2 locations, southeastern Nebraska and northeastern Nebraska (2006–2010), which were populations within and outside the September hunt-season bounds, respectively. We constructed 16 models to assess variation in survival and recovery rates. The global model for the analysis included location (l) and year ($S(l \times t)$ $f(l \times t)$). We used latitude 41.40° as the boundary between the 2 areas. Age classes were pooled for this analysis because of low sample sizes for HY-banded birds; age-specific survival of HY birds was not estimable during preliminary analyses. We included all models that carried ≥0.01 AIC weights in our tables. We checked for overdispersion in all global models using the median $\hat{c}$ test in Program MARK (White and Burnham 1999).

We estimated harvest rates using the direct band return rate divided by the corrected reporting rate (0.763) for geese in Montana, North Dakota, Wyoming, South Dakota, Colorado, Nebraska, and Kansas (Zimmerman et al. 2009) because >75% of geese banded in southeastern Nebraska were recovered in the northern Central Flyway (Groepper 2011). We determined chronology of combined direct and indirect band recoveries by month for AHY and HY birds and performed Fisher's Exact tests (Fisher 1925) to test for differences in proportion of band recoveries in September, October, and November–February for the pre- and post-initiation of September hunting seasons. We combined the months of November–February because we were most concerned with differences due to September hunting seasons.

Results

We banded 4,406 AHY and 2,793 HY Canada geese in southeastern Nebraska in 1999–2010 (1,089 AHY and 1,535 HY during 2006–2010) and 519 AHY and 1,659 HY Canada geese in northeastern Nebraska in 2006–2010. Hunters recovered 1,443 (33%) AHY geese and 913 (33%) HY geese from the 1999–2010 cohorts in southeastern Nebraska, including 489 (45%) AHY and 534 (35%) HY recovered from 2006–2010 cohorts in southeastern Nebraska. Hunters recovered 117 (23%) AHY geese and 391 (24%) HY geese from the 2006–2010 cohorts from northeastern Nebraska.

Hunt season (h) was not in our top model in our assessment of pre- versus post-initiation of September hunting seasons in southeastern Nebraska (Table 1). The top model, $S(a)\ f(a \times t)$, used age class to estimate survival and age class and year to estimate recovery probability (Table 1). Survival varied by age (S_{AHY}: 0.696, SE = 0.009; S_{HY}: 0.896, SE = 0.041). Recovery estimates differed by year and age class (Fig. 2). The third-ranked model in our analysis was the highest ranked model that included September season initiation (h) as a parameter, but it carried only 12% of the weight (Table 1). In addition, S_{HY} (pre-initiation S_{HY} = 0.863, 95% CI = 0.691–0.947; post-initiation S_{HY} = 0.914, 95% CI = 0.739–0.976) and S_{AHY} (pre-initiation S_{AHY} = 0.707, 95% CI = 0.675–0.736; post-initiation S_{AHY} = 0.694, 95% CI = 0.663–0.717) were not different during pre- and post-initiation periods. Harvest rates in southeastern Nebraska did not change after implementation of the September season for either age class. Mean harvest rate across all years was 0.142 (SE = 0.013; pre-initiation = 0.140, 95% CI = 0.110–0.171; post-initiation = 0.144, 95% CI = 0.101–0.186) and 0.160 (SE = 0.017; pre-initiation = 0.140, 95% CI = 0.096–0.183; post-initiation = 0.174, 95% CI = 0.125–0.223) for AHY and HY geese, respectively.

The model $S(.)\ f(l \times t)$, which estimated a combined survival estimate for southeastern and northeastern Nebraska and location and year to estimate recovery, was selected as the top model during our assessment of the post-initiation

Table 1. Summary of models used to compare effects of September hunting seasons on survival and recovery rates of Canada geese banded in southeastern Nebraska, USA, 1999–2010.

Model[a]	AIC[b]	ΔAIC	w[c]	Likelihood	K[d]
$S(a)\ f(a \times t)$	16,404	0	0.530	1.000	26
$S(a \times t)\ f(t)$	16,406	2	0.235	0.448	34
$S(a \times h)\ f(a \times t)$	16,407	3	0.121	0.231	28
$S(a)\ f(t)$	16,409	5	0.051	0.098	14
$S(a \times t)\ f(a \times t)$global	16,409	5	0.046	0.088	46
$S(a \times h)\ f(t)$	16,410	6	0.023	0.043	16

a. S = survival estimate, f = recovery estimate, a = age (after-hatch-yr or hatch-yr), h = hunt season (pre- or post-Sep hunting season), t = yr.
b. Akaike's Information Criterion.
c. Model wt.
d. No. of parameters included in the model.

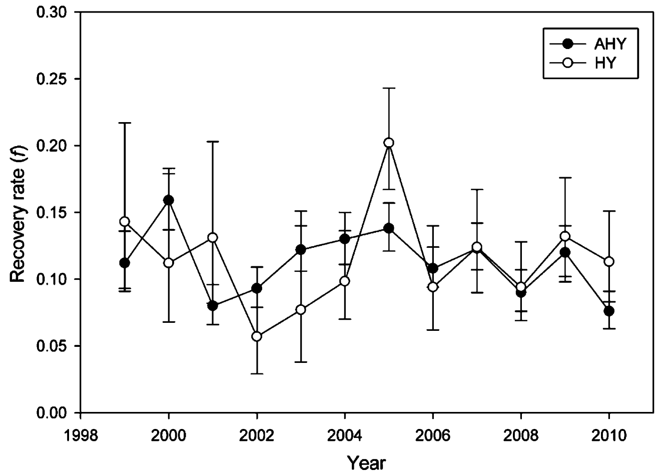

Figure 2. Estimates of recovery (*f*) rates from the model *S*(*a*) *f*(*a* × *t*)of after-hatch-year (AHY) and hatch-year (HY) Canada geese banded in southeastern Nebraska, USA, 1999–2010.

period in southeastern versus northeastern Nebraska (Table 2). Survival estimates did not differ between locations, but recoveries differed by location and year (Table 3). The second-best model, *S*(*l*) *f*(*l* × *t*), carried substantial weight and included variation in survival between the 2 regions; however, confidence intervals for survival estimates overlapped (southeastern: $S = 0.690$, 95% CI = 0.635–0.741; northeastern Nebraska: $S = 0.744$, 95% CI = 0.666–0.809). Geese banded in southeastern Nebraska had a lower estimated harvest rate (0.101, SE = 0.026) than did geese banded in northeastern Nebraska (0.159, SE = 0.023). Following initiation of September seasons, hunter recoveries of geese banded in southeastern Nebraska shifted from the regular hunting season into September (Table 4), but mean harvest rates for AHY ($P = 0.79$) or HY ($P = 0.11$) did not differ between pre- and post-initiation of September hunting seasons.

Discussion

We did not detect differences in survival of Canada geese nesting in Nebraska after initiation of September hunting seasons or between areas with and without September seasons. Mean harvest rates appeared similar before and after initiation of September seasons. Other studies have documented reduced survival rates or increased harvest with September seasons (Heusmann 1999, Sheaffer et al. 2005, Dieter et al. 2010). Our data fail to show an immediate impact of September seasons on survival and we noted a small (< 3%) decrease in survival of geese banded in southeastern Nebraska when compared with survival of geese from the same area during 1990–2000 (Powell et al. 2004*b*). Baseline or pre-initiation data would have been useful to compare survival of geese in both southeastern and northeastern Nebraska and examine the effects of the September season. We expected survival rates in the 2 regions would be similar before and differ after the initiation of the September season; however, we found no evidence to support such a shift in survival rates. Thus, we believe that the lack of difference in survival rates that we observed following the implementation of the September season is further evidence of the absence of an effect of the season on survival of Canada geese.

We did not measure hunter participation or satisfaction in relation to the September season. Although the September season accounted for <2% of the total goose-hunting days in Nebraska in 2008 and 2009 (M. Vrtiska, Nebraska Game, and Parks Commission, unpublished data), NGPC received requests from hunters to eliminate the September season to retain days in the regular dark-goose season. Thus, we believe that removing days from the regular dark-goose season, especially days that overlap with duck seasons, and shifting them into an early September goose season may have reduced overall hunter participation (*sensu* Heusmann 1999). Further, shifting hunting days into September only appeared to redistribute harvest but did not increase it. This also may explain why survival was similar between northeastern and southeastern Nebraska, despite northeastern Nebraska being more rural. Regular hunting-season dates for Canada geese coincided with opening of duck seasons for most of northeastern Nebraska, which may have increased the take of Canada geese through opportunistic harvest.

We believe expansion of urban areas is leading to higher populations of nesting Canada geese in southeastern Nebraska (Groepper 2011). There is evidence that the population growth rate for Canada geese in southeastern Nebraska is higher than previously reported estimates (Powell et al. 2004*b*, Groepper 2011). Our data do not show that a September season influenced harvest or survival rates of Canada geese. However, the September season may have prevented an increase in survival rates through increased harvest

Table 2. Summary of models used to compare survival and recovery rates of Canada geese banded in southeastern (Sep hunting seasons) versus northeastern (no Sep hunting seasons) Nebraska, USA, 2006–2010.

Model[a]	AIC[b]	ΔAIC	*w*[c]	Likelihood	*K*[d]
S(.) *f*(*l* × *t*)	7,209.6	0.00	0.454	1.000	11
S(*l*) *f*(*l* × *t*)	7,210.2	0.62	0.334	0.734	12
S(*l* × *t*) *f*(*l* × *t*)global	7,212.2	2.63	0.122	0.269	18
S(*t*) *f*(*l* × *t*)	7,212.9	3.29	0.088	0.193	14

a. *S* = survival estimate, *f* = recovery estimate, *l* = location (southeastern or northeastern NE), *t* = yr, (.) = location/yr combined parameter.
b. Akaike's Information Criterion.
c. Model wt.
d. No. of parameters included in the model.

opportunity. Our analyses indicated HY geese had higher survival than AHY geese. Although HY waterfowl typically are more vulnerable to hunting mortality (Bellrose 1980), higher mean survival rates for HY than AHY Canada geese do not appear uncommon (Sheaffer et al. 2005, Berdeen and Rave 2008, Dieter et al. 2010, Heller 2010). Hatch-year birds likely remain in family groups throughout the year; thus, recoveries may be influenced by the habits of AHY geese (Hanson 1962, Bellrose 1980). Also, juvenile geese in urban areas may experience high survival as a result of relatively safe environments (Luukkonen et al. 2008, Heller 2010); especially given high site-fidelity rates (Groepper et al. 2008).

Our estimates of HY survival and harvest rates may be biased high. When banding operations (such as winter banding) are separated from the recovery period by a substantial amount of time, survival and recovery may be positively correlated and resulting estimates of survival may be positively biased (Nichols et al. 1982). Our banding operations were conducted about 2 months before the start of September seasons. Nichols et al. (1982) suggested such bias was responsible for trends of generally higher survival estimates (up to 0.20) from winter-banded populations of some duck species, relative to August- and September-banded populations. Also, our harvest rates were calculated under the assumption of a reporting rate of 0.763 (Zimmerman et al. 2009). If reporting rates for geese in Nebraska were 0.60 or 0.90, our harvest-rate calculations would have been 0.20 or 0.13, respectively. Unfortunately, we have no way to test for either potential bias. Regardless of potential bias, our results suggest harvest accounts for a significant portion of mortality among HY birds in eastern Nebraska.

We are uncertain how high HY survival fits into the population and harvest dynamics of temperate-nesting Canada geese. Potentially, it may result in abundant numbers of second-year (SY), non-breeding geese, which may buffer harvest. We can only speculate on the impact these SY geese have on harvest dynamics, given their propensity for molt migration (Dieter and Anderson 2009) and the possibility of their harvest affecting survival rate of AHY birds (Heller 2010, Groepper 2011).

Table 3. Estimates of survival (S) and recovery (f) from the model $S(.)\,f(l \times t)^{a}$ of Canada geese banded in southeastern (Sep hunting season) and northeastern (no Sep hunting season) Nebraska, USA, 2006–2010.

Region	Year	K^{b}	β^{c}	SE	Lower 95% CI	Upper 95% CI
Combined		S	0.712	0.022	0.666	0.752
Southeastern	2006	f	0.081	0.011	0.063	0.104
	2007	f	0.114	0.011	0.094	0.139
	2008	f	0.099	0.010	0.080	0.121
	2009	f	0.166	0.017	0.136	0.202
	2010	f	0.151	0.015	0.124	0.182
Northeastern	2006	f	0.148	0.027	0.102	0.210
	2007	f	0.136	0.015	0.109	0.168
	2008	f	0.146	0.013	0.122	0.174
	2009	f	0.157	0.015	0.130	0.188
	2010	f	0.061	0.006	0.050	0.075

a. S = survival estimate, f = recovery estimate, l = location (southeastern or northeastern NE), t = yr, (.) = location/yr combined parameter.
b. Parameter.
c. Model estimate.

Table 4. Number of geese recovered and mean proportion (bold) of combined direct and indirect recoveries of after-hatch-year (AHY) and hatch-year (HY) Canada geese banded in southeastern Nebraska, USA, before and after initiation of September Canada goose hunting seasons in 2004.

		Sep		Oct		Nov–Feb	
Period	**Year**	**AHY**	**HY**	**AHY**	**HY**	**AHY**	**HY**
Pre-hunt	1999	0	0	36	16	52	15
	2000	8	0	26	5	116	32
	2001	16	11	21	2	53	18
	2002	22	5	17	5	83	20
	2003	8	9	46	19	109	22
		0.09	0.14	0.25	0.26	0.67	0.60
Post-hunt	2004	25	31	20	41	90	20
	2005	54	93	23	44	106	73
	2006	56	55	18	19	59	37
	2007	35	53	15	23	72	89
	2008	23	34	14	17	42	71
	2009	22	46	13	27	48	91
	2010	27	66	7	26	24	43
		0.30[a]	0.38[a]	0.14[a]	0.18[b]	0.55[b]	0.44[b]

a. Proportion of harvest differs between pre- and post-initiation of Sep hunting seasons ($P < 0.001$).
b. Proportion of harvest differs between pre- and post-initiation of Sep hunting seasons ($P < 0.01$).

Management implications

Our analysis indicated that initiation of 9-day September hunting seasons to target Canada geese nesting in Nebraska did not reduce survival and appears to have only redistributed harvest timing. Given that the primary objective of the September season in Nebraska was to decrease survival, continuation of the September season in Nebraska may not be warranted. Other management actions to decrease survival, such as increasing daily bag limits in both September and regular seasons, implementation of an August management harvest or other techniques such as translocation or nest destruction (e.g., Holevinski et al. 2006, Luukkonen et al. 2008) may reduce survival. The Environmental Impact Statement on resident Canada goose management (U.S. Fish and Wildlife Service 2005) provided for some of these additional actions, but it may not have gone far enough to fully address population reduction. Implementation of new regulations or techniques needs to be considered in conjunction with existing regulations for unambiguous evaluation (Sheaffer et al. 2005). Continued banding of Canada geese in Nebraska also will assist in evaluation of new management actions. Increasing the number of Canada geese banded in Nebraska will likely improve estimates of survival and recovery. Heller (2010) provided recommendations for banding studies to increase precision of annual survival estimates and detect temporal changes in recovery rates. Additionally, banding of Canada geese in other areas of the Central Flyway and western Mississippi Flyway would provide a better understanding of movements of Canada geese among states. Data on hunter participation and satisfaction also could be critical to making informed decisions regarding hunter preferences for such seasons.

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