Management Plan for Midcontinent Cackling Geese in the Mississippi Flyway

Approved July 2013

Population Definition

In 2004, the American Ornithologists' Union recognized cackling geese (*Branta hutchinsii*) as a separate species from Canada geese (*Branta canadensis*; Banks et al. 2004). The two species are similar in appearance, but cackling geese are generally much smaller, nest mainly in arctic tundra and coastal habitats and can be definitively distinguished from Canada geese based on mitochondrial DNA. For the purposes of this management plan, the midcontinent population of cackling geese will include all cackling geese nesting north of the tree line in Canada (Figure 1), and wintering mainly in the Central and Mississippi Flyways. According to band recovery data, birds banded in the westernmost nesting areas generally winter farther west than those from the central nesting areas, which in turn winter farther west than those from the easternmost nesting areas (Fig. 2). Cackling geese nesting in the central and western arctic are most commonly recovered in eastern Alberta, western Saskatchewan and western portions of the Central Flyway. Those nesting in the western Hudson Bay region between about 75-95^{o}W longitude are mainly recovered in eastern Saskatchewan, southwestern Manitoba and eastern portions of the Central Flyway, and cackling geese nesting on Baffin Island are recovered in southern Manitoba and in nearly equal proportions in the eastern Central Flyway and western Mississippi Flyway. Few cackling geese are recovered in the eastern Mississippi Flyway or in the Atlantic Flyway.

Population Status and Trends

Until recently, cackling goose population size had not been estimated on either the breeding or wintering grounds, though trends from midwinter counts and local breeding ground counts suggested that the population was stable or increasing. For example, on western Baffin Island annual helicopter transect surveys were flown in August, from 1996 through 2009. The estimated number of cackling geese that occupied the Great Plain of the Koukdjuak on Baffin Island ranged from about 124,000 to 202,000 birds, and averaged approximately 160,000 birds, with no apparent trend over that time (Fig. 3). Midwinter counts of cackling geese in the Central and Mississippi Flyways averaged about 325,000 birds in the 1970s and increased to an average of about 687,000 birds from 2002-2011, inclusive (Figure 4).

Total numbers of cackling geese are difficult to estimate on their breeding grounds using traditional survey techniques due to the sheer size of the nesting range, and on their wintering grounds due to intermixing with other white-cheeked (Canada) geese. Recently, Alisauskas et al. (2009) suggested that Lincoln's (1930) approach could be used to estimate population size of several species of arctic-nesting geese for which band recovery data and age-specific harvest estimates were available. This method can be used to estimate population size of adult birds in August (i.e., at the time of banding), and a summary of the general methodology based on Lincoln (1930) and Alisauskas et al. (2009) is provided below.

Briefly, population size can be calculated indirectly using the following relationship: Harvest rate (h) is the proportion of the population (N) that is harvested by hunters (H = harvest), or

$$(1)\ h = H/N.$$

Harvest rate (*h*) can also be calculated independently using band recovery data as:

$$(2)\ h = \text{DRR}/r,$$

where DRR is direct recovery rate, and *r* is band reporting rate. For example, if 2% of adult geese are shot and reported in the first hunting season after banding (DRR = 0.02), and only half of the bands are reported ($r = 0.5$), then the actual harvest rate of adults is 0.04 ($h = \text{DRR}/r = 0.02/0.5 = 0.04$). In this example, 4% of the adult population was shot by hunters in the first hunting season following banding. If we also estimated the number of adults harvested (H), then we would know that this harvest equals 4% of the population size at the time of banding. To continue with this example, if the harvest of adult geese was 10,000 birds, then we would know that 10,000 adults represented 4% of the population (because harvest rate, *h*, is the proportion of the population harvested by hunters, or H/N). So, substituting what we know into equation (1), h = H/N, or 0.04 = 10,000/N. If we rearrange this equation to find N, we get N = H/*h* = 10,000/0.04 = 250,000. In this example, population size at the time of banding was 250,000 adults.

So, in order to calculate population size, we require the following: (1) estimate of DRR from banding data; (2) estimate of reporting rate (*r*) from reward band studies; and, (3) an estimate of age-specific harvest (H). Reward band studies have shown that reporting rates can vary geographically but do not vary much by species in the same geographic areas (e.g., Nichols et al. 1995; Zimmerman et al. 2009), so reporting rate estimates of midcontinent mallards, for example, can be used as a proxy for midcontinent goose band reporting rates in years for which no goose reward band studies were done (e.g., Alisauskas et al. 2009, 2011). Once we obtain estimates of DRR from banding data, and *r* from reward band studies, we can estimate harvest rate using equation 2 above.

To estimate adult population size at the time of banding, we used only harvest rate (*h*) of adult birds and harvest estimates (H) of adult birds, and used only band recovery data from birds banded as adults that were recovered in geographic areas for which there were corresponding harvest estimates of adult cackling geese. Specifically, we used only band recoveries and harvest estimates from SK, AB, (ignoring ON, NU and NWT because harvest was very low with very few band recoveries in those locations) and states of the Mississippi and Central Flyways. Estimates of cackling goose harvests were not available in the Mississippi Flyway until 1994, so from 1975 through 1993, only data from SK, AB, and the Central Flyway states were used to estimate population size. Estimates of reporting rate were year-specific and were the same as those used by Alisauskas et al. (2009) for estimating population size of midcontinent geese. Finally, Padding and Royle (2012) suggested that goose harvest estimates in the United States were biased high, and recommended using a multiplicative adjustment factor of 0.67 to correct estimates based on the harvest questionnaire survey for years prior to 1999, and to use an adjustment of 0.61 for HIP-based estimates of harvest from 1999 onward. To be conservative, harvest estimates from both the United States and Canada were adjusted by these factors.

In 2010, for example, 1905 adult cackling geese were banded that year of which 35 were shot and reported during the first hunting season after banding, for a direct recovery rate (DRR) of 35/1905 = 0.018. Using the latest available reporting rates for midcontinent geese, the reporting rate (r) used was 0.73 (Zimmerman et al. 2009). Harvest rate was therefore DRR/r = 0.025. Harvest of adult cackling geese in prairie Canada and the MF and CF states combined was 120,986 adults. After multiplying this estimate by 0.61 to account for potential bias in harvest estimates (Padding and Royle 2012), the harvest estimate declined to 73,801 adult cackling geese. Population size was then calculated as H/h = 73,801/0.025 = 2,952,040 adult cackling geese in August, 2010. Looking at trends in population size for all years where sufficient data were available, it appears that midcontinent cackling geese have increased markedly since the 1970s based on Lincoln estimates (Figure 5). The population estimates averaged about 368,000 birds from 1975-1979, and about 2.39 million adults from 2001-2010.

Harvest and Survival Rates

Harvest rates of cackling geese appear to have decreased over time, perhaps stabilizing recently, and rates for adult and juvenile cackling geese appear to follow similar trends (Figs. 6 and 7). In the Mississippi Flyway, estimated harvests of cackling geese averaged 22,918 birds per year from 2001-2010, and appear to have declined over time (Fig. 8) and are similar for adults and juveniles (Fig. 9). However, harvest estimates for juvenile cackling geese ceased to be done around 2004 because of protocol changes at the Mississippi Flyway Wing Bee, so actual harvests are likely to be higher than is suggested by harvest data. Estimated harvests in prairie Canada have been relatively stable, averaging 85,178 birds per year from 2001-2010 (Fig. 10); harvests of adult and juvenile birds exhibited similar trends (Fig. 11).

Annual survival and recovery rates for 1988-2011 were estimated using Brownie models as implemented in program MARK. Input data for the analysis involved 24,789 adult cackling geese marked on arctic nesting/molting areas in Canada, of which 2,622 were subsequently recovered. The candidate set of models considered for this analysis included the four standard Brownie models for an analysis involving one group; those are:

1) Full time-dependency (i.e., annual variation) in both survival and recovery probability (model S(t)f(t))
2) Constant survival, annual variation in recovery probability (model S()f(t))
3) Annual variation in survival, constant recovery probability (model S(t)f())
4) Constancy in both survival and recovery probability (model S()f())

In addition, models in which survival was constrained to vary as a linear-logistic or quadratic function of calendar year (i.e., linear and quadratic time trend models) also were considered. Model selection was based on minimization of AIC. Model-averaged parameter estimates were computed, averaging over all models in the candidate set after weighting each estimate by the appropriate AIC-based model weight.

Model selection results (e.g., AIC ranking, model weights) indicated that the best model was one in which survival was constrained to vary as a quadratic (curvilinear) function of time (Table 1). Under this model, survival declined from a value of about 0.85 in the late 1980s to a low of 0.80 in 1997, then increased sharply during the 2000s, reaching a high of 0.90 in 2010. Because the quadratic time trend model was strongly supported by the data (model weight = 0.86; Table 1), model-averaged survival rate estimates showed a similar pattern of declining survival during the late 1980s and early 1990s; a period of stabilization during the late 1990s; and, a subsequent increase between 1999 and 2010 (Table 2; Figure 12). Over all years, model-averaged survival rate estimates ranged from 0.804 to 0.893 (Table 2). Model-averaged recovery rate estimates varied considerably among years but showed a general pattern of increase between 1992 and 2003, followed by an apparent decline (Table 2; Figure 13). It is worth noting, however, that the terminal recovery rate estimate (2011) may be biased low due to incomplete reporting (at the time of analysis) of birds recovered during the 2011/2012 hunting season. Over all years, recovery rate estimates ranged between 0.015 and 0.037 (Table 2).

Management Goal

The management goal is to maintain a population that allows maximum harvest opportunities for cackling geese in the Central and Mississippi Flyways. To do this, the objective is to maintain a minimum of 1 million adult birds in the population, based on a 3-year running average of Lincoln (1930) estimates of abundance. In addition, adult harvest rates should remain below 10%, based on a two-year running average.

The 10% harvest rate objective was selected because harvest rates higher than this have been sustainable for the management of several Canada goose populations in North America, including some in the Mississippi Flyway (e.g., see Table 3 in Zimmerman et al. 2009). A recent analysis of harvest potential of midcontinent cackling geese also indicated a maximum sustainable yield (MSY) of 9.6% for this population in the Central Flyway (Zimmerman et al. 2013, unpublished report; see Appendix 1). Also, there is evidence that harvest rates were likely higher than 10% in the past; for example, from 1975-1979 direct recovery rates of adult cackling geese banded in the Canadian arctic averaged ~ 4.7%. At that time, reporting rates (*r*) for midcontinent mallards were likely in the range between 0.26 and 0.39 (e.g., Henny and Burnham 1976, Nichols et al. 1995). If we assume that band reporting rates were similar for cackling geese (recent studies suggest that band reporting rates do not vary appreciably between species, e.g., Zimmerman et al. 2009), then it is likely that adult harvest rates (*h*) at that time were at least 12% (i.e., $h = \text{DRR}/r = 0.047/.39 = 0.121$). Under existing harvest rates, the number of cackling geese on western Baffin Island remained relatively stable from 1996 through 2009 (Fig. 3), midwinter counts more than doubled (Fig. 4), and Lincoln estimates of population size increased more than 5-fold between the 1970s and 2000s (Figure 5). Unless harvest rates for adult cackling geese exceed 10%, harvest opportunities for white-cheeked geese in the Mississippi Flyway could be liberalized, and no additional population monitoring programs need to be implemented to obtain more accurate estimates of the cackling goose population.

Harvest Management Strategy

Historically, Canada goose populations in both the Central and Mississippi Flyways were defined and managed based on their wintering grounds affiliations to ensure that hunting regulations for specific goose populations matched geographic variations in goose numbers and productivity, migration and wintering concentrations, and harvest pressure (EPP (EPP Committee 2006), MVP (Brook and Luukkonen 2010) and SJBP (Abraham et al. 2008). In recent years, the management of most Canada goose populations has been based on the status of their breeding grounds populations. Additionally, hunting regulations have been relaxed in most parts of the Mississippi and Central Flyways to increase harvests of temperate nesting (giant) Canada geese that have exceeded population objectives.

Traditionally, midcontinent cackling geese were managed as two populations in the Central and Mississippi Flyways, the Short Grass Prairie Population (Marquardt 1962, Grieb 1970), and the Tall Grass Prairie Population (Marquardt 1962, MacInnes 1966). The Short Grass Prairie Population was harvested almost entirely in the Central Flyway, while the Tall Grass Prairie Population was harvested in nearly equal proportions in the Mississippi and Central Flyways. This necessitated a joint flyway harvest management strategy, adding a layer of bureaucracy to harvest management processes to ensure that each of these populations was maintained at a self-sustaining level. However, because these populations are comprised of geese that are genetically indistinguishable and because birds from many breeding areas overlap in winter, midcontinent cackling geese should be managed as one population.

Management plans for both the Central Flyway and Mississippi Flyway midcontinent cackling goose populations share the following common elements:

(1) **Allow flyway-specific harvest regulations with regard to this population and in accordance with other Canada goose management plans.**

(2) **Maintain a minimum population of 1,000,000 adults, calculated as a 3-year running average of Lincoln-based calculations, as summarized in the management plan.**

(3) **Establish a threshold maximum acceptable adult harvest rate of 10%, calculated as a 3-year running average.**

(4) **Implement appropriate regulation changes based on recent harvest patterns when necessary (e.g., if the 10% adult harvest threshold is exceeded).**

(5) **Maintain existing indices (e.g., age-specific harvest estimates and banding data) to evaluate population status.**

Additionally, because Canada goose populations have maintained – and even increased – with harvest rates exceeding 10% in some instances, regulating goose harvests so that the harvest rate for midcontinent cackling geese is below 10% should suffice to ensure that this population is able to maintain itself in the future. Because cackling goose harvest rates are well below the stated maximum of 10% in both the Central and Mississippi Flyways, the impacts of Canada goose harvest on cackling goose population growth appear to be minor at this time. However, if the harvest rate for cackling geese should approach or exceed 10%, then harvest strategies and regulations for white-cheeked geese in both the Central and Mississippi Flyways may need to be revisited and revised.

Population Monitoring Strategy

The midcontinent population of cackling geese will be monitored primarily by banding a representative sample of these geese on their breeding grounds in northern Canada each year. Recoveries of these banded birds will provide information on distribution of harvest and, more importantly, annual survival and harvest rates. Additionally, age-specific harvests will be estimated annually in both the United States and Canada using tail feathers collected via the annual waterfowl parts collection survey. Age-specific harvest estimates, when combined with band recovery data, allow estimation of the number of adult birds in the population and the trend information provided by these estimates can be used for monitoring purposes as has been proposed for several other species of arctic-nesting geese (Alisauskas et al. 2009). August helicopter surveys on western Baffin Island were discontinued after 2009, but Midwinter Survey estimates will continue to provide annual information on the distribution of cackling geese on concentration areas. Experimental transect surveys of some arctic nesting areas were conducted from 2005-2011 to provide additional information about the distribution and abundance of cackling geese on arctic nesting areas in Canada. Efforts are also underway to evaluate the use of banding and harvest data to estimate population size and/or trends in population size over time (e.g., Alisauskas et al. 2009).

Information Needs

1) Evaluate tail fan criteria used to separate cackling geese and Canada geese in the harvest in different harvest regions. Accurate estimates of harvest are important for monitoring the midcontinent population of cackling geese and may be useful for estimating the population size and/or trends in abundance using the Lincoln (1930) estimator. Analytical methods to deal with large numbers of ‘unknown’ age-sex tail fans may need to be developed.
2) Evaluate the effectiveness and precision of using Lincoln’s (1930) method to estimate the size of the midcontinent cackling goose population using age-specific harvest estimates and band recovery data.
3) Maintain or improve the geographic representation of the banded samples from the 3 primary nesting areas for cackling geese in Canada – western, central, and eastern.
4) Complete the evaluation of the exploratory arctic surveys conducted from 2005-2011 to determine their potential as a monitoring tool for midcontinent cackling geese.

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Figure 1. Map of the breeding range of midcontinent cackling geese.

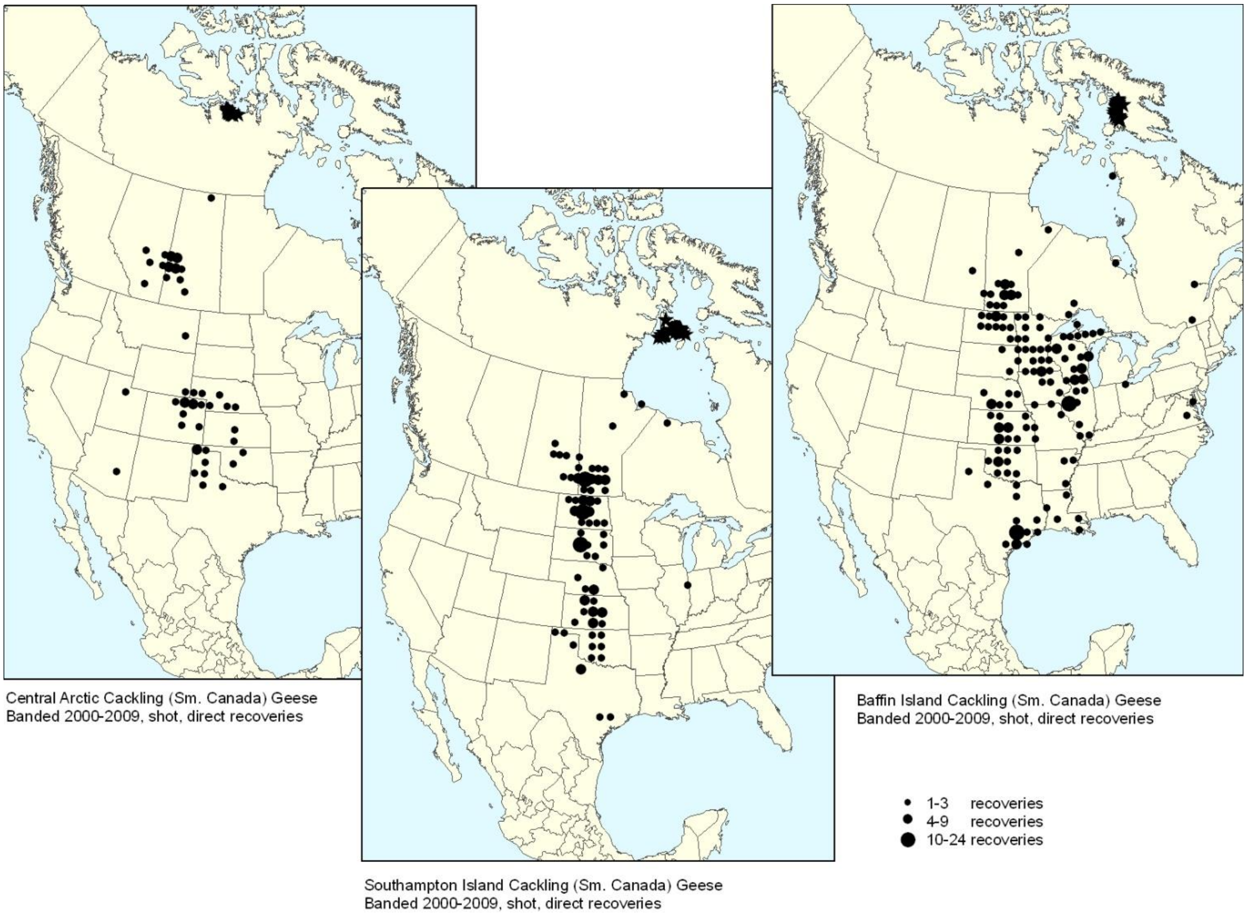

Figure 2. Longitudinal variation in band recovery distributions of cackling geese marked in different regions of the Canadian arctic. Only direct recoveries of shot birds that were banded from 2000-2009 are included.

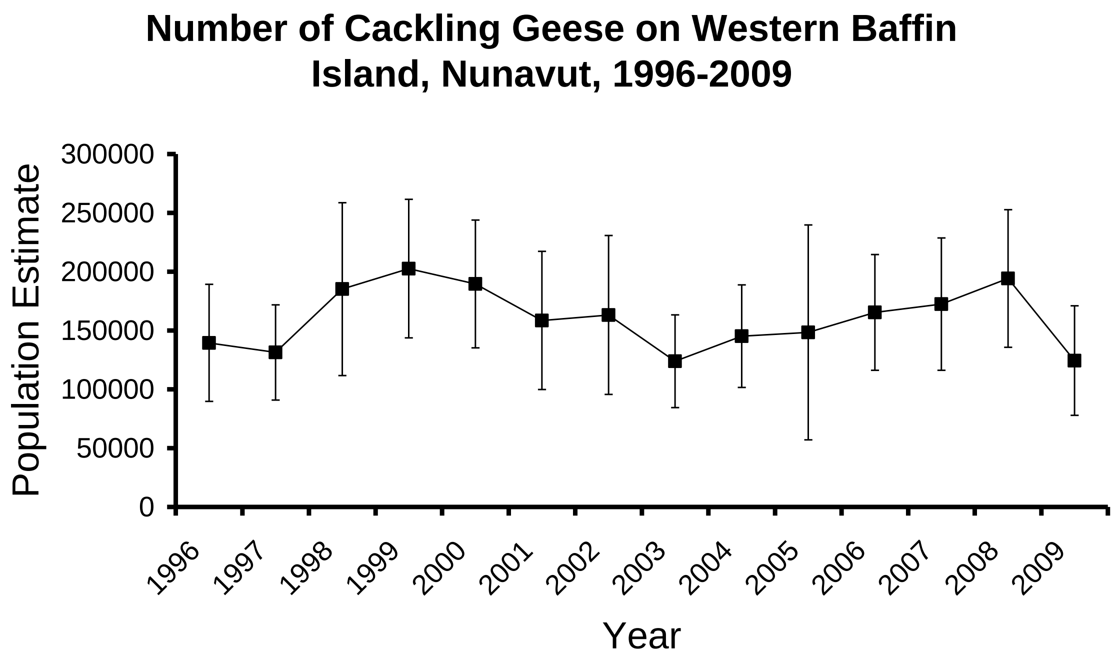

Figure 3. Estimated number of adult cackling geese on the Great Plain of the Koukdjuak, Baffin Island, Nunavut based on August helicopter surveys, 1996-2009.

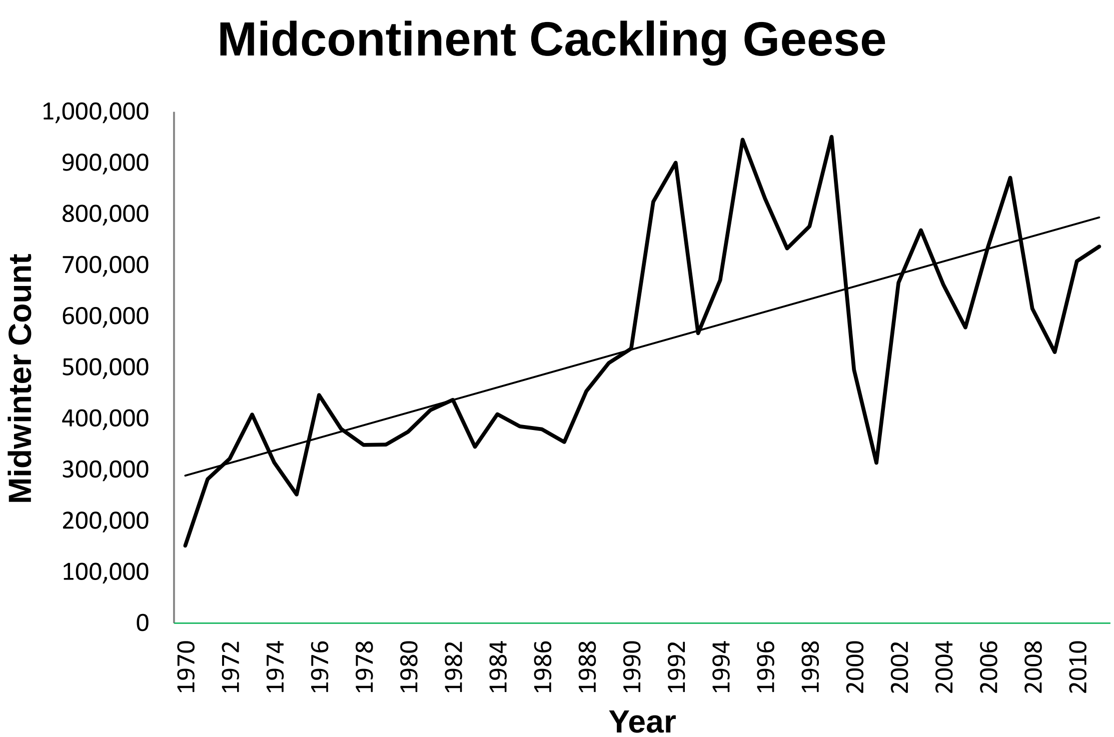

Figure 4. Midwinter counts of cackling geese in the Central and Mississippi Flyways, 1970-2011.

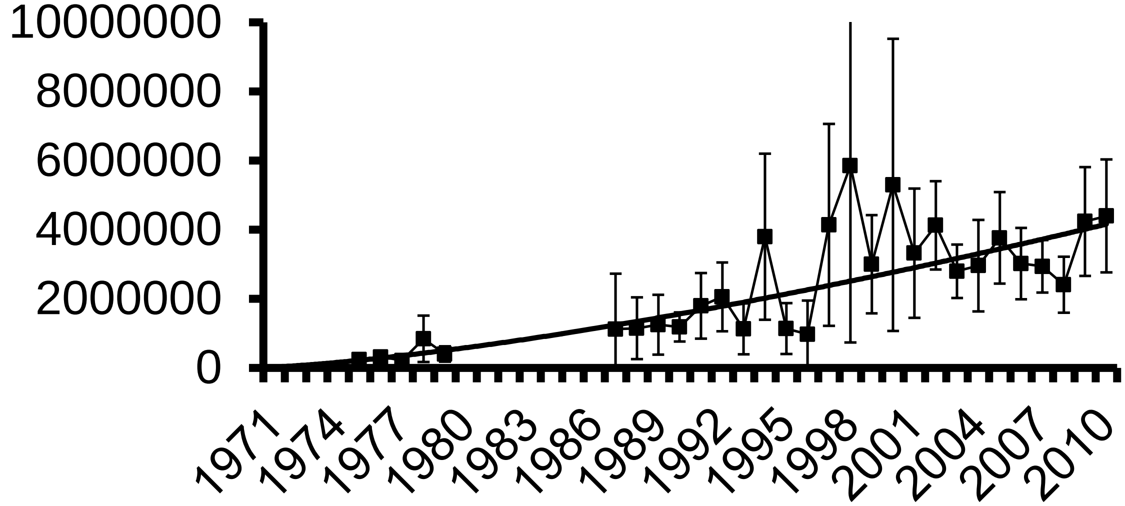

Figure 5. Lincoln population estimates of midcontinent cackling geese, 1975-2010.

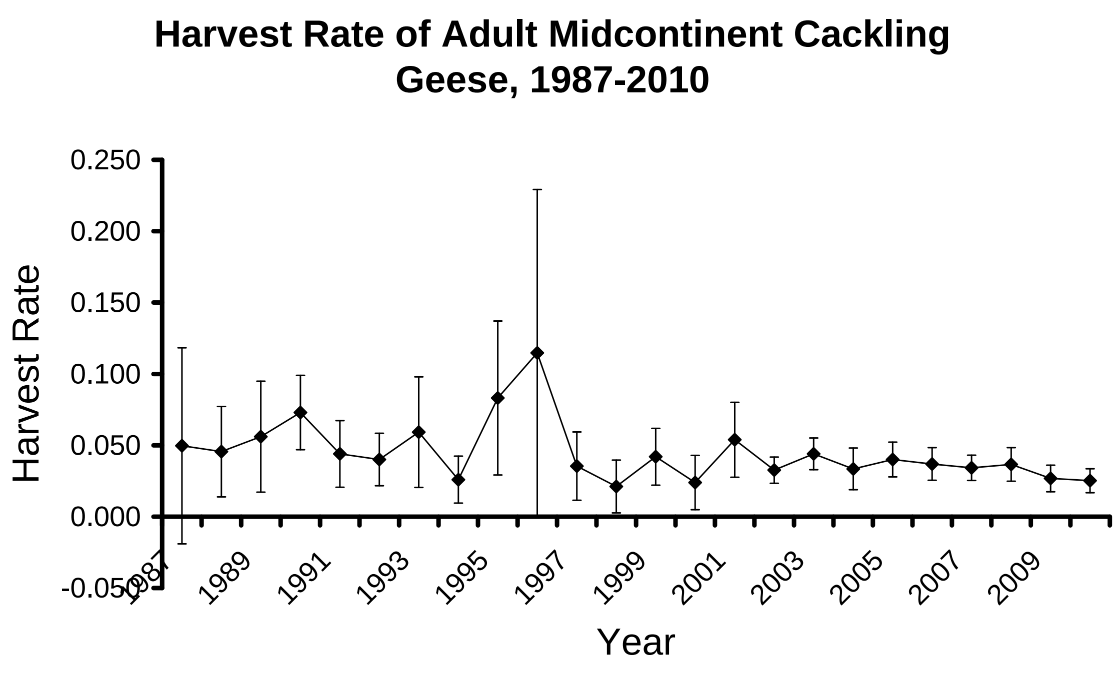

Figure 6. Annual harvest rate (± 95% CL) of adult midcontinent cackling geese, banded 1987-2010.

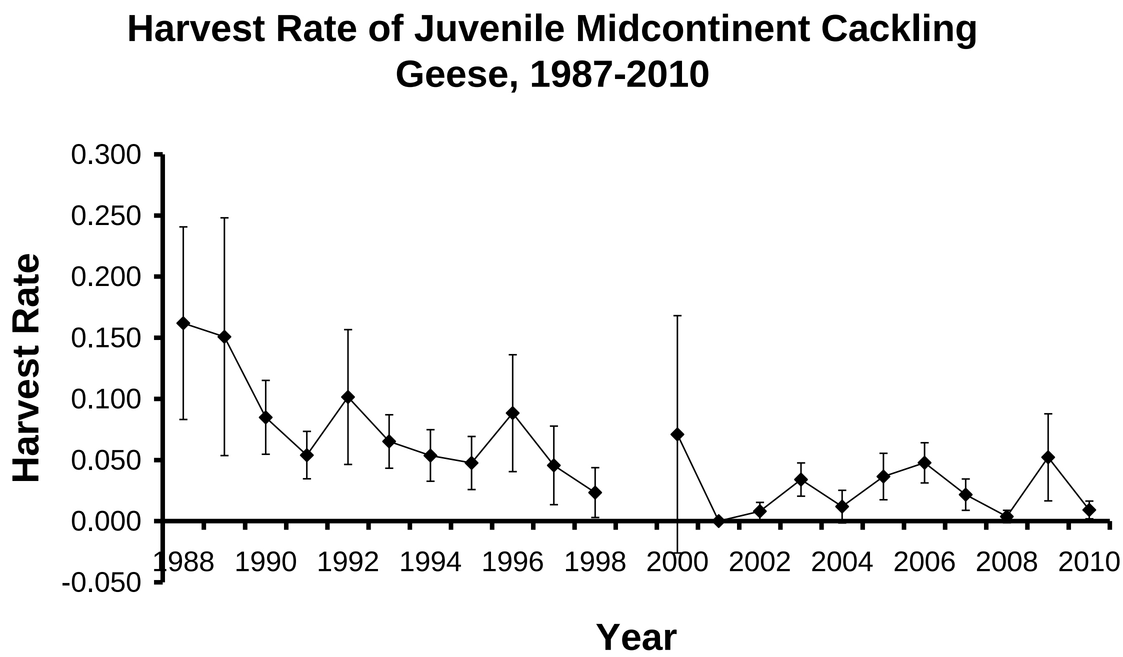

Figure 7. Annual harvest rate (± 95% CL) of juvenile midcontinent cackling geese banded mainly on Baffin Island and the west coast of Hudson Bay, Nunavut, 1988-2010.

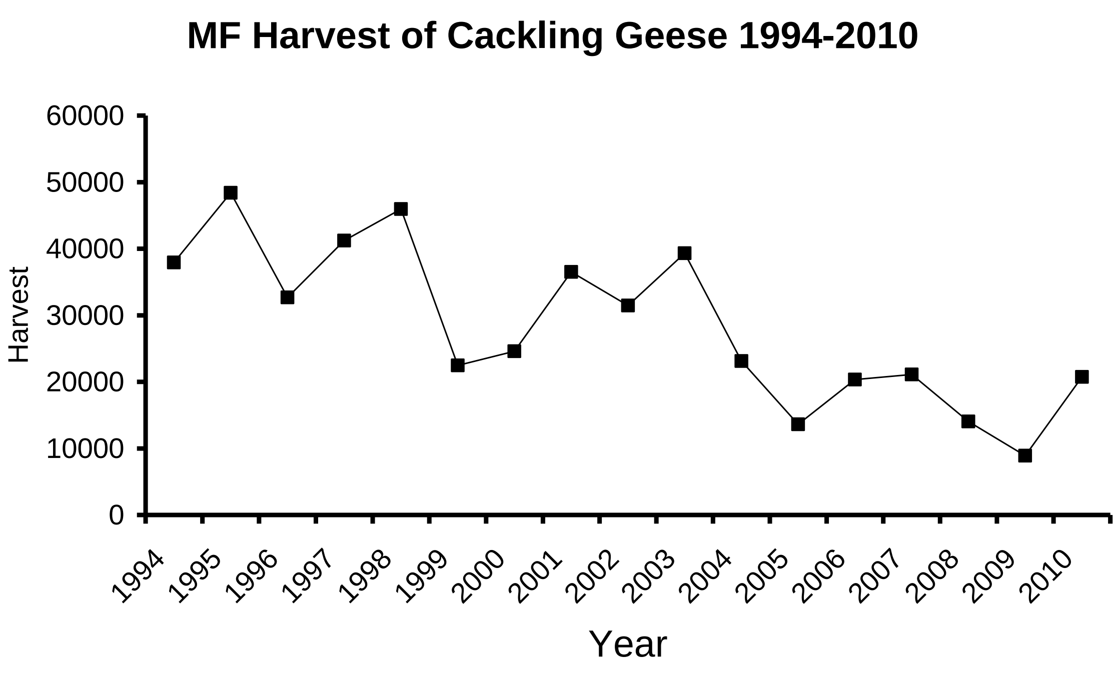

Figure 8. Annual harvests of cackling geese in states of the Mississippi Flyway, 1994-2010.

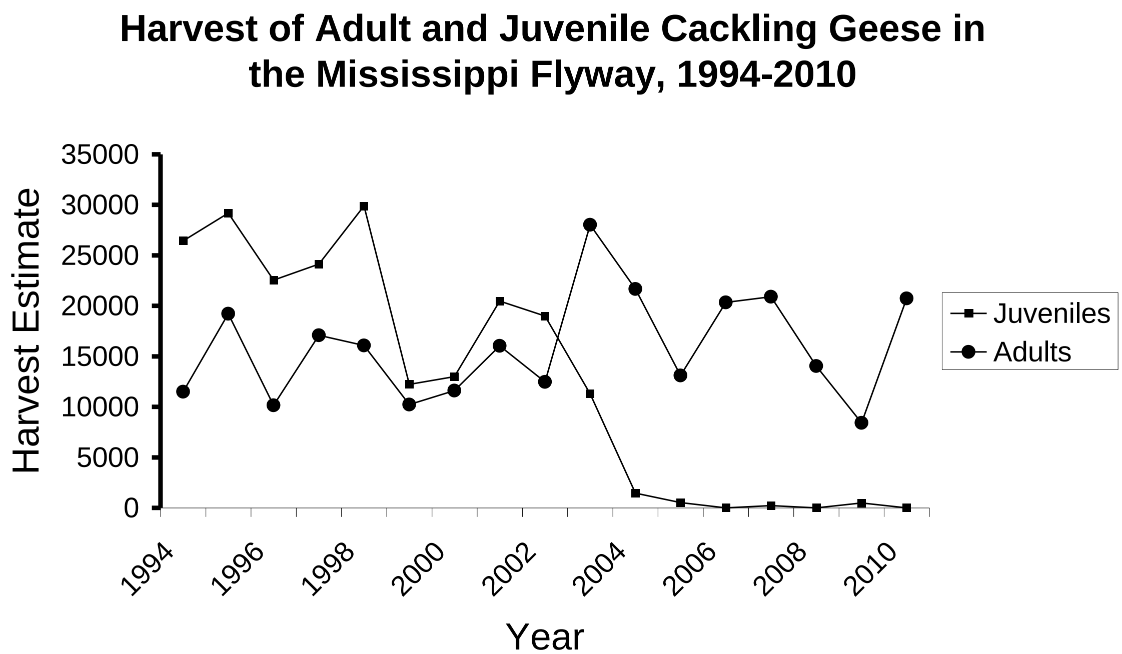

Figure 9. Annual estimated harvest of adult and juvenile cackling geese in states of the Mississippi Flyway, 1994-2010.

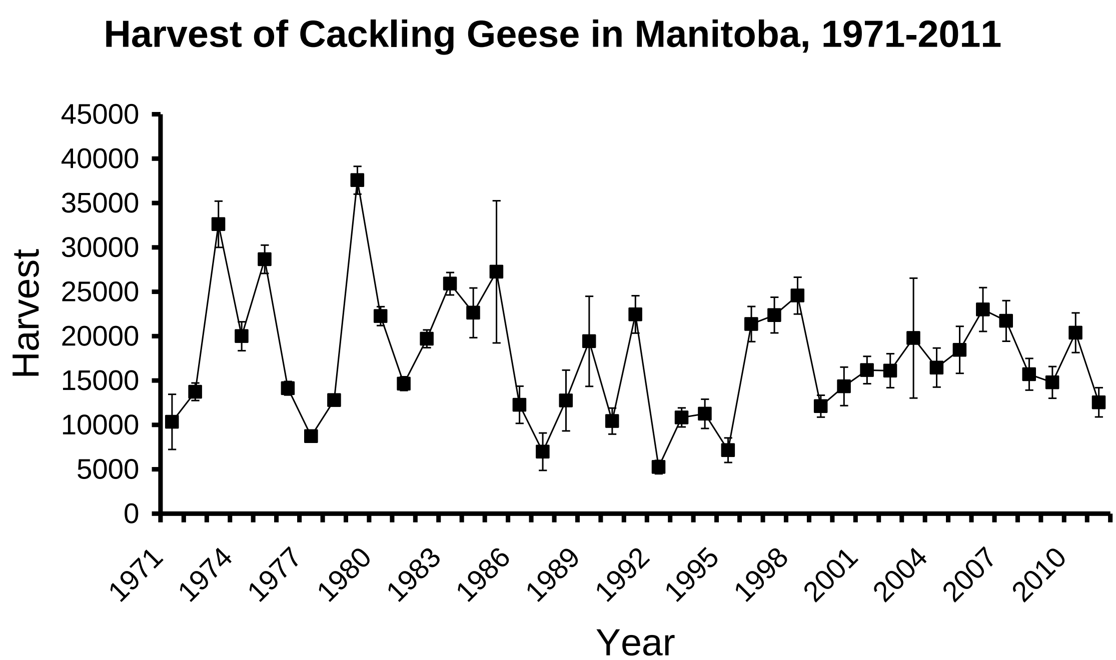

Figure 10. Annual harvests (± SE) of midcontinent cackling geese in Manitoba, 1971-2011.

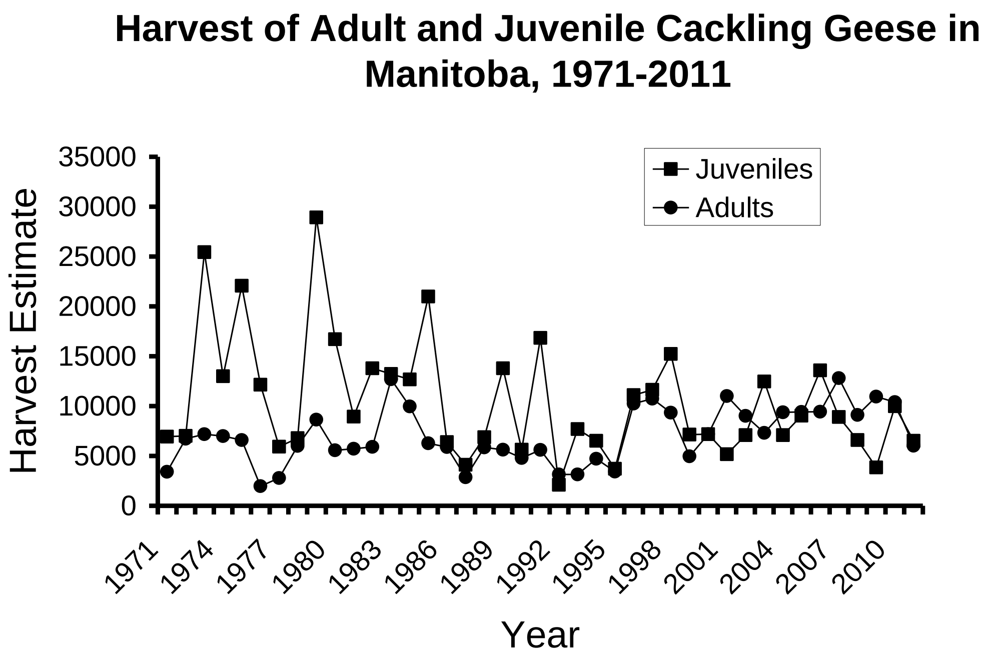

Figure 11. Harvest of juvenile and adult cackling geese in Manitoba, 1971-2011.

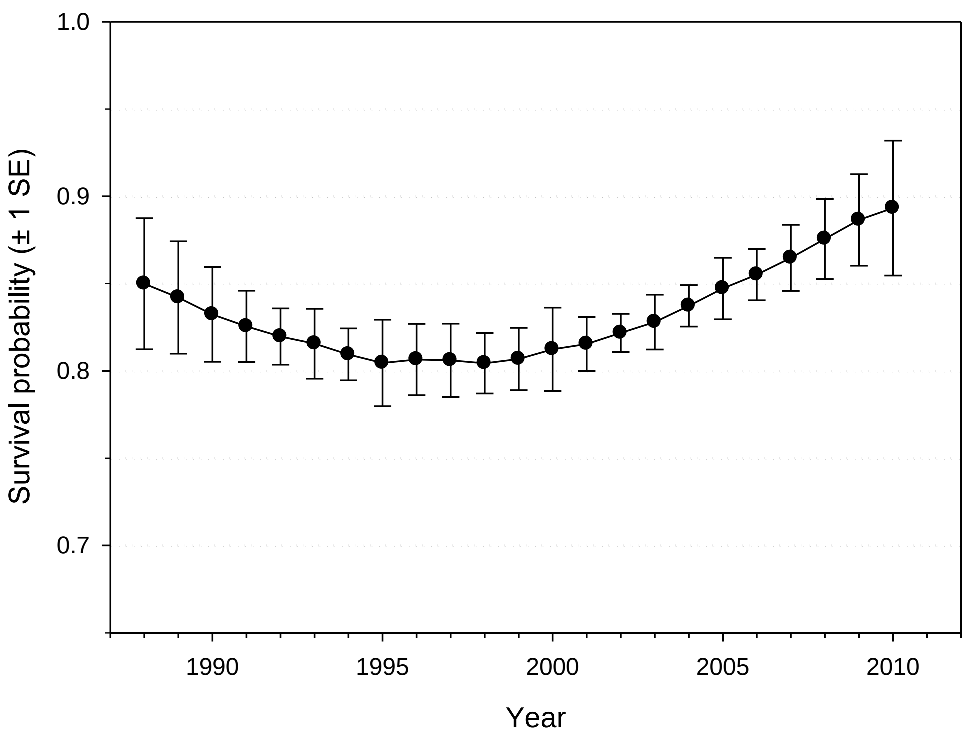

Figure 12. Model-averaged survival rate estimates (Ŝ) for adult cackling geese captured and marked in Canada's eastern and central arctic, 1988-2011.

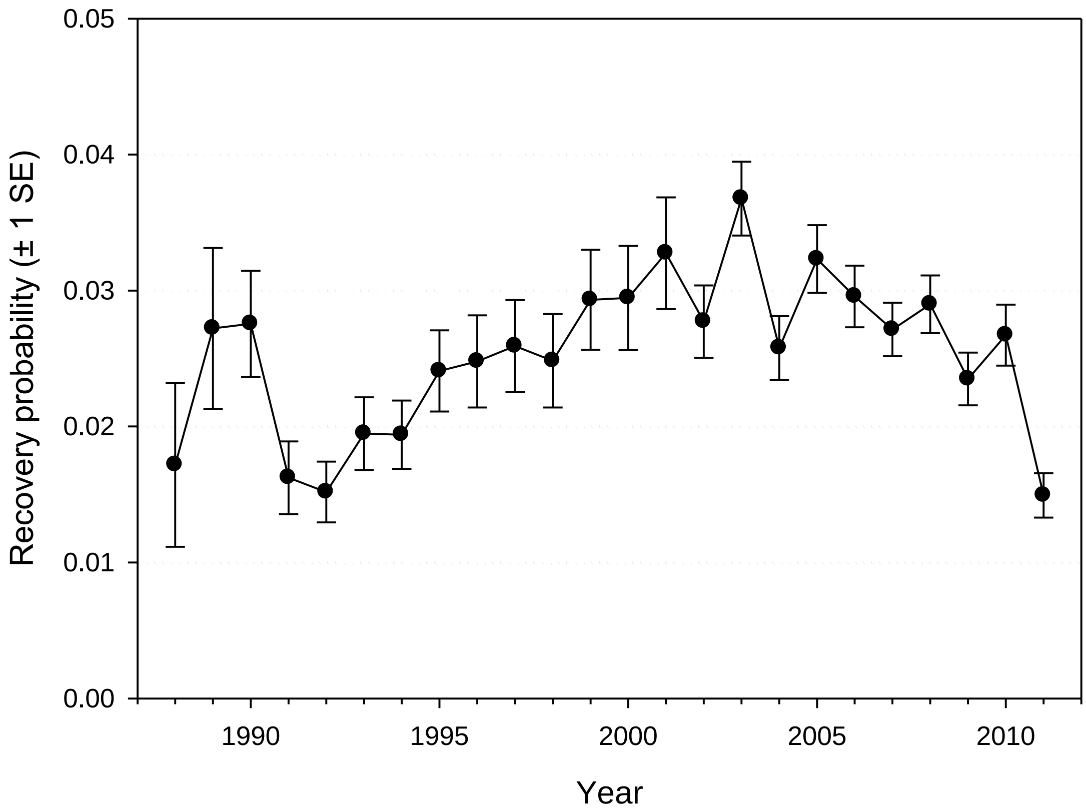

Figure 13. Model-averaged recovery rate estimates (*f*) for adult cackling geese captured and marked in Canada’s eastern and central arctic, 1988-2011.

Table 1. Summary output from competing band-recovery models developed to estimate annual survival and recovery probabilities for adult cackling geese captured and marked in Canada's eastern and central arctic, 1988-2011.

Model[a]	Number of Parameters	AIC_c[b]	ΔAIC_c[c]	AIC_c weight[d]
$S_{quadratic}$, f_t	27	26883.91	0.00	0.86
S_{linear}, f_t	26	26887.91	4.00	0.12
S, f_t	25	26891.80	7.87	0.02
S_t, f_t	47	26893.07	9.16	0.01
S_t, f	24	26933.16	49.25	0.00
$S_{quadratic}$, f	4	26945.64	61.73	0.00
S_{linear}, f	3	26954.40	70.49	0.00
S, f	2	26965.82	81.90	0.00

[a] Model notation: S = survival probability, *f* = recovery probability; subscript "t" denotes time-dependency (i.e., annual variation), "linear" denotes linear-logistic trend over time, "quadratic" denotes quadratic time trend, no subscript denotes constancy.

[b] Akaike's Information Criterion with small-sample bias adjustment (Burnham and Anderson 2002).

[c] Difference between AIC_c of the current model and the minimum observed value.

[d] Normalized Akaike weight (Burnham and Anderson 2002).

Table 2. Model-averaged survival and recovery rate estimates for adult cackling geese captured and marked in Canada's eastern and central arctic, 1988-2011.

	Survival[a]		Recovery[b]	
Year	S	SE	*f*	SE
1988	0.850	0.038	0.017	0.006
1989	0.842	0.032	0.027	0.006
1990	0.832	0.027	0.028	0.004
1991	0.826	0.020	0.016	0.003
1992	0.820	0.016	0.015	0.002
1993	0.816	0.020	0.019	0.003
1994	0.809	0.015	0.019	0.003
1995	0.805	0.025	0.024	0.003
1996	0.806	0.020	0.025	0.003
1997	0.806	0.021	0.026	0.003
1998	0.804	0.017	0.025	0.003
1999	0.807	0.018	0.029	0.004
2000	0.812	0.024	0.029	0.004
2001	0.815	0.015	0.033	0.004
2002	0.822	0.011	0.028	0.003
2003	0.828	0.016	0.037	0.003
2004	0.837	0.012	0.026	0.002
2005	0.847	0.018	0.032	0.002
2006	0.855	0.015	0.030	0.002
2007	0.865	0.019	0.027	0.002
2008	0.876	0.023	0.029	0.002
2009	0.886	0.026	0.023	0.002
2010	0.893	0.039	0.027	0.002
2011	-	-	0.015	0.002

[a] Survival from year i to year i+1. [b] Recovery during the interval year i - year i+1.

Appendix 1.

Yield Curve for Adult Midcontinent Cackling Geese in the Central Flyway

Guthrie Zimmerman, Scott Boomer, James Dubovsky, Jon Klimstra, and Ken Richkus

The Central Flyway is interested in reviewing desired harvests of Cackling Geese within the flyway. Consequently, the Population and Habitat Assessment branch was asked whether a yield curve could be generated with existing data in the most recent management plan (Leafloor 2012). We reviewed the management plan and determined that there were no models linking population performance with density (i.e., either density dependent recruitment or survival), or estimates of demographic rates in the absence of harvest. Therefore, we could not develop a yield curve based on demographic rates. The report did present a time series of population sizes based on the Lincoln-Petersen (LP) estimator (Alisauskas et al. 2009), that potentially could inform parameters in a discrete logistic model (Boomer and Johnson 2007):

$$N_{t+1} = N_t + r \times N_t \times (1 - \frac{N_t}{K}) - H_t,$$

where r represents the per-capita growth rate at low densities in the absence of harvest, K represents carrying capacity, and H represents total harvest. Our only concern with using LP estimates in a discrete logistic is the estimator for N includes harvest estimates:

$$N_t = \frac{H_t}{h_t}.$$

In this formulation, H is used to estimate N and would account for losses due to harvest, as a result, there will be a dependence between the population estimates (N) and the harvest in the model. We attempted to account for this by calculating the LP estimate directly in WinBUGS while estimating the discrete logistic model:

$$\frac{H_{t+1}}{h_{t+1}} = \left[\frac{H_t}{h_t} + r \times \frac{H_t}{h_t} \times (1 - \frac{H_t}{h_t \times K}) \right] \times (1 - d * h_t).$$

By modeling the LP estimator directly in WinBUGS while estimating the parameters of the discrete logistic, the MCMC process would account for the correlation between the estimate of N based on harvest and losses due to harvest. The rest of the estimation framework followed that used for western mallard adaptive harvest management (Johnson et al. 2007, USFWS 2012). The parameter d represents a scaling factor to account for a variety of factors that may relate harvest to the population dynamics of Cackling geese (Johnson et al. 2007, USFWS 2012).

Our LP estimates based on adult H and h were consistent with those presented in the management plan (Figure 1a). Estimated harvest rates for adult Cackling geese in the CF appeared to decline slightly since the late 1980s and were <5% since 1997 (Figure 1b). All R-hat values were <1.004, indicating that our mcmc evaluation of our Bayesian assessment converged adequately. Observed population estimates were within 95% CI of the posterior mean estimates for most years. There were some particularly high observations from some years that were well beyond the 95% CI (Figure 1c). The specific estimates from the models were r = 0.19 (95% CI = 0.08 to 0.45), K = 5.01 million (95% CI = 3.24 to 9.28 million), d = 0.81 (95% CI = 0.04 to 1.91), and process variance σ^2 = 0.194 (95% CI = 0.076 to 0.450). The model indicated that maximum sustained yield (MSY) was approximately 248,000, a maximum sustained harvest rate of approximately 9.6%, and an equilibrium population size of 2,511,061 under MSY (Figure 1d). Although this assessment provides a rough estimate of MSY using the available data, we caution that it assumes that density dependence response in Cackling geese occurs in adults and that the form of density dependence is linear. This may be inconsistent with previous information from the management plan, which indicates that survival rates of adult Cackling geese were greatest when the population was highest (Leafloor 2012). This result may be explained by density dependence factors influencing juvenile survival. We also caution that the CVs for the parameter estimates were high (CV r = 46%, K = 29%, d = 64%, and σ^2 = 114%), indicating that there is substantial uncertainty associated with the demographic parameters estimated with the model. An alternative assessment based on demographic rates or an independent assessment could help strengthen the inferences from this analysis.

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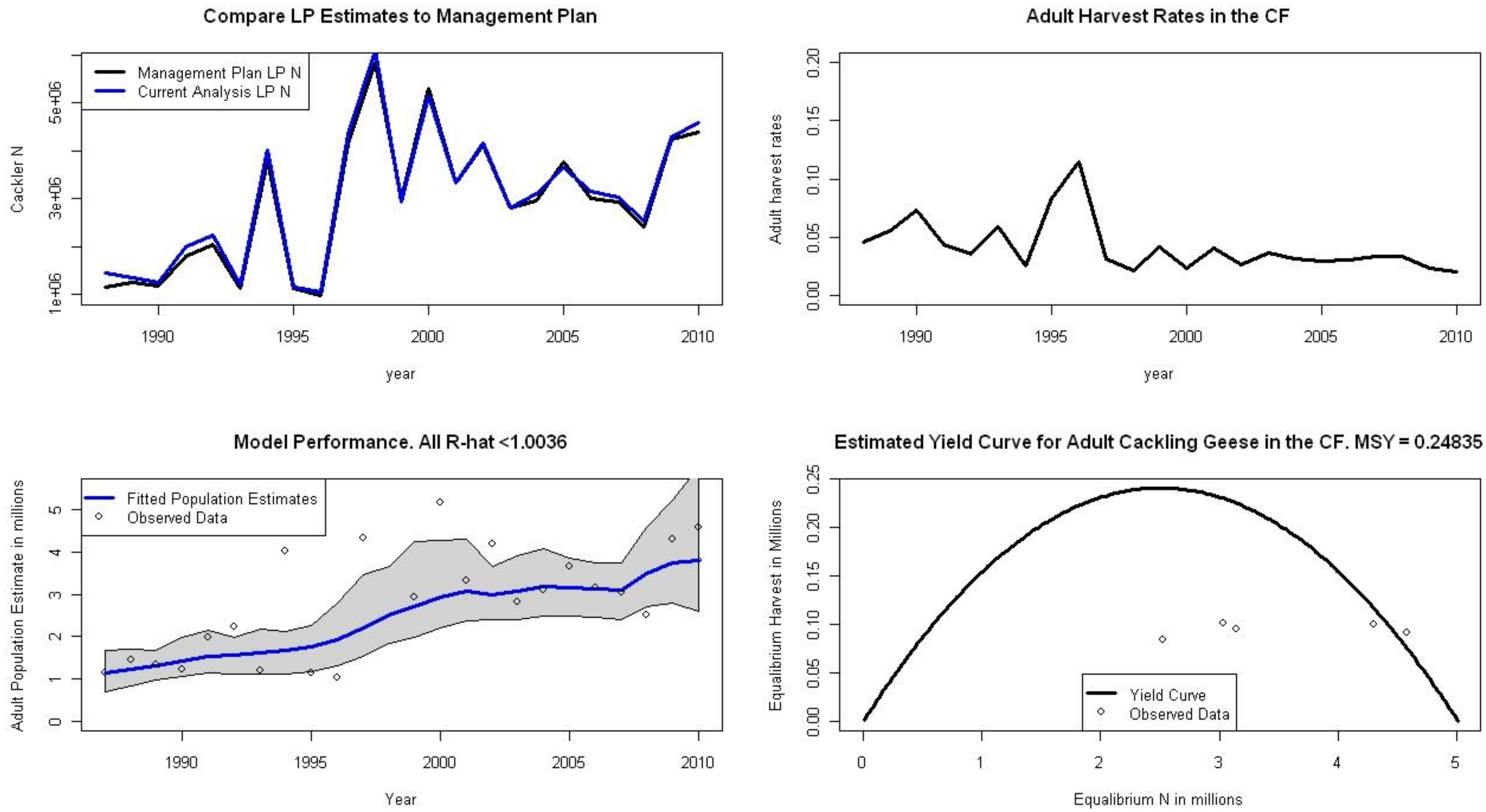

Figure 1. **A**. Comparison of population estimates from the Cackling goose management plan to the estimates derived using the harvest and harvest rate data used in this analysis. **B**. Estimated adult cackling goose harvest rates in the Central Flyway. **C**. Discrete logistic model performance for fitting Cackling goose LP estimates in the Central Flyway. **D**. Estimated yield curve for adult Cackling geese in the Central Flyway.