MANAGEMENT GUIDELINES FOR MIDCONTINENT LESSER SNOW GEESE IN THE CENTRAL FLYWAY

Central Flyway Council

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Prepared by the Light Goose Subcommittee
Central Flyway Council Waterfowl Technical Committee
With consultation from
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Mississippi Flyway Council Technical Section

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MANAGEMENT GUIDELINES FOR

LESSER SNOW GEESE IN THE CENTRAL FLYWAY

Foreword

These guidelines are to enhance and advance the cooperative management of lesser snow geese (*Anser caerulescens caerulescens*) in the Central Flyway (hereafter, the midcontinent population of lesser snow geese, or simply mid-content snow geese). This population is managed in collaboration with the Mississippi Flyway Council. Each flyway has its own management plan with agreed upon key elements: population delineation, population status and trends, and management goals and objectives. These key elements are described below:

1. **Population Definition** - For the purposes of this management plan, mid-content snow geese include all those that winter in the Central and Mississippi Flyways.
2. **Management Objective** – The management goal is to maximize harvest opportunity with the intent of increasing adult harvest rates (considered the most accepted means of slowing or reducing the population growth rate) to reduce the risk of arctic habitat degradation. To achieve population reductions, it will be necessary to increase adult harvest rates to at least 11%, assuming that all harvest is additive to natural mortality. Harvest levels in this range are necessary to reduce adult survival below 80%, the level predicted to result in negative population growth.
3. **Harvest Management Strategy** – Harvest opportunity should be maximized when the 3-year running average of the adult harvest rate remains at or below 11%, and populations remain above the minimum threshold population size of 5 million adults (based on a 3-year running average of Lincoln estimates).
4. **Population Monitoring Strategy** – Population levels and trends of mid-content snow geese will be monitored primarily by Lincoln estimates, which are calculated from estimates of harvest rate (from banding data) and total harvest (from hunter harvest surveys). Recoveries of banded geese will provide information on distribution of harvest and, more importantly, estimates of annual survival and harvest rates through which

progress toward the management objective can be measured (see above). Mid-winter surveys should continue, at least in key areas, in order to track winter distribution and numbers.

Mid-content snow geese migrate into or through many jurisdictions in three nations. They are of great interest to many individuals and organizations. The Central Flyway Council has directed that this plan be dynamic and include provisions for periodic review, and appropriate revision, to consider current information, to adapt to changing circumstances, and/or to accommodate new intentions and desires. These guidelines were adopted by the Central Flyway Council during their official sessions August 31, 2018, in Waskesiu Lake, Saskatchewan, Canada. The Central Flyway Council will periodically review and update the management plan as needed, and any minor revisions will be distributed as amendments to this document once approved by the Councils. The Central Flyway Council solicits the cooperation of all who are responsible for and interested in the management of this international resource. Inquiries or comments may be addressed to:

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9/13/2018
Date

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I. Introduction

The purpose of this plan is to enhance and advance the cooperative management of the midcontinent population of lesser snow geese (*Anser caerulescens caerulescens*) in the Central Flyway (hereafter, mid-content snow geese). As abundance of mid-content snow geese greatly increased, so too have the challenges to their management. Concerns regarding their potential impacts to habitats and other species prompted managers to undertake measures to reduce the size of the population (Ankney 1996, Batt 1997). This led to the liberalization of hunting regulations and amendments to migratory bird regulations in Canada and the United States that allowed for harvest to occur outside of hunting seasons accompanied by the use of special methods (U.S. Fish and Wildlife Service [USFWS or Service] 1999 and Canadian Wildlife Service [CWS] 1999). These actions were implemented to reduce adult annual survival rates to reduce population growth (Rockwell et al. 1997, Ankney et al. 1999).

Historically, during periods of lower abundance, goose populations were defined and managed based on their wintering ground affiliations. This was done to ensure that hunting regulations for specific, separate goose populations matched geographic variations in goose numbers and productivity, migration and wintering concentrations, and harvest pressure. Traditionally, within the Central Flyway, lesser snow geese were managed as two populations, the Mid-continent Population, and the Western Central Flyway Population. These two populations were primarily harvested in the east and west-tier Central Flyway states, respectively. Because geese from these two populations are now demographically similar with overlapping breeding and wintering ranges, for this purpose of this management plan, it includes all lesser snow geese that nest in north-central and north-west Canada and winter in the Central Flyway (Figure 1). This plan replaces the guidelines for management of the Mid-Continent Population of Lesser Snow Geese (adopted by the Central Flyway Council and the Mississippi Flyway Council on March 28, 1982, in Portland, Oregon) and lesser Snow Geese in the Western Central Flyway (adopted by the Central Flyway Council on July 29, 1982, in Colorado Springs, Colorado).

II. Population Status and Trends

Mid-Continent snow goose populations have been monitored by midwinter counts in all states of the Central and Mississippi Flyways since the mid-1950s (USFWS 2016; Figure 2), and by photographic surveys on known breeding colonies since the mid-1960s (Kerbes et al. 2014). More recently, Lincoln estimates (Lincoln 1930) have been used to calculate population size of geese (Alisauskas et al. 2009, 2011). All indices for mid-content snow geese indicate long-term increases in abundance, with significant population increases after the 1970s (Alisauskas et al. 2009). Based on Lincoln estimates, the mid-content snow goose population averaged 12.5 million adults during 2006–2015 (Alisauskas et al. 2018).

Lesser snow geese in the Central and Mississippi Flyways were declared overabundant in 1999 (USFWS 1999; Leafloor 2012). As a result of that designation, spring take (i.e., after March 10, the closing date of hunting seasons) became legal in parts of the U. S. and Canada in 1999 for the first time since the Migratory Bird Convention was signed in 1916. Overall harvest increased substantially during the 1990s, but has plateaued or declined in recent years, perhaps due to behavioral adjustments by the geese to increased hunting pressure, stabilized or decline in population of hunters, and/or due to satiation of hunter demand (Johnson et al. 2012). During the same period of increased harvest, harvest rate (i.e., the proportion of the population that is harvested annually based on banding and recovery data) actually declined. This finding indicates that increased harvest has not kept pace with increases in population size. Harvest rates of mid-content snow geese have shown a long-term decline and averaged only 2.7% during from 2012–2016 (Figure 3).

After implementation of spring conservation harvests in 1999, annual survival estimates of adult geese from the southern-most nesting colonies (i.e., sub-arctic, south of 60° N latitude), representing about 10% of the mid-content, appeared to decline from approximately 0.89 to about 0.83 (Alisauskas et al. 2011, Dufour et al. 2012). However, annual survival of adult geese from northern nesting colonies (i.e., Arctic, north of 60° N latitude), constituting about 90% of

the mid-content, remained relatively unchanged at about 0.87 (Alisauskas et al. 2011, Dufour et al. 2012). Updated analysis of band recovery data from 1999 to 2015 suggests that survival of the Arctic component of the population has continued to increase and has been >0.90 in 9 of the 10 years from 2004 to 2013 (Calvert et al. 2017). Thus, adult survival rates overall for the mid-content continued to increase during the time period that harvest regulations were substantially liberalized.

Although recent abundance estimates of mid-content adult snow geese were higher than, or as high as, any time period on record, growth rates have declined in recent years (Figure 4). This decreasing growth rate occurred simultaneously with increasing annual adult survival, suggesting that recruitment levels may have declined over time. In addition, age ratios in August, based on Lincoln estimates of adults and juveniles, indicated a decline from about 0.55 in the early 1970s to about 0.35 in the early 2010s (Figure 5). Age ratios of snow geese harvested in the Central and Mississippi Flyways showed a similar decline over a longer period (Figure 6). Reduced population growth and declining age ratios suggest that density-dependence population regulation may be occurring through a reduction in recruitment. Alternatively, changing environmental and habitat (during all times of year) conditions may be influencing population dynamics of mid-content snow geese to operate on a more k-selected basis.

IV. Management Goal and Objectives

The 1982 management plan for mid-content snow geese established a goal of a stable population of between 800,000 to 1,200,000 breeding lesser snow geese based on breeding ground surveys (Central and Mississippi Flyway Councils 1982). The 1982 plan expressed concern about snow goose damage to habitats on the west coast of Hudson Bay. In 1997, the Arctic Goose Habitat Working Group recommended a management goal of reducing the number of light geese in the midcontinent region (lesser snow and Ross's geese (*Anser rossii*) in the Central and Mississippi Flyways) by 50% to address habitat degradation on migration and breeding areas (Batt 1997). At the time, this suggested a reduction in the light goose winter

index mid-content from about 3.1 million (in 1997) to 1.6 million (USFWS 1999). The goal to reduce the light goose population in the midcontinent region by 50% was adopted by the Service and was used to justify liberalizations in regulations during hunting seasons and implementation of a conservation order (USFWS 2007; 73 FR 65928). The U.S. regulations stipulated that the conservation order would be suspended "*...if at any time evidence clearly demonstrates that an individual light goose population no longer presents a serious threat of injury to the area or areas involved.*" (73 FR 65953). Flyway Councils did not establish population goals in the past for the WCFP snow geese in the mid-continent region.

MANAGEMENT GOAL: *To maintain the number of mid-content snow goose population in the Central Flyway consistent with the long-term welfare of the population, their habitat constraints, international treaties, and the interests of all Central Flyway provinces and states.*

MANAGEMENT GUIDELINES: Management decisions for the mid-content snow goose population in the Central Flyway are based on population size and distribution, its habitats, and use programs. Accordingly, management guidelines are presented for the following objectives:

Objective 1. *Population Size and Distribution*

Objective 2. *Habitat Management*

Objective 3. *Opportunities for Use*

Objective 1. Population Size and Distribution: *The population objective for the* mid-content *snow geese is 5 million adult snow geese based on a 3-year running average of Lincoln estimates of abundance. To the extent practicable, the distribution of* mid-content *snow geese in the Central Flyway should be maintained to benefit all interests throughout their range without jeopardizing components of the population or their habitats.*

Rationale:

Mid-content snow geese can have deleterious effects on habitats in nesting, migration, and wintering areas, and can negatively affect other species through competition and habitat

degradation. Their depredation of agricultural crops and pastures can result in human-goose conflicts. They also can be a potential source for disease outbreaks. Risks of negative effects increase as abundance of the mid-content snow goose population increases (Batt et al. 1997, USFWS 2007, Leafloor et al. 2012). A population objective of 5 million adult geese based on Lincoln estimates corresponds to a reduction of 50% from the abundance observed in the late 1990s, which was before the population was declared overabundant and is consistent with previous management targets for implementing Conservation Order regulations.

The longest continuous dataset for monitoring mid-content snow geese is the Midwinter Waterfowl Survey (MWS). The MWS data were used in previous management plans to inform regulatory actions based on population thresholds. However, there are longstanding concerns about the ability of the MWS to provide much more than a very coarse index of wintering light goose numbers in limited spatial areas, rather than an accurate index of total population size (e.g., Alisauskas et al. 2012). In addition, winter surveys in Mexico and parts of the U.S. have been discontinued creating data gaps. Budgetary realities have also led to concerns about the future continuation of the MWS. With an expansive breeding range across vast areas of the Arctic, estimating the breeding size of mid-content snow goose from aerial or photographic surveys is costly and logistically difficult, and it is not practical to obtain complete coverage of all spatial areas. The use of Lincoln estimates to derive population objectives in this plan update deviates from previous plans' population objectives, which were based on breeding and/or winter index population objectives.

Lincoln estimates, which are derived from current operational banding and harvest survey programs, provide indirect estimates of total population size that represent the entire spatial area of the managed population. Typically, this is the parameter of management interest to be obtained or represented from logistically difficult count surveys. Finally, uses of data-derived indirect population estimates of mid-content snow geese are value-added to already highly informative banding and hunter-harvest data sets.

Strategy 1-A: Monitor the status and distribution of mid-content snow geese by:

Task 1.1. Monitor abundance, survival rates, harvest rates, age ratios, and distribution of harvest of mid-content snow geese.

Rationale: Banding and harvest data provide a viable alternative to monitor the status of mid-content snow geese. Monitoring annual survival and harvest rates, age ratios, and harvest distribution will enable managers to better assess whether they are achieving their objectives, and to assess spatial changes in distribution and harvest. Hunter recoveries of geese banded annually on breeding areas provide data necessary to estimate annual survival and harvest rates and information on distribution of harvest as well as. Additionally, age-specific harvests are estimated annually in both the U.S. and Canada using tail feathers and wing-tips collected via the annual waterfowl Parts Collection Survey (PCS). Age-specific harvest estimates, when combined with harvest rate estimates derived from banding data, allow estimation of the number of adult and juvenile birds in the population in August via indirect population estimates; moreover, these estimates also can be used to assess changes in recruitment over time (Alisauskas et al. 2011, 2018).

Total numbers of mid-content snow geese are difficult to estimate using count surveys because of large flock sizes, expansive area of their range, and extensive overlap with the morphologically similar Ross's goose throughout the year. The Lincoln estimator has frequently been used to estimate populations of geese (e.g., Central Flyway Arctic Nesting Canada geese [Central Flyway Councils 2013]; snow geese [Alisauskas 2009]) and ducks (e.g., mallard [Alisauskas et al. 2014], wood duck [Garretson 2007, Balkcom et al. 2010]. Details regarding population estimation via the Lincoln estimator are provided in Appendix at the end of this document.

Task 1.2. Monitoring mid-content snow geese using coordinated winter surveys

Rationale: The MWS in the U.S. and periodic surveys in Mexico, assist in monitoring winter abundance and distribution. Although MWS have limitations for providing an accurate index to total population size, they should continue, at least in key areas, in order to assess winter

distribution and changes in distribution.

Task 1.3. Monitor results of national, provincial, territorial, state and other harvests surveys.

Rationale: These estimates are needed to determine the efficacy of mid-content management toward meeting objectives. Current federal harvest surveys provide estimates of regular season harvest. A feasibility assessment should be conducted to determine if current methods to estimate Conservation Order take (i.e., each state generating estimates using their own procedures) are sufficient, or whether the value of the data could be improved using a different procedure (e.g., agreed-upon methods across states/flyways and conducted instead by USFWS).

Task 1.4. Monitor subsistence harvests

Rationale: Subsistence harvests are critically important to Alaskans and Indigenous peoples in Canada, and monitoring subsistence harvest is necessary for determining the impacts of all harvests on the mid-content snow goose population.

Task 1.5 Monitor non-hunting mortality caused by disease and other factors

Rationale: The influence of disease and other forms of non-hunting mortality on the population dynamics of lesser snow geese are not well known. However, a recent study suggested that non-hunting mortality and changes in recruitment currently play a larger role than harvest in determining population dynamics (Calvert et al. 2017). Gregarious, colonial-nesting birds such as lesser snow geese are highly susceptible to a variety of epizootic diseases. Disease occurrences such as avian cholera is prevalent in these populations where often a single outbreak can affect hundreds to thousands of light geese and other bird species. High mobility and expansive annual migrations indicate that lesser snow geese could potentially facilitate disease transmission. Although there is currently no indication of any unusual or extraordinary disease effects limiting mid-content snow goose populations, monitoring should be conducted, and appropriate action taken if the situation warrants. Coordination with the USGS National Wildlife Health Center is essential in responding, documenting, and preventing avian disease events associated with lesser snow geese.

Strategy 1-B: ***Develop and implement harvest regulations and other take options to assist in reaching population objectives for mid-content snow geese.***

Rationale: Harvest rates should be maximized as long as abundance is above the population objective. To achieve the population objective, target adult harvest rates should be at least 11% (Dufour et al. 2012). Harvest levels in this range are necessary to reduce adult survival to below 80%, the level predicted to result in negative population growth (Rockwell et al. 1997). Currently, adult harvest rates are approximately 2.5% for both mid-continent lesser snow and Ross's geese (Figure 3).

Task 2.1: Harvest regulations should have a target harvest rates of 10-12% when the mid-content snow goose population is above the objective (5 million adult lesser snow geese).

Rationale: To achieve the population objective of mid-content snow geese, 11% harvest rates should be targeted. If the mid-content population declines below 5 million adults, spring conservation harvests should be curtailed first, and then additional hunting restrictions during the regular season should be considered. Given the current population abundance of mid-content snow geese, it would not be expected that mid-content abundance would decline to the population objective during the tenure of this plan (5-10 years). If adult harvest rates reach threshold levels (i.e., 11%) and the population declines to 5 million adults, analyses shall be conducted to determine which hunting regulation would be most effective in achieving survival rates consistent with the long-term population objective. Flyways can independently set season structures without required approval of the other Flyway(s) as long as the overall harvest rate goal is not exceeded.

Task 2.2. Coordinate the management of mid-content snow geese with aboriginal and subsistence hunters.

Rationale: Coordination of goose management with aboriginal peoples and sharing information on mid-content snow goose status, current research, management efforts, harvest levels, and reporting are very important to achieving the plan objectives. A strong commitment of

cooperation among all stakeholders of mid-content snow geese are necessary to ensure the successful implementation of this plan.

Task 2.3: Continue to assess potential alternative take measures and determine whether they are warranted; continue to define feasible alternative take options.

Rationale: As mid-content snow goose populations have been deemed overabundant, alternative take options have been discussed as a means to limit the potential impacts of overabundant lesser snow geese on their habitats and other species. In 2003, the Arctic Goose Joint Venture (AGJV) developed an in-depth report of direct control and alternative harvest measures for North American light geese. It explored alternative strategies, beyond current hunting practices and habitat management that could be implemented should ongoing management actions eventually prove inadequate to stem large scale impacts of overabundant light geese (Johnson and Ankney 2003). The AGJV re-examined the need for direct control in January 2014 and adopted a position statement that stated: "*Although we feel a sense of urgency, the necessity, cost and public concern over using direct control to reduce snow geese populations is such that the AGJV Management Board is not recommending broad-scale direct control actions at this time. While we search for additional answers to the questions above, we encourage and continue to explore additional actions to take and use snow geese".* The Central Flyway should continue discussions and explore additional take options. This should include not only feasibility testing, but social, legal and economic issues associated with direct control measures.

Objective II. Habitat Management and Protection: *Ensure adequate food, water and protection on nesting, migration and wintering areas consistent with population objectives, habitat status, and landowner tolerances.*

Strategy 1: Monitor the status of habitats to assess their ability support mid-content snow geese at objective levels.

Rationale: Habitat conditions throughout the nesting, migration, and wintering areas vary annually and can have a great influence on mid-content snow goose population status. Therefore, it is necessary to monitor and periodically evaluate the status and condition of nesting, migration, and wintering areas important to mid-content snow geese.

Task 3.1 Identify and monitor habitat conditions, potential development projects, and examine potential impacts of overabundant mid-content snow goose on their habitats.

Rationale: The nesting area for mid-content snow geese is expansive, ranging across much of the Arctic and sub-arctic region of North America. As mid-content snow goose populations have grown, so have concerns regarding their potential impacts to their nesting and brood-rearing habitats. Classification and inventory of habitats throughout the lesser snow geese breeding range should be conducted to enable quantification of exploited habitat, and whether use by geese limits use by other species. Proposed development and exploration projects within the lesser snow geese nesting range should be monitored and potential impacts identified and evaluated at the planning and review stages.

Task 3.2 Monitor migration and wintering areas to examine impacts of overabundant mid-content snow goose on their habitats as well ensure adequate resources (food, water, and sanctuary) necessary to sustain the mid-content snow geese.

Rationale: The quantity and quality of migration and wintering areas are important to mid-content snow goose overwinter survival. Accumulated and stored reserves obtained on fall migration areas enable continued migration and survival through inclement weather encountered during this period. Reserves accumulated during spring migration enable breeding geese to meet energy requirements associated with nesting and can affect annual productivity. Monitoring of important migration and wintering areas should continue in order to determine if these areas are adequate to sustain mid-content snow geese in addition to marking/recovery data, information on the impacts of overabundant mid-content snow geese should be evaluated to determine if these, or other landscape and climate changes are altering mid-content snow goose migration and wintering patterns. For example, mid-content snow geese

have been declining over the last 30 years at traditional southern wintering areas. Recently, estimated movement probabilities provided evidence that considerable numbers of geese from the Gulf Coast are wintering farther north into Arkansas, Kansas, and Missouri, a region of high habitat suitability. Several hypotheses put forth to explain this distributional change suggest a link between land use patterns, climate and other system changes driving changes in migration and wintering patterns. Periodic assessments should be conducted to evaluate changes in migration and wintering areas to track changes mid-content snow goose migration patterns and determine if these areas are adequate to sustain mid-content snow geese. Assessments should also determine how mid-content snow geese impact other species using these areas.

OBJECTIVE III. USE GUIDELINES: *Provide maximum use opportunities consistent with the population objective and the social and economic values of lesser snow geese*

Rationale: The intent of this objective is to permit the maximum use possible and/or practical under current and future circumstances. "Use" means take (sport harvest, conservation orders, subsistence, direct control) and non-consumptive recreation.

Strategy 3.1: Support and promote harvest.

Task 4.1 Continue to implement and evaluate practices that are consistent with international treaties and regulatory frameworks to increase harvest through liberalized season lengths, bag limits, and methods of take.

Rationale: Regulations have been greatly liberalized in response to concerns of mid-content snow goose overabundance. While harvest has not achieved targeted harvest rates, it is an important recreational use of mid-content snow geese and a primary, direct, and controllable management option to affect adult survival. Regulations should maximize recreational opportunities and be consistent with the ethical mores of hunting (e.g., fair chase, use of animals, etc.). Efforts should be made to actively promote hunter participation, improve access, and identify potential barriers reaching target harvest rates.

Strategy 3.2: Encourage non-consumptive uses, photography, bird watching, and other programs, which provide additional uses consistent with the objectives.

Task 5.1 Support other uses for mid-content snow geese by:

A. Providing greater information and outreach to the public regarding the status and management of mid-content light geese.
B. Improving access for viewing where mid-content snow geese concentrate.
C. Encouraging initiatives that allow non-consumptive users to contribute to conservation efforts of mid-content snow geese.
D. Providing support for management actions, including monitoring and assessment activities, as well as support for policies at administrative levels.

Rationale: mid-content snow geese are conspicuous, forming in large, spectacular flocks that often appeal to bird-watchers and photographers. As the number of non-consumptive users continues to increase, they will be an increasing constituency than may serve as an avenue to garner management and financial support.

INFORMATION NEEDS

Information needs for mid-content snow geese were recently summarized in the AG JV Strategic Plan (AGJVTC 2016). The growth and expansion of this population continues to cause concern over their potential adverse impacts on habitat and sympatric species, especially in Arctic and subarctic habitats. Much of the initial research regarding habitat changes caused by mid-content snow geese came from studies on intertidal marsh habitats along the coasts of James Bay and Hudson Bay. These habitats are heavily used by light geese and other migratory birds, especially during migration, but they make up only a small proportion of the habitats used by light geese overall. Freshwater wetland habitats in the Arctic are much more expansive and affected by a multitude of biotic and abiotic factors, making it more difficult to quantify the overall continental impact of mid-content snow geese on Arctic breeding habitats.

Overall, the AGJV identified the following high priority information needs for mid-content snow

geese:

- Improved knowledge of habitat use in Arctic and subarctic staging areas.
- Improved knowledge of habitat quality and availability at Arctic staging areas and breeding colonies.
- Recovery times (i.e., time to return to pre-impact conditions) for freshwater habitats altered by foraging activities of large numbers of geese in Arctic and subarctic staging and nesting areas.
- Impact of habitat changes caused by lesser snow geese on other populations of geese, other migratory birds, and other species.
- Evaluation and improvement of harvest surveys. Improve estimates of hunter participation and harvest, species composition criteria (used to separate Ross's geese and lesser snow geese) and age ratios derived from the USFWS Parts Collection Survey in the U. S. and the Species Composition Survey (SCS) in Canada.
- Standardization and improvement of the accuracy of take estimates during the spring Light Goose Conservation Order.

With greater dependency on Lincoln estimates in mid-content snow goose management, there is also a need to improve information on band reporting rates. Assessments of reporting rates should be conducted, particularly when changes are made to band inscriptions and/or reporting options (1-800 number, web reporting, etc.). Additionally, long-term research projects like those at Hudson Bay and Karrak Lake are vital for monitoring and management of mid-content snow geese and should be supported. Projects like those at Hudson Bay and Karrak Lake gather information on factors regulating population size, goose-habitat interactions, and other information needs regarding mid-content snow geese.

The **La Perouse Bay Snow Goose Project** was initiated in 1968 by Dr. Fred Cooke. In the mid-1990s, the project expanded to include ecosystem research in wetland and upland habitats along the James Bay and Hudson Bay coasts, as a result of additional funding provided by Central and Mississippi Flyway states and other partner agencies. It has provided invaluable information on

the biology and population dynamics of lesser snow geese, the interaction of these birds with other nesting species, and their impact on the coastal ecosystem they inhabit. Work during the coming years will be an important component necessary to evaluate the success of current management strategies intended to reduce light goose populations and will provide valuable insights on processes controlling subarctic coastal ecosystems.

The **Karrak Lake Project** has provided much information pertinent to the management of both Ross's geese and mid-content snow geese and has contributed importantly to recent assessments of the effectiveness of efforts to reduce light goose populations. This study is conducted in a very large colony (now >1 million nesting light geese) and is at a latitude representative of most Arctic nesting midcontinent snow geese. Studies of Ross's and snow geese at Karrak Lake include nesting studies to estimate colony size and recruitment rates, and cooperative banding studies to estimate annual survival, as well as interactions of light geese with other components of Arctic ecosystems in Canada's central Arctic. This long-term study provides a unique set of uninterrupted data on Ross's and snow geese covering the time period prior to, and since, the implementation of the Light Goose Conservation Order. Annual information on population size, population growth rate, recruitment and survival has been, and will continue to be, collected. The study also provides an assessment of vegetative response to geese and impact of goose populations on other wildlife.

Maintenance of Plan

This Plan will be reviewed periodically by a joint committee of the Central and Mississippi Flyway Councils. That committee will draft and recommend to the Central and Mississippi Councils pertinent changes that may be necessary to keep the plan current and functional as guidelines for managing mid-content snow geese.

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Figure 1. Geographic distribution of the Mid-Continent Population (blue shading) of lesser snow geese.

Figure 2. Counts from the Mid-Winter Survey of light geese (Ross's geese and lesser snow geese combined) in the Central and Mississippi Flyways, 1970-2016 (data from USFWS 2016).

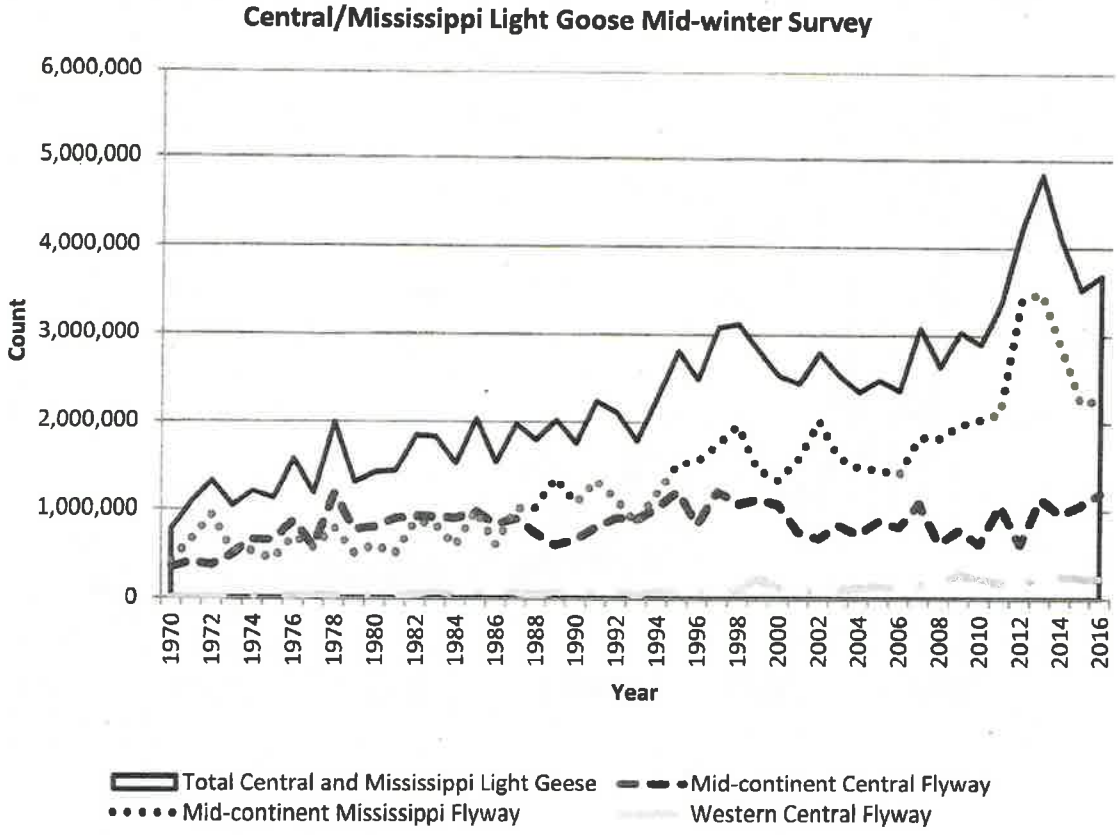


Figure 3. Harvest rates of adult (black dots) and juvenile (open dots) midcontinent lesser snow geese, 1970-2013 (R. T. Alisauskas, Environment and Climate Change Canada).

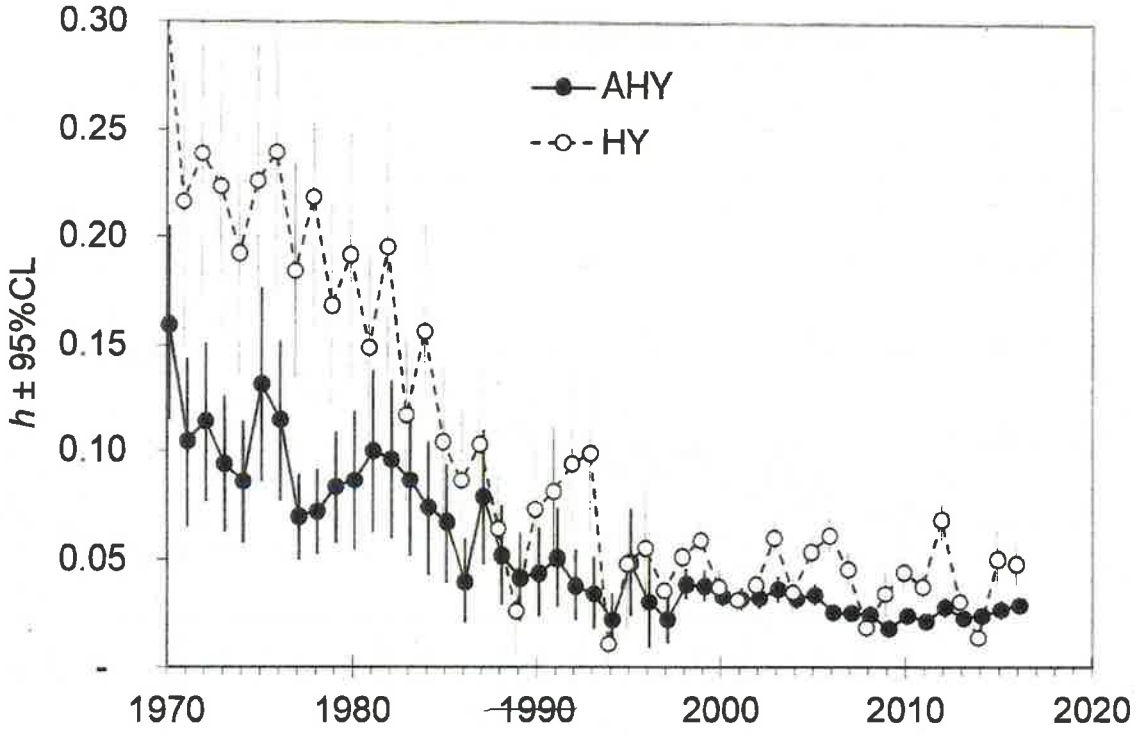


Figure 4. Lincoln estimates of population size (+/-95%) in August for adult (black dots) and juvenile (open dots) midcontinent lesser snow geese, 1970-2013 (R. T. Alisauskas, Environment and Climate Change Canada).

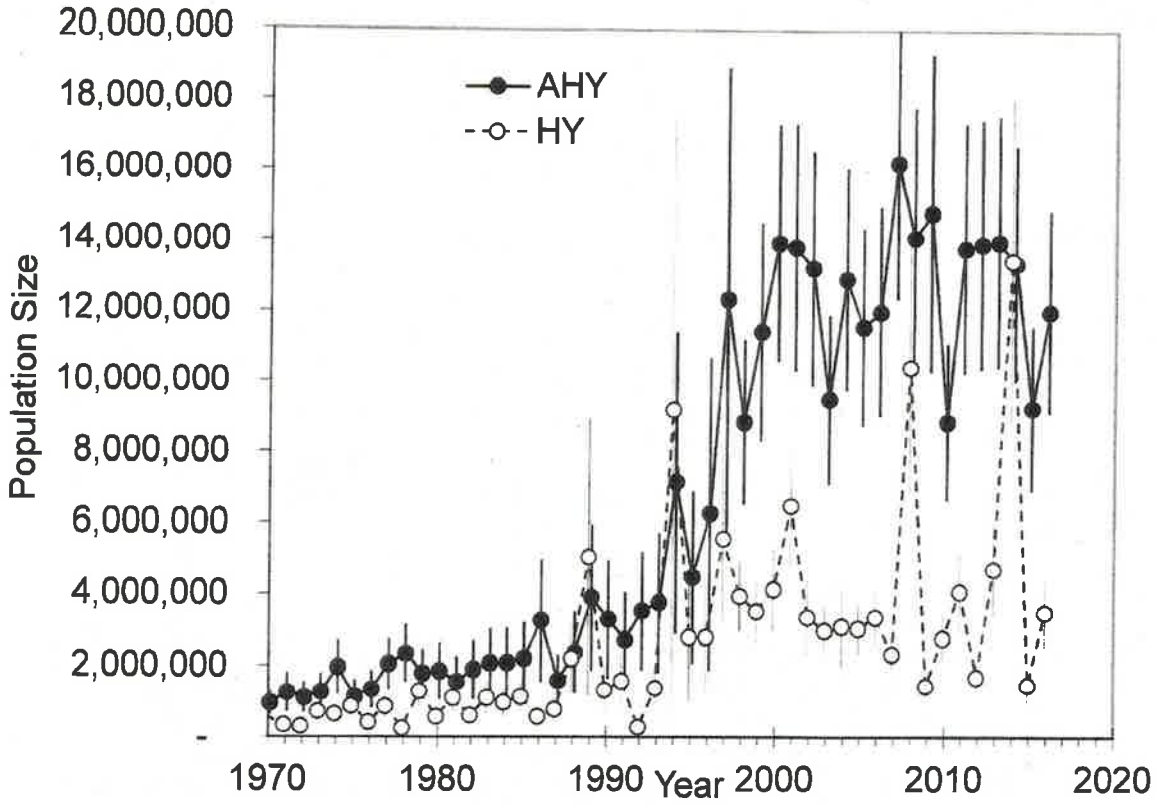


Figure 5. August age ratio of midcontinent lesser snow geese shown as the ratio of the number of goslings, N_{HY}, to number of adults, N_{AHY} ,each estimated annually using Lincoln's method from 1970-2016 (R. T. Alisauskas, Environment and Climate Change Canada). Estimates are not adjusted for breeding phenology resulting from annual variation in climate severity (Alisauskas 2002).

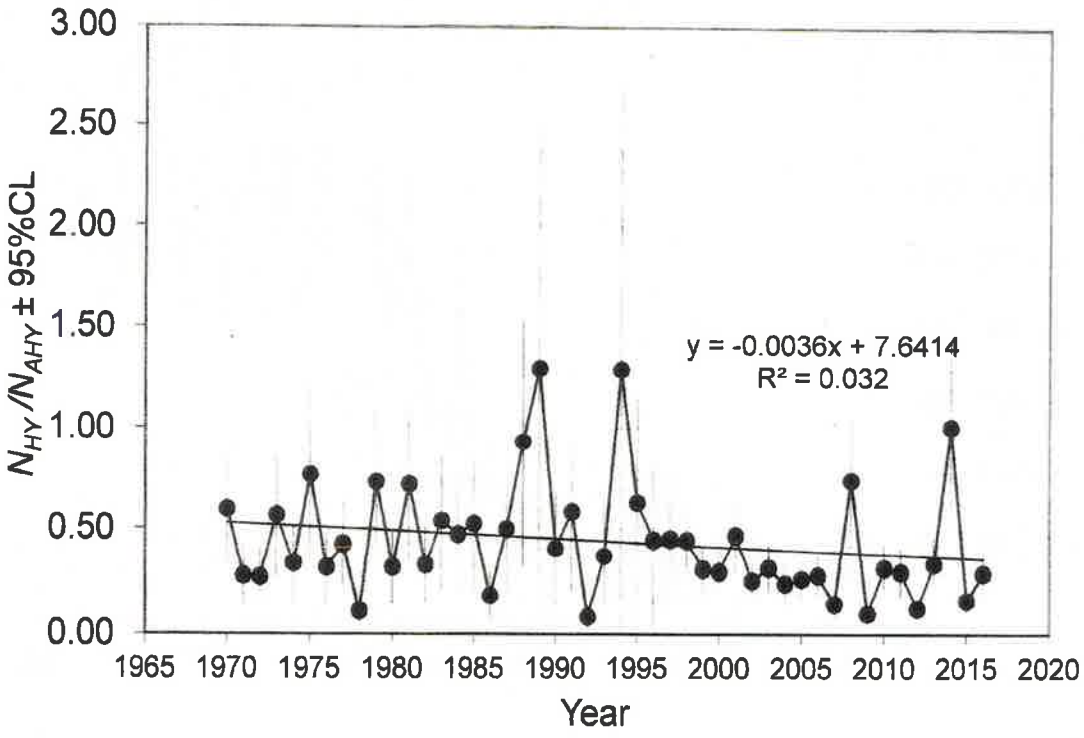
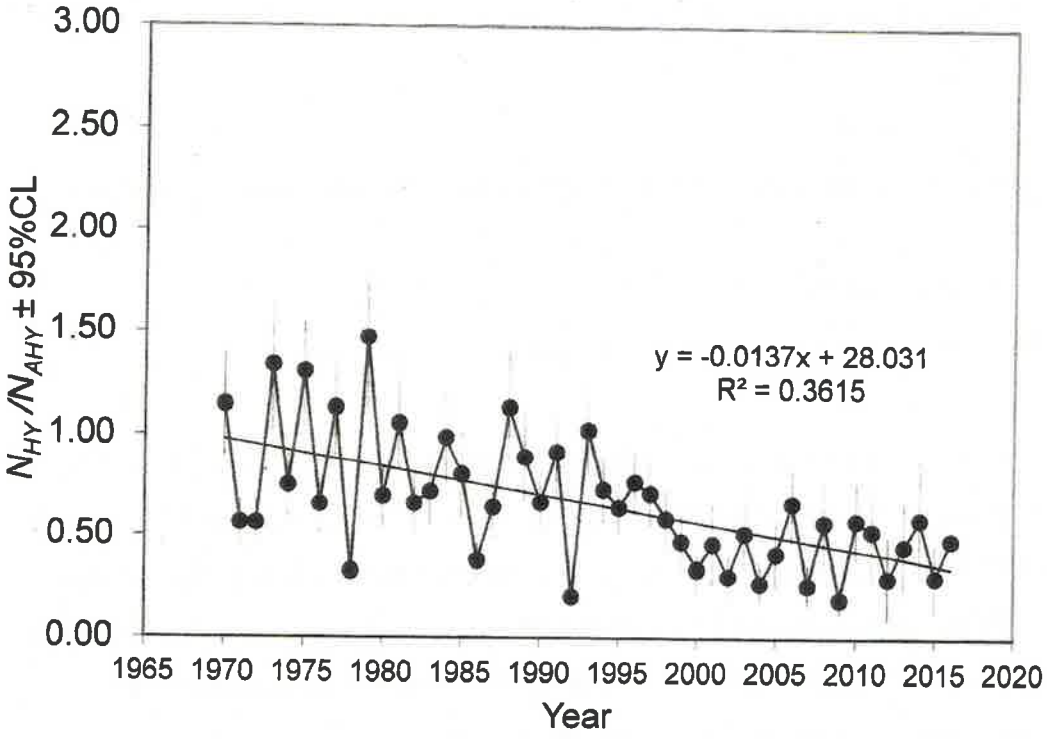


Figure 6. Age ratios (immature:adult) of midcontinent lesser snow geese harvested in the Central and Mississippi Flyway, 1963-2013 (R. Raftovich, USFWS).



Appendix A. Lincoln estimates for population estimation

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) $h = DRR/r$,

where: DRR is direct recovery rate, and r is band reporting rate.

To calculate population size, the following is required: (1) estimate of age-specific 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). Therefore, 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 population size at the time of banding, we used harvest rates (h) of adult and juvenile geese separately and also separated harvest estimates (H) of juvenile and adult birds. We also used only band recovery data from birds that were recovered in geographic areas for which there were corresponding harvest estimates of adult and juvenile snow geese. Estimates of reporting rate were year-specific and were the same as those used by Alisauskas et al. (2011, 2012) 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 they also advised using an adjustment of 0.61 for the Harvest Information Program (HIP) estimates from 1999 onward. To be conservative, harvest estimates from both the U.S. and Canada were adjusted by these factors.

Appendix B. Annual banding targets for mid-continent light geese for 2014-2023.

Location	Species	Banding target
Southampton Island	Ross's geese	500
	Lesser snow geese	3,000
Baffin Island	Ross's geese	500
	Lesser snow geese	3,000
Karrak Lake	Lesser snow geese	3,000
	Ross's geese	3,000
La Perouse Bay	Lesser Snow Geese	3,000