MANAGEMENT PLAN FOR GREATER SNOW GEESE IN THE ATLANTIC FLYWAY

Prepared by the Snow Goose, Swan and Brant Committee
of the Atlantic Flyway Gamebird Technical Section

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

Greater snow geese (*Chen caerulescens atlantica*) breed from the northern Foxe Basin and central Baffin Island northward to Ellesmere Island and into northwest Greenland. They winter almost exclusively along the Atlantic Coast. In spring, the main staging area is located in southern Québec, where nearly the entire continental population can be found prior to the northward migration to the breeding grounds. In 1981, a management plan was published by the United States Fish and Wildlife Service (USFWS) and the Canadian Wildlife Service (CWS). At that time, the greater snow goose population was estimated at approximately 200,000 and was recovering from a low of several thousand birds in the early 1900's. As such, the objective of the 1981 plan was to ensure that the population did not fall below 120,000.

In the nearly 3 decades since the original plan, the greater snow goose population, as indexed by the spring survey, has undergone a five-fold increase to over 1 million birds. This increase in population has led to numerous concerns about integrity of natural habitats and increased crop depredation. Conservation measures implemented in Canada in 1999 resulted in increased adult harvest, reduced adult survival, and slowed population growth. Recent decreasing effectiveness of these conservation measures implies that increased harvest in the U.S. will be required to further reduce greater snow goose numbers.

The management goal for greater snow geese is to sustain the greater snow goose population at a level that maximizes a balance between benefits to society and habitat integrity. This current management plan has a population objective set at a level (range of 500,000 to 750,000) that optimizes the balance between a healthy population that can easily recover from catastrophic events and does not negatively impact its natural habitats and associated biodiversity, while minimizing crop damage on staging and wintering areas, and maximizes other human-related benefits such as recreational hunting opportunity and wildlife viewing.

Short of aggressive and expensive direct culling of greater snow geese on the breeding grounds, population objectives will likely only be attained through increasing harvest rates of adult greater snow geese, primarily through increased harvest in the U.S. portion of the Atlantic Flyway. Influencing the distribution of geese on wintering and staging areas may result in greater opportunity for recreational harvest, relieve pressure on some natural ecosystems, and provide for more aesthetic benefits for society.

Continued monitoring of greater snow goose vital rates and response to management activities is critical. Existing programs and new avenues for research and monitoring are outlined within the specific strategies contained in the plan.

PREFACE

The four Flyway Councils are administrative bodies established in 1952 to represent the state/provincial wildlife agencies and work cooperatively with the USFWS, CWS, and Mexico (SEMARNAT) for the purpose of protecting and conserving migratory gamebirds in North America. The Councils have prepared numerous management plans to date for most populations of swans, geese, doves, pigeons, and sandhill cranes in North America. These plans typically focus on populations, which are the primary unit of management, but may be specific to a species or subspecies. Management plans serve to:

- Identify common goals.
- Establish priority of management actions and responsibility for them.
- Coordinate collection and analysis of biological data.
- Emphasize research needed to improve management.

Flyway species management plans are products of the Councils, developed and adopted to help state and federal agencies cooperatively manage migratory gamebirds under common goals. Management strategies are recommendations and do not commit agencies to specific actions or schedules. Fiscal, legislative, and priority constraints influence the level and timing of implementation.

The first management plan for greater snow geese was adopted in 1981. This original plan was prepared in response to an identified need by the CWS the USFWS and the Atlantic Flyway Council. At the time of the 1981 plan's completion, the greater snow goose population was recovering from a low of several thousand birds in the early 1900's to over 200,000. As such, the over-riding objective of the 1981 plan was to ensure that the population did not fall below 120,000. The current estimated population is over 1 million birds. Much concern exists that the current population trajectory of the greater snow goose population will soon be uncontrollable through traditional means, and that Arctic breeding habitats will experience irreversible damage similar to those caused by the mid-continent lesser snow goose population. The continued growth of the greater snow goose population and the extended time period since the 1981 plan have precipitated the development of this management plan.

This management plan, scheduled for review and updating in 2014, sets a goal, objectives, and strategies for the management of greater snow geese in the states and provinces of the Atlantic Flyway. The continued partnership and involvement of the USFWS, the CWS, and state and provincial wildlife management agencies is critical to the successful implementation of this plan.

INTRODUCTION

History of Greater Snow Geese in the Atlantic Flyway

The greater snow goose (*Chen caerulescens atlantica*), is the larger of the two sub-species of snow geese, and differs taxonomically from the lesser snow goose (*Chen caerulescens caerulescens*) by its greater size and the almost complete absence of "blue-phase" individuals.

Historic data on greater snow goose numbers are few. Lemieux (1959) presented data on numbers recorded in the St. Lawrence River Valley from 1900 to 1958. Those data show an increase from a few thousand in the early 1900's, to more than 25,000 individuals by the late 1960's. The greater snow goose population has increased dramatically from about 180,000 in 1980 (spring count) to 947,000 in 2008. Greater snow geese winter almost exclusively in the Atlantic Flyway.

Breeding

Greater snow geese breed from the northern Foxe Basin and central Baffin Island northward to Ellesmere Island and into northwest Greenland (Fig. 1). This subspecies does not appear to have recognizable, distinct affiliations on the breeding grounds. Recent range expansion, however, has brought them into closer contact with some eastern flocks of lesser snow geese. The highest nesting concentrations (10-15% of the world population) are found on Bylot Island, Nunavut (73° N, 80° W; Reed et al. 1992, 2002). Aerial photographic surveys of the 1,600 km^2 southern plain of the island have been conducted every 5 years since 1983 during brood rearing (mid-July and early August). These surveys provide an estimate of population size on Bylot Island according to breeding status, as well as an index of the abundance of broods in habitats of varying quality.

Several measures of greater snow goose productivity are evaluated each year, beginning on the breeding grounds at Bylot Island (Lepage et al. 1999, 2000 and Bêty et al. 2001). On average, >300 nests (annual range, 86 to 846) have been monitored each year since 1989. Determined for each nest are (1) egg-laying date (the date that a first egg is laid in a nest), (2) clutch size (the total number of eggs found in the nest), and (3) nesting success (the proportion of all nests in which at least one egg hatches, calculated by the Mayfield [1975] method). Breeding propensity (i.e., probability that a mature female attempts to breed) is another important vital rate but is difficult to determine; however, using radio-marked birds, Mainguy et al. (2002) and Reed et al. (2004a) were able to estimate it for a subset of years. Finally, during banding drives in early August, at a time when molting adults are flightless and young have not yet fledged, the ratio of juveniles per adult is determined from the sample of geese captured in banding drives, as an index of productivity for the summer.

Staging

The major staging area is located in southern Québec in the marshes and agricultural lands, from Lake Champlain to Lake St-Jean and from the Québec-Ontario border to Baie-des-Chaleurs (Fig. 2). During spring and fall staging along the St. Lawrence River in Québec, geese rely primarily on tidal marshes as their natural feeding habitats (Giroux et al. 1998a). These marshes are located on both the north and south shores of the river in the upper estuary, and provide a major staple food for staging geese in the form of *Scirpus* rhizomes (Bédard and Gauthier 1989). Their foraging activities reduce *Scirpus* biomass (Giroux and Bédard 1988) and alter the composition of the marsh plant community (Bélanger and Bédard 1994b).

Beginning in the early 1970s, greater snow geese expanded their staging area to include farm fields along the south shore of the St. Lawrence River and in regions adjacent to federal and provincial refuges (Filion et al. 1998; Gauthier et al. 2005). Grazing in hayfields became particularly common during spring (Gauthier et al. 1988; Bédard and Gauthier 1989), in addition to feeding on waste grain (Filion et al. 1998). The importance of agricultural foods increased during the period of rapid population growth, possibly due to a reduction in the per capita availability of marsh vegetation caused by the increase in goose abundance (Bélanger and Bédard 1994a; Filion et al. 1998; Gauthier et al. 2005). Changes in distribution observed in recent years, away from the estuary and towards all of southern Québec where feeding occurs solely in farmlands (mostly cornfields), showed that dependence of geese on agricultural foods has continued to increase (Gauthier et al. 2005, J. Lefebvre, pers. comm.).

Wintering

The greater snow goose population winters exclusively along the United States Atlantic Coast with major concentrations of birds occurring from southern New Jersey to North Carolina (Fig. 2). Prior to mid 1980's, most of the entire population was confined to the coast.

Winter distribution of greater snow geese also has changed over time (Fig. 3). Federal wildlife refuges in the south-central Atlantic Flyway (Virginia, North Carolina) were traditionally areas of highest densities of wintering geese, but since the mid-1980s the population has shifted northward with larger concentrations now occurring in Maryland and Delaware, and to a lesser extent New Jersey (Reed et al. 1998). The change in wintering distribution also resulted in a shift in the harvest distribution and harvest rates on greater snow geese in the U.S. (Calvert et al. 2005). These distributional shifts in recent years may have been due in part to the greater availability of grain fields in mid-Atlantic states than farther south, and to increasing temperatures throughout the wintering grounds (Gauthier et al. 2005).

From the mid-1970's to the late 1990's, the number of snow geese using the salt marshes near Forsythe National Wildlife Refuge (NWR) in New Jersey increased (Batt 1998). Concurrently, the amount of salt marsh vegetation severely damaged by snow geese

increased. In an attempt to alleviate this damage, in 1998, Forsythe NWR instituted special hunts for snow geese within their impoundments during October. Special hunts were held from 1998-2002 and then again in 2004. No special hunts were held in 2003 due to the decline in the number of snow geese using the refuge that year. When comparing pre-hunt years (1993-1997) to years when hunting occurred (1998-2003), peak and average number of snow geese using Forsythe NWR during the fall declined by about 50%. Despite this decline, significant damage remains.

The acreage of damaged salt marsh at Forsythe NWR has remained relatively stable since about 1998. Minimum area damaged is estimated currently to be 270 ha adjacent to Refuge impoundments. Additional areas have also been degraded, but there is no estimate of acreage. In addition to salt marsh degradation, eat-outs have affected the NWR infrastructure, with occasional storms damaging the dike system. Batt (1998, chapter 2) indicated that about 2% of salt marsh cordgrass (*Spartina alterniflora*) and salt meadow cordgrass (*Spartina patens*) marshes along the Delaware Bay shore of New Jersey were impacted from 1970 to the mid-1990's. No surveys are in place to measure snow goose damage on these marshes, but anecdotal observation suggests that the present level of damage is minor and similar to that observed over the previous decades. In addition, damaged areas are not consistent from year to year thereby allowing regeneration of previously damaged marshes.

Prime Hook NWR in Delaware, which typically winters between 100,000 and 150,000 greater snow geese, has shown increased annual seed production on moist soil impoundments (A. Larson, pers. comm.). Presumably this increased production is due to the high influx of nutrients (feces) and annual soil disturbance from feeding bouts. *Spartina* marshes at Prime Hook have experienced severe damage, but tend to recover the following year. The situation is much different at nearby Bombay Hook NWR, where estimates of annual damage to salt marsh habitats by snow geese are about 400 ha (R. Brown, pers. comm.).

Extensive eat-outs on *Spartina alterniflora* have occurred in wetlands along Newport Bay, Maryland. The source of these problem birds is a private sanctuary adjacent to the Newport Bay marshes that was once used by 500-2,000 wintering Canada geese (*Branta canadensis*). The sanctuary now is dominated by about 30,000-50,000 greater snow geese that have displaced the Canada geese. Other extensive eat-outs by greater snow geese occur on small islands in Chincoteague Bay and along Assateague Island National Seashore from snow geese that winter at nearby Chincoteague NWR in Virginia and make daily movements north into Maryland to feed.

The number of snow geese reported on the mid-winter inventory in Virginia has not changed much in the last ten years. However, larger numbers of snow geese often stage in Virginia earlier in the year (November) before heading farther south. A redistribution of some birds in the State has led to snow geese using new areas of coastal marsh. Although snow goose impacts to coastal marsh habitats are not widespread in Virginia, damage can be significant in specific localized areas. Damage to coastal marshes and eat-out areas (20-30 ha) still exist in the Chincoteague area where they have been

observed for a long time. Additional damage has been noted farther south along the coast where a flock of 8,000-10,000 snow geese have wintered for the past 4-5 years. An area of about 20 ha of *Spartina alterniflora* marsh has been denuded and is now generally devoid of any vegetation. Other marsh areas in this vicinity where snow geese have been feeding show sparser vegetation but have been impacted to a lesser degree.

Numbers of snow geese wintering along coastal North Carolina have generally declined over the long-term. The core wintering areas in coastal habitats, Pea Island & Mackay Island NWRs, winter approximately 6,000 - 10,000 snow geese. Reports of damage to native vegetation have likewise declined over the long-term. Snow geese occasionally denude very small patches of *Spartina alterniflora* at Pea Island, but these appear to recover quickly.

The northward redistribution of greater snow geese on their wintering grounds may in part be a consequence of their growing dependence on agricultural foods, as corn acreage decreased in southern states but not in mid-Atlantic states (Gauthier et al. 2005). Moreover, an informal survey suggested that the number of depredation complaints by farmers in Virginia and North Carolina declined, while the number of complaints concurrently increased in Delaware, Maryland and Pennsylvania in the late 1990's (Filion et al. 1998), consistent with the shift in distributional by wintering snow geese.

Delaware is the only Atlantic Flyway state, with wintering or staging greater snow geese, that has recently conducted an annual survey of snow goose damage. Damage to agricultural crops in 1998, the first year of the survey and the year before liberalization of hunting regulations (i.e., allowing staggered hunting days after January 4), was 8,130 ha resulting in an estimated loss of $515,091. Damage to agricultural crops was greatly reduced following further liberalization of hunting regulations, but has been variable across years. For 2001-02, snow goose damage amounted to 2,827 ha with a landowner-assessed loss of $235,078. This is substantially below that reported in 2000 (4,159 ha, $394,440), and slightly below that reported in 1999 (2,849 ha, $235,252). Damage was primarily to wheat, barley, and rye crops during late winter. Damage was most frequent in Sussex County adjacent to Prime Hook NWR (T. Whittendale, Delaware Department of Natural Resources, pers. comm.). Maryland also reported important damage to agricultural crops but this was not been quantified. Maryland's approach to alleviating problems of crop damage has been to inform farmers on how to apply for federal depredation permits (L. Hindman, Maryland Department of Natural Resources, pers. comm.). Damage to agricultural crops, mostly winter wheat, in Virginia, still occurs on a localized basis. However, little quantitative information is available because farmers receive no payments for damage caused by wildlife and seldom report acreage figures (G. Costanzo, Virginia Department of Game & Inland Fisheries, pers. comm.). Damage to winter wheat likely occurs on a localized basis in North Carolina, but few if any reports are received by the state wildlife agency or U.S. Department of Agriculture – Wildlife Services (J. Fuller, North Carolina Wildlife Resources Commission, pers. comm.). Pennsylvania experiences agricultural depredation mainly during the spring migration. Although no formal assessment is conducted, damage is minor and seems to have stabilized.

Impetus for 1981 Plan

The first management plan for greater snow geese was adopted by the Atlantic Flyway Council in 1981. This original plan was prepared in response to an identified need by the CWS, the USFWS, and the Council. At the time of the 1981 plan's completion, the greater snow goose population was just over 200,000, and was recovering from a low of several thousand birds in the early 1900's. As such, the objective of the 1981 plan was to ensure that the population did not fall below 120,000. As a safeguard against the population falling to the critical level of 120,000, two of the main objectives of the 1981 plan were to maintain high population levels and to encourage wider dispersal on both the staging and wintering grounds. Both have been achieved. Another goal of the 1981 plan was to manage the greater snow goose population at a level that maximized benefit to society. This explicit recognition of the need to balance greater snow goose numbers with both recreational interests and ecological concerns was tempered by a lack of both qualitative and quantitative assessment of just what that balance might be.

Need for 2009 Revision

Assessment and need for international coordination- Québec plan

In the nearly 3 decades since the original plan, the greater snow goose population, as indexed by the spring survey, has undergone a five-fold increase to over 1 million birds. This spectacular increase in population size has resulted in negative impacts to natural habitats as well as increased conflicts with humans, particularly in agricultural areas. The Arctic breeding grounds are particularly vulnerable to overgrazing and it is based on that threat that the greater snow goose population was determined to be overabundant in 1998 (Batt 1998).

Thus, the management targets for greater snow geese have shifted from maintaining or increasing the population in 1981, to reducing the size of the population (Batt 1998, NAWMP 2004). This major shift in management objectives emphasizes the need for a contemporary management plan.

Clearly, the population objectives and several of the goals of the original 1981 management plan are not germane to the current situation. To address the overabundance issue, special conservation measures were put in place in Canada in 1998-99 in order to increase the harvest of greater snow geese through sport harvest. A recent scientific assessment of the efficacy of the Canadian special conservation measures and changes in regular season harvest regulations in the U.S clearly showed that, although current regulations in both countries have succeeded in slowing the growth of the population, better coordination in management at the international level will be required to reach the goal of reducing the population size down to acceptable levels (Gauthier and Reed 2007).

Recent modeling work incorporating socio-economic variables with greater snow goose population numbers (Bélanger and Lefebvre 2006) have made it possible to develop population goals for greater snow geese that explicitly balance ecological and social values associated with various levels of goose abundance. Furthermore, the CWS has recently adopted a management plan for greater snow geese in the province of Québec).

These recent advances and the Atlantic Flyway management plan should allow for a strong science-based plan and increased opportunities for international coordination of management actions.

Current Population Size

The estimate of the size of the 2008 spring population was 947,000 ± 64,000 geese. The population has been relatively stable since 1999, the year in which special conservation measures were implemented in Canada (Fig. 4). Trends in the spring population size over the last few years indicate that the conservation actions have been successful in halting the growth of the population, which now numbers between 800,000 and over one million individuals. Stabilization of the population at this level was one of the main suggestions of the previous working group (Batt 1998). In spite of this apparent stabilization of population growth rate, it appears that the environmental conditions that have led to the overabundance of geese are still present and may even be increasing in eastern North America. These environmental conditions include global warming (milder summers on the Arctic breeding grounds) and increasing acreages of cornfields near staging and wintering grounds. These conditions are likely to result in better individual body condition of geese and a concomitant reduction in natural mortality rates (Gauthier et al. 2005). Batt (1998) warned that a population size greater than one million individuals could cause serious ecological damage to habitats used by greater snow geese and that it would be increasingly difficult to manage such a large population.

Harvest

Harvest of greater snow geese occurs on the breeding, staging and wintering grounds. Subsistence harvest on Arctic breeding grounds is poorly documented but likely comprises a very small proportion of the total harvest (Reed et al. 1998). Harvest on staging grounds in southern Québec and wintering areas along the Atlantic Coast of the U.S., however, are well documented through harvest surveys, and in recent years, are fairly substantial.

Historically, hunting seasons and bag limits for greater snow geese were conservative (Table 1). In fact, hunting of greater snow geese in the U.S. was prohibited until 1975. Hunting of greater snow geese in the U.S. resumed in 1975 following completion of an Environmental Assessment (EA): "Proposed Open Season on Greater Snow Geese". From 1975 through 1995, daily bag limits in the U.S. increased from 2 to 5. In 1996 daily bag limits were increased to 8 and by 1998 were at 15, with no possession limits. Starting in 1990, the U.S. allowed greater snow goose hunting for the entire framework maximum (e.g., 107 days). In Québec, the daily bag limit was 5 between 1971 and 1989. By 1997 the daily bag in Québec was 12, and in 1999 it was increased to 20.

The rapid increase in the size of the greater snow goose population prompted the CWS to liberalize existing regulations during the hunting season in Québec starting in the fall of 1999 and implementation of special conservation measures on the staging areas in southern Québec. The special conservation measures included the use of previously banned methods such as baiting and electronic calls, as well as allowing a conservation harvest to occur outside of regular seasons (CWS Waterfowl Committee 2001a, 2001b).

Special conservation measures are designated by the Canadian government to be temporary and only apply to populations designated as overabundant. The conservation measures included a spring conservation season from 15 April to 31 May in Québec during 1998-1999 (extended to 1 April to 31 May in 2000-2001 season). Electronic snow goose calls were allowed as long as the decoys used represented white-phased snow geese, and baiting or hunting over bait crop was permitted under specific permits issued by the CWS Regional Director. Daily bag limits during the special conservation harvest periods were the same as those for the regular season, and sneaking was allowed. This special conservation harvest was limited to farmlands.

As a result of the liberalization of hunting regulations on both the staging and wintering grounds, greater snow goose harvest steadily increased until 2002. Since 2002, harvest has stabilized, albeit at lower levels than during the late 1990's (Table 2). From the period 1990-1997, continental greater snow goose harvest averaged 83,000. The initiation of the special conservation measures in Canada in 1998-1999 resulted in a substantial increase in harvest of geese, although the effect was short-lived. From 1998-2001, greater snow goose harvest averaged 209,000. As the interest in spring harvest waned and hunting success rates declined due to snow goose behavioural changes, harvest declined. From 2002-2006, harvest has averaged 133,000.

Ecological Considerations

The impacts to natural ecosystems and increasing agricultural depredation on wintering and staging grounds constitute the main ecological concerns that the growing greater snow goose population represents. With the exception of the annual monitoring that occurs on Bylot Island and ongoing monitoring of the bulrush marshes in the Cap Tourmente National Wildlife Area (NWA) in Québec, few studies or monitoring efforts have recently occurred to better document continued degradation of important habitats used by greater snow geese.

Current monitoring intensity indicates that ecological damage on the breeding grounds has not significantly increased in the past 10 years. Whether this is due to stabilization of the population or favorable growing conditions in recent years, however, is unknown. Similarly, increasing use of agricultural lands in southern Québec make interpretation of data collected in the St. Lawrence River estuary difficult. Bulrush stem densities at Cap Tourmente NWA are substantively similar to densities observed in 1999 when conservation measures were first initiated.

Damage to coastal marshes is a prime concern on the wintering grounds. Denuding of vegetation by snow goose foraging coupled with rising sea levels due to global climate change hasten the loss of low marsh ecosystems critical for many migrant and resident species. Lack of extant monitoring programs in key wintering areas is a problem for measuring the magnitude of salt marsh damage from snow geese.

Agricultural damage is fairly well documented in southern Québec (Bélanger and Lefebvre 2006). Levels of depredation have remained relatively constant, however, distribution of damage and crops being impacted have changed over time. In the

wintering areas of the U.S. there are few programs to monitor annual losses attributable to greater snow geese.

Light Goose Environmental Impact Statement

Concern surrounding the overabundance of snow and Ross's goose populations and the problems associated with high populations of these birds prompted the USFWS to develop a Light Goose Environmental Impact Statement (EIS) aimed at addressing the overabundance of light geese. The Environmental Protection Agency (EPA) published a Notice of Intent to prepare such an EIS on May 13, 1999 (64 FR 26268). Subsequently, on July 13, 2007 (72 FR 38576) EPA published a notice of availability of the Final EIS (FEIS). The FEIS evaluated 5 alternatives for management of overabundant light geese: Alternative A (No Action), Alternative B (Preferred-Modify harvest regulation options and refuge management), Alternative C (Implement direct light goose population control on wintering and migration areas in the U.S.), Alternative D (Seek direct light goose population control on breeding grounds in Canada), and Alternative E (Two-phased approach to light goose population management).

The Preferred Alternative modified 50 CFR 20 to allow the use of additional hunting methods to hunt light geese (i.e., lesser and greater snow geese, and Ross's geese) within current U.S. migratory bird hunting season frameworks by authorizing the use of electronic calls and unplugged shotguns when all other seasons for migratory birds are closed. In addition, a new subpart to 50 CFW 21 was created, establishing a Conservation Order in the Atlantic and Pacific Flyways, similar to that currently in effect in the Central and Mississippi Flyways. The final part of the Preferred Alternative would allow for alteration of current management practices on several NWRs.

The initiation of a Conservation Order in the U.S. will hopefully result in a short-term elevation in harvest of greater snow geese. Similar to what occurred in Québec with the special conservation measures; it is likely that both interest and success will wane after an initial 3-4 year increase in snow goose hunting participation. Unlike the situation in the Mississippi and Central Flyways, access to harvest greater snow geese in the spring is not as good in the Atlantic Flyway. This is due in large part to an increase in hunting leases and in some areas a reluctance on the part of private landowners to grant hunting access. Given these circumstances (e.g., the potential for a limited window for success, current harvest levels, and population status), it is imperative that once this Conservation Order is implemented, that resource managers and hunters alike take advantage of the opportunity to bring the population back into ecological and social balance.

GOALS AND OBJECTIVES

THE MANAGEMENT GOAL IS:

Sustain the greater snow goose population at a level that maximizes a balance between benefits to society and integrity of native vegetation communities.

Greater snow geese provide numerous benefits to society including wildlife viewing and recreational hunting. Opportunities for this resource to provide benefits to the general public are determined by the population size, its geographic and temporal distribution, and by interaction between consumptive and non-consumptive uses. Particularly pertinent to the management of the greater snow goose is the need to keep the population at a controllable level. Managers are concerned that once population levels reach in excess of 1 million birds it may become very difficult to change the population trajectory (Batt 1998, Reed and Calvert 2007). Information obtained through research and monitoring provides data on which management decisions are based. Accordingly, objectives and strategies are presented for each of the following guidelines.

POPULATION GUIDELINES

OBJECTIVE A: Reduce and maintain the population in a range between 500,000 and 750,000 as indexed by the spring survey in southern Québec.

The population objective is set at a level that optimizes the balance between a healthy population that can easily recover from catastrophic events and does not negatively impact its natural habitat and associated biodiversity, while minimizing crop damage on staging and wintering areas, and maximizes other human-related benefits such as recreational hunting opportunity and wildlife viewing.

The current North American Waterfowl Management Plan (NAWMP) goal for greater snow geese of 500,000 (NAWMP 2004) was determined in a largely subjective manner. However, wintering and staging ground carrying capacity were major considerations in the original discussions. Despite the recognition that greater snow goose population objectives should be based on the carrying capacity of their natural habitats, with the exception of Arctic habitats (e.g., Massé et al. 2001), few studies have looked at the capacity of other habitats used by greater snow geese (staging and wintering areas) throughout their life cycle. Absent empirically based estimates of winter and staging habitat carrying capacity, and the recognition that the social and economic benefits of the greater snow goose population should be incorporated into a contemporary population objective, the CWS (Bélanger and Lefebvre 2006) undertook an analysis aimed at deriving an optimal population size or range for greater snow geese.

The analysis identified potential indicators of socially related values associated with the presence of greater snow geese throughout their life cycle in North America (hunting, birding, refuge public attendance, crop damage, etc.). A cost-benefit analysis of select management scenarios of those socially related values was then conducted. These were then integrated into a single index linked to the population size from 1965 to 2004. Principal Components Analyses were performed on the various social value indicators based on the presence of the geese on their U.S. Atlantic Coast wintering grounds, their staging areas in southern Québec, and from a continental standpoint. These analyses excluded remote Arctic breeding areas. Although data from the wintering grounds were incomplete, many of the data used from the staging grounds (southern Québec) are likely very comparable to those that would be derived from the wintering grounds. The final analysis also incorporated other main aspects of greater snow goose population management such as actual knowledge of the carrying capacity, the ecological integrity of natural habitats and the potential of sport hunting to act as a population control tool. All these parameters were used to determine an optimal management scenario and population objective.

The population goal as outlined in this Plan will not impact the implementation of a Conservation Order in the U.S. (J. Kelley USFWS, pers. comm.).

Strategy A-1. Harvest management in Canada and U.S.

Rationale: Short of aggressive and expensive direct culling of greater snow geese on the breeding grounds, population objectives will likely only be attained through sustained harvest in both Canada and the U.S. Current harvest intensity is not sufficient to significantly reverse the current population trajectory. Increasing harvest levels in Canada, given the current trend in hunter numbers and interest, is not likely. Thus, in order to achieve the population objective, the harvest of greater snow geese in the U.S. needs to increase. Several existing impediments to increasing hunting interest and subsequent snow goose harvest on the wintering grounds need to be addressed for this to occur. Chief amongst these impediments is lack of hunter access to feeding fields in several key wintering areas. Declining hunter success as the season progresses, increasing opportunity for traditional Canada goose hunting, and the need for large, expansive decoy spreads are also impediments to significantly increasing greater snow goose harvest in the U.S.

Access to privately owned agricultural feeding areas on the Delmarva Peninsula of Maryland and Delaware is difficult. This lack of access impairs hunter success, which in turn, erodes participation. Geese hunted in one field will merely move short distances to adjacent areas where there is no hunting pressure. This situation is very different from staging areas in southern Québec, where access to feeding areas is not as difficult. An example of how lack of success impacts snow goose hunting participation comes from many of the USFWS Region 5 (R5 VA north to ME), NWRs. In most years, particularly when productivity is low, interest in snow goose hunting on NWRs typically wanes after the first few of weeks of the hunting season. This decline in interest coincides with

declining hunter success rates, as the birds become wary of hunting pressure and adjust their roosting and feeding patterns.

Historically, through the 1990's, approximately 80% of the entire Atlantic Flyway Midwinter Waterfowl Survey (MWS) greater snow goose estimates came from NWRs. At the same time, snow goose harvest from NWRs only accounted for 4-6% of the Flyway total. This lack of congruence between abundance and harvest is due in large part to the use of many NWRs as roosts rather than primarily for feeding. One way to potentially increase harvest on NWRs is to plan certain hunts around nighttime roosts, and recruit hunters willing to shoot birds on the water or on the ground. Another potential method for increasing harvest on NWRs is to allow snow goose hunting only in certain areas. This would specifically direct hunting activity towards snow geese, and might actually increase hunting opportunity for other species in other areas of the NWR. Allowing waterfowl outfitting services to guide hunts on NWRs may result in increased harvest of snow geese. Snow geese may be one of the most difficult species in North America to consistently harvest. Allowing outfitters who are effective in hunting snow geese to guide hunters onto NWR areas would likely result in much greater harvest of geese.

Regardless of the methods employed, increasing harvest of greater snow geese on the wintering grounds will require better coordination between state and federal agencies and private landowners. Coordinating hunting pressure on NWRs and private lands may increase success rates. Hesitance to allow hunters onto private lands might be alleviated by assurances that hunters are responsible and ethical. Advanced hunter education programs such as those employed for alleviation of Canada goose depredation in the Lower Columbia River may be effective (D. Kraege pers. comm.).

Implementation of many of the recommendations contained herein that pertain specifically to activities on NWR's in both R4 and R5 will require considerable effort in staff time to ensure that the various laws and regulations that govern activities on NWR's are followed.

Recommendation 1: Continue spring conservation season in Canada.

Responsibility: CWS.

Recommendation 2: Encourage state participation in expanded hunting methods and Conservation Order.

Responsibility: Atlantic Flyway Council

Recommendation 3: Increase hunting opportunity on select Region 4 (R4) and R5 NWRs through opening areas to snow goose only hunting, participation in Conservation Order, and targeted habitat manipulation (see Strategy C-2 below).

Responsibility: USFWS, USFWS R4 and R5 NWRs.

Recommendation 4: Promote need for increased snow goose hunting, develop documents to inform hunters on successful snow goose hunting techniques, work with waterfowl outfitting services to increase exposure to hunters about snow goose hunting and successful snow goose hunting techniques, and work with NWRs to promote outfitting services on NWR lands and potentially opening up certain areas to outfitting hunting only.

Responsibility: USFWS, R4 and R5 NWRs, Atlantic Flyway states harboring significant greater snow geese during winter or spring migration.

Recommendation 5: Work with private landowners in key wintering areas to develop lease programs or merely promote increasing hunter access for snow goose hunting, particularly once the Conservation Order is implemented. Providing access to snow goose hunting could result in increased harvest rates of geese.

Responsibility: State wildlife agencies

POPULATION MONITORING

OBJECTIVE B: Develop and enhance existing population monitoring programs that will provide precise and accurate demographic data and inform managers on the effectiveness and efficiency of strategies outlined in this Plan.

Informative monitoring programs are integral towards determination of meeting population and habitat objectives. Monitoring programs will be used to evaluate the efficacy of the strategies outlined in this Plan. As snow goose population response to various management actions is evaluated, strategies can be modified accordingly.

Strategy B-1. Maintain and improve spring surveys.

Rationale: Key to implementation and assessment of management activities is the ability to accurately and precisely measure annual population size. Since the mid 1960's, population size has been estimated by annual spring aerial-photographic censuses when geese concentrate in southern Québec. Due to the clumped and unpredictable wintering distribution of greater snow geese, it is generally agreed that the spring staging survey provides the most accurate estimate of total numbers and of annual changes (Batt 1998). Since 1975, the spring population has increased from 153,800 to 947,000 in 2008.

In recent years, as goose numbers have increased and their geographic range has expanded, it has become increasingly difficult to obtain complete coverage of the population. In response to this difficulty, a project was conducted between 1998 and 2000 using radio telemetry to assess the proportion of the population that might be missed during the survey. An estimated 11% to 29% of the radio-marked geese (Béchet et al. 2004) were missed. Due to the low precision associated with the population estimates, the methods were again revised in 2001.

In 2001, all of southern Québec and southeastern Ontario was over-flown by three aircraft, which covered the entire staging area in a single day, thus reducing biases caused by movements of geese during the survey (Cotter 2002). The surveys were also conducted early in the season before much fragmentation of the flock occurred, and were synchronized at each site to coincide with the daily return of birds to their main roosts. The survey method was again modified in 2004 as a result of additional changes in staging distribution. Five aircraft were used simultaneously during one day of surveying. This modification allowed for an increased coverage of agricultural land (including south-eastern Ontario) and also optimized survey timing (Fig. 5). The revised survey methodology likely resulted in more complete coverage of the area used by geese, allowing a larger proportion of the population to be counted at roosting sites. Yet, even if the accuracy of the survey has increased, the proportion of the population missed with this new methodology remains unknown. Ultimately, managers must determine what level of precision is acceptable for this index and maintain stable survey methodology so that a true measure of population size in response to management efforts can be derived and tracked.

Recommendation 1: Maximize spring survey coverage.

Responsibility: CWS, USFWS.

Recommendation 2: Develop correction factor for spring population estimates using satellite telemetry.

Responsibility: CWS, USFWS.

Recommendation 3: Develop technique to utilize digital photos for enumeration.

Responsibility: CWS, USFWS.

Recommendation 4: Determine acceptable survey precision and maintain stable survey methodology.

Responsibility: CWS, USFWS

Strategy B-2. Maintain and enhance breeding survey and banding program.

Rationale: Greater snow geese have bred successfully (>10% young in fall flight) in 28 of the past 33 years (1976 to 2008), maintaining an average rate of approximately 25% young in the fall flight (Table 3). Productivity is currently appraised in the fall by age ratio counts in southern Québec. Detailed information on nesting effort, nesting success, and rearing success has been obtained annually since 1989 from a field study on Bylot Island. This work is slated to continue through 2012. Because of mounting evidence of density dependent declines in body condition, there is a need to obtain statistically sound estimates of survival rates of both juvenile and adult cohorts.

Although data recorded on Bylot Island is considered to be highly representative of the situation occurring throughout the main breeding area which includes much of northern Baffin Island, some colonies are located at considerable distances from this core area and may therefore be subject to different conditions (effects of weather on reproduction; longer migratory distances affecting survival rates; effects of grazing pressure on habitat integrity).

Recommendation 1: Additional studies outside the core area, surveys, banding and neck collaring efforts in parts of eastern Axel Heiberg and western Ellesmere islands should be conducted to obtain data for evaluation of survival rates.

Responsibility: CWS, all cooperating agencies.

Recommendation 2: Maintain current monitoring programs on staging grounds, including annual fall productivity estimates.

Responsibility: USFWS, CWS.

Strategy B-3. Monitor wintering distribution and movements of greater snow geese.

Rationale: The geographic and temporal distribution of snow geese on the wintering grounds dictates, in large part, not only the damage incurred to natural ecosystems and cultivated crops, but also the vulnerability of geese to harvest. Monitoring changes in distribution and temporal presence of geese will serve to inform managers on the efficacy or lack thereof of strategies outlined in this Plan.

Recommendation 1: Continue utilizing satellite telemetry to assess goose movement patterns in response to increased hunting pressure during the Conservation Order.

Responsibility: CWS, Atlantic Flyway Council

POPULATION DISTRIBUTION

OBJECTIVE C: Influence as necessary and practical, geographic and temporal distribution of greater snow geese to the extent possible. Distributional shifts should be consistent with the welfare of natural habitats, depredation concerns on staging and wintering grounds, and in support of both population and public use objectives.

Active management can influence distribution of greater snow geese on both the staging and wintering grounds. Distributional changes can be manifest primarily through habitat management and changes in land use practices, and to a lesser extent, human disturbance through hunting pressure and hazing. Greater snow geese are valued throughout their range for both aesthetic and recreational pursuits. Protection of natural habitats and agricultural crops should be the highest priority for efforts to potentially influence the distribution of large numbers of staging and wintering geese. Thus, managers should strive to reduce snow goose use and damage to priority ecological and agricultural habitats. Wherever possible, recreational objectives of affected stakeholders should be incorporated into management decisions.

Strategy C-1. Reduce agricultural damage on spring staging and wintering areas.

Rationale: Greater snow goose depredation of agricultural crops causes significant financial loss on both wintering and staging areas. Relatively good estimates of crop damage and loss exist for the staging grounds in southern Québec. A recently conducted analysis indicated that from 1999-2004 an average 4,194 ha of crops were damaged by greater snow geese. These damages resulted in an average financial loss of $800,957 (Canadian dollars). A better understanding of areas of depredation risk, timing of damage, and efficacy of hazing activities needs to be undertaken. An important issue that needs to be resolved on the spring staging grounds is the development of a better linkage between hazing activities and crop damage compensation.

In contrast, estimates and reporting of damage on the wintering grounds are meager. No states have a systematic survey of crop damage due to snow geese and no states within the Atlantic Flyway currently have a damage compensation program. Since 2003, the number of depredation permits issued annually by the USFWS in R5 has ranged from 7-13. The total number of snow geese taken on these permits ranged from 255-496. In the absence of a compensation program, much damage goes unreported, as there is no real incentive for farmers to report damage. Intensive hazing of geese from agricultural areas on the wintering grounds may be effective in deterring damage and increasing the vulnerability of flocks to harvest pressure. Targeted hazing programs to abate Canada goose depredation in localized areas (Lower Columbia River) have proven to be effective in reducing crop damage (D. Kraege pers. comm.).

Recommendation 1: Maintain and refine crop damage prevention program on forage crops in Québec.

Responsibility: CWS.

Recommendation 2: Assess crop depredation program in Québec.

Responsibility: CWS.

Recommendation 3: Develop better estimates of crop damage on private lands on the wintering grounds.

Responsibility: USDA Wildlife Services, Atlantic Flyway states.

Recommendation 4: Implement hazing programs specifically targeting areas on the wintering grounds where hunting does not occur.

Responsibility: USDA Wildlife Services

Strategy C-2. Work with NWRs and surrounding landowners on wintering grounds to reduce conflicts.

Rationale: At Bombay Hook, Prime Hook, Blackwater, and Back Bay NWRs, croplands are managed to provide food for wintering migratory gamebirds, primarily migrant Canada geese. As of 2001, a total of 2,478 acres of croplands were available to snow geese at R5 Refuges. These croplands are used by both Canada geese and snow geese. However, only at Blackwater NWR does cropland use by Canada geese exceed use by snow geese. Primary crops available to wintering snow geese at these NWRs include: harvested or un-harvested corn, sorghum, soybeans, winter wheat or rye cover crops, buckwheat, and clover. Regardless of the extent of cropland and natural marsh food available at any NWR, snow geese at most NWRs do not meet all their dietary needs within the confines of the refuge. After initial arrival and extensive feeding on most NWRs, the geese soon begin to use the refuge primarily as a nighttime roost and daytime resting location, with daily feeding flights to nearby private agricultural lands (Hill and Frederick 1997). However, the one exception to this scenario may be Forsythe NWR, which does not have croplands either on the refuge or within the surrounding area. Thus, snow goose feeding at Forsythe is primarily restricted to grubbing within *Spartina* marshes.

As food resources both on and nearby the R5 NWRs are depleted, snow geese appear to relocate to other locations. This is evident from a decline in use at both Bombay Hook and Prime Hook NWRs as the wintering period progresses. During these periods of declining use at the two NWRs, a concomitant increase in snow geese roosting and feeding farther west on the Delmarva Peninsula has been observed. Damage to adjacent agricultural crops on private lands increases as the geese decrease their use of NWRs as feeding areas.

Similar situations occur at some R4 NWRs. The Pungo Unit of Pocosin Lakes NWR in North Carolina is intensely managed for wintering migratory waterfowl. The Pungo Unit includes 1,250 acres of cropland and over 400 acres of moist soil habitat. The 1,250 acres of croplands are farmed cooperatively with local farmers. Crop rotations include corn, winter wheat, soybean and some Japanese millet and milo. The over 400 acres of moist soil units are managed intensely for early successional, emergent wetland plants. The units are drained in late spring to provide conditions for plants to germinate. In late October, the units are flooded to provide habitat for wintering migratory waterfowl. The adjacent farmlands do receive a lot of snow goose use, and are hunted. As foraging resources on the NWR decline, more goose use off refuge occurs.

Implementation of many of the recommendations contained herein that pertain specifically to activities on NWR's in both R4 and R5 will require considerable effort in staff time to ensure that the various laws and regulations that govern activities on NWR's are followed.

Recommendation 1: Develop localized strategies/plans between private landowners and wintering NWRs to increase hunting pressure and reduce crop depredation and damage to natural ecosystems. Coordinated hunting programs between wintering NWRs and adjacent private lands will result in greater harvest pressure on geese.

Responsibility: USFWS, R4 and R5 NWRs, Atlantic Flyway states.

Recommendation 2: Develop and work to achieve specific target population goals for R4 and R5 NWRs.

Responsibility: USFWS, R4 and R5 NWRs, Atlantic Flyway states.

Recommendation 3: Should snow goose numbers on individual NWRs be below desired goals (e.g., Back Bay NWR, Prime Hook NWR), implement programs to attract and hold snow geese.

Responsibility: USFWS

Strategy C-3. Attract geese to certain areas to enhance non-consumptive use.

Rationale: Wildlife viewing and photography are increasingly popular activities. In several areas of the wintering and staging grounds greater snow geese are the central attraction for wildlife viewing enthusiasts. For instance, the majority of visitation by wildlife viewing enthusiasts at Pocosin Lakes, Bombay Hook, and Forsythe NWRs coincides with the arrival and subsequent wintering of greater snow geese. A snow goose festival is held in Vermont each fall, and several large snow goose festivals are annually held in southern Québec. Increasing opportunities for viewing of snow geese is important for not only providing the public with a resource in demand, but also may be an integral part of educating the public to the issues associated with greater snow geese.

Recommendation 1: Where appropriate, encourage planting of lure crops to attract snow geese to suitable areas for viewing by the public.

Responsibility: All cooperating Agencies.

Recommendation 2: Where appropriate, engage NWRs and state wildlife agencies to develop new viewing opportunities for greater snow geese.

Responsibility: USFWS, Atlantic Flyway states.

HABITAT MANAGEMENT

OBJECTIVE D: Monitor habitat conditions on breeding, staging, and wintering grounds.

Continued monitoring of habitat conditions is critical for assessing the effects of population management activities. The overriding objective for habitat management is to reduce the negative impacts that increasing greater snow goose populations have on breeding, staging, and wintering habitats. Increased use of agricultural fields in staging and wintering areas may reduce or at least stabilize the amount of damage to natural habitats, but may lead to goose populations that exceed the limits of Arctic breeding grounds, leading to irreparable damage to those Arctic habitats.

Strategy D-1. Develop estimates of carrying capacity of various wintering and staging habitats

Rationale: The only estimate of carrying capacity for any habitat used by greater snow geese is from the Arctic breeding grounds on Bylot Island. Undoubtedly, due to their lack of resilience, the breeding areas are the most critical habitats for which to develop an estimate of carrying capacity. However, development of estimates of carrying capacity for staging and wintering habitats is important for developing management strategies. Assessment of carrying capacity of natural habitats (e.g., coastal marsh) in staging and wintering areas is confounded by goose use of other habitats (i.e., agricultural fields).

Recommendation 1: Initiate pilot studies throughout the wintering range to estimate carrying capacity of various habitats used by greater snow geese. These studies would identify the landscape attributes of those areas where large numbers of geese concentrate. For example, what is the landscape composition within 20+ miles around Bombay Hook NWR and what are the characteristics and the nutritional benefit of the various habitats used by the geese?

Responsibility: Atlantic Flyway Council, USFWS R4 and R5 NWRs.

Recommendation 2: Develop and implement a standardized monitoring program that tracks changing habitat conditions.

Responsibility: Atlantic Flyway Council, USFWS R4 and R5 NWRs.

Strategy D-2. Develop restoration methods for mitigating damage to staging areas.

Rationale: The marshes of the St. Lawrence River estuary represent critical habitats that are vital for many migratory bird species. Greater snow goose grazing and grubbing of tidal *Scirpus* marshes has resulted in a decline of resources available not only to snow geese, but the other species dependent upon the estuary. Development and

implementation of cost-effective methods for restoring lost function of these impacted estuaries may prove to be beneficial, regardless of whether snow goose use and numbers can be reduced.

Recommendation 1: Implement marsh restoration programs in the St. Lawrence River estuary.

Responsibility: CWS, USFWS, ACJV, EHJV, NGO's.

Strategy D-3. Balance levels of beneficial and detrimental habitat impacts on NWRs.

Rationale: A common feeding strategy of snow geese is to grub for underground roots and tubers. Primary marsh vegetation species exploited in this fashion are: salt marsh cordgrass (*Spartina alterniflora*), salt meadow cordgrass (*S. patens*),Olney's bulrush (*Scirpus americanus*), black needlerush (*Juncus romerianus*), and cattail (*Typha sp*). Grubbing for rhizomes of these species, especially in salt marshes, results in areas denuded of vegetation, typically referred to as "eat-outs". Presently, eat-outs occur on Forsythe, Bombay Hook, Prime Hook, and Blackwater NWRs in R5. The most extensive eat-outs occur at Bombay Hook NWR where approximately 650 acres are denuded each year. With the exception of Smith and Odum (1981), few studies have been conducted on the long-term impact of greater snow geese wetland grazing along the Atlantic Coast. Therefore, the consequences for wetland vegetation are poorly understood. As on staging grounds, *Scirpus* biomass and growth were negatively impacted by goose grazing (A. Froelich and D. Lodge unpubl. data, presentation at the Intecol Millennium Wetland Event in 2000, Québec City, PQ). However, during the 1990s this damage did not increase at the same rate as goose population growth in regions where nearby agricultural fields provided an alternative food source (mainly waste corn and winter cereals), although eat-outs did persist in traditional wintering areas without farm foods available (Giroux et al. 1998b). Generally, natural habitats affected by snow geese along the Atlantic coast have been limited to small areas (in proportion to the area covered by salt marshes) where damage is intense but localized, mostly in wildlife refuges (Giroux et al. 1998b).

Snow goose eat-outs in salt marshes tend to re-vegetate during the subsequent growing season, however at a reduced vegetative density. Vegetation density at these eat-outs may increase after several years to pre-eat-out levels, if left alone. However, at most NWRs where eat-outs occur within salt marsh habitats, snow geese return each winter to the same areas to feed. This may be a result of the vegetative growth being at an earlier stage of development, being more nutritious, or having a less dense root mat and therefore easier to grub. It is also speculated that during the time snow geese are feeding in a salt marsh, much of the soil and sediment may be loosened and placed into suspension. This material may then be washed away during high or flood tide periods. After several years of successive eat-outs at the same location, a lowering of ground elevation may occur causing a more permanent impact to the site.

Most agree that salt marsh eat-outs are detrimental to habitat integrity and other wildlife species. This is a result of the radical change of habitat structure from dense vegetation to mudflat. Undoubtedly, this conversion negatively impacts invertebrate communities as well as species such as rails and waterfowl that feed on these invertebrates and rely on the dense vegetative structure for cover. However, over the years these eat-out areas have generally not increased in size, and currently comprise only a small portion of the total salt marsh acreage available at each NWR. In addition, some Refuge staff report increased use of snow goose eat-outs by numerous shorebirds during migration, as well as some species of waterfowl. This is particularly the case at Prime Hook, Forsythe, and Bombay Hook NWRs.

Greater snow geese also create eat-outs within freshwater wetlands and impoundments at several R5 NWRs. When this occurs within refuge impoundments, it is often viewed as a beneficial activity. This differing viewpoint is due to the type of habitat and resources that each refuge is attempting to provide within impoundments. Generally, NWRs favor "annual" vegetation as opposed to "perennial" vegetation within impoundments. Annuals often provide larger quantities of seed, thus greater quantities of food resources to wildlife. Annuals also breakdown and decompose much faster than does perennial vegetation, thereby providing a food source for many aquatic invertebrates. The ready decomposition of annuals during winter flooding, also changes the vegetative structure of the site following the winter season to basically a bare mudflat which benefits shorebirds. Thus, when snow geese grub on rhizomes of perennial vegetation such as: cattail, saltmeadow cordgrass, or black needlerush within impoundments it is considered a beneficial activity to maintain the impoundment in an early successional stage. This form of natural vegetation control has been observed at Bombay Hook, Prime Hook and Back Bay NWRs.

Recommendation 1. Quantify impacts of greater snow goose use on NWR habitats (e.g., increased shorebird use at areas such as Prime Hook NWR and loss of low marsh at areas such as Forsythe and Bombay Hook NWRs).

Responsibility: USFWS, R4 and R5 NWRs.

Recommendation 2. Develop cost/benefit index for wintering NWRs that can be used to guide specific management actions at individual Refuges.

Responsibility: USFWS, R4 and R5 NWRs.

Recommendation 3. Incorporate new data on impacts into socio-economic model.

Responsibility: USFWS, CWS.

PUBLIC USE

OBJECTIVE E: Maintain and increase opportunities for recreational and subsistence use of greater snow geese consistent with population and distribution objectives.

Greater snow geese are valued for viewing, photography, and hunting throughout their annual range. Due to the large flocks of geese that are present during migration and on some wintering areas, public viewing and photography is much sought after. Greater snow geese provide abundant recreational hunting opportunity throughout their range. The continuation of these use opportunities is in the public interest and contingent upon ensuring that population and distribution objectives are achieved and maintained into the future.

Strategy E-1. Increase and promote non-consumptive use of greater snow goose resource on staging and wintering areas.

Rationale: The spectacle of the greater snow goose migration and the presence of large wintering flocks result in a large amount of revenue from photography and other non-consumptive uses of the resource to local economies in both Canada and the U.S. The estimated annual revenue from bird watching and eco-tourism, in the 4 main spring staging areas in Québec was $19 million (Canadian dollars) (Bélanger and Lefebvre 2006). Although not presently quantified, non-consumptive interest in greater snow geese is on the rise in the U.S. For example, several recently organized festivals in the U.S. are geared specifically for greater snow geese (e.g., Dead Creek Wildlife Management Area in VT). Pocosin Lakes, Forsythe, and Bombay Hook NWRs derive a large proportion of their annual visitation during the period when large flocks of greater snow geese are present. Thus, the potential exists to derive substantial benefit for non-consumptive use on both staging and wintering areas.

Recommendation 1: Develop new outreach programs or enhance existing programs on R4 and R5 NWRs.

Responsibility: USFWS, R4 and R5 NWRs.

Recommendation 2: Quantify, from all sources (hunting, tourism, etc) public benefit derived from greater snow geese on the wintering grounds.

Responsibility: Atlantic Flyway Council, USFWS, R4 and R5 NWRs.

Strategy E-2. Promote hunting opportunities afforded by greater snow geese in the U.S.

Rationale: Recent modeling exercises and survey data (Gauthier and Reed 2007) indicate that the only sustainable management solution to control the size of this population through harvest alone in North America would be to substantially increase harvest in the U.S. The regular season in the U.S. is as liberal as it can be as allowed by the Migratory Bird Treaty Act. Implementation of special conservation measures in the U.S., particularly a late winter/spring conservation hunt, will be required to increase the overall harvest of greater snow geese. Most of the major snow goose wintering states in the Atlantic Flyway (DE, MD, NJ, NY, PA, and VT) participated in conservation measures beginning in the spring of 2009. All states feel that they could have a significant effect on greater snow geese in years with good production. One potential way of increasing participation and harvest during the conservation season in the U.S. may be to allow reciprocal licenses/permits between states and Québec for snow goose hunters only. Reciprocal licenses have been used between the adjoining states of Maryland and Delaware for several years.

Snow goose harvest during existing frameworks needs to increase as well. Increased opportunity for Canada goose hunting throughout the wintering range may be negatively impacting snow goose hunting participation. Efforts should be made to promote late season snow goose hunting, and should include information on effective methods and tactics to maintain enthusiasm by hunters who may be disinclined to participate if success is low. Despite the stigma in many hunting circles for stalking and ground shooting, this may be an effective tactic for reducing snow goose numbers in certain situations.

Implementation of many of the recommendations contained herein that pertain specifically to activities on NWR's in both R4 and R5 will require considerable effort in staff time to ensure that the various laws and regulations that govern activities on NWR's are followed.

Recommendation 1. Investigate and promote methods to increase harvest during the regular seasons in the U.S. (see Recommendations A-3 and A-4).

Responsibility: USFWS, Atlantic Flyway states.

Recommendation 2. Implement Conservation Order and expanded hunting methods in the U.S., including key NWRs that hold staging snow geese.

Responsibility: USFWS, Atlantic Flyway states.

RESEARCH NEEDS

OBJECTIVE F: Continue to address key uncertainties on the biology and ecological impact of greater snow geese. Refine current models to enhance predictive ability of various management strategies.

Continued responsible international management of greater snow geese will rely upon decisions based upon the best available science. For the past decade a scientifically based management approach has been used to manage greater snow geese throughout their range, and that should continue. Targeted research and monitoring programs should be continued in order to supply managers with the best data on which to base management strategies. Prioritized research will also direct limited resources towards addressing critical uncertainties in greater snow goose biology and population response to management activities.

Strategy F-1. Continue to monitor movement patterns and vital rates in response to increased hunting and hazing.

Rationale: Increased disturbance to greater snow geese on the spring staging grounds initially resulted in a decrease in female body condition, leading to lowered breeding efforts and nesting success. Temporal changes in distribution of geese on the spring staging grounds were also a consequence. As harvest pressure on greater snow geese increases in the U.S. and the Conservation Order is implemented, wintering distribution of geese may change. Similarly, targeted hazing programs and management strategies outlined in this Plan, if successful, will also influence movement patterns and distribution of snow geese.

Recommendation 1: Develop monitoring program on wintering grounds once Conservation Order is implemented.

Responsibility: USFWS, Atlantic Flyway states.

Strategy F-2. Continue to refine socio-economic analyses.

Rationale: The over-riding goal of this management Plan is to balance greater snow goose population levels with ecological function and integrity of natural ecosystems and societal tolerances and benefits. This balance and the resulting population objective described herein has been developed using a multivariate modeling approach that incorporated social and economic variables. As such, it is incumbent upon managers to refine model inputs and adjust objectives, if deemed necessary, as new information is gathered and incorporated.

Recommendation 1: Develop better estimates of cost-benefit analysis of greater snow geese on wintering grounds.

Responsibility: Atlantic Flyway Council, USFWS, R4 and R5 NWRs.

Recommendation 2: Monitor farmer and public attitudes towards snow geese in southern Quebec.

Responsibility: CWS.

Strategy F-3. Develop models to predict effects of changing environmental factors on greater snow goose demography.

Rationale: The effects of global climate change on habitats used by greater snow geese throughout their life cycle are largely unknown. Increasing sea levels will undoubtedly result in a loss of coastal salt marsh on the wintering grounds and a likely shift in habitat use throughout the wintering area. Changes to Arctic breeding habitats will also occur as the planet warms. Changes in agricultural practices throughout the range of the greater snow goose are very likely to be manifest as both the US and Canada shift agricultural emphasis towards more bio-fuel production. Increasing temperatures and changing natural vegetation communities may impact not only habitat use, but also snow goose vital rates. If vital rates are affected by factors outside of harvest related impacts, these changes need to be recognized and incorporated into management strategies.

Recommendation 1: Monitor environmental factors and effects upon natural habitats throughout the range of greater snow geese.

Responsibility: All cooperating agencies.

Recommendation 2: Incorporate knowledge accrued through various monitoring programs (vital rates, environmental factors, etc.) into new population models.

Responsibility: CWS, USFWS.

RESPONSIBILITIES FOR AND FUNDING OF RESEARCH, SURVEY, AND BANDING PROJECTS DEVELOPED AS A RESULT OF THIS PLAN SHOULD BE SHARED AMONG STATES AND PROVINCES BENEFITTING FROM GREATER SNOW GEESE, AND FROM THE CANADIAN WILDLIFE SERVICE AND U.S. FISH AND WIDLIFE SERVICE IN ACCORDANCE WITH THEIR RESPONSIBILITIES UNDER THE MIGRATORY BIRD TREATY.

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APPENDIX A

FIG.URES AND TABLES

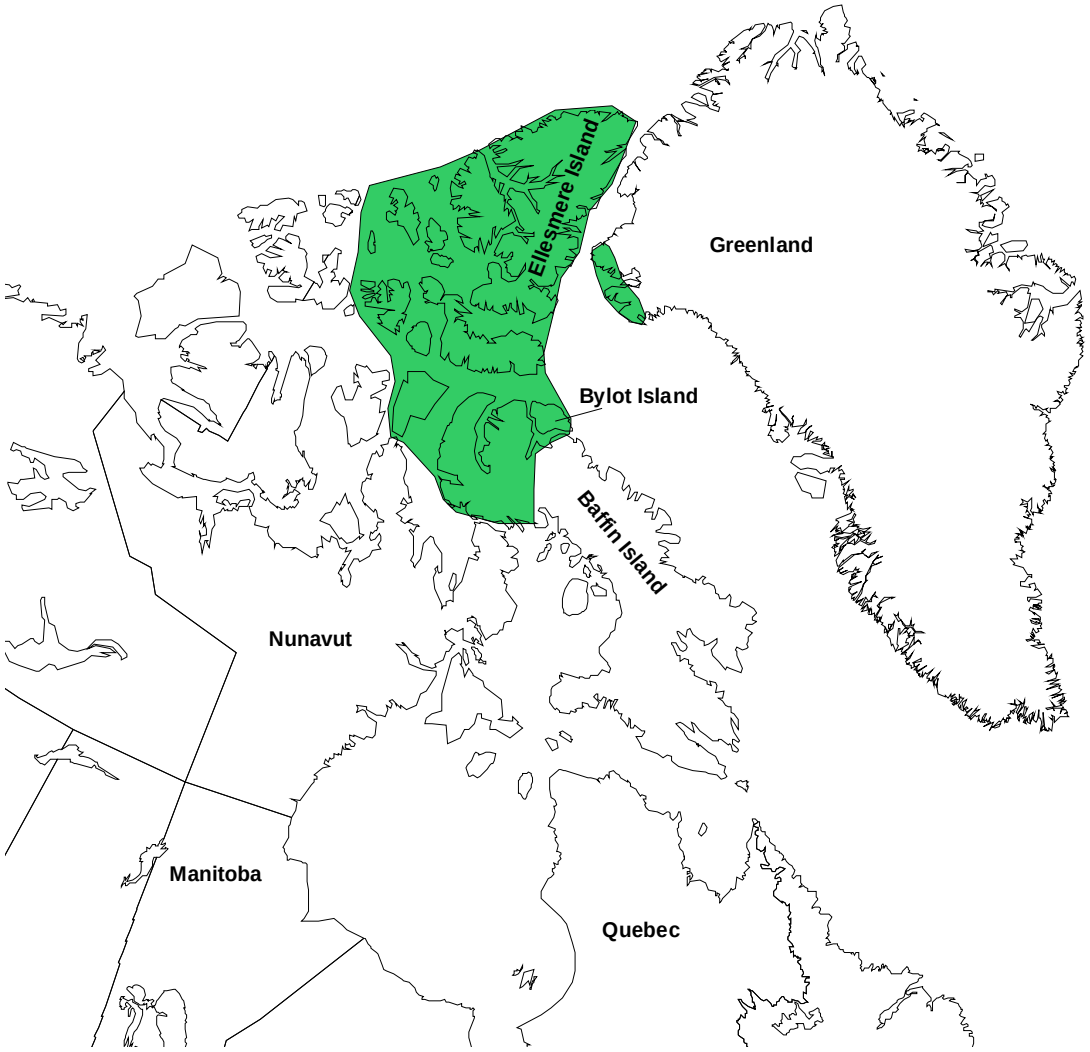

Fig. 1. Breeding range of greater snow geese.

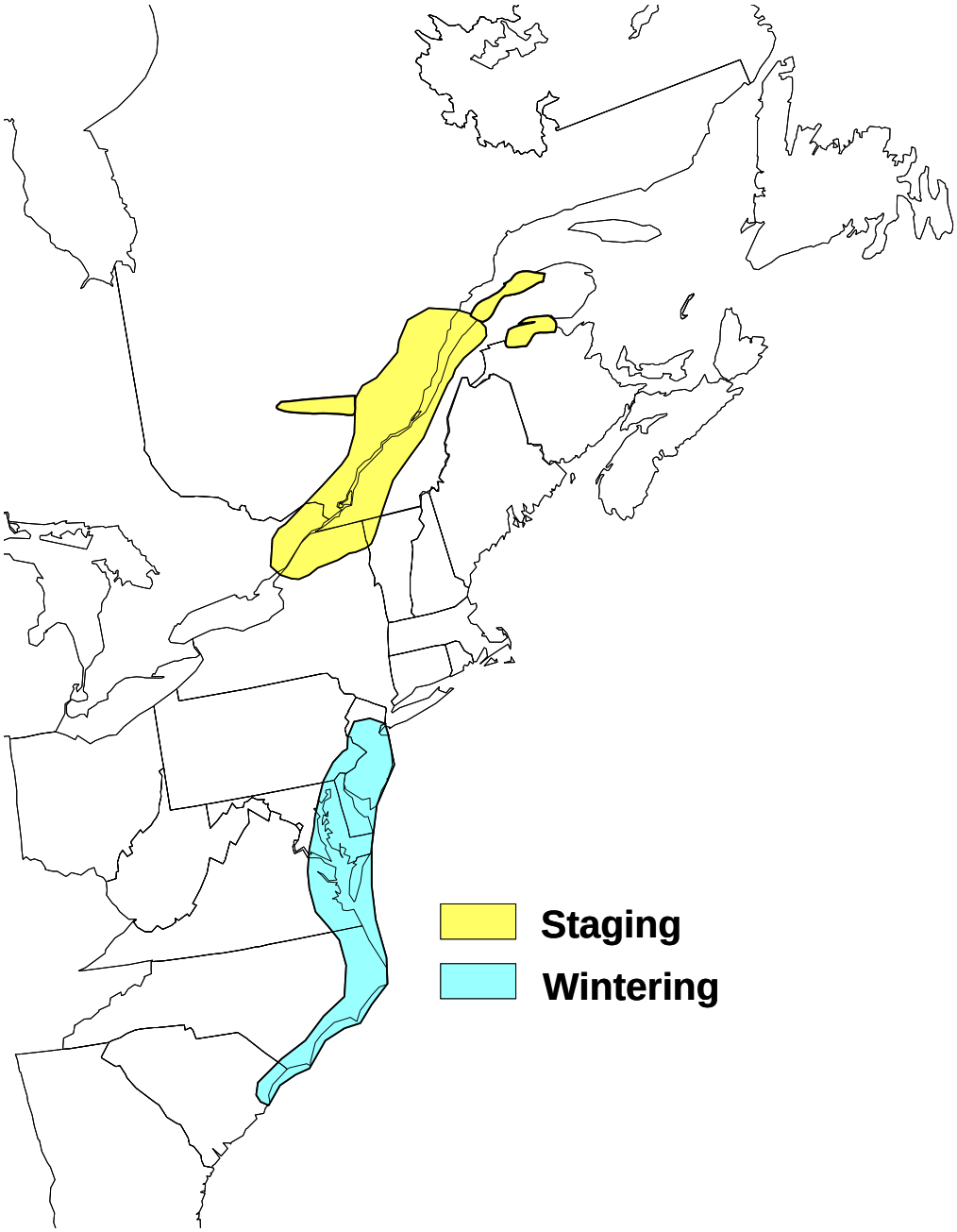

Fig. 2. Primary staging and wintering grounds of greater snow geese.

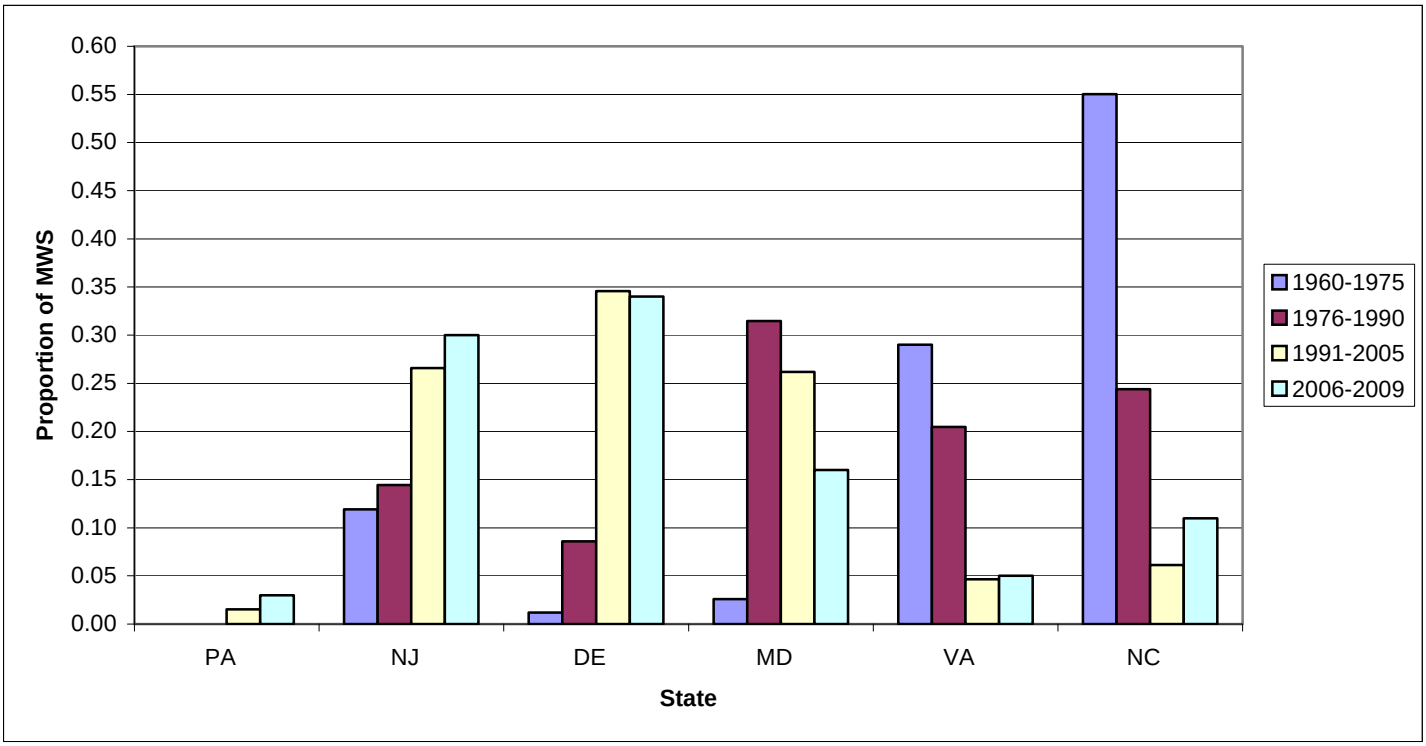

Fig. 3. Distribution of wintering greater snow geese in the Atlantic Flyway, 1960-2009.

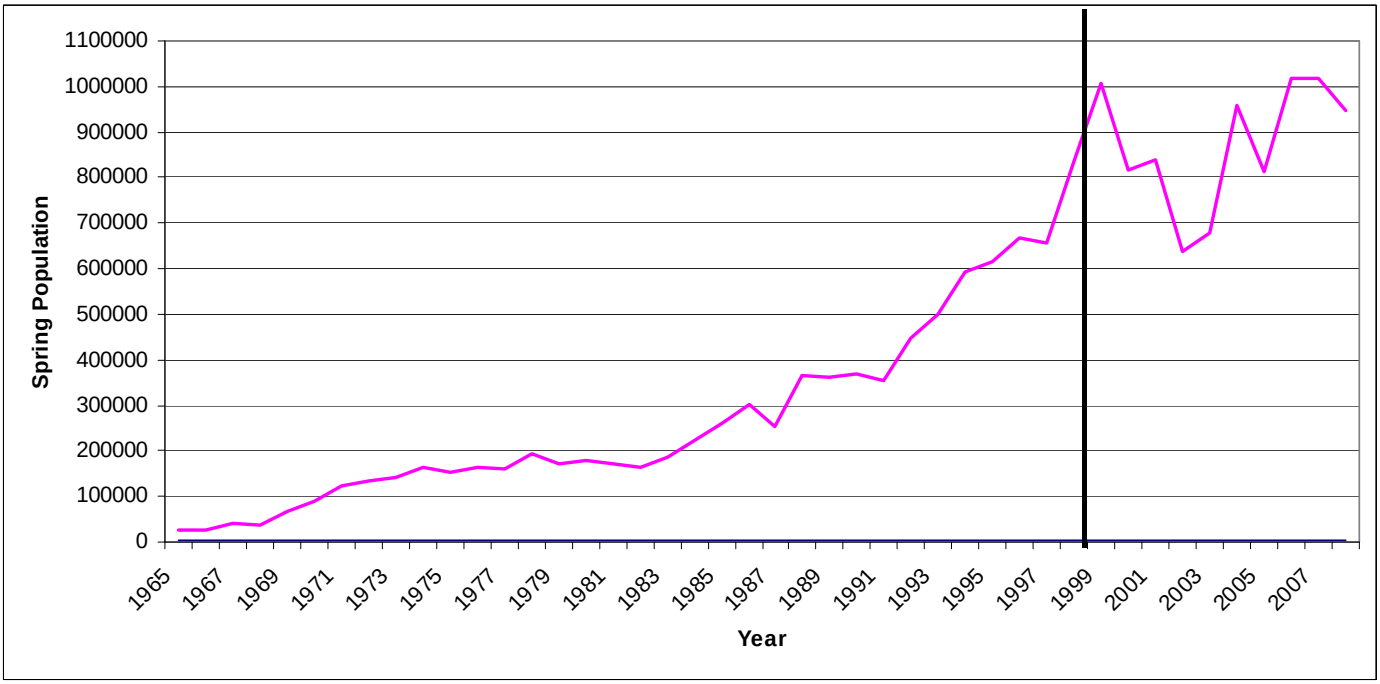

Fig. 4. Spring population estimates of greater snow geese, 1965-2008. Dark line denotes implementation of special measures in Canada.

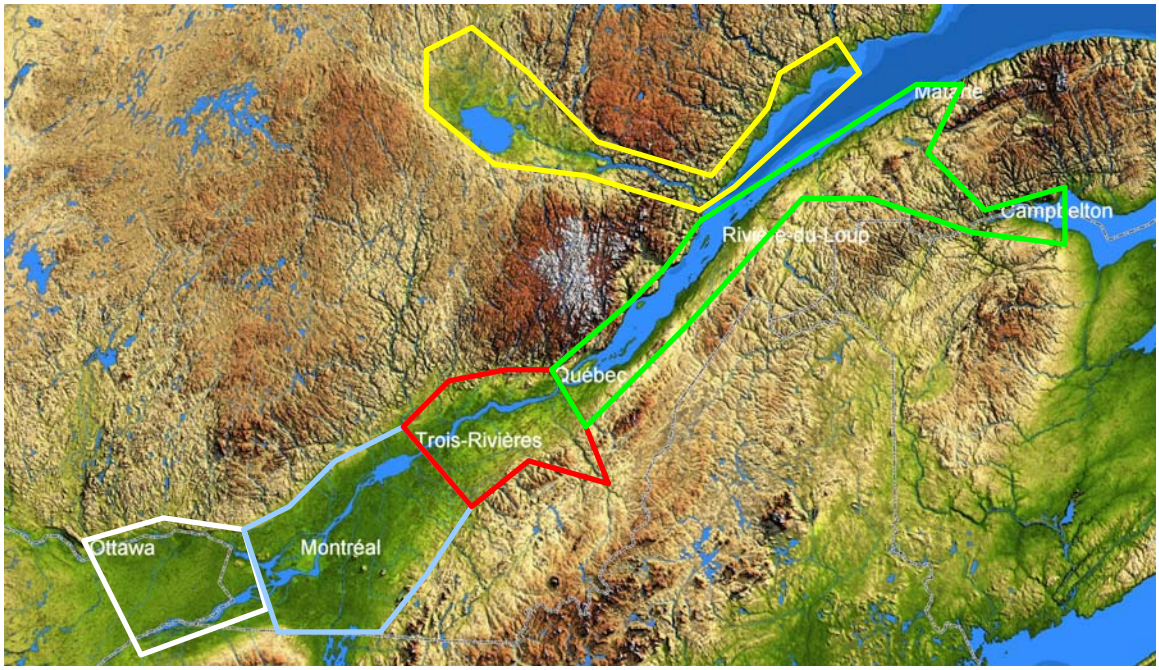

Fig. 5. Current aerial coverage of spring survey of greater snow geese in southern Quebec.

Table 1. Historic hunting regulations for greater snow geese, 1971-2008.

	Québec fall (south-central area)				Atlantic Flyway states winter			Québec spring			
Year[a]	Season length[b, c]	Daily bag	Possession[d]	Methods[e, f]	Season length	Daily bag	Possession	Season length	Daily bag	Possession	Methods[f]
1971	86	5			closed	-					
1972	86(41)	5			closed	-					
1973	109(41)	5			closed	-					
1974	100(34)	5			closed	-					
1975	100(33)	5			30	2	4				
1976	102(27)	5			30	2	4				
1977	102(30)	5			60	2	4				
1978	101(30)	5			70	2	4				
1979	96(30)	5			70	44	8				
1980	98	5	10		70	4	8				
1981	99	5	10		90	4	8				
1982	100	5	10		90	4	8				
1983	101	5	10		90	4	8				
1984	103	5	10		90	4	8				
1985	97	5	10		90	4	8				
1986	98	5	10		90	4	8				
1987	99	5	10		90	4	8				
1988	101	5	10		90	4	8				
1989	93	5	10		90	5	10				
1990	93	6	12		107	5	10				
1991	93	6	12		107	5	10				
1992	93	8	16		107	5	10				
1993	93	8	16	Sneaking prohibited	107	5	10				
1994	94	8	16	Sneaking prohibited	107	5	10				
1995	93	8	16	Sneaking prohibited	107	5	10				
1996	93	8	16	Sneaking prohibited	107	8	24				
1997	93	12	36	Sneaking prohibited	107	10	30				
1998	105	12	36	Sneaking prohibited	107	15	No limit	47	12	36	Calls, bait
1999	117	20	60	Calls, bait	107	15	No limit	47	20	60	Calls, bait
2000	117	20	60	Calls, bait	107	15	No limit	61	20	60	Calls, bait
2001	117	20	60	Calls, bait	107	15	No limit	61	20	60	Calls, bait
2002	117	20	60	Calls, bait	107	15	No limit	61	20	60	Calls, bait
2003	117	20	60	Calls, bait	107	15	No limit	61	20	60	Calls, bait
2004	117	20	60	Calls, bait	107	15	No limit	61	20	60	Calls, bait
2005	117	20	60	Calls, bait	107	15	No limit	61	20	60	Calls, bait
2006	117	20	60	Calls, bait	107	15	No limit	61	20	60	Calls, bait
2007	117	20	60	Calls, bait	107	15	No limit	61	20	60	Calls, bait
2008	117	20	60	Calls, bait	107	15	No limit	61	20	60	Calls, bait

a These years refer to the 12 months beginning during the reproductive season, i.e. "1980" is the period from summer 1980 to summer 1981.
b Season length from 1971 to 1979 refers to Quebec's Central District and Cap Tourmente (in parentheses)
c Seasons over 107 days (i.e. 1999-2002) were possible under special conservation measures only.
d Prior to 1992, total possession of snow and Canada geese combined was also limited, at limits higher than the numbers shown.
e Sneaking was prohibited in Québec from 1993-98 , forcing hunters to use blinds and decoys when hunting in fields.
f Baiting was only allowed under permit from the CWS Regional Director. In fall, this involved hunting in a bait crop field, and in spring, laying out bait.

Table 2. Greater snow goose harvest in the Atlantic Flyway, 1967-2006.

	QUÉBEC FALL		US STATES WINTER		QUÉBEC SPRING		ANNUAL TOTAL		
Year	Quebec Fall Adults	Quebec Fall Juveniles	AF Adults	AF Juveniles	Quebec Spring Adults	Quebec spring Juveniles	Total Adults	Total Juveniles	Total
1971	4,361	8,939					4,361	8,939	13,300
1972	5,304	796					5,304	796	6,100
1973	1,965	24,235					1,965	24,235	26,200
1974	5,389	3,611					5,389	3,611	9,000
1975	5,690	33,289					5,690	33,289	38,979
1976	12,763	16,336	9,098	3,002			21,860	19,339	41,199
1977	1,779	18,914	8,571	13,629			10,351	32,542	42,893
1978	10,160	33,121	12,108	7,992			22,268	41,113	63,381
1979	7,517	20,971	16,092	11,908			23,609	32,879	56,488
1980	13,273	58,138	9,647	17,653			22,920	75,791	98,711
1981	9,848	18,218	6,585	6,915			16,433	25,133	41,566
1982	10,503	31,825	12,191	9,509			22,694	41,334	64,028
1983	5,960	40,227	10,745	29,655			16,704	69,883	86,587
1984	12,089	36,024	17,327	20,273			29,416	56,297	85,713
1985	8,267	16,781	7,872	6,928			16,139	23,709	39,848
1986	8,204	2,872	7,607	1,293			15,811	4,165	19,976
1987	5,871	34,055	8,074	20,426			13,945	54,481	68,426
1988	11,165	34,611	7,867	15,733			19,032	50,344	69,376
1989	16,617	28,748	7,435	9,665			24,052	38,413	62,465
1990	22,427	39,022	12,647	8,853			35,074	47,875	82,949
1991	8,871	42,406	9,231	17,169			18,102	59,575	77,677
1992	20,890	6,685	9,123	1,277			30,013	7,962	37,975
1993	14,732	90,455	9,325	21,075			24,057	111,530	135,587
1994	27,114	14,641	10,173	7,427			37,287	22,068	59,355
1995	14,360	36,761	11,090	6,210			25,450	42,971	68,421
1996	18,510	51,086	20,194	11,106			38,703	62,193	100,896
1997	13,096	50,811	12,626	22,474			25,722	73,285	99,007
1998	31,754	71,763	43,320	67,580	27,607	16,564	102,681	155,907	258,588
1999	39,967	3,597	38,431	769	53,769	807	132,168	5,172	137,340
2000	37,303	71,996	17,636	27,864	37,976	11,794	92,915	111,654	204,569
2001	31,549	66,885	28,684	36,716	44,599	27,205	104,832	130,806	235,638
2002	34,829	13,758	30,941	8,354	22,169	466	87,940	22,577	110,517
2003	27,471	62,498	16,460	18,607	14,688	18,213	58,619	99,318	157,937
2004	35,838	30,570	15,650	15,897	27,027	7,567	78,515	54,034	132,549
2005	29,765	37,563	19,593	15,801	19,825	5,551	69,183	58,915	128,098
2006	31,631	43,303	21,354	11,365	16,738	9,541	69,723	64,209	133,932

Table 3. Greater snow goose productivity estimates, 1973-2008.

YEAR	QUÉBEC GROUND SURVEY				AF GROUND SURVEY	
	Proportion juveniles	Number of Geese	Brood size	Number of Broods	Proportion juveniles	
1973	40.6	800	2.94	49	41.1	4,900
1974	6.4	7,282	2.19	119	2	6,148
1975	31.2	17,579	2.71	1,294	37.3	11,460
1976	12.6	20,847	2.46	419	9.8	34,892
1977	23.9	10,297	2.28	396	23.8	7,531
1978	17.9	9,679	2.34	309	14.7	16,159
1979	28.2	20,849	2.65	1,226	23.2	8,041
1980	35.3	12,120	2.76	651	36.3	12,140
1981	16.3	10,683	2.30	229	17	17,229
1982	25.1	9,577	2.48	661	23.8	12,773
1983	47.4	12,353	2.86	1,246	48.9	19,206
1984	30.4	39,781	2.63	2,434	27.4	11,133
1985	25.8	33,700	2.49	1,682	31	14,972
1986	2.3	22,998	1.89	74	2.3	13,109
1987	40.2	33,278	2.77	1,882	37.9	17,467
1988	33.1	40,246	2.76	2,444	31.2	14,467
1989	31.1	29,191	2.59	2,014	30.1	17735
1990	23.6	20,313	2.54	830	17.2	24,439
1991	38.3	15,102	2.69	1,247	26.2	27,805
1992	5.4	32,252	2.06	404	4.5	10,501
1993	47.8	24,136	2.75	2,743	44.6	23,082
1994	9.2	16,444	2.44	242	13.4	19,726
1995	16.6	19,519	2.47	665	13.3	13,221
1996	25.1	22,595	2.34	1,247	30.5	23,728
1997	36.8	17,586	2.69	1,222	28.7	30,905
1998	33.1	17,982	2.52	1,440	26.5	43,321
1999	2.1	20,822	2.09	91	2.8	21,619
2000	22.7	26,492	2.54	1,302	34.6	25,022
2001	27.5	22,106	2.36	1,072	21.2	12,646
2002	6.0	18,930	1.91	274	2.8	20,444
2003	27.0	15,900	2.36	1,092	15.8	9,201
2004	17.8	26,206	2.44	1,031	21.1	33,748
2005	20.7	29,022	2.38	1,470	15.5	11,969
2006	19.7	23,338	2.34	1,143	27.1	8,823
2007	20.6	25,453	2.28	1,371	Discontinued in 2007	
2008	40.0	32,017	2.62	3,188		