Direct Control and Alternative Harvest Strategies for North American Light Geese

Report of the Direct Control and Alternative Harvest Measures Working Group

A Special Publication of the Arctic Goose Joint Venture of the North American Waterfowl Management Plan

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Edited by: Michael A. Johnson and C. Davison Ankney

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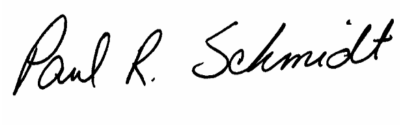
PREFACE

Areas of pristine tundra ecosystems and valuable coastal marshes in North America have been degraded, perhaps irreversibly, by unprecedented increases in numbers of lesser snow geese, Ross's geese, and greater snow geese (*Chen caerulescens caerulescens, C. rossii, and C. caerulescens atlantica, respectively);* collectively referred to as light geese. The Arctic Goose Joint Venture (AGJV) has been coordinating extensive scientific efforts to understand the impacts of light goose populations on their habitats, to publicize pertinent information, and to recommend appropriate solutions. Through a series of comprehensive reports (Batt 1997, Batt 1998, Moser 2001), the AGJV has brought the best available science to bear on these issues.

Regulatory agencies responsible for North American migratory bird conservation (U.S. Fish and Wildlife Service, Canadian Wildlife Service, and State and Provincial wildlife agencies), have implemented many measures to reduce the growth of problem-inducing light goose populations. However, wildlife science cannot determine with certainty that these measures will be adequate to reduce light goose populations to levels that will achieve the ultimate objective of ecosystem recovery. In light of this uncertainty, the AGJV requested a distinguished working group of biologists and managers to explore alternative strategies, beyond current hunting practices and habitat management that could be implemented should ongoing management actions eventually prove inadequate to stem large-scale habitat loss.

This report represents the work of that working group's thoughtful examination of measures of "last resort." It provides valuable insight into an arena where wildlife science has rarely gone – the intentional reduction of native migratory bird population levels. The AGJV and those on this working group believe that the current population reduction measures can be successful, and hope that these remedies will never be required. But we also believe the management community must accept responsibility and understand alternatives as we pursue resolution of this human-induced ecological dilemma. This working group examined the practical side of implementing direct control measures; the social acceptability of these measures will need to be evaluated before implementation is ever pursued.

Throughout this entire process, the AGJV and regulatory agencies have held the premise that light geese are highly valued components of our ecosystems and wildlife heritage. We still hold that premise, and continue to seek solutions that will restore degraded habitats and all endemic flora and fauna. The next few years will tell if our cumulative efforts can negate the need to consider any of the "measures of last resort" described in the following pages. The AGJV and the working group conclude that this report is a calling for all to sustain or increase their efforts to reduce light goose populations with current methodologies, and to restore ecological integrity to impacted habitats.

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EXECUTIVE SUMMARY

It has become increasingly common for wildlife populations to increase to levels where they adversely affect their own habitat, that of other wildlife species, the economic interests of people and/or human health and safety. Some populations of lesser snow geese (*Anser caerulescens caerulescens*), Ross's geese (*Anser rossii*), and greater snow geese (*Anser caerulescens atlantica*), collectively referred to as light geese, have increased dramatically over the last thirty years. These increases are attributed to high adult and juvenile survival rates related to their increased use of agricultural foods on migration and wintering areas.

These growing populations are causing destruction of breeding and migration habitats of lesser snow geese and Ross's geese and winter and migration habitats of greater snow geese. Despite many significant actions taken to increase the harvest of light geese, it is unknown yet if these have affected light goose survival rates and more importantly, population size. Furthermore, it is not known whether hunters can harvest sufficient numbers of geese to reduce population size and then maintain populations at the desired level. Because of this uncertainty, the Arctic Goose Joint Venture (AGJV) undertook to explore other ways to reduce light goose numbers if hunter harvest does not reduce populations to desired levels. This report is the product of that effort.

The Direct Control and Alternative Harvest Measures Working Group, formed by the AGJV, was charged to examine potential direct control techniques (i.e. beyond conventional hunting practices) for reducing light goose populations and to assess the biological and economic constraints and opportunities associated with the use of direct control techniques. We defined direct control as the purposeful removal of large numbers of birds from a target population over a short period of time.

The Working Group considered all techniques that had the potential to directly control light (snow/Ross's) goose populations. We used the best available science and expertise to find one or more humane methods for killing many light geese in a short time in a way that maximized subsequent use of the birds or, at least, minimized waste of the birds and had minimal negative impacts on other wildlife.

This report consists of 6 parts plus the introduction and background chapter. Chapters address alternative harvest strategies, direct control methods in the Arctic, direct control methods on migration and wintering areas, potential chemicals for controlling light geese, processing and using geese for human food and other products and a chapter with an overall discussion and conclusions. These chapters are summarized below:

Alternative strategies to increase light goose harvest in the United States and Canada

This section examines potentials for light goose population control by hunters and by wildlife agencies beyond actions that are currently in place. Increasing light goose harvest beyond what has already been done will be difficult, but not impossible. Several factors affecting the harvest of light geese are examined including: declining numbers of hunters, legislative and administrative regulations, access to land and to geese, changes in goose behavior, costs, experience, knowledge and skills of hunters, conflicts with local governments and landowners, gun control, and the ability of hunters to legally use a large number of harvested geese.

Increasing the harvest of light geese by hunters may require several different but related general strategies: increasing the number of hunters that pursue light geese; increasing the number of days that hunters pursue light geese; and/or increasing the effectiveness or success of individual hunters in bagging birds.

Specific strategies for increasing light goose harvest include changes or improvements in (1) hunting methods – live decoys, baiting, shooting at night, electronic calls, methods of concealment, hazing and rallying in the spring, herding with model airplanes, (2) firearm restrictions – shotgun gauge restrictions, hunting with rifles, firearm sound suppression, (3) refuge management, (4) information and education programs to increase hunter success, (5) private land access, (6) requirements and opportunities for disposition of birds, and (7) awards, bounties and financial incentives.

If current actions aimed at reducing light goose numbers are not successful, agencies could consider one or more of the above strategies to increase light goose harvest. There appears to be no single strategy with the potential to substantially reduce light goose numbers. Thus, agencies may need to consider a number of actions working collectively to increase light goose mortality and thus reduce populations to the desired level.

Direct control methods for population reduction of light geese in the Arctic

Reduction of adult survival is the most efficient means to reduce population growth in long-lived species. In this section, we address the effectiveness for population reduction of light geese by removing adults from Arctic nesting and breeding areas. We assume that effects of Arctic harvest would be additive to harvest of adults during regular fall seasons, conservation measures in the United States and Canada, and any aboriginal harvest. Although intended to demonstrate how harvest might be adjusted to produce desired population trajectories of lesser snow geese (LSG), adjustments in vital rates, logistical considerations, and cost estimates could be made to model harvest of Ross's geese and greater snow geese.

Arctic breeding colonies, although remote, provide the only place where light geese are relatively sedentary and isolated by species, colony, age, and sex. Nesting pairs of geese are discernible from groups of immature and non-breeders making selective harvest possible. Adult females and males also can be removed during the summer wing molt, when mass capture is possible.

Simple deterministic population models are used to evaluate the effect of various harvest scenarios on a colony-specific basis. For instance, with a harvest of 50,000 adults from a hypothetical colony of 100,000 nesting snow geese, 2 years are required for elimination of local nesting, regardless of the sex ratio of the harvest. For populations of 250,000 breeders any annual harvest >100,000 resulted in elimination of local nesting within 4 years. However, greater variability exists for colonies >250,000, with local elimination of nesting within 10 years dependent on size of the annual harvest. Population trajectories for a variety of colony sizes and annual harvest levels are provided to assess rates of decline and population growth following termination of harvest. Population dynamics examining reduced survival of juveniles and nonbreeders during and outside the breeding period are also considered.

The logistics and costs of shooting nesting adults and helicopter-assisted mass capture of adults and goslings during brood-rearing are assessed. In both instances, estimates of harvest efficiency, in terms of numbers of geese that can be killed per day and at what cost, are highly variable. The mid-continent LSG population breeds primarily in the central and eastern Arctic with colonies occurring at various distances from communities with available personnel, aircraft, and fuel. Consequently, costs associated with population reduction are largely a function of geography. Also variable, in terms of efficiency and cost, are options for disposition of harvested geese. These range from complete removal, where all birds are transported back to the nearest community, to leaving the carcasses on site.

Harvest of 50,000 nesting geese from a colony is estimated to range in cost from $55,000 to $158,000 (1999 Canadian dollars), plus capital costs associated with the initial setup of field camps. Increasing the harvest to 100,000 birds essentially doubles the cost estimate. Harvest of mass-captured LSG during the brood-rearing period is comparable in cost to harvest during nesting and shown to be less efficient because of inclusion of goslings in the total harvest. If complete removal of harvested geese from a site is desired, the cost estimate is increased by 5 or 6 fold.

Large-scale harvest of LSG from Arctic regions is possible, but very expensive. However, implementation of any harvest program designed to reduce mid-continent LSG populations and arrest damage to Arctic vegetation should not proceed without a complementary evaluation program. Such a program could provide an experimental framework for measuring the cost efficiency and biological effectiveness of Arctic harvest, as well as an opportunity to learn about population response to large-scale management.

Trapping and shooting light geese on migration and wintering areas

Live capture of light geese for direct population control is desirable for several reasons including (1) birds could be processed like domestic fowl, producing food of the highest possible quality for human consumption (although some birds will contain previously embedded shot), (2) birds would be captured alive and there would be complete control over the sex and age of birds to be killed, and (3) loss of non-target species would be minimized. Rocket netting has been the only proven measure of live capturing light geese, although other potential methods for capturing light geese are presented herein. However, failure of light geese to readily respond to bait makes live capture of 50,000-250,000 birds a daunting proposition. Consequently, it is important that research on the feasibility and effectiveness of capturing light geese via rocket nets and other methods on migration and wintering areas be considered. Other methods of direct population control presented include contractual hunting and remotely detonated shot-charge devices. Our review indicates that contractual hunting would lead to competition between contractual and public hunters, and, consequently, to dissatisfaction among public hunters. Remotely detonated shot-charge devices including punt-guns, shotgun batteries, and other devices that essentially function as large shotguns have great potential for rapidly achieving population-reduction goals during migration and winter. If live capture of light geese via rocket nets or other means proves unfeasible or ineffective, our review indicates that this alternative be given priority consideration in the event that direct population control on migration and wintering areas becomes necessary. Preliminary assessment of public opinion to various approaches, given that direct population control becomes necessary, would help guide future management decisions.

Potential chemicals to manage light goose populations

There are various management strategies that could potentially be used to manage over-abundant light goose populations on breeding and wintering areas and along migration routes. One approach that could potentially affect thousands of light geese in a relatively short time period is the use of chemical avicides at key staging areas on migration routes. Currently, there are three registered avicides that could potentially be modified and used for light goose population management: 3-chloro-4-methyl benzenamine HCl (Denver Research Center (DRC)-1339), 4-aminopyridine (Avitrol) and alpha chloralose (AC). The selectivity of these chemicals for light geese could be enhanced by: (1) pre-baiting with untreated bait and ensuring that light geese are the only species taking the baits, (2) using baits that are most preferred by light geese, (3) using the minimal concentration of chemical to cause mortality, and (4) applying baits to prime feeding locations. The use of these chemicals would be most effective at staging areas on wintering areas and along migration routes. The logistics and manpower to locate and bait light goose staging areas (wintering areas and migration routes) that would result in removal of 50,000 or 250,000 light geese would cost from $2.82 to $2.96/goose for Avitrol and DRC-1339, and $8.34/goose for AC. Discussions need to focus on what research is needed to effectively use one of the potential chemicals, and where and when chemical management of light geese would be most effective and socially acceptable.

Factors affecting the use of these avicides for light goose management are registration issues, environmental factors, non-target and/or threatened and endangered species, animal welfare concerns and bait acceptance

Human food, processing, marketing, food programs and other products

Managers and others have stressed the desire and importance of using geese taken to control population numbers. Geese taken by direct control methods could be used for human food, food for animals that provide human food, food for other domestic animals, other uses that benefit humans or could be recycled into the environment. However, making use of large numbers of geese taken by direct control methods presents problems different than those in making use of geese taken by hunters. The nature of the possible direct control techniques, numbers of birds involved, and location where birds are captured or killed could make it difficult to use birds for human consumption or other purposes. Direct control actions may not be conducive to easy retrieval of birds, transporting them to processing facilities, or in converting carcasses to safe and palatable human food. Although uses of light geese for purposes other than human food are also possible, there are legal and logistical issues that must be addressed before that can be done.

There are two potential sources of geese: (1) from alternative harvest strategies or (2) from direct control strategies. Also, there are two general geographic areas and time periods where these actions could take place: (1) Arctic breeding grounds in spring and summer and (2) wintering and migration areas in fall, winter and spring. In each location and time period, birds could be obtained through killing by shooting or some other technique, such as chemicals, or by live capture. Each strategy or technique and each geographic location and time period presents unique challenges, opportunities and difficulties, both in taking and in attempting to make use of the birds.

Every year hunters take large numbers of light geese throughout their range. These birds are shot, retrieved, processed and consumed by the hunter or associates. Light geese have higher protein (22.7%) and less fat (3.6%) than beef and pork. An estimated 1.5 million light geese taken in 1999-2000 yielded a potential 2.4 million pounds of lean edible meat for U.S. and Canadian citizens. This does not include the "subsistence" harvest in the far north.

There are no state or federal laws that require consumption of harvested migratory birds, only their retrieval. Some states or provinces require retention of parts such as legs and wings in addition to breast meat. Hunters may give away birds – but laws of possession, tagging, identification and gifting can be complex and confusing. Developing suitable outlets for hunters to donate birds for human food (e.g. Hunters for the Hungry) could facilitate additional harvest.

Birds shot or captured flightless could be processed for human or animal food in the Arctic. However this would be very difficult and expensive. On migration and wintering areas, converting large numbers of birds to human food would be much easier and cheaper. The food potentials are heavily dependent on whether the birds are killed or captured alive. Birds taken in either the far north or on migration and wintering areas could not be sold, but could be donated as whole birds or processed carcasses or meat products to charitable individuals or organizations. Birds taken by chemicals are not likely to be used for human food even if allowed under label restrictions.

Research should be considered to test the feasibility of commercial processing of both live captured and dead light geese. Additional work on portable processing facilities would also be useful. Investigations into the potential of using light geese in food donation programs should also be considered.

Discussion and conclusions

Increased harvest by hunters is the most desirable solution to the problem of any overabundant goose population. However, many hunters already harvest as many light geese as they can either consume or readily give to others. Consequently, it is suggested that government agencies could do much more to 1) make it easier for hunters to provide harvested birds to individuals and groups (e.g., foodbanks) who want them for food, and 2) enable hunters to legally process birds (e.g., as sausage or other meat products) and then transport or ship or transfer possession of them. If, subsequent to such government actions to facilitate increased hunter harvest, light goose populations remain overabundant, then further action would be necessary to solve the problem. Such action could include direct control (i.e., killing large numbers of birds in a short time) on Arctic breeding areas and/or on staging and wintering areas.

Capturing and killing large numbers of light geese could be done most easily on Arctic breeding areas, but this strategy also presents, by far, the most difficulty in transporting and processing birds for human food or other uses. Killing geese at Arctic breeding colonies would, however, allow the numbers killed to be directly related to colony size and to severity of habitat destruction. Overall, it would be easiest to directly kill, collect, transport and process geese on migration and winter areas, but this approach could involve the greatest "social resistance."

This Report does not attempt to determine how much wildlife agencies might be willing to spend in time, effort and dollars to ensure that birds killed for population reduction are used for food or other purposes. Further, the Report does not attempt to assign real dollar estimates to these costs because data are unavailable for most of the steps that are required to convert a live goose in the wild into a processed goose in storage. Relatively, however, the costs would be far higher in Arctic as opposed to non-Arctic areas.

Ultimately, the fate of light goose populations and their habitats lies in the hands of wildlife managers and the citizens of the United States and Canada. Appropriate management actions, beyond those currently underway, may need to be considered to prevent an ecological disaster. How this may best be accomplished will be a very difficult decision and could involve high costs. Management agencies should carefully consider the findings in this report, consider initiating tests and recommended research and begin planning for additional harvest measures should they become necessary. Increasing harvest by hunters is the most appropriate first step and hunter harvest should be continued in addition to any other strategies that may be employed. Any implementation plan must include evaluation strategies to measure its effectiveness in reducing light goose populations and their impacts to Arctic habitats.

Part I

INTRODUCTION AND BACKGROUND

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It has become increasingly common for wildlife populations to increase to levels that result in them adversely affecting their own habitat, that of other wildlife species, the economic interests of people and/or human health and safety. There are two main causes for this phenomenon. First, society has demanded that all native wildlife receive protection from persecution and, for harvested species, from over-harvest. Second, more and more species have adapted to and benefited from widespread habitat alterations, especially due to agriculture, that have occurred in North America. Consequently, wildlife managers have been charged with dealing with such "over-populations." This has frequently involved using techniques of direct control, i.e., the killing of animals by wildlife agency employees and their agents. Direct control has been used for hunted species, when increased harvest has proved insufficient and/or unfeasible, and for non-hunted species. Examples of direct control of wildlife populations are abundant and include species such as elk (*Cervus elaphus)*(Houston 1982), white-tailed deer (*Odocoileus virginianus*)(Stradtmann et al. 1995 and DeNicola et al. 1997), beaver (*Castor canadensis*)(Mastrangelo 1995), wolves (*Canis lupus*)(Boertje et al. 1996), coyotes (*Canis latrans*)(Knowlton et al. 1999), blackbirds (*Icterus spp.)*(White et al. 1985, Heisterberg et al. 1990, and Cummings et al. 1992), brown-headed cowbirds (*Molothrus ater*) (Kelly and DeCapita 1982), gulls (*Larus spp*.)(Dolbeer et al. 1993), double-crested cormorants (*Phalacrocorax auritus*)(Belant et al. 2000), Canada geese (*Branta canadensis*) (Cooper and Keefe 1997) and many other native and non-native fish and wildlife species.

Some populations of lesser snow geese (*Anser caerulescens caerulescens*), Ross's geese (*Anser rossii*), and greater snow geese (*Anser caerulescens atlantica*), collectively referred to as light geese, have increased dramatically over the last 30 years. These increases are attributed to high adult and juvenile annual survival rates related to increased use of agricultural foods by geese on migration and wintering areas (Ankney 1996 and Batt 1997). Although all demographic variables have benefited from the nutrient subsidy, the increase in population growth rate is due primarily to the increase in adult survival, which is augmented by reduced harvest rates (Rockwell et al. 1997). These growing populations are causing destruction of Arctic breeding and migration habitats of lesser snow geese and Ross's geese (Abraham and Jefferies 1997) and winter and migration habitats of greater snow geese (Batt 1998).

Despite a number of significant actions taken to increase the harvest of light geese, their impact on light goose survival and, ultimately, population size is yet unknown. While there is reason to hope that existing actions may reduce and stabilize populations, additional strategies designed to further increase harvest may be needed. This report examines alternative population control strategies and their potential to reduce light goose populations. Managers need to consider carefully both the potential and impacts of additional hunting and direct control strategies to increase the kill of light geese. While some actions may seem extreme, it may be helpful to remember that such actions would be considered only after other strategies, such as expanded hunting opportunities, have been attempted and found to be inadequate for achieving population and habitat goals. It is also important to note that population response to any management action will be closely monitored by wildlife agencies.

Thus, any direct control actions would be a management strategy of nearly "the last resort." The primary purpose of more extreme actions would be to reduce light goose populations and prevent further loss of Arctic ecosystems, which could require generations to recover (Batt 1997). Of nearly equal importance, reduction of light goose populations would reduce impacts to other migratory birds and their habitats throughout North America. These additional strategies must be viewed as additive measures, which could be implemented in concert with other direct control measures and possible indirect population control and habitat management actions, to contribute to reducing light goose populations and conserving Arctic ecosystems.

We defined direct control (direct population management) as the purposeful removal of large numbers of birds from a target population over a short period of time. Direct control most likely would be conducted by federal, state and/or provincial wildlife agencies or under the direction of such agencies. These additional measures could take the form of direct action by wildlife agencies or hunters could be engaged to take additional harvest. To be effective, it may be necessary to use combinations of strategies (both direct control actions and increased hunter harvest actions) to increase mortality over large geographic areas at different times of the year.

Direct Control is not a “cull”, defined as “to identify and remove ...something rejected esp. as being inferior or worthless” (Webster’s Ninth New Collegiate Dictionary, 1989). We find nothing “inferior or worthless” about light geese. In fact, light geese are a highly valued resource of significant importance to citizens all across North America. Rather than removing inferior birds, direct control activities would be most efficient if directed at the highest quality or most productive portions of the population (Batt 1997). The purposes of such removal would not be to improve the overall quality of the remaining population, but to reduce its numbers to a level more appropriate to the ecological resources available to support it at a sustained level.

Management strategies presented by the various authors in this report could be applied to any population of light geese, but information presented applies most directly to the following light geese: Mid-continent population of lesser snow geese, Ross’s Geese, West Central Flyway population of snow geese and greater snow geese. Western Canadian Arctic Light Geese are not considered over-abundant at this time. These populations are defined in Kelley (2001).

BACKGROUND

The overabundance of light geese in North America has been addressed by the AGJV in three reports. The first of these entitled “Arctic Ecosystems in Peril” (Batt 1997) was produced by the Arctic Goose Habitat Working Group (AGHWG) of the AGJV. This study examined available information on all light geese, but its primary focus was on the Mid-continent Population of lesser snow geese. This report concluded that:

> 1. Over-abundance of several populations of Arctic-nesting geese in North America is causing serious and extensive damage to Arctic habitats used by geese and other wildlife. In some cases this goes beyond a simple "habitat problem" and is more on the scale of an "ecosystem in peril".

2. A "trophic cascade" of events, resulting from over-grazing and grubbing by some Arctic geese, creates soil salinity and moisture conditions that lead to desertification of affected Arctic landscapes. These habitats will not likely regain their original plant communities for many decades, if ever. The most degraded of these habitats may never recover.

3. This habitat damage is increasing in extent and probably will not be checked or reversed by any known natural phenomena. We cannot forecast how long it will be before most of the finite supply of habitat that is available for nesting by tundra- and coastal-breeding birds, will be permanently degraded or destroyed. However, destruction is progressing at a rapid rate with the habitats of several major breeding colonies of mid-continent lesser snow geese showing extensive signs of permanent degradation.

4. Habitats used by mid-continent light geese are in particular jeopardy. The degradation is such that recruitment rates at several large nesting colonies have declined. In the near-term, however, such declines will not likely bring those colonies or the entire mid-continent population under control through density-dependent regulation (i.e. reduced reproductive rates as population densities increase). The reason is that as nesting and, especially, brood rearing habitat declines, many, if not most, families simply disperse to adjacent areas that are not yet degraded. Recruitment for dispersing families is higher and the geographically larger colony grows in number and continues to spread further. At the same time, geese which do not disperse continue to reproduce, although at a much lower rate, and exert enough grazing pressure to prevent vegetative recovery. It is unknown for how long or over what geographic range this expanding cycle of local growth, degradation and dispersal can or will continue.

In addition to the destruction of Arctic habitats by breeding geese, large numbers of northward migrating light geese exert tremendous grazing pressure on any exposed vegetation in the early spring. This annual grubbing and uprooting of vegetation contributes significantly to the trophic cascade of vegetative destruction (Abraham and Jefferies 1997).

More importantly, high adult survival rates (exceeding 0.9) result in population increases, even with recruitment rates as low as 0.1 and only half of the females breeding annually (R. Rockwell, personal communication). Thus, if adult survival is not reduced, populations will continue to grow despite density dependent effects that depress reproduction.

5. There appears to be only two ultimate outcomes if management agencies choose to do nothing about dealing with these problems: first the population could decline dramatically (crash) after recruitment rates fall to the level where they could not maintain numbers in the face of mortality from all hunting and non-hunting causes, especially those related to senescence of surviving adults. If this were to occur, we believe the recovery of populations from such a decline might be protracted over several decades because the habitat to support population recovery would be extremely limited. Alternatively, the population could remain at relatively high levels, continuing to grow for many years, with geese in ever-declining physiological condition concurrent with the ultimate destruction of a major component of the Arctic ecosystem that is important not only to light geese, but also to other geese and a wide variety of migrant and resident vertebrates. Problems with light geese and agriculture in southern areas would likely

increase. Besides the ecosystem consequences, continued population growth could lead to large populations of poorly conditioned birds, increased starvation of goslings and prevalence of stress-induced disease.

6. Natural resource managers, charged with the long-term welfare of these populations and their habitats, have responsibility for implementing management programs to prevent the future ecological disaster. A time-frame for the occurrence of widespread ecosystem breakdown is not readily apparent, because there has been no directly related "real world" experience for managers and scientists by which to make such projections. However, the process has already begun, it is expanding and damage to the most severely degraded habitat may be essentially permanent.

7. The most effective population reduction efforts will focus on reducing adult survival as this is the prime factor sustaining growth of these populations (Rockwell et al. 1997).

8. No single technique will solve these problems. Multifaceted and multi-agency approaches are required. Most of these will require actions beyond normal waterfowl harvest management frameworks.

Among a series of recommendations in the report, it was recommended that "...responsible public agencies in Canada and the United States should implement proactive population reduction measures to reduce mid-continent light goose populations to a level of about 50% of current numbers by the year 2005." It was estimated that harvest rate would have to be increased to about 3 times the level in 1997 to achieve this level of population reduction.

Following completion of the Arctic Ecosystems in Peril report, a second working committee within the AGHWG was formed to examine the issue of overabundant greater snow geese. The Greater Snow Goose Report (Batt 1998) concluded:

1. Under current management strategies the greater snow goose population will soon exceed 1 million birds and continue to double every eight years.

2. Expansion of greater snow geese into new habitats has not kept pace with increases in the population in some portions of the range.

3. Greater snow goose populations have reached carrying capacity in some marshes within staging and wintering areas and could exceed it in Arctic breeding areas in the near future under current management. This may be detrimental to the snow geese themselves and to other wildlife with which they share these habitats.

4. Increasing numbers of greater snow geese feeding in agricultural fields causes economic losses for farmers and will increasingly interfere with wildlife management programs for other species.

Further, AGHWG in their report recommended that the population be stabilized by 2002 at a population level of 1 million or less. With a 9% annual increase in population size, they recommended management actions be implemented to stop growth of the greater snow goose population by 2002. This included increasing hunting mortality by 75 percent. They also recommended that the carrying capacity of the spring staging grounds be estimated, especially along the St. Lawrence estuary where crop depredation is important. Finally, they recommended the carrying capacity of wintering salt marshes should be evaluated and that these estimates should be determined during the period of population stabilization. The lowest carrying capacity estimates among the three habitats should then guide the establishment of the target population.

If the spring population is permitted to become greater than 1,000,000 birds, the AGHWG believed that adverse ecological effects would be an inevitable result and that population control would be increasingly difficult. Therefore they pointed out that it was imperative to initiate the proposed measures as soon as possible. They also pointed to the need to investigate management strategies beyond simply increasing the harvest by hunters and stated: **"... that hunters alone may not be able to control greater snow goose numbers, other methods to increase mortality and decrease productivity of adult geese should be simultaneously explored."**

Suggested strategies in the report included:

1. Implement a greater snow goose communication program.

2. Increase the interest and effectiveness of recreational snow goose hunters.

3. Promote and facilitate subsistence harvest.

4. Initiate conservation hunts that utilize hunting periods and techniques distinct from traditional recreational hunting.

5. Manage snow goose use of public and private lands to increase hunter success, minimize impacts of natural wintering and staging habitats and reduce agricultural depredation.

6. Explore the feasibility, logistics and effectiveness of non-traditional means to reduce numbers of snow geese.

The Ross's goose subcommittee of the Arctic Goose Joint Venture authored a third report compiling information on Ross's geese. Their report (Moser 2001) compiles findings that summarize the abundance and distribution, harvest information, population dynamics, interactions with habitats, and disease issues for Ross's geese. They documented expansion in Ross's goose numbers and breeding and wintering ranges and concluded that Ross's geese were impacting habitats in the Queen Maud Gulf Migratory Bird Sanctuary and the west Hudson Bay Lowlands. They also pointed to the ability of Ross's geese to closely crop above-ground vegetation that may delay or prevent the recovery of tundra vegetation already impacted by snow geese. Ross's goose population growth rates were estimated at 8 to 10 percent per year. Models predicted that the continental population of Ross's geese would remain above North American Waterfowl Management Plan and the Pacific Flyway Council goals even under sustained implementation of new harvest provisions. Ross's geese are likely carriers of avian cholera and increased numbers of Ross's geese contribute to the density and crowding associated with cholera events. They urged the continued estimation of survival and recruitment of Ross's geese to evaluate effects of increased harvest.

MANAGEMENT OF MID-CONTINENT LIGHT GEESE

Strong recommendations were made by the AGHWG to reduce mid-continent light geese through increased hunter harvest. These recommendations were based on an analysis by Johnson (1997) that proposed the following 14 strategy classifications for "Population Control by Hunters:"

A. Spring Harvest by Shooting

B. Late Season Hunting

C. Hunting Methods

D. Subsistence Harvest in the Far North

E. Egging

F. Provide Additional Hunting on State, Provincial and Federal Refuges

G. Award Programs

H. Reciprocal, International or Inter-state/Provincial Snow Goose Hunting Licenses

I. Improved Access for Hunting on Private Land

J. Subsidize Hunting

K. Bag Limits and Possession Limits

L. Shooting Hours

M. Nonresident Hunter Quotas, Day and Zone Restrictions

N. Information and Education Programs

These management strategies were proposed as ways to increase the harvest of light geese by increasing or promoting harvest opportunities, and/or removing restrictions that hinder or limit the take by individual migratory game bird hunters. This list of strategies was developed through consultation with waterfowl managers and the Flyway Councils. It included only those items thought to be “implementable” and that had the potential to increase light goose mortality. Not included in this list were strategies that would be more difficult to implement because of legal, administrative, political or logistical hurdles or that did not meet the guiding principle that any birds taken be used as food (Batt 1997). Under a scenario where direct control might be considered, management strategies that go beyond the list above would be required.

Since work began on the "Arctic Ecosystems in Peril" report, a number of management strategies and research activities have been implemented in the United States and Canada to reduce light goose numbers. These include:

- Regular hunting season frameworks were extended to March 10, the latest date allowed under the Migratory Bird Treaty[1].
- Bag and possession limits were increased.
- A research project was conducted to evaluate the effectiveness of electronic calls for increasing harvest of light geese (Olson and Afton 2000).
- Caswell and Afton conducted a study of the impacts on non-target species from the use of electronic snow goose calls during the regular season in Canada (Caswell 2001).
- New methods of take (electronic calls and unplugged shotguns) for hunting light geese were implemented during the regular hunting seasons in 8 states in 1998-99, 3 states in 1999-2000, and 1 state in 2000-2001 (Table 1).
- Special harvest opportunities outside the hunting season for light geese were implemented in 5 Mississippi Flyway states, 5 Central Flyway states and in Quebec and Manitoba in spring 1999; in 9 Mississippi Flyway states, 8 Central Flyway states and in Quebec and Manitoba in spring 2000; in 9 Mississippi Flyway states, 9 Central Flyway states and in Nunavut, Manitoba, Quebec and Saskatchewan in springs 2001 and 2002 (Table 2).
- Hunting was permitted until one-half hour after sunset during the Conservation Order in the United States.
- Restrictions on nonresident waterfowl hunters have been eased in some jurisdictions.
- Efforts have been made to increase subsistence take by northern residents (Bromley et al. 1997).
- Hunting restrictions have been eased on some state and federal refuges.
- Habitat management on NWRs has been altered to reduce benefits to light geese.
- Increased efforts to inform hunters about effects of over abundant light geese and to provide information to help increase their hunting success.
- Increased efforts to help hunters learn how to use harvested birds for food (Knudson, no date).

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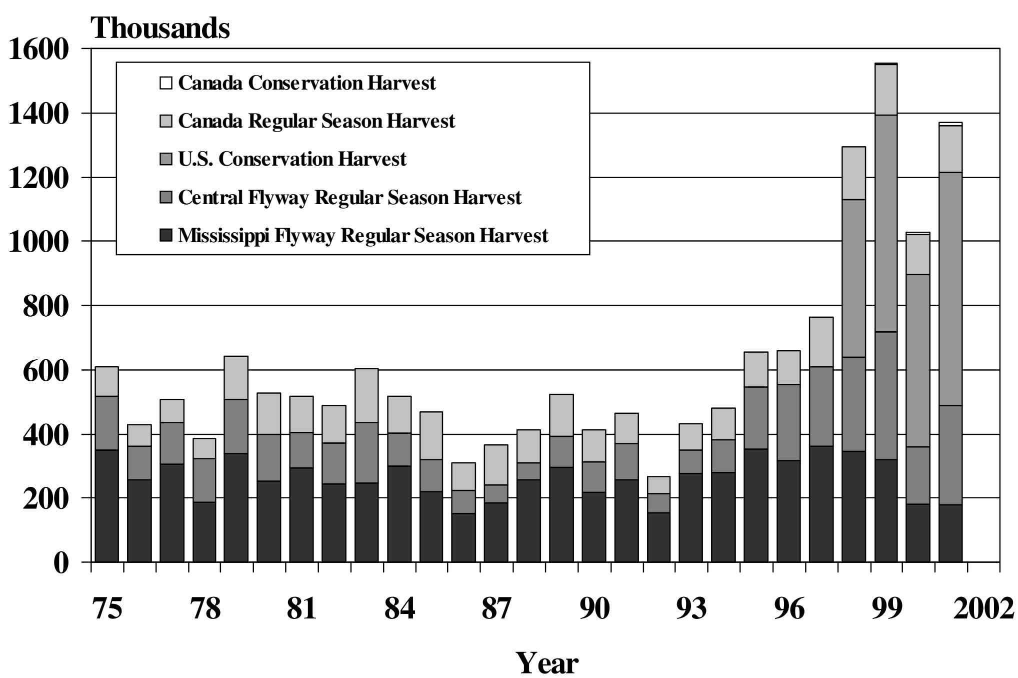
[1] The international treaty between the U.S. and Great Britain (for Canada) was signed in 1916 and amended in 1999 by the governments of Canada and the U.S. This agreement is termed the Migratory Bird Convention in Canada and the Migratory Bird Treaty in the U.S. For simplicity, this agreement is referred to as the “Migratory Bird Treaty” or “Treaty” throughout this and all parts of this report.

These management strategies coupled with an increased hunting effort by waterfowl hunters have significantly increased harvest of light geese in both regular and special conservation harvests (Figure 1). Harvest of mid-continent light geese in the United States and Canada during the regular season has increased from an average of 580,944 during the 1980's to over 1 million birds annually from 1998 through 2002. The 2000-2001 regular season light goose harvest in the United States and Canada declined to a preliminary estimate of 483,076 (Sharp 2001). States and provinces that implemented light goose only seasons and spring special conservation harvests increased the harvest by 491,308 in 1998-99, 676,008 in 1999-2000, 542,930 in 2000-2001 and 736,314 in 2001-2202 (Table 2)(Sharp et al. 2001, and D. Sharp, personal communication).

Figure 1. Mid-Continent Light Goose Harvest in U.S. and Canada (excluding AB, BC and YK). U.S. conservation harvest includes conservation order and regular seasons with special harvest provisions. Data for a particular year includes harvest for the fall of that year and the winter and spring of the following year. After Sharp (2001) with updates provided by USFWS and CWS.



Despite the number of significant actions taken to increase the harvest of light geese, it is not known yet if these have affected light goose survival and more importantly, population size. Furthermore, it is not known whether hunters can harvest sufficient numbers of geese to reduce population size and then maintain the populations at the desired level. In the face of this uncertainty, the AGJV undertook the task of exploring other ways to reduce light goose numbers in the event that hunter harvest does not reduce populations to desired levels. Accordingly, they appointed an Ad Hoc Committee on Alternative Management of Snow Geese in March 1999 (Appendix A). In their May 18, 1999 report, the committee recommended the formation of three working groups to address:

1. Large-scale landscapes - What could be done to better manage the landscape changes believed to be responsible for the large and growing light goose populations?

2. Non-lethal control - What alternatives are available for controlling light goose populations through non-lethal methods?

3. Direct population control - What are the potentials and problems with direct actions to control light goose populations beyond what is currently being done with hunting?

In addition, the Ad Hoc Committee stressed the continued importance of current management practices and that initiating the analyses, described above, was considered as contingency planning and did not mean that the AGJV was promoting the use of any of the alternative management actions being examined by these working groups (Appendix A).

The Direct Control and Alternative Harvest Measures Working Group, formed by the Arctic Goose Joint Venture (AGJV), was charged to:

1. Examine potential direct control techniques (i.e. beyond conventional hunting practices) for reducing light goose populations

2. Assess social, political, biological and economic constraints and opportunities associated with the use of direct control techniques.

Through this action, the AGJV recognized the need to investigate management actions, beyond those currently implemented through "conservation orders" and other management activities in the United States and Canada, which could reduce numbers of overabundant light goose populations in North America. See Appendix A for additional information on the AGJV charge to the Direct Control Working Group.

The Light Goose Direct Control and Alternative Harvest Measures Working Group's work began with an organizational meeting of the co-chairs, Michael A. Johnson and C. Davison Ankney and David Duncan, CWS snow goose coordinator, in Regina, Saskatchewan in October 1999. At this meeting, we developed a plan of action for the working group, a list of required expertise and potential working group members, a proposed schedule and developed a first draft of a statement of principles and an overriding principle of "maintaining ecosystem integrity." The working group was comprised of biologists and others from state wildlife agencies, U.S. Fish and Wildlife Service, Canadian Wildlife Service, U.S. Geological Survey, U.S Department of Agriculture, and Universities. All are listed in front of this publication.

A progress report was presented to the AGJV Management Board at its November 1999 meeting. The management board provided further direction to the working group in the form of a document entitled "Terms of Reference for AGJV Adhoc Group to Examine Direct Control (Cull) Methods" dated January 13, 2000 (Appendix B).

The first meeting of the working group was held in Minneapolis in January 19-21, 2000. At this meeting, the working group refined the draft statement of principles and developed a list of all possible methods of direct population control. This list was then reviewed and refined to exclude those items that did not fit our statement of principles or did not seem feasible based on our current knowledge. We developed a report outline and created five writing teams to work on individual report chapters.

The working group met again on August 29-30, 2000 in Minneapolis to review draft chapters. At this meeting our statement of principles was finalized to read as follows:

> Statement of Principles
>
> "We will consider all techniques that have the potential to directly control light (snow/Ross's) goose populations and preserve/restore the integrity of Arctic and other ecosystems and light geese. Our goal is to find one or more humane methods for killing many light geese in a short time in a way that maximizes subsequent use of the birds or, at least, minimizes waste of the birds and has minimal negative impacts on other wildlife. We will use the best available science and expertise to accomplish our goal."

These principles formed the yardstick against which we measured the various strategies investigated in this report. Johnson, Ankney and Alisauskas met in Ontario in June 2001 to edit chapters and draft final content.

This report is comprised of 7 parts or chapters including the introductory and background information in this paper.

Part II, by Michael A. Johnson of the North Dakota Game and Fish Department examines strategies for taking geese by hunters that go beyond the actions currently authorized in the United States and Canada. If current strategies are unsuccessful in reducing snow goose numbers to desired levels, then providing hunters with additional tools would likely be the next action to be considered. This chapter is a major expansion of an analysis of techniques that could be used to increase the harvest of light geese by hunters (Johnson 1997).

Part III is a thorough analysis of the effects on population numbers of several scenarios for killing large numbers of adult light geese at Arctic breeding areas. It evaluates several ways in which dead birds could be used including the ecologically based idea of simply allowing their nutrients to be re-cycled into tundra ecosystems. This chapter, written by Dr. Ray Alisauskas of the Canadian Wildlife Service and Dr. Richard Malecki of the New York Cooperative Fish and Wildlife Research Unit, also presents a comprehensive analysis of the financial costs and logistical requirements for the direct control of light geese at remote breeding colonies.

Part IV was prepared by Dr. Robert Cox of the U.S. Geological Survey and Dr. Dave Ankney of the University of Western Ontario. They evaluate several approaches that could be used to capture or kill large numbers of light geese on migration and wintering areas. They conclude that although it is likely not possible to capture large numbers of geese in such areas, it would be feasible to kill large numbers using remotely detonated shot-charge devices.

Part V, written by Dr. John Cummings and Peter Poulos of the U.S. Department of Agriculture, Wildlife Services), evaluates the efficacy of using three registered chemicals (DRC-1339, Avitrol, and alpha-chloralose) for capturing or directly killing large numbers of light geese on migration and wintering areas. They note that only alpha-chloralose is federally (U.S.) authorized for use on waterfowl (capture only) and that further research would be required before it would be feasible to apply for federal authorization for the other two chemicals.

Part VI describes and evaluates the various procedures that could be used to process light geese, killed or captured via direct control, into human food or other products. The authors, Allen Maier and Dr. Nathaniel Clark of the U.S. Department of Agriculture (Food Safety Inspection Service) and Michael A. Johnson, North Dakota Game and Fish Department, conclude that because the Migratory Bird Treaty now prohibits the sale of migratory birds, the best and simplest way to use light geese is to process them and donate the food to food banks or other charitable organizations.

Finally, Part VII discusses the major findings in the report and presents several recommendations and conclusions derived from those findings. All members of the Working Group had the opportunity to comment and contribute to all chapters in the report.

ACKNOWLEDGEMENTS

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LITERATURE CITED

Abraham, K.F. and R.L. Jefferies. 1997. High goose populations: causes, impacts and implications. Pages 7-72 *in* Batt, B.D.J., editor. 1997. Arctic ecosystems in peril: report of the Arctic Goose Habitat Working Group. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario.

Ankney, C.D. 1996. An embarrassment of riches: too many geese. Journal of Wildlife Management 60: 217-223.

Anonymous. 1982. Management guidelines for snow and Ross's geese in the western Central Flyway. Central Flyway Council. 19pp. + appendices.

Anonymous. 1982. Management plan for mid-continent snow geese. Central Flyway Council and Mississippi Flyway Council. 22pp. + appendices.

Atlantic Flyway Council. 1981. A Greater Snow Goose Management Plan. Canadian Wildlife Service, Atlantic Flyway Council, U.S. Fish and Wildlife Service, and Atlantic Flyway Council. Washington, D.C. 69pp

Batt, B.D.J., editor. 1997. Arctic ecosystems in peril: report of the Arctic Goose Habitat Working Group. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario. 120pp.

Batt, B.D.J., editor. 1998. Greater Snow Goose: report of the Arctic Goose Habitat Working Group. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario. 120pp

Boertje, R.D., P. Valkenburg, and M.E. McNay. 1996. Increases in moose, caribou, and wolves following wolf control in Alaska. Journal of Wildlife Management 60: 474-489

Bromley, R.G., D. Aglukark and A. Carpenter. 1997. The role of aboriginal people in the co-management of over-abundant geese in northern Canada. Paper presented at the Symposium on Overabundant Goose Populations: An Emerging Challenge in Wildlife Conservation. The Wildlife Society 4th Annual Conference. September 23, 1997. Snowmass Village, Colorado.

Caswell, J.H. 2001. Vulnerability of non-target goose species to hunting with electronic snow goose calls. M.S. Thesis, Louisiana State University, Baton Rouge. 29pp +iv.

Cooper, J.A. and T. Keefe. 1997. Urban Canada goose management: policies and procedures. Transactions North American Wildlife and Natural Resources Conference 62:412-430.

Cummings, J.L., J.E. Glahn, E.A. Wilson, J.E. Davis, D.L. Bergman and G.A. Harper. 1992. Efficacy and non-target hazards of DRC-1339 treated rice baits used to reduce roosting populations of depredating blackbirds in Louisiana. Technical Report 481. National Wildlife Research Center. Fort Collins, Colorado. 136pp.

DeNicola, A.J., S.J. Weber, C.A. Bridges and J.L. Stokes. 1997. Nontraditional techniques for management of overabundant deer populations. Wildlife Society Bulletin 25:496-499.

Dolbeer, R.A., J.L. Belant, and J.L. Sillings. 1993. Shooting gulls reduces strikes with aircraft at John F. Kennedy International Airport. Wildlife Society Bulletin 21: 442-450.

Heisterberg, J.F., J.L. Cummings, G.M. Linz, C.E. Knittle, T.W. Seamans and P.P Woronecki. 1990. Field trial of a CPT-avicide aerial spray. Pages 350-356 *in* L.R. Davis and R.E. Marsh, editors. Proceeding of the 14th Vertebrate Pest Conference, Davis, California.

Houston, D.B. 1982. The northern Yellowstone elk herd, ecology and management. Macmillan Publishing Co., Inc. New York. 474pp.

Johnson, M.A. 1997. Management strategies to address the mid-continent lesser snow goose overpopulation problem. Pages 101-111 *in* Batt, B.D.J., editor. 1997. Arctic ecosystems in peril: report of the Arctic Goose Habitat Working Group. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario.

Kelly, S.T. and M.E. DeCapita. 1982. Cowbird control and its effect on Kirtland's warbler reproductive success. Wilson Bulletin 94:363-365.

Kelley, J. 2001. Draft Environmental Impact Statement: Light Goose Management. U.S. Fish and Wildlife Service. 125pp. + appendices.

Knowlton, F.F., E.M. Gese, and M.M. Jaeger. 1999. Coyote depredation control: An interface between biology and management. Journal of Range Management 52: 398-412.

Knudson, D., (editor) no date. Snow goose cookbook. Arctic Goose Joint Venture. 40pp.

Mastrangelo, P.M. 1995. Beaver damage management in the southeast: A cooperative effort. Pages 22-31 in C. Brown, ed. Proceedings of the 1995 Joint Fur Workshop, Davis, WV.

Moser, T., editor. 2001. The status of Ross's geese. Report of the Arctic Goose Joint Venture Ross's Goose Subcommittee. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario. 120pp.

Olsen, R.E. and A.D. Afton. 2000. Vulnerability of lesser snow geese to hunting with electronic calling devices. Journal of Wildlife Management 64: 983-993.

Rockwell, R.,E. Cooch and S. Brault. 1997. Dynamics of the mid-continent population of lesser snow geese – projected impacts of reductions in survival and fertility on population growth rates. Pages 73-100 *in* Batt, B.D.J., editor. 1997. Arctic Ecosystems in Peril: Report of the Arctic Goose Habitat Working Group. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario.

Sharp, D.E., compiler. 2001. Central Flyway harvest and population survey data book. U.S. Fish and Wildlife Service, Denver, Co. 126pp.

Sharp, D.E., K.L. Kruse and K.E. Gamble. 2001. Light geese in the Central Flyway. U.S. Fish and Wildlife Service Report, November 2001. 48pp.

Stradtmann, M.I., J.B. McAninch, E.P. Wiggers and J.M. Parker. 1995. Police sharpshooting as a method to reduce urban deer populations. pp 117-122 *in* J. B. McAninch, editor. Urban deer: A manageable resource? 55th Midwest Fish and Wildlife Conference, St. Louis, MO. December 12-14, 1993.

White, S.B., R.A. Dolbeer and T.A. Bookhout. 1985. Ecology, bioenergetics, and agricultural impacts of a winter-roosting population of blackbirds and starlings. Wildlife Monographs 93.

Table 1. Mid-continent light goose harvest in the United States and Canada (excluding AB, BC and YK). After Sharp et al. (2001) with updates provided by USFWS and CWS.

		Regular Season	Regular Season with Special Harvest Provisions	Conservation Harvest**	Totals
1998-1999	United States	637,105	93,302	397,506	1,127,913
	Canada	165,985	--	500	166,485
	Total	803,090	93,302	398,006	1,294,398
1999-2000	United States	718,030	31,618	643,470	1,393,118
	Canada	158,248	--	1,000	159,248
	Total	876,278	31,618	644,470	1,552,366
2000-2001	United States	359,607	2,299	534,631	896,537
	Canada	123,469	--	6,000	129,469
	Total	483,076	2,299	540,631	1,026,006
2001-2002*	United States	486,308	647	727,667	1,214,622
	Canada	146,507	--	8,000	154,507
	Total	632,815	647	735,667	1,369,129

* Preliminary

** "Conservation Order" in the United States and "Special Conservation Measures" in Canada

Table 2. States using Special Harvest Provisions during regular light goose only hunting seasons and Conservation Order, 1998-2002.

	1998-1999		**1999-2000**		**2000-2001**		**2000-2001**	
State	Special Harvest Provisions	Conservation Order	Special Harvest Provisions	Conservation Order	Special Harvest Provisions	Conservation Order	Special Harvest Provisions	Conservation Order
Central Flyway								
Colorado	X	X		X	X	X	X	X
Kansas	X		X	X		X		X
Montana								
Nebraska	X		X	X		X		X
New Mexico				X		X		X
North Dakota		X		X		X		X
Oklahoma		X		X		X		X
South Dakota	X	X		X		X		X
Texas		X		X		X		X
Wyoming						X		X
Mississippi Flyway								
Alabama								
Arkansas	X	X		X		X		X
Illinois	X	X		X		X		X
Indiana				X		X		X
Iowa	X	X	X	X		X		X
Kentucky				X		X		X
Louisiana		X		X		X		X
Michigan								
Minnesota				X		X		X
Mississippi				X		X		X
Missouri	X	X		X		X		X
Ohio								
Tennessee								
Wisconsin								
Number of States	8	10	3	17	1	18	1	18

Part II

ALTERNATIVE STRATEGIES TO INCREASE LIGHT GOOSE HARVEST IN THE UNITED STATES AND CANADA

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INTRODUCTION

This paper examines potential alternative strategies to increase the harvest of light geese (lesser snow (*Anser caerulescens caerulescens*), greater snow (*A. c. atlantica*), Ross's geese (*A. rossii*)) by hunters in the United States and Canada. Management strategies to reduce numbers of mid-continent light geese were described by Johnson (1997). These strategies were divided into two major categories: (1) Population control by hunters and, (2) Population control by wildlife agencies. Population control by wildlife agencies is generally referred to as "direct control" because it involves the purposeful removal of animals from a population. Population control by hunters generally refers to allowing licensed migratory game bird hunters to harvest birds by legal hunting methods during regular hunting seasons, or during special conservation harvests[1] as have been conducted in the United States and Canada during 1999-2001. The term 'hunters' also includes Aboriginal people in Canada and northern residents of Alaska who take birds for subsistence purposes. Subsistence hunters are not, necessarily, licensed by government agencies.

In this paper, I examine factors that affect the ability of hunters to take light geese and discuss strategies that could be used to increase the number of hunters, the number of days they hunt and their daily harvest success. I consider changing laws and regulations to allow new hunting techniques, some that were legal at one time, developing new hunting techniques, and implementing other actions to facilitate the additional harvest of light geese. This Chapter also presents several techniques for direct control that would likely be used by agency personnel only, but could be used by hunters, depending on how the techniques are implemented and on the rules and regulations in place at that time.

Since work began on the "Arctic Ecosystems in Peril" report (Batt 1997), a number of management strategies have been implemented in the United States and Canada to reduce light goose numbers. These are summarized in Johnson and Ankney (2003). These management strategies coupled with increased hunting effort by waterfowl hunters have significantly increased harvest of light geese in both the regular season and during special conservation harvests (Sharp 2001, Sharp et al. 2001).

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[1] The term "Special conservation harvests" is used to describe the "Conservation Order" and "Special Harvest Provisions during Regular Hunting Seasons" in the U.S. and "Special Conservation Measures" in Canada.

INCREASING THE HARVEST OF LIGHT GEESE

Increasing light goose harvest beyond what has already been done will be difficult, but not impossible. A key question to consider in developing strategies to increase light goose harvest is: Why aren't more light geese harvested, or more specifically, what factors prevent hunters from taking more birds? Following is an annotated list of nine factors that affect the ability of hunters to take more light geese. All of these limitations need to be kept in mind as work progresses to increase the harvest of light geese.

Declining Numbers of Hunters

Despite all the other factors involved in success of light goose hunters and thus the number of geese harvested, fewer hunters results in fewer geese harvested. The number of waterfowl hunters has declined in both the United States and Canada. In the United States, the number of active adult waterfowl hunters has declined nearly 50 percent from 2,025,000 in 1970 to 1,019,000 in 1988. Since 1998, the number of active adult waterfowl hunters has increased to 1,382,000, but is 32 percent below that of 1970 (Kruse and Sharp 2002). The number of migratory bird hunting permits sold (resident and non-resident) in Canada has declined by 61 percent since 1978 (525,000 to 204,000) and 35 percent since 1990 (312,000 to 204,000). This decline is due to decreased hunting by residents, even though non-resident hunter numbers continue to increase. The number of nonresident Migratory Game Bird Hunting Permits in Prairie Canada increased from 8,361 in 1991 to 19,185 in 2000 (Caswell and Schuster 2002). Consequently, nonresidents now take a significant portion (more than one-half in 1998) of the total goose harvest in Manitoba and Saskatchewan (Boyd et al. 2002).

The reasons for declining participation in waterfowl hunting are not clear, but a wide variety of factors seem to be involved (Enck et al. 1993 and Ringelman 1997). Several of the issues discussed in the following sections are related to total light goose harvest and also affect hunter participation. These issues include but are not limited to: access to land, access to geese, cost, regulations, gun control.

Legislative and Administrative regulations

Laws, regulations and administrative rules sometimes prevent actions to increase light goose harvest. Generally, laws and regulations have become more restrictive over time in controlling when, where, and how birds are taken (defined as "take" in U.S. Code of Federal Regulations Title 50). A major exception to this has been the conservation order that has dramatically liberalized the harvest of light geese. Changes in restrictions on hunting method of take for migratory game birds are not always easily accomplished, but may be a necessary part of more aggressive harvest strategies. Input from the general public, special interest groups and wildlife agency personnel is important in influencing lawmakers and administrators to enact new regulations and laws needed to provide management options. Often, any resistance to change is based on questions of ethics, fair chase, equitability, enforceability or simply the desire to maintain tradition, rather than the biological need of the resource in question. Whatever the reason, it seems clear that implementing any additional harvest strategies or any type of direct control will require changes in laws and regulations. The only way that this will occur is if affected individuals and organizations are educated about the problem, the need for change and eventually how to accomplish the necessary actions.

Access to Land

In many, maybe even most, areas of the United States, access to waterfowl hunting is limited because private landowners control access to hunting areas. For example, in Texas and Louisiana many landowners sell or lease waterfowl hunting rights. Leases are expensive and may cost several thousands of dollars per year. In other cases, hunting guides or guiding services may lease large portions of the landscape to provide hunting sites for clientele willing to pay for hunting. In some areas, such as Louisiana, large corporations (e.g. oil, timber or farming companies) own huge tracts of prime coastal marsh habitat, which are leased to hunters or guides. Such arrangements provide excellent hunting for a few, but limit the access of large numbers of hunters to lands used by large numbers of geese.

Access to Geese

The issue of access to geese is similar to the land access issue. However, in some cases, sanctuaries are established on public or private lands to hold and protect large numbers of geese so that there are opportunities for viewing by the public, or simply to provide resting areas for birds. These sanctuaries have been established by federal, state or provincial governments or by private individuals and organizations. In many cases, the total area closed may be small while providing a safe haven for large numbers of geese. In some situations, local harvest may be increased with small closures designed to provide roosting areas for geese that are hunted in surrounding fields (Schroeder 1978).

Changes in Goose Behavior

Mid-continent light geese are now hunted virtually nonstop from September 1 through the end of May. Light geese are long-lived and many of the adult birds have experienced many hunting seasons - some 20 or more. It is evident that more experienced birds are less vulnerable to hunting. Hunters across the United States and Canada report that light geese have become more wary of hunters and the hunting techniques they employ. Reports from hunters are consistent in their descriptions of geese that are now too wary to hunt effectively. Geese are congregating in larger flocks, altering migrations patterns and learning to avoid decoys and electronic calls. I received reports from numerous hunters after the second spring Conservation Order indicating that light geese had started to avoid electronic calls after only one season of use. Although it is unknown if the observed behavior could simply be a product of fewer juveniles (which are less wary than adults) in the population during that year, clearly, light geese have demonstrated the ability to learn to avoid hazardous situations such as fields with decoys or electronic calls.

During the past five decades, mid-continent light geese have dramatically shifted migration routes, timing of migration, and winter distribution. Managers have noted a westward shift in fall migration routes and staging areas in the United States (Schroeder 1981) and Canada (R. Alisauskas, personal communication). There also has been a northerly shift in fall staging areas over the decades from Sand Lake NWR in South Dakota to Saskatchewan and Manitoba (Syme 1989 and M. Johnson, unpublished data). Typically one-third to one-half of the light goose harvest in the Central Flyway occurred in North Dakota. Warm fall weather during 1998 through 2000 has encouraged light geese to remain late in Saskatchewan where they are hunted relatively little. Once migration begins, these birds tend to migrate over North and South Dakota and beyond without stopping. A marked declined in summer fallow and an increase in fall stubble food sources in Saskatchewan during the past 10 or more years are also causing light geese to remain north longer (Podruzny et al. 2002). Also, in Saskatchewan there has been a major increase in new crops such as lentils, peas and beans, which provide abundant high-energy food sources for spring and fall migrating geese. Bateman et al. (1988) documented the dramatic change in mid-continent light goose migration chronology and winter distribution that had occurred since the 1940's. These changes are attributed most directly to changes in cropping patterns and hunting pressure, but expanding populations, lower body mass of fledged goslings, wetland drainage, loss of habitats and long-term changes in weather patterns also may be involved.

Reed et al. (1998) described significant shifts in spring and fall migrational distribution of greater snow geese along the St. Lawrence River in Quebec. These geese have expanded their distribution along in this area to take advantage of agricultural foods. In addition, they reported that up to 22% of the geese no longer stop in Quebec but over fly directly to staging or wintering areas in the United States.

Cost

The most recent survey of hunting and fishing in the United States (U.S. Department of the Interior et al. 2002) showed that 3.0 million migratory bird hunters (of which 1.0 million hunted geese and 1.59 million hunted ducks) spent $1.4 billion on trips, equipment and related expenditures. The cost to participants of waterfowl hunting is relatively high, second only to big game hunting. Costs for waterfowl hunting include:

Licenses – resident and/or nonresident licenses and state and federal stamps and fees

Transportation – gas and other vehicle expenses, airfare and related expenses

Guide fees

Fees for land access

Food and lodging

Equipment and supplies – guns, ammunition, decoys, waders, clothing, dogs, boats, trailers, etc.

Migratory bird hunters annually spent an average of $548 (U.S.) for hunting related expenditures. Those migratory bird hunters who purchased special equipment, such as boats, campers, cabins, etc., spent an average of $3,527 beyond trip related and other equipment expenditures. Costs for goose hunting equipment can be very high. Field decoys can cost from $5 to $25 (U.S.) each and many goose hunters use hundreds of decoys. Additionally, shotguns, shells, waders, blinds, boats, outboard motors, retrieving dogs, electronic calls and other waterfowling equipment are all relatively expensive items. Costs for those purchasing such hunting-related equipment averaged $639 (U.S.).

Experience, Knowledge and Skills

It seems obvious that the overall success of a hunter or group of hunters is related to their knowledge, experience and skills in hunting geese. Those with more experience have a better understanding of bird locations, movements and behavior, expected response to decoys and calls, methods of concealment, places and times to hunt and other hunting skills. They also are likely to have better shooting performance. More experienced hunters will, on average, be able to plan and execute more successful hunts and thus have higher average bags than less experienced hunters who lack this knowledge. Age also plays a significant role in hunter success. Older hunter have increased experience and knowledge, but also reduced vigor, physical strength and stamina such as is needed for field hunting. Additionally, as hunters age their desire and ability to harvest large numbers of birds may wane.

Conflicts with Local Governments and Landowners

Some opposition to spring hunting of light geese comes from local governments, various groups and associations and landowners. Major reasons cited have been fear of damage to wet and soft roads and trails and interference or conflicts with agricultural operations. Special conservation harvests have not been implemented or were delayed in some jurisdictions (Johnson and Ankney 2003) for these reasons. As an example, Saskatchewan did not have spring conservation harvest until 2001 because of opposition from local groups. Despite conflicts, goose hunting, at least in some areas, can benefit agriculture by reducing losses due to depredation.

Gun Control

Hunters tell us that actions in both the United States and Canada to increase gun control may have negative effects on hunting and hunter participation. New gun registration laws in Canada require nonresident hunters to register guns and pay a $50 (Canadian) fee when entering the country. Although a variety of reasons have been cited for the decline in resident hunter numbers (see 1. Declining numbers of hunters, in this section), gun control and increasing anti-gun attitudes and policies may be contributing factors. If the number of nonresident hunters in Canada decreases because of newly implemented firearms policies, the light goose harvest in Canada will decline. Many of these non-Canadian hunters already hunt light geese in the United States; therefore there would be no new source of harvest to replace that lost in Canada. In addition, the current temporal and geographic distribution of light geese, during spring and fall migrations, makes Canada a critically important location to harvest significant numbers of mid-continent light geese.

Ability of Hunters to Legally Use a Large Number of Harvested Geese

Many hunters limit their take of birds because of difficulties expected or experienced in using the meat from harvested birds. Hunters do not want to waste birds they harvest and most want to use them for food for themselves and their family or give them to someone who will eat them. Some hunters express the opinion that current regulations in the United States and Canada regarding possession, transfer of possession, carcass identification and transportation of migratory game birds are complex, confusing and burdensome to hunters wishing to take large numbers of light geese. Regulations in the United States require that a fully feathered head or wing remain attached to a legally taken migratory game bird (except doves and band-tailed pigeons) for identification purposes. In Canada, only a fully feathered wing is legal for identification. These identification requirements increase the difficulty of cleaning and storing large numbers of light geese. In the United States, hunters may transport birds without identification attached if they have been processed at a "migratory bird preservation facility" (50CFR 20, Subpart E, 20.43). However, some states (North Dakota for one) do not allow transportation of birds without identification attached, even after processing by a "migratory bird preservation facility." This option also is not available to hunters in Canada. In addition, American hunters returning from Canada must have one fully feathered wing attached to each bird they are bringing into the United States. They may not have birds processed and identification removed from their birds in Canada. Regulations restricting the giving of birds to others and/or transportation by others in the field vary greatly by political jurisdiction and are confusing to most hunters.

WHAT ARE THE OPPORTUNITIES TO INCREASE THE HARVEST OF LIGHT GEESE?

Increasing the harvest of light geese by migratory bird hunters would seem to require several different but related general strategies:

1. Increasing the number of hunters that pursue light geese.

2. Increasing the number of days that hunters pursue light geese.

3. Increasing the effectiveness or success of individual hunters in bagging birds.

Because the total harvest of light geese is a function of the number of hunters, the amount of time they hunt and their success in bagging birds, strategies to increase harvest must address these factors individually or in combination. The term 'hunters' includes waterfowlers, subsistence hunters in the north and, potentially, contractual hunters, but it does not include commercial hunters. Waterfowlers are men and women who hunt waterfowl for the enjoyment of this traditional activity. Their families or others generally use the birds harvested for food. Subsistence hunters are residents (generally of northern Canada and Alaska) who hunt waterfowl mostly for food provision. This is also a traditional activity that has important recreational and cultural aspects. Contractual hunters would be those who are paid to hunt birds for direct control purposes. They could not sell or barter any birds taken under current laws in the United States and Canada. Commercial hunters, who operated prior to the 1916 Migratory Bird Treaty[2], harvested birds for sale, an activity which is now illegal in the United States or Canada. The revised (1995) Migratory Bird Treaty with Canada prohibits the sale of migratory birds. The 1916 Migratory Bird Treaty did not prohibit this activity, but the Migratory Bird Treaty Act (1918 in the United States) prohibited the sale of migratory birds and they have not been legally sold in the United States or Canada since that time.

Following are descriptions of a number of strategies involving hunting methods, firearms, or other issues that could be addressed to increase the take of light geese by hunters. The Direct Control and Alternative Harvest Methods Working Group of the Arctic Goose Joint Venture developed this list. In developing the list and the accompanying descriptions, the Working Group relied on a broad range of experience and expertise to initially consider every conceivable technique. After considerable deliberation, the Working Group eliminated from further consideration all strategies they believed to have little possibility of being implemented, small likelihood of success or were not in keeping with their statement of principles (Johnson and Ankney 2003).

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[2] The international treaty between the U.S. and Great Britain (for Canada) was signed in 1916 and amended in 1999 by the governments of Canada and the U.S. This agreement is termed the Migratory Bird Convention in Canada and the Migratory Bird Treaty in the U.S. For simplicity, this agreement is referred to as the "Migratory Bird Treaty" or "Treaty" throughout this paper.

The following list of strategies that could be used to increase the harvest of light geese by hunters is grouped by strategies involving hunting methods, strategies involving firearms and other strategies.

HUNTING METHODS

Live Decoys

At one time maintaining a flock of call ducks or live ducks or geese for decoys was a common and accepted practice for waterfowl hunters. While most live decoys were ducks that were used for duck hunting, Canada geese were also kept for use as live decoys by goose hunters (Hanson 1997). The use of live decoys for hunting migratory birds was partially restricted in 1931 and then completely banned in the United States in 1935 (U.S. Department of the Interior 1975 and Havera 1999). Live decoys are not permitted in Canada. The ban on live decoys was part of a more extensive effort aimed at conserving waterfowl resources by restricting several hunting techniques and thus reducing harvest.

The use of domestic or captive birds to lure or call wild birds into gun range was reportedly an effective technique that allowed hunters to take more birds. Today, the notion of using live decoys to lure birds into gun range immediately raises concerns of ethics, fair chase and a variety of other negative reactions. A frequently stated concern about live decoys is the potential risk to increase the transmission of disease to wild migratory birds. This may well be a valid concern and the degree of risk is related to the health of captive birds and their degree of exposure to wild birds. However, we do not know that the risk from the use of live decoys would be any greater than already exists from wild birds mixing with domestic birds in tens of thousands of situations across North America.

However, under a scenario where more extensive efforts are needed to control light goose numbers, this technique likely would be effective in helping light goose hunters attract more light geese into shooting range and thus increase the harvest. While it is likely that few hunters would be willing to spend the resources and endure the difficulties of maintaining live decoys, it seems reasonable to consider this technique in direct control efforts to reduce light goose numbers. Larger guiding or commercial hunting operations might find it reasonable to develop and use flocks of decoy birds to increase hunting success. Additionally, agencies or other organizations could maintain decoy birds for use by hunters. Current federal regulations in the United States do not require a permit to keep domesticated wild strain ducks or geese. However, these birds (except mallards) must be acquired from a federally licensed propagator (50CFR 21.13). A federal avicultural permit is required in Canada to have snow geese in captivity. Many states and provinces have additional laws and regulations requiring licenses or permits for anyone possessing or propagating these birds. For light goose hunting, domestic white geese could be used and these would not require state, provincial or federal permits to possess or sell.

Baiting

Like the use of live decoys, hunting over bait, or using grain to lure migratory birds to hunters was once a traditional waterfowling technique. Bait was often used in combination with live decoys to lure ducks to hunters in Illinois (Havera 1999). Most historic descriptions of baiting relate to its use for duck hunting. However, geese also are likely to be attracted to baited areas. The lack of attention to geese in historical descriptions is probably due, at least in part, to the relative scarcity of geese compared to ducks during the early part of the twentieth century. The government of the United States banned baiting of waterfowl in 1935. It was outlawed because it was thought to lead to over-harvest of ducks and because of the concern for depressed waterfowl populations resulting from the drought of the 1930's.

It is unknown how effective baiting would be for increasing harvest of light geese. It may be difficult to attract light geese to bait in areas rich in residual agricultural grains. Baiting may be more effective in the northern part of the prairies where geese become hyperphagic (have increased drive to eat) just prior to migrating to the breeding grounds (Alisauskas and Ankney 1992).

However, under a situation requiring direct control of the light geese, the use of bait may be justifiable. This is especially true during a light goose only special conservation harvest. Because of the large numbers of birds involved and their behavior, it seems that baiting would be an expensive endeavor. Nonetheless, there likely are situations in both the United States and Canada where bait could attract birds and provide additional harvest opportunities. Crop manipulation has been used to lure and alter the distribution of geese and cranes in Illinois and New Mexico (D. Sharp, personal communication). Baiting is currently allowed during the special conservation measures for greater snow geese in Quebec. It is conceivable that large blocks of cropland could be managed to lure light geese into situations specifically managed to allow a high harvest by hunters. Such situations have been developed in private hunting situations (both legally and illegally) for hunting Canada geese and other waterfowl. The application of baiting deserves additional research.

In some states, especially the mid-latitude states, wildlife agencies manage crops to provide foods for birds during winter and spring migration. Under current baiting laws, these areas cannot be hunted during the special conservation harvests. This means that either (1) agencies must stop providing these important foods, or (2) if the food sources remain, birds cannot be hunted over the foods and they become sanctuaries for light geese during the special conservation harvests. The Central Flyway Council has forwarded a recommendation to the U.S. Fish and Wildlife Service to permit light goose hunting over such wildlife food plots during the light goose Conservation Order (Central Flyway Council Recommendation Number 4, July 28, 2000, Memphis Tennessee). Implementing the recommendation would provide additional harvest opportunities and reduce confusion and conflicts between wildlife habitat management programs and light goose population reduction.

Shooting at Night

There is potential to eliminate shooting hour restrictions as a constraint in taking light geese. Researchers have reported that roosting flocks of light geese can be, under some conditions, readily approached at night (R. Cox, personal communication). These same researchers have reported that, once approached, large numbers of birds could be taken with a shotgun. This technique is similar to techniques used by commercial hunters to take canvasbacks and other ducks on the Chesapeake Bay and elsewhere in the early 1900's (Bent 1925, Havera 1999). These hunters learned that roosting flocks of ducks could be approached by boat at night and large numbers of birds could be killed using large punt guns or batteries of smaller bore shotguns. Eliminating shooting hour constraints would allow hunters to take geese at any time of day or night. Safety issues, that may be a concern with this strategy, could be addressed by government agencies carefully managing this activity, such as allowing only trained hunters to operate only in designated areas and at designated times. Additionally, shooting into flocks at night could result in large numbers of wounded birds that would be difficult to recover in the dark. These birds could be recovered with the aid of lights or during daylight hours. Trained retrievers would be very useful in recovering any wounded birds. Retrieval problems would likely be significantly reduced if shooting took place later at night and or at dawn. The fact that most of the birds are white or have white heads would also aid in finding dead or wounded birds. There is also concern that excessive numbers of other non-target birds also could be killed if they were in the area. Careful scouting and monitoring of a flock and avoiding roosting flocks with significant numbers of birds other than light geese would significantly reduce the number of non-target birds killed.

Electronic Calls

Electronic calls were made illegal for waterfowl hunting in the United States in 1965 or 1966 (Olson and Afton 2000). Since 1999 they have been allowed during light goose only seasons and during the light goose Conservation Order in the United States. Olson and Afton (2000) demonstrated the effectiveness of electronic calls for harvesting light geese during special conservation harvests. There is potential to allow electronic calls for light goose hunting only, during the regular waterfowl season. Hunters frequently request the legalization of electronic calls for light geese during the regular season because they believe this would help increase their success. Regulations could be established that allow users of electronic calls to harvest only light geese and only when light goose decoys were in use. Recent work in Canada has demonstrated a negative response of Canada and white-fronted geese to electronic calls used for light goose hunting (Caswell 2001). Because of this work, the CWS has permitted the use of electronic calls for light goose hunting in Saskatchewan, Manitoba and Quebec beginning in the fall of 2002. Only white decoys will be allowed when an electronic call is being used. Conversely, the use of electronic calls during regular hunting seasons would provide more time for birds to become conditioned to avoid electronic calls. This could reduce their effectiveness, overall, and reduce the effectiveness of extended seasons for increasing the harvest of light geese.

Methods of Concealment

There are many state, provincial and federal laws and regulations which regulate how and where hunters may conceal themselves and from where they may shoot. There are restrictions on shooting from vehicles, in open water, in a boat, sinkboxes, etc. There also are regulations on blind type, size, spacing and placement in many areas that vary among states, provinces and individual management areas. Once again, many of these regulations were put in place for conservation purposes to reduce the effectiveness of hunters and prevent over-harvest of migratory game birds or for equability issues. Some or all of these regulations could be considered for change or elimination by the appropriate agencies to allow hunters additional opportunities to harvest birds.

Hazing and Rallying in the Spring

Current regulations prohibit hunters from “herding, rallying and driving” migratory birds for the purposes of hunting. These regulations could be changed or eliminated to allow hunters to use these techniques to increase the harvest of light geese. Such activities may have secondary benefits in reducing the foraging time available to migrating geese in the spring. This could reduce nutrient acquisition by birds prior to breeding and thus their productivity (Alisauskas 2002 and Mainguy et al. 2002). A disadvantage is that the additional hazing may reduce the ability of hunters to harvest geese in some areas. There also would be disturbance of non-target species and possibly endangered species in some instances.

Herding with Model Airplanes

Light geese have been herded into gun range with radio-controlled model airplanes. Although this practice is illegal, it has been demonstrated to be effective. There is potential to use model airplanes to move birds off of sanctuaries or to move groups of geese to areas where they could be harvested. This work could be done by trained operators or trained agency personnel. Use of trained operators operating under specific regulations would reduce concerns about excessive stress on birds. An alternative that has been suggested is to test the use of recorded sounds of airplanes or helicopters or other disturbances to move birds. This may work in some situations until birds become acclimated to such sounds and learn that they pose no threat.

Firearms

Shotgun gauge restrictions

Shotguns larger than 10 gauge were probably outlawed for migratory bird hunting in the United States in 1919 (U.S. Department of the Interior 1975). Shotguns larger than 10 gauge are not allowed in Canada. However, manufacturers still produce 8 gauge shells for industrial use. Presumably, shotgun gauge size was regulated as a conservation measure to prevent over-harvest of birds. It may have also been implemented to reduce wounding loss from shooting large shot charges at flocks of birds. At one time, market hunters used large-bore (4 gauge and larger) shotguns or punt guns to kill large numbers of birds roosting on the water at night (Havera 1999). Besides night shooting restrictions, eliminating large bore guns probably made this practice impractical. Some antique shotguns larger than 10 gauge still exist and most of these probably require black powder propellants. Some hunters have requested that these antique firearms be allowed for taking light geese, especially during special conservation harvests. Because current 10 gauge ammunition carries a larger and higher velocity shot charge than the large bore shotguns that have been outlawed, consideration should be given to allowing these larger gauges, especially in antique firearms.

Hunting with rifles

Hunting migratory game birds with rifles is currently illegal in the United States and Canada. Rifles were outlawed for migratory birds hunting in the United States probably in 1919 along with shotgun gauge restrictions. They most likely were outlawed for conservation purposes (presumably too effective in taking birds) and for public safety reasons. Alisauskas and Malecki (2003) have discussed the potential use of rifles for taking nesting geese in the Arctic. Under a direct control scenario, rifles would be effective for taking large numbers of birds in a short time period on migration and wintering areas. Hunters could use rifles to take geese, similar to situations where wildlife agencies have used sharp-shooters to reduce deer herds (DeNicola et al. 1997 and Stradtmann et al. 1995). Highly accurate target-style .22 caliber, or the newly developed .17 caliber, rimfire rifles could be used on roosting or feeding areas to take birds. Under the right wind conditions such firearms would not make enough noise to scare birds away from these situations. Center-fire rifles could also be used and would increase the effective range for taking birds. However, the noise level of center-fire rifles is much greater than that of rimfire rifles and it could be difficult to keep birds within close range without scaring them.

Technology exists to silence or at least muffle the sound of center and rimfire rifles (see below) that would greatly enhance the efficiency of taking birds.

Safety is another reason cited for not permitting rifles for taking geese, because a stray bullet could strike a human, occupied building, vehicle, etc. However, this situation is no different from any other rifle-hunting situation. It is always the responsibility of the shooter to make sure he has a safe background before firing. While human safety may be an issue in some areas, it is certainly not a problem in all areas. Many situations exist where geese stage and roost where they could efficiently and safely be taken with rifles. In these areas, rifle shooting could be carefully regulated to guarantee the safety of hunters and the public, while allowing increased take of light geese (e.g. allow use in fields only or from towers constructed specifically for such a purpose that would eliminate the risk of bullets ricocheting off water).

Firearm sound suppression

Firearm reports (gun noise) is one factor that reduces hunting success. Waterfowl are rapidly conditioned to associate the sound of shooting with danger and learn to avoid such situations. If shotguns could be equipped with sound suppression devices (commonly called silencers) this could increase the harvest by hunters. Currently such devices may be owned and used by citizens in the United States if they are registered and a Federal tax ($200) is paid (United States Code, Title 18, Section 921, Chapter 53 and Title 26, Subtitle E, Sections 5845 and 5811). State or federal agencies would be exempt from this tax provided sound suppression devices or firearms fitted with these devices were not turned over to private citizens. Silencers or any type of gun muffling device are prohibited under current law in Canada and may be used only by law enforcement or the military. They are legal and used for hunting in Finland, Sweden, Norway and United Kingdom (BR-Tuote Ky, Joensuu, Finland; www.guns.connect.fi/rs/Reflex.html). A major manufacturer (AWC Systems Technology, Phoenix Arizona) of firearms silencers for law enforcement and other uses indicated that producing a silencer for a shotgun was probably not feasible. However, it was indicated that there has probably been little research on developing "silenced shotguns" (R. Cox, personal communication). Sound suppressed shotguns are manufactured and used in Finland (BR-Tuote Ky, op cit.) and in Minnesota (Metro Gun; www.metrogun.com). Silenced or muffled shotguns would likely enhance the harvest of light geese by hunters.

Current silencer technology can muffle the sound of a center-fire rifle to a very low level and that of .22 rimfire weapons to a mere whisper, especially when using ammunition with subsonic velocities. A silenced rifle could be a very effective weapon for shooting large numbers of birds in roosting or feeding flocks. This technique would be especially useful in the Arctic for taking birds on the breeding grounds (see Alisauskas and Malecki 2003), but could also be invaluable in taking birds in rifle shooting situations on migration and wintering areas as described above. Currently, USDA Wildlife Services personnel use silenced or sound suppressed rifles to take depredating and nuisance wildlife, including geese.

REFUGE MANAGEMENT

Refuges include state, federal and private lands that are regulated or managed to provide a "safe haven" for migratory birds or other wildlife. Many federal refuges allow waterfowl and other hunting on a portion of the refuge. However, because refuges and other sanctuaries provide roosting and feeding habitats that may not be hunted, refuges are generally very attractive to waterfowl. Since the completion of the "Perils" report (Batt 1997), state and federal refuge managers have worked cooperatively to increase hunter access to light geese on refuge lands. To increase harvest of light geese beyond that already accomplished by special conservation harvests, managers will need to consider additional options for harvesting light geese using refuge lands.

Actions to enhance light goose hunting activity could include such improvements as providing hunting situations on refuges (blinds, access trails and roads, parking, transportation, shooting locations, cleaning facilities, guides, hunter training, equipment, etc.) Light geese could be attracted to sanctuary areas that provide exceptional hunting situations through placement of bait, live decoys, and water level and habitat management. Managers would need to be thoughtful and creative in devising ways to increase harvest on refuges. Since publication of "Arctic Ecosystems in Peril" (Batt 1997), there has been much discussion and significant actions taken to reduce the attractiveness of refuges to light geese. Most of this effort has been directed at eliminating agricultural crop food resources and safe haven areas. In the United States wintering areas, only 15 percent of light geese use NWRs (D. Sharp, personal communication). Managers should consider if creating refuge situations that attract large numbers of geese and that provide situations that would allow a harvest of a large percentage of the birds could increase the overall harvest of light geese.

INFORMATION AND EDUCATION TO INCREASE HUNTER SUCCESS

Increasing the knowledge and skills of hunters could improve their ability to harvest larger numbers of light geese. Mentoring programs could serve to pass knowledge and skills of more experienced hunters to those with less experience. Enhanced communication tools could be developed and improved to help hunters learn to hunt and to be successful light goose hunters. In recent years, migration and bird distribution information on various Internet web sites has helped hunters to track the progress of migration and learn where huntable numbers of geese are located. Additional information could be provided in regular news releases and on periodic or even daily telephone hotlines that contain the latest information garnered from agency personnel and hunters. North Dakota and other states have used a phone message line to provide spring light goose migration information to hunters for Conservation Order since 1999.

Private Land Access

Agencies could work with hunting guides and landowners to improve the availability of good hunting locations to hunters. Agreements could be made with private landowners to allow hunting. In Montana, a block access program for private land has been successful for management of hunter access for big game hunting. Under block access, the agency enters an agreement with private landowners to allow hunting on their land. Agency personnel control and enforce access by hunters on these large blocks of habitat. Agreements often involve leasing large blocks of land during the hunting season for a relatively low fee, e.g. $1/acre. This system relieves the landowner of the need to deal with large numbers of hunters requesting permission throughout the season. It also serves to prevent over-crowding and more evenly distributes hunting pressure by providing more good places to hunt.

Disposition of Birds

Many of the more successful hunters report that a major factor limiting the number of geese they bag is how many birds they can use. No one, especially hunters, wants to see birds wasted. At the same time, there are physical limits to the number of light geese that individual hunters can give away or process, store and consume. If additional outlets were found that would use the birds, this could increase the number of geese taken by the more successful hunters. State and federal government agencies could facilitate the use of harvested birds by charitable organizations or other outlets. Additionally, state and federal laws and regulations in the United States and Canada could be changed to allow in-field possession of processed light geese or light goose meat and meat products. United States federal regulations currently do not restrict the number of light geese a person may have in possession. However, the Canadian government and possibly some states maintain light goose possession limits. Consideration should be given to changing these regulations so that charitable organizations, especially in Canada, may have more than a possession limit of light geese. One advantage of increasing the harvest by hunters is that the problem of use of the birds is not as difficult or expensive as with direct control by agencies.

One approach that might facilitate increased harvest by hunters would be to establish drop-off centers where hunters could donate fresh or frozen light geese. This approach is based on the premise that light goose hunters stop hunting geese after they have killed all that their immediate families or friends wish to consume. It seems to have merit because the most successful hunters are most likely to be limited by freezer space or consumption restraints. Under this approach, drop-off centers where hunters could bring geese could be established. A liaison would coordinate distribution of light geese to individuals and organizations willing to receive them. Primary advantages of this approach are that harvested birds would be suitable for human consumption and donating harvested geese is currently legal. Potential disadvantages are that the program may be costly to administer, depending on the difficulty in locating people that want geese and the time required to coordinate distribution. This activity might be a good project for a local wildlife club or others interested in volunteering time to a wildlife conservation program. Government agencies could consider how they might facilitate getting such programs started.

Awards, Bounties and Financial Incentives

While bounties have never been proven to be an effective wildlife population management tool (Henderson 1972), a system of awards or payments, similar to bounties, could be used to entice hunters to hunt light geese and reward them for taking significant numbers of birds. A program such as this would be a step beyond simply requesting or encouraging hunters to take more light geese. The purpose of the program would be to provide additional incentives that would help encourage hunter participation and increase their effectiveness. There are successful programs of hunter-sharing incentives among northern Quebec aboriginal communities (A. Reed, personal communication). It is possible that state and federal tax incentives could be provided to hunters who take light geese and thus help resolve this significant ecological problem. Some states (e.g. North Dakota) have successfully implemented a program where furtakers can deduct their trapping or hunting expenses (equipment, mileage, etc.) as a charitable contribution (to the state) on their federal income tax. It seems reasonable that hunters who volunteer to help agencies control light goose numbers should also qualify for a similar deduction for their expenses. The potential for a similar program for those helping conserve light geese could be pursued with the Internal Revenue Service.

DISCUSSION AND CONCLUSIONS

If the current actions to increase the take of light geese by hunters (increased shooting hours, unplugged shotguns, electronic calls and special conservation harvests) are not successful in reducing the number of light geese to desired levels, then agencies will need to consider additional actions to reduce the size of light goose populations.

This paper presents nine broad categories of factors that restrict or limit the harvest of light geese. If agencies want to increase the take of light geese through alternative harvest strategies (hunting) they will need to consider one or more of these limitations. I describe a number of strategies that have the potential to deal with these restrictions and increase the number of light geese taken by hunters by dealing with one or more of these limiting factors. Most of the strategies discussed may be new or foreign to the thinking of wildlife management professionals. However, the same can be said of the light goose overabundance issue. We have never dealt with an issue of this type, nor of this magnitude. The overabundance of a migratory game bird population, especially to the point where they are destroying their own habitat and developing a potential trophic cascade of environmental destruction is something that professional managers have never before faced (Batt 1997). Thus, the solutions may have to entail strategies that no one has ever envisioned. To do this requires that we think "outside the box," beyond where we have experience or possibly by returning to strategies and techniques that wildlife managers or society dropped from consideration decades ago. Dr. Lewis Cowardin (personal communication) wisely instructed us years ago "a big problem requires a big solution." This is true with the issue of light goose overabundance.

Trying to solve the light goose problem with techniques that are as close to traditional hunting approaches as possible was the first recommendation of the Arctic Goose Habitat Working Group (Batt 1997). It has also been the first choice of the U.S. Fish and Wildlife Service, the Canadian Wildlife Service, and state and provincial wildlife agencies. The reasons for this initial approach are sound and described by Johnson (1997). However, it is unknown whether hunters using the tools now available to them will reduce the number of light geese to the level needed for Arctic and sub-Arctic habitat recovery. If time demonstrates that they cannot, then wildlife managers will need to consider additional strategies. These strategies could be those detailed in this paper or they could involve strategies detailed in companion documents to this paper (Cox and Ankney 2003, Alisauskas and Malecki 2003, Cummings and Poulos 2003) or they could be a combination of these strategies.

One point remains clear in trying to solve the problem of overabundant light geese- there is no single strategy that is believed to be capable, by itself, of reducing light goose numbers to desired levels (Johnson 1997). No single strategy should be considered as the only approach to the solution of the light goose problem. Rather, all strategies should be considered collectively to increase the total mortality rate of light geese and thus reduce the population to the desired level. Increased harvest by hunters should be one of a suite of strategies to increase light goose mortality. Strategies that are not fully successful should not necessarily be dropped in favor of another, but consideration should be given to combining them with new strategies in an additive manner until success is achieved.

In trying to better understand where we could have the most impact in increasing the harvest of light geese, we can consider harvest as a function of hunting effort, such that:

$$H = N \times S \times D$$

Where:

H = Harvest or number of birds taken by hunters

N = Number of hunters

S = Daily success of each hunter

D = Number of days each hunter hunts

In trying to maximize harvest (H) we need to consider strategies that affect the number of hunters (N), the success of each hunter (S) and the number of days they hunt (D). While there seems to be considerable overlap in the strategies affecting each variable, we might consider the following as a starting point:

Number of Hunters	**Hunting Success**	**Number of Hunting Days**
Awareness of where to hunt	Electronic calls	Season length
Awareness of when to hunt	Access to geese	Bird use opportunities
Access to land	Access to land	Cost - travel, licenses, equipment, etc.
Cost	Shooting hours	Refuge management
License fees	Firearms	Awards, bounties and incentives
Refuge management	Hunting skills	
Bird disposal opportunities	Other manner of taking	
Awards, bounties and incentives	Live decoys	
	Baiting	
	Methods of concealment	
	Hazing and rallying	
	Model airplane herding	
	Refuge management	

The costs of implementing strategies discussed in this paper are highly variable. Many of the strategies could be put in place with a regulation or rule change. In some cases, the changes could be accomplished in the annual hunting regulation process of the states, provinces or federal governments. Other changes would fall into the category of administrative rules requiring more lengthy administrative procedures, public review and documentation. Still others would require legislation in the states or provinces or by the United States Congress or the Canadian Parliament. Finally, treaty changes could require extensive negotiations between the United States and Canada and/or Mexico and would need to be followed by both legislative and executive branch approval in these countries. Implementing some changes may require additional fieldwork by agency personnel, research, and monitoring or law enforcement efforts to ensure compliance. Thus, agencies would incur additional costs of implementation to do this work.

Francis (2000) discussed and analyzed the relative value of a spring harvest versus a fall harvest. There are differential impacts to the population between the two harvest periods. He pointed out that a bird shot in the spring represents a higher proportion of the population because the population has already been reduced by fall hunting and natural mortality. Second, the age ratio in the harvest will be different because of changes in the relative vulnerability of young birds. This is related to both changes in behavior and changes in the age ratio of the population because of fall/winter mortality. Third, he noted that breaking pair bonds through spring hunting may decrease productivity. There may be some recent field evidence to support this final point. Feret et al. (2001) found reduced fat and protein reserves in greater snow geese collected along the St. Lawrence River in Quebec in years with spring hunting compared to previous years. Mainguy et al. (2001) reported that laying greater snow geese had lower body size indices, smaller clutch sizes and delayed laying dates in years with spring hunting (1999-2000) compared to previous years (1989-1990). Thus spring hunting activity is believed to reduce the ability of birds to store nutrient reserves needed for successful reproduction (Alisauskas 2002).

The potential for negative effects on species other than light geese is highly variable among the suggested strategies, but there is no strategy that has absolutely no risk to other species. Of course, no one wants non-target species to be taken or unnecessarily harassed as part of a management action, but it may be an acceptable or necessary cost for preventing what otherwise would be an ecological disaster impacting many species. Impacts to other species can be minimized, but never totally eliminated, by careful implementation and management of a strategy. If we reach a point where more intensive strategies, such those outlined in the paper, need to be considered, managers may have to accept loss of individuals of other species as part of the process of fixing or preventing a looming ecological disaster. Impacts to endangered species would certainly be avoided at all costs. An important consideration is if the light goose population is not brought under control, the negative effects from overabundant light geese in both the north (e.g. habitat loss) and in the south (e.g. disease losses) could far exceed any impacts to non-target species caused by control measures.

Beyond the biological basis for implementation of more aggressive harvest strategies, ethical questions need to be considered. An in-depth discussion of ethical considerations is beyond the scope of this work. However, a few points need to be mentioned. A frequent concern is whether a specific action or proposal will "destroy the image of the hunter with the general public." All of the techniques used to date and described in this paper might be considered unethical by someone who considers themselves a "true hunter." At the same time, it might be considered unethical to not do whatever it takes to resolve the problem of overpopulation by light geese and avoid an ecological disaster. Because this is a human-induced problem, humans have an obligation to try to resolve it. Although there will be debate over the best strategy to use, any strategy selected will be viewed as "unethical" by some segment of our society.

Ethics frequently change, are based on the most recent traditions or practices and are highly individual. For example, today market hunting is generally considered unethical. However, when market hunting provided wild game for food for a significant portion of society in the late 1800's and early 1900's it was an accepted practice. In fact, market hunting provided a strong incentive to minimize waste. Every bird retrieved was economically important. As a second example of changes in ethical consideration, in the early 1900's the use of dogs for upland gamebird hunting was illegal and considered unethical in North Dakota (Johnson and Knue 1989). Today, however, hunting with a dog is considered to be an important conservation tool.

The issue of fair chase is irrelevant when the issue of population control goes beyond simply allowing additional hunting opportunities to harvest additional birds. If agencies undertake the task of direct population control, it will be incumbent on them to make the operations as efficient, effective, safe and inexpensive as possible. Ethical considerations will need to be reevaluated in light of human health and safety and the time, money, staff and budgets available to accomplish the work.

In the Guiding Principles statement developed by the Direct Control and Alternative Harvest Measures Working Group (Johnson and Ankney 2003) issues of humaneness and minimizing waste were addressed. Constraints of humaneness and especially wastage of birds are relative to the specifics of the task at hand. For example, we would generally consider that shooting birds and leaving them to decay on the landscape would be a waste of the resource.

However, if this were the only way to control the population without exceptional cost and risk to human life, then leaving the birds to naturally recycle into the environment may be looked at differently.

Research

There are several areas where additional research would be beneficial. First, consideration should be given to doing more work on baiting and how to develop baited situations that would attract and hold large numbers of geese so hunters could harvest them. This work should go beyond traditional approaches in that we should examine the effectiveness of developing large landscape areas, perhaps many square miles that are attractive to migrating light geese in the spring and the fall and that provide effective harvest situations for hunters.

Secondly, further work should be considered to acquire and test noise suppressed shotguns as are currently used in Europe. Noise suppressed shotguns could contribute towards increasing the effectiveness of hunters or agency personnel attempting to do direct control work on light geese.

Third, we should be working with agency land managers to find new ways to manage public and adjacent private lands to increase the harvest of light geese. We need new and innovative approaches to make geese more available and vulnerable to hunting so that hunters can harvest and use the birds.

Fourth, investigations should be considered to determine the most effective management for state, provincial and federal refuges to increase the harvest of light geese. What are the most effective management strategies for increasing light goose harvest? Should refuges be managed to discourage use by light geese, or should they be managed to attract large numbers of light geese that can be harvested by hunters or other direct control techniques?

Fifth, research is needed on the effectiveness of half-day hunting seasons for keeping light geese in an area to increase their harvest. Is half-day hunting contributing to an increase in harvest or would a more effective approach be to apply extensive and continuous hunting pressure to the birds throughout fall to increase harvest and reduce overall survival of adults and young of the year birds.

Finally, many of the methods for increasing light goose harvest described in this paper are new or at least have not been used for decades. Rigorous evaluations should be conducted to measure the effectiveness and impacts of any of the strategies proposed. Such evaluations could be done as part of a management process or as part of smaller scale pilot projects. Each would require careful implementation, planning and execution so that managers are assured that any strategies employed contribute to an overall increase in light goose mortality and cause minimal impacts to non-target species.

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LITERATURE CITED

Alisauskas, R.T. 2002. Arctic climate, spring nutrition and recruitment in mid-continent lesser snow geese. Journal Wildlife Management 66:181-193.

Alisauskas, R.T. & Ankney, C. D. 1992. Spring habitat use and diets of mid-continent adult lesser snow geese. Journal Wildlife Management 56: 43-54.

Bateman, H.A. 1988. History and status of mid-continent snow geese on their gulf coast winter range. Pages 495-515 *in* Weller, M. W. editor. 1988. Waterfowl in winter. University of Minnesota Press. Minneapolis, Minnesota. 694pp.

Batt, B.D.J., editor. 1997. Arctic ecosystems in peril: report of the Arctic Goose Habitat Working Group. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario. 120pp.

Bent, A.C. 1962. Life Histories of North American Wild Fowl, Part II. Reprint of: Bent (1925) Smithsonian Institution United States National Museum Bulletin 130. Dover Publications, New York, NY. 244pp, + ix, + plates.

Boyd, H., H. Levesque and K.M. Dickson. 2002. Changes in reported waterfowl hunting activity and kill in Canada and the United States, 1985-1998. Canadian Wildlife Service Occasional Paper Number 107. 24pp.

Bromley, R.G., D. Aglukark and A. Carpenter. 1997. The role of aboriginal people in the co-management of over-abundant geese in northern Canada. Paper presented at the Symposium on Overabundant Goose Populations: An Emerging Challenge in Wildlife Conservation. The Wildlife Society 4th Annual Conference. September 23, 1997. Snowmass Village, Colorado.

Caswell, J.H. 2001. Vulnerability of non-target goose species to hunting with electronic snow goose calls. M.S. Thesis, Louisiana State University, Baton Rouge. 29pp +iv.

Caswell, F.D. and M.H. Schuster. 2002. Prairie waterfowl status report, a briefing document, February 2002. Canadian Wildlife Service. Winnipeg, Manitoba. 24pp.

DeNicola, A.J., S.J. Weber, C.A. Bridges and J.L. Stokes. 1997. Nontraditional techniques for management of overabundant deer populations. Wildlife Society Bulletin 25:496-499.

Enck, J.W., B.L. Swift and D.J. Decker. 1993. Reasons for decline in duck hunting: Insights from New York. Wildlife Society Bulletin 21:10-21.

Francis, C.M. 2000. The relative impact of a spring hunt on snow geese population dynamics. Pages 6-15 *in* Boyd, H., editor. 2000. Population modeling and management of snow geese. Canadian Wildlife Service Occasional Paper Number 102.

Feret, M., G. Gauthier, J-F. Giroux and K. Hobson. 2001. Impact of spring conservation hunt on nutrient storage of greater snow geese staging in Quebec. Page 36 *in* Gauthier, G. and J-F. Giroux, eds. 2001. Program and Abstract. Tenth North American Arctic Goose Conference and Workshop. Quebec.

Hanson, H.C. 1997. The giant Canada goose. Revised edition. Illinois Natural History Survey. Carbondale. xxvi + 252pp.

Havera, S.P. 1999. Waterfowl of Illinois: status and management. Illinois Natural History Survey Special Publication 21. xliii + 629pp.

Henderson, F.R. 1972. Controlling coyote damage. Cooperative Extension Service, Kansas State University, Manhattan. 24pp.

Johnson, M.A. 1997. Management strategies to address the mid-continent lesser snow goose overpopulation problem. Pages 101-111 *in* Batt, B.D.J., editor. 1997. Arctic ecosystems in peril: report of the Arctic Goose Habitat Working Group. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario.

Johnson, M.A. and C.D. Ankney. 2003. Introduction. Pages 7 – 21 *in* Johnson, M.A. and Ankney, C. D., editors. 2003. Direct control and alternative harvest strategies for North American Light Geese. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario.

Johnson, M.D. and J. Knue. 1989. Feathers from the prairie. North Dakota Game and Fish Department, Bismarck. 292pp.

Kruse, K.L. and D.E. Sharp. 2002. Central Flyway harvest and population survey data book. U.S. Fish and Wildlife Service. Denver, CO. 136pp.

Knudson, D., editor. No date. Snow goose cookbook. Arctic Goose Joint Venture. 40pp.

Mainguy, J., J. Bety, G. Gauthier and J-F. Giroux. 2002. Are body condition and reproductive effort of laying greater snow geese affected by the spring hunt? Condor 104(1): 156-161.

Olsen, R.E. and A.D. Afton. 2000. Vulnerability of lesser snow geese to hunting with electronic calling devices. Journal Wildlife Management 64(4): 983-993.

Podruzny, K.M., J.H. DeVries, L.M. Armstrong, and J.J. Rotella. 2002. Long-term response of northern pintails to changes in wetlands and agriculture in the Canadian Prairie Pothole Region. Journal of Wildlife Management 66:993-1010.

Reed, A., J-F. Giroux and G. Gauthier. 1998. Population size, productivity, harvest, and distribution. Pages 5-31 *in* B.D.J. Batt, ed. The Greater Snow Goose: report of the Arctic Goose Habitat Working Group. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario.

Ringleman, J.K. 1997. Effects of regulations and duck abundance on duck hunter participation and satisfaction. Transactions North American Wildlife and Natural Resources Conference. 62:361-376.

Schroeder, C.H. 1981. The westward extension of the fall snow goose migration through North Dakota. North Dakota Outdoors 43(11): 8-11.

Schroeder, C.H. 1978. One-quarter century of goose hunting, 1953-1977. North Dakota Outdoors 41(6): 9-13.

Sharp, D.E. 2001. Central Flyway harvest and population survey data book. U.S. Fish and Wildlife Service Report. 126pp.

Sharp, D.E., K.L. Kruse and K. Gamble. 2001. Light geese in the Central Flyway. U.S. Fish and Wildlife Service Report, November 2001. 48pp.

Stradtmann, M.I., J.B. McAninch, E.P. Wiggers and J.M. Parker. 1995. Police sharp-shooting as a method to reduce urban deer populations. Pages 117-122 *in* J. B. McAninch, editor. Urban deer: A manageable resource? 55th Midwest Fish and Wildlife Conference, St. Louis, MO. December 12-14, 1993.

Syme, D.M. 1989. Fall migration pattern of the lesser snow goose (*Anser caerulescens caerulescens*). B.S. Thesis. Queen's University, Kingston, Ontario. 68pp. U.S. Department of the Interior. 1975. Issuance of annual regulations permitting the sport hunting of migratory birds. U.S. Fish and Wildlife Service final environmental statement. Wash. D.C. 710pp.+ appendices.

U.S. Department of the Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau. 2002. 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.

Part III

DIRECT CONTROL METHODS FOR POPULATION REDUCTION OF LIGHT GEESE IN THE ARCTIC

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INTRODUCTION

It is generally recognized that population change in geese is more sensitive to changes in adult survival than to recruitment of young. For example, Trost et al. (1986) developed a model for age-specific survival and recruitment in Canada geese that showed an increase of about 5% in annual adult survival rate had the same effect on population growth rate as did a 50% increase in recruitment. Rockwell et al. (1997), using elasticity analyses of vital rates in population projections for mid-continent lesser snow geese (LSG), concluded that reduction of adult survival had the greatest potential influence on population growth. However, estimation of target harvest levels required to reduce adult survival to the extent required for population decline, and achieving those harvest levels are separate issues. For example, Cooke et al. (2000) predicted that a further increase of at least 2.1-fold relative to estimated continental harvest for 1997, was required to achieve population reduction of mid-continent LSG. In addition to fall and winter harvest, Francis (2000) estimated that the impact of spring harvest was between 1.1 and 1.5 times the impact of killing the same number of birds in early fall. Currently, spring seasons, whether within the existing framework under the Migratory Bird Treaty Act or under new Conservation Orders, exist in virtually all jurisdictions of North America in which mid-continent LSG are found in large numbers.

The importance of adult survival as the key variable influencing population growth can be refined further by models that only consider survival of the adult female component of the population. If present practices aimed at reducing adult survival through more liberal limits and seasons are unable to reverse population growth, then more direct methods may be needed. In this section, we address the potential effectiveness for population reduction of light geese by killing adults on Arctic nesting and brood-rearing areas.

Various population models have been formulated to evaluate effects of changes in vital rates on population trajectory (Rockwell et al. 1997, Cooke et al. 2000, Rockwell and Ankney 2000, Francis 2000). In this paper, we extend assessment of harvest on LSG populations beyond those models by considering harvest on Arctic breeding areas. We assume that effects of Arctic harvest would be additive to harvest of adults during regular fall seasons, conservation orders in the United States and Canada, and any aboriginal harvest. Although aboriginal harvest of nesting geese is low or non-existent in Canada’s central or eastern Arctic, an exception is at the McConnell River near Arviat, Nunavut. This is the only major colony of mid-continent LSG that has shown consistent declines over the last 2 decades. Thus, this modeling exercise may prove valuable for understanding how harvest could be adjusted to produce desired population trajectories. This chapter focuses on Arctic harvest of LSG, but appropriate adjustments in vital rates, logistical considerations and cost estimates could be made to model harvest of Ross's geese and greater snow geese.

WHY THE ARCTIC?

Light geese breed in remote Arctic colonies at a time of year when geese are relatively sedentary and relatively isolated by species, colony, age, and sex. During nesting, pairs of geese are discernible from groups of immatures and nonbreeders, thus making selective harvest possible. Breeding light geese fly little and are tenacious to nest sites, particularly as incubation advances. Additionally, females can be identified by their smaller size and stronger association with nests, compared to males. This is an optimal period for a selective harvest of breeding adults. Such harvest should lower survival rate of local adult females and reduce reproductive output of the colony. LeShack et al. (1998) found that harvest of paired males resulted in only a moderate reduction of nest success by nesting Ross's and snow geese, although gosling survival may be reduced in widowed geese.

Adult females and males also can be killed during the wing molt. At this time, successful breeding adults are accompanied by young-of-the-year, and nonbreeding adults may be encountered, often separately, in flightless molt on larger lakes. This is also when mass-capture of geese is possible either on foot, or with helicopters.

The motivation for current management to reduce population size of mid-continent LSG has been concern for degradation of Arctic vegetation communities. Compared to harvest at other times of the year, harvest of adult LSG in Arctic areas would allow selection of colonies based on breeding numbers of geese, overall densities, and/or vegetative damage to colonies and surrounding areas. Additionally, population reduction in the Arctic should have an influence beyond immediately surrounding areas, and include salt marsh along the west coast of Hudson Bay, where comparatively few snow geese nest, but which is severely impacted by large numbers of migrants that nest elsewhere.

DISTRIBUTION OF MID-CONTINENT LESSER SNOW GEESE

Region Variation in Population Size

There are 5 regions in Canada's Arctic that support breeding mid-continent LSG: (1) Central Arctic (around Queen Maud Gulf, Figure 1), (2) Baffin Island (Great Plain of the Koukjuak, Figure 2), (3) Southampton Island (Figure 2), (4) West Hudson Bay (Figure 3), (5) South Hudson Bay/James Bay (Figure 4). Population estimates were based on ground studies (Queen Maud Gulf Bird Sanctuary, Central Arctic, 1998, R. T. Alisauskas [CWS], unpublished data), photosurvey (Jenny Lind Island, Inglis R., Kuugarjuk R., Central Arctic, Baffin & Southampton Islands, West Hudson Bay, 1997, R.H. Kerbes [CWS], unpublished data), or helicopter transects (Cape Henrietta Maria, K. Abraham [OMNR] & K. Ross [CWS], unpublished data). Most historical information on population size of breeding LSG at specific colonies has been based on aerial photo survey methods (e.g., Kerbes 1994). Note, however, that these numbers do not include nonbreeding snow geese, yet numbers of these can be substantial. For example, LSG breeding south of Queen Maud Gulf were estimated in 1998 at 1,224,000, whereas numbers of nonbreeders were 794,000, representing about 39% of all geese in the region (Alisauskas et al. 1998). Moreover, photosurveys were not designed to estimate nonbreeders, hence this substantially-sized fraction of the mid-continent LSG population (Cooke et al. 2002) is unsampled. Finally, there likely are other colonies that have not been found. Thus, population estimates used in this report are biased low if number of mid-continent snow geese are considered regardless of breeding status. Nevertheless, we use breeding snow goose numbers for each area as estimated above because that is what is available. In this report, Ross's goose regional abundances are not considered. Moreover, we restrict our consideration to colonies with >50,000 nesting snow geese because this is where the most vegetation damage likely has occurred or will occur in the short (years) or medium (decades) term.

HARVEST DURING NESTING AND LOCAL POPULATION DYNAMICS

Population Model

We evaluated the effect of various harvest scenarios on a colony-specific basis. We used a simple deterministic population model where rate of population increase, λ, is related to adult survival, S_a, and recruitment of young to breeding adult stage, F^{br}, as:

$$\lambda = S_a + F^{br} \tag{1}$$

Further, F^{br} normally is a function of breeding propensity of adults, B_{ad}, clutch size, C, survival of eggs during incubation, S_e, survival of prefledging goslings, S_g, survival of fledged young (i.e., < 1 year old), S_j, survival of subadults (i.e., adult plumage, < 2 years old), S_s, as

$$F^{br} = B_{ad} \bullet C \bullet S_e \bullet S_g \bullet S_j \bullet S_s \tag{2}$$

S_e was calculated by $S_{egg} \bullet S_{nest}$, where S_{egg} = survival rate of eggs in successful nests and S_{nest} = nest success (Alisauskas et al., in prep.). However, snow geese do not breed until they are at least 2 years old (Cooke et al. 1995), so it was necessary to include a lag in recruitment. Therefore, number of new recruits (i.e., breeding 2-year-olds) is

$$R^{br}_{t+1} = (N^{br}_{t-1})(F^{br}) \tag{3}$$

Conversely, the number of 2-year-olds that do not breed is

$$R^{non}_{t+1} = (N^{br}_{t-1})(F^{non}) \tag{4}$$

where $F^{non} = (1\text{-}B_{ad}) \bullet C \bullet S_e \bullet S_g \bullet S_j \bullet S_s$. Finally, the number of yearlings (all nonbreeders) is

$$R^{yr}_{t+1} = (N^{br}_{t})(F^{yr}) \tag{5}$$

where $F^{yr} = C \bullet S_e \bullet S_g \bullet S_j$. We assumed equal sex ratio among recruits to the population.

In the absence of Arctic harvest, projected population size of breeders at $t+1$ includes (1) the number of breeders from t, N^{br}_t , that survive to $t+1$, plus (2) first time breeders hatched at $t-1$, R^{br}_{t+1}, or

$$N^{br}_{t+1} = N^{br}_t (S_a) + N^{br}_{t-1} (F^{br}). \tag{6}$$

At year $t = 0$, before any harvest at breeding colonies, number of nonbreeding adults >2 years old was calculated as

$$N^{non}_{t+1} = N^{br}_{t+1}(B_{ad})^{-1} - N^{br}_{t+1}. \quad (7)$$

For years $t > 0$, nonbreeding adults of each sex were calculated as

$$N^{non}_{t+1} = N^{non}_{t}(S_a) + W_t(S_a) \quad (8)$$

where W_t are the number of widowed adults of either sex produced from any sex-biased harvest at year t (see eqs. 11, 12 below).

Total populations of geese at $t+1$ associated with breeding colonies include (1) breeding adults N^{br}_{t+1} (from eq. 6), (2) nonbreeding adults, N^{non}_{t+1} (3) nonbreeding 2-year-olds, R^{non}_{t+1}, and (4) nonbreeding 1-year-olds, R^{yr}_{t+1} :

$$N_{t+1} = N^{br}_{t+1} + N^{non}_{t+1} + R^{non}_{t+1} + R^{yr}_{t+1}, \quad (9)$$

assuming that adult survival probability outside the breeding season is the same for breeders and nonbreeders. Interestingly, the number of nonbreeders, $N^{non}_{t+1} = N_{t+1} - N^{br}_{t+1}$, comprise a substantial fraction of local populations. For example, for a colony of 100,000 breeding LSG, this model predicts that there are ~67,000 nonbreeding geese (adults, subadults and yearlings).

The local influence of harvesting breeding adults at specific colonies was assessed by calculating N^{br}_{t+1} where $t = 0$ on the first year of the harvest. Thus the effect of the previous year's harvest on N^{br}_{t+1} becomes

$$N^{br}_{t+1} = R^{br}_{t+1} + (N^{br}_{t} - N^{harvest}_{t})\, S_a \;, \quad (10)$$

where $N^{harvest}_{t}$ is the number of breeding geese harvested at t.

To accommodate sex-specific harvests, we estimated the number of breeding females at $t+1$ as

$$N^{br\,fem}_{t+1} = R^{br\,fem}_{t+1} + (N^{br\,fem}_{t} - N^{br\,fem\,harvest}_{t})S_a \;\Big|\; N^{br\,fem\,harvest}_{t} \leq N^{br\,fem}_{t} \text{ and } N^{br\,fem\,harvest}_{t} \leq N^{br\,mal}_{t} \quad (11)$$

and number of breeding males as

$$N^{br\,mal}_{t+1} = R^{br\,mal}_{t+1} + (N^{br\,mal}_{t} - N^{br\,mal\,harvest}_{t})S_a \;\Big|\; N^{br\,mal\,harvest}_{t} \leq N^{br\,mal}_{t} \text{ and } N^{br\,mal\,harvest}_{t} \leq N^{br\,fem}_{t}. \quad (12)$$

Thus, harvest of breeding females at t was constrained not to exceed the number of females nesting at t; in turn, number of females breeding at t was constrained not to exceed the number of males. Assuming no immigration of females from other colonies, female-specific harvests result in a highly skewed local sex ration in favor of males. Moreover, we assumed that surplus males would be nonbreeders existing outside of breeding colonies and thus unavailable for harvest during nesting. It is not clear how geese behave following mate loss - particularly on the scale considered - whether they disperse to other colonies, or how quickly they pair with a new mate. Presumably the number of potential mates for repairing would depend on the number of surplus nonbreeding adults. Further, we assumed that breeders never again breed after mate loss because of limitation by fewer geese of the opposite sex in the absence of immigration. Thus, the number of, e.g., widowed females that were former breeders but whose mates are killed during nesting is

$$W^{fem}_{t} = N^{br\,fem}_{t} - N^{br\,mal\,harvest}_{t} \tag{13}$$

which become part of the nonbreeding cohort in eq. 8. We reasoned that, even though males with lost mates likely would not breed at target colonies, such widowers, in addition to all nonbreeding yearlings and 2-year-olds, should be considered because they continue to consume vegetation. Thus, besides showing how the local *breeding* population changes in response to various scenarios, the number of locally-produced breeders and nonbreeders also is portrayed over 10 years. In all population projections, we assumed absence of density-dependence in either recruitment or survival (but see below); however, density-dependent recruitment and repairing by males should reduce effectiveness of summer harvests. In general, the simplifying assumptions that we make in simulations and cost projections would lead to maximized effects on population size relative to cost of management action. Moreover, this lack of information should motivate additional research on behavior of geese following mate loss.

Estimates of Population Growth Rate, Survival and Recruitment

From log-linear regression (Eberhardt and Simmons 1992), the estimate of average population change in snow geese breeding at Karrak Lake from 1993 to 2001 was 95%CL(λ_{snow}) = 1.076 ± 0.058 (Alisauskas 2001). In other words, mid-continent LSG breeding at Karrak Lake have increased at 7.6% per year over that interval.

The most recent estimates of annual adult survival rate are from QMG 1989-1995 (0.94 for males and 0.92 for females) and La Pérouse Bay 1990-1994 (0.94 for both males and females, Cooke et al 2000). As a check, we used band recovery models that estimate survival, *S*, and reporting rate of dead birds, *r*, in program Mark (White and Burnham 1999) on information from 25,720 adult and 23,117 juvenile lesser snow geese (goslings and adults). These geese were marked N of 53 degrees N latitude and E of 115 degrees W longitude in June, July or August, 1988-1998. Of these, 2930 were shot or otherwise found dead from 1988 to 1998 hunting seasons. We excluded any geese marked with neckbands as there is sufficient evidence to suspect that neckbands reduce survival of geese (Ankney 1975, Castelli and Trost 1996, Schmutz and Morse 2000, Alisauskas and Lindberg 2002). We began with the global model for 2 age classes (time dependence for juveniles and adults in both survival and reporting rates, i.e., $\{S_j(t)*S_a(t),\ \ r_j(t)*r_a(t)\}$). We then calculated a variance inflation factor, c-hat = 1.1406, by dividing model deviance by the deviance from bootstrap simulation with 100 iterations of the saturated model. Thus, we used QAICc rather than AICc (Burnham and Anderson 1998) for model selection. The best of 7 models considered was one with time dependence in survival rates of both juveniles and adults, with an additive effect of age on time for both survival and reporting rate. For population modeling, we were interested in mean annual survival 1988-1998/99, which we calculated from β after manipulating the design matrix, following White et al (1999), and back-transforming β using the logit link. Thereby, we estimated $S_j = 0.30 \pm 0.02$(SE) and $S_a = 0.92 \pm 0.13$. The global model with time dependence interacting between ages in both survival and reporting rates had ΔQAICc=13.88, compared to the best model, i.e., $\{S_j(t)+S_a(t), r_j(t)+r_a(t)\}$, which had a model weight of 0.98. We assumed that $S_s = S_a = 0.92$. Mean lifespan, therefore, is estimated to be about 12 years if snow geese survive their first year.

Liberalization of seasons and limits of LSG since 1999 may have resulted in annual survival probability of adults that is now less than 0.92. However, numbers of snow geese nesting at Karrak Lake showed no decline as of 2001 (Alisauskas 2001). Nevertheless, we also simulate populations over 10 years using adult survival rates of 0.86 as proposed by Rockwell et al. (1997), and 0.78 estimated by Frances et al (1992) for 1970 - the year before which there was little change in indices of mid-continent population size during winter (Alisauskas 1998). Mean juvenile survival rate in 1970 was 0.50, as estimated by Frances et al. (1992).

For components of F, we used values determined from QMG (Alisauskas at al, in prep) instead of those measured at La Perouse Bay (Rockwell et al. 1997) because (1) QMG is at a latitude where most mid-continent snow geese nest (Figure 5), (2) estimates from QMG are for a recent period (1991-1998) compared to those from LPB (Cooke et al 1995). Unfortunately, vital rates are not available for each major colony. Means of annual estimates for LSG nesting at Karrak Lake in QMG are: C = 3.67 for 1991-1998, S_{egg} = 0.87 for 1995-1998, S_{nest} = 0.81 for 1991 to 1998, (thus S_e = 0.71). To estimate B = 0.61, we divided the number estimated nesting (1,223,869) by total number estimated (breeders+nonbreeders = 2,017,359) at QMG in 1998 (Alisauskas et al, in prep). Numbers of nonbreeders so estimated include nonbreeding adults, subadults and yearlings. Thus, B_{ad} = 100,000/133,000 = 0.75 , but B = 100,000/164,300 because associated with e.g., 100,000 breeding geese would be ~33,000 nonbreeding adults, ~5,300 nonbreeding 2-year-olds, and ~26,000 yearlings (see below); so, B_{ad} = 0.75 refers to the breeding propensity among adults geese ≥ 2 years old. We have no reliable estimate of gosling survival (from hatch to fledging) over the long-term. Hence, given that

$$\lambda = S_a + B_{ad} \bullet C \bullet S_e \bullet S_g \bullet S_j \bullet S_s, \quad (14)$$

S_g was calculated from this relation by substituting estimates for each variable, i.e.,

$$1.076 = 0.92 + 0.75 \bullet 3.67 \bullet 0.71 \bullet S_g \bullet 0.30 \bullet 0.92$$

giving S_g = 0.29.

The influence of immigration and emigration on local population growth of LSG has been investigated only for the La Perouse Bay colony (Cooch et al 2001). That colony likely is not representative of most mid-continent LSG because of it's small size and low latitude (see above), but in the absence of such estimates for other more substantial colonies, we operated under the unlikely assumption of no movement of birds among colonies. Such processes are currently under investigation within the Queen Maud Gulf metapopulation, and between Queen Maud Gulf and more eastern colonies (Alisauskas and Drake 2001).

Sex Ratio of Harvest During Nesting

We considered scenarios where 50,000 nesting geese were harvested from a hypothetical colony of 100,000 nesting geese, but the sex ratio in the harvest was 0%, 25%, 50%, 75%, and 100% females. Such annual harvests were projected for 10 successive years.

Outcomes of population control during nesting depend on whether number of breeders only, or numbers of all geese hatched from target colonies are considered. Immigration rates depend on the likelihood of locally-nesting widows repairing with nonbreeding males from other colonies during winter and spring migration. For harvests of 50,000 from a hypothetical colony of 100,000 nesting snow geese with the vital rates assumed above, 2 years are required for elimination of local nesting if harvest composition is 0% female, 25%, 75% or 100%; a harvest of 50,000 with equal sex ratio requires 3 years for elimination of local nesting (Figure 6a). This is because harvests of other than 50% sex ratio result in a surplus of one sex which become nonbreeders in the following year, and so cannot be harvested at nesting colonies. When total numbers of geese are considered (~156,000 including 100,000 breeders at *t*), however, an equal sex ratio in harvest is most expeditious for population reduction, followed by harvests composed of 75% and 25% females (Figure 6b). This is because, in the absence of immigration, the number of either sex nesting and available for harvest during nesting is constrained by the number of live breeders of the opposite sex (eqs. 11, 12). However, complete elimination of nesting females and their erstwhile recruitment, still produces a surplus, or reservoir, of 50,000 nonbreeding males, with an annual survival rate of 0.92. Such males and other nonbreeders would continue to consume Arctic vegetation.

At higher initial population size of 250,000 breeders (Figure 6c), the efficacy of reduction in local nesting populations continues to increase with increasing proportion of females in the harvest of breeders. However, the differences in effect on total population size stemming from variation in sex ratio of the harvest declines with increasing initial population size (Figure 6d). Thus, curtailment of population damage through reduction of breeders and nonbreeders may be most efficient by disregarding sex of breeding geese during harvest at larger colonies.

Large-Scale Harvest During Nesting

Given that harvests of equal numbers of males and females reduce total population size most effectively at relatively small colonies, we considered the effect of substantially larger harvests at substantially larger colonies. We applied the harvest model, assuming vital rates as above, to colonies of 250,000, 500,000, and 1,000,000, with annual harvests of zero, 50,000, 100,000, 150,000, 200,000, and 250,000 nesting geese (Figure 7).

For populations of 250,000, any annual harvest >100,000 could result in elimination of local nesting within 4 years (Figure 7a). However, for larger colonies local elimination of nesting within 10 years depends on size of annual harvest. Population reduction of breeding geese could result from realized annual harvests of 50,000 geese for colonies of 500,000 (Figure 7c), but this would be insufficient to reduce populations at colonies of 1 million (Figure 7e). In none of these scenarios, will harvest of breeders eliminate all geese locally during a decade of sustained annual harvest; again, this is because nonbreeders are not harvested. In the case of local elimination of breeding, the population rate of change will roughly equal the annual survival rate of adults, assuming no immigration or emigration.

Duration of Annual Harvest

Although elimination of locally nesting geese is not an objective, number of years (up to a maximum of 9 sequential years of annual harvests) to achieve this is presented in Figure 8. This also is useful to know so as to avoid plans that may lead to overharvest. If regional population objectives are determined, the number of years to achieve those objectives with different initial colony sizes and variable intensity of annual large-scale harvests also can be judged from Figure 8. It is instructive to understand population trajectories if harvests are terminated after a number of years, either as a result of achieving local population objectives or resulting from budgetary constraints. We considered harvests of 50,000 geese for 0, 1, 3, 5, 7, and 9 years at colonies with initial populations of 250,000, 500,000, and 1.0 million nesting snow geese. The predicted rebound of populations after termination of population reduction depends strongly on population size after termination, regular harvest during fall and winter, and number of years that harvests are done (Figure 8). Harvests of 50,000 did not effect population declines in colonies of 1 million geese (Figure 8c, d, e, f). It is noteworthy that populations of 250,000 projected 10 years were below initial populations if annual harvests of 50,000 were done every year for only the first 5 years (Figure 8a, b).

Population Dynamics with Reduced Survival Outside of the Arctic

Adult survival rates may decline due to harvest during regular hunting seasons in fall and winter, or during spring outside of the breeding season. It is generally considered that hunting mortality is additive to nonhunting mortality for long-lived species with low natural mortality, such as geese (Francis et al. 1992, Rexstad 1992, Hestbeck 1994, Gauthier et al. 2001), so we considered effects of harvest during nesting to be additive to those during the rest of the year. Colonies with initial populations of 250,000 projected over 10 years with no harvest, but with adult survival = 0.85 suggested by Rockwell et al. (1997) and juvenile survival =0.30, (estimated above for 1988-1998) results in predicted population growth rates ≈ 0.992, i.e., essentially weak population stability, if all components of recruitment, other than juvenile survival remained the same (Figure 9a); total numbers of geese also show a decline (Figure 9b) because numbers of nonbreeders decline more rapidly with adult survival = 0.85 instead of 0.92. With adult survival = 0.78 estimated by Francis et al. (1992), and juvenile survival = 0.30, annual rate of population change becomes ~ 0.910, or population declines of both breeders and total geese (Figures 9c, d). Substituting juvenile survival = 0.50 (the mean of male and female juveniles estimated by Francis et al. (1992)) for 0.30 (estimated above for mid-continent LSG from 1988 to 1998) in the model predicts stable populations of nesters ($\lambda \approx 0.997$). This may be an important finding because it suggests that harvest of juveniles might play an important role in population reduction. If reduced juvenile survival from non-hunting mortality during migration from brood-rearing areas is linked to degraded vegetation on brood-rearing areas near colonies (as suggested by Francis et al. 1992 and Cooch et al. 1993), then the extent to which juvenile survival could increase depends on the permanence of vegetation degradation on brood rearing areas. Alisauskas (2002) recently showed that age ratios in mid-continent LSG have shown a long-term decline, possibly a result of density-dependent effects on gosling survival, juvenile survival, or reduced fecundity. If effects of overpopulation by geese on vegetation are relatively long-term, then survival of goslings and juveniles raised near degraded colonies may not increase, even if local populations of geese decline. In such cases, local density dependence shown by Cooch et al. (1992) may not be reversible in the short term. Moreover, Alisauskas (2002) has demonstrated that declining body size, presumably arising from density dependence such as demonstrated at La Perouse Bay by Cooch et al (1992), is typical of mid-continent LSG. Although our insular population model does not consider movement among colonies, formation of new colonies at undegraded sites in the Arctic may allow some reversal of density-dependent effects. For example, most colonies south of QMG are located in the eastern portion of the QMG sanctuary, even though there appear to be large expanses of available habitat remaining to the west. In any event, our model suffers from the lack of information about such density-dependent effects.

LOGISTICS AND COSTS OF ARCTIC HARVEST

Cost estimates of population reduction measures were calculated based on several possible approaches on Arctic breeding areas: (1) shooting nesting adults, and (2) helicopter-assisted mass capture of adults and goslings during brood-rearing. In both cases, costs are influenced largely by (1) logistics of transportation, (2) the efficiency with which geese could be harvested within temporal constraints of nesting or brood-rearing, and (3) how harvested geese are to be used. Estimates in Canadian funds were based on approximate costs in 1999.

Transportation

The mid-continent LSG population breeds largely in the central and eastern Canadian Arctic south to the southern coasts of James and Hudson Bays (Figures 1-5). Unlike regions in southern prairie Canada and the mid-continent of the United States, there are no extensive road networks making travel by air and, secondarily, by ship the sole methods available for large-scale transportation. Consequently, Arctic travel is expensive, further compounded by availability of aircraft fuel, which in turn is expensive, or frequently unavailable where it may be required for remote field operations. Moreover, there are relatively few communities and fewer charter aircraft companies, impinging on availability of aircraft. Also, not all communities have bulk fuel (Figure 10) or runways (Appendix I) so that caching of drummed jet fuel may be required. This can be accomplished in large volumes either by air or barge annually, but is expensive and somewhat complicated, and is one reason why an expediter or coordinator is suggested at any community requiring fuel delivery.

Finally, snow goose colonies are at various distances from the nearest communities with available personnel, aircraft and fuel. Thus, cost of transport to each colony is highly variable. Consequently, costs associated with population reduction are a function of geography, but these are relatively easy to estimate, as are costs associated with salaries, equipment, and number of personnel. Cost of operations were estimated usually from the nearest community to a target colony and so do not include travel to or from the Arctic, either for personnel or for ferrying aircraft from outside of Nunavut. Transport estimates are influenced by our experiences with logistics while studying Arctic geese primarily in the central Arctic region of Kitikmeot in Nunavut and in northern Quebec. All calculations (unrealistically) assume complete availability of aircraft and perfect weather conditions for travel from nearest communities and deployment of crews at colonies. No attempt was made to account for weather as this is highly unpredictable. Transportation delays due to weather may not increase cost of control measures/bird if number of days required to harvest target numbers (50,000) of adults is less than the ~30 days of nesting during which harvest of adult birds could be done. Another assumption concerns the ability of Twin Otters to land at all target colonies when required. While this is possible and likely for Twin Otters equipped with skis or wheeled skis early during nesting when there may be good snow cover, or if there are deep lakes that retain ice cover after snow melts from terrestrial habitats, aircraft may be unable to land close to target colonies as incubation proceeds. In cases where fixed-winged aircraft cannot land at or near enough to target colonies that they could be reached by crews from the ground, helicopters would be required to transport personnel, equipment and geese from target colonies to locations perhaps 5-15 km distant where Twin Otters can land. If so, then costs rise further due not only to helicopter charter, but also the need to cache turbo fuel for helicopters. Each colony is likely to be unique in its ability to accommodate aircraft with changing offstrip conditions as snow melts. We made no attempt to estimate such additional costs because we lacked detailed knowledge of topography and conditions at each of the major nesting areas of mid-continent LSG. In our consideration of kill during brood-rearing, we assume that helicopters would be used, as is done for standard mass-capture of geese for banding operations. Reliance on helicopters permits more flexibility in establishing base camps, which would need to be in areas where Twin Otters can land.

Disposition of Snow Geese

There are two clear options for disposition of geese harvested from nesting colonies - (1) Nutrient Replacement Option, whereby all geese are left on site, or (2) Complete Removal Option, whereby all geese are transported back to the nearest community. A third option is some combination of the first two, and a fourth includes partial processing that might involve separation of breast meat, leg meat, or other parts from the carcass, for return to nearest communities. In addition to Hunting and Gathering Crews, the Partial Processing Option would likely require a Processing Crew to butcher and package goose parts for transport from target colonies to communities. This option would require additional equipment for sanitary processing and storage; however, savings in transportation costs would be realized because breast and leg meat of snow geese weigh only an average of about 0.5-0.6 kg compared to and average of 2.5 kg/whole goose.

There are uncertainties about the efficiency with which snow geese could be harvested, gathered, butchered and packaged. It was very difficult even to speculate about the efficacy of partially processing 50,000 geese, but a smaller-scale pilot study would be instructive in anticipating logistics. Therefore, we limited ourselves to estimation of costs for harvesting of geese during nesting, to the (1) Nutrient Replacement and (2) Complete Removal Options.

Nutrient replacement option

Under this scenario, carcasses are left where birds are killed, whereby nutrients are allowed to return to the substrate and, essentially, replace nutrients formerly removed from tundra ecosystems. Such nutrient enrichment may accelerate recovery of plant communities damaged by snow geese, the efficacy of which may interact with the extent of former soil erosion associated with overgrazing and excavation by geese. The effects of nutrient replacement on Arctic communities that have been damaged by snow geese are unknown and nutrient replacement may be confounded by both abiotic (e.g., leaching) and biotic processes. Goose carcasses may be consumed by, and so, benefit local populations of Arctic carnivores and scavengers such as grizzly bears (*Ursus arctos*), polar bears (*U. maritimus*), wolves (*Canis lupus*), Arctic fox (*Alopex lagopus*), wolverine (*Gulo gulo*), herring gulls (*Larus argentatus*), glaucous gulls (*L. hyperboreus*), jaegers (*Stercorarius spp.*) etc. Such consumption would tend to dilute nutrient enrichment at target colonies because of transience of carnivores after eating goose carcasses. Superabundance of food may concentrate predators that could reduce survival or reproduction of alternative non-target prey species (e.g., White-Fronted geese [*Anser albifrons*], or Canada geese [*Branta canadensis*]) near target colonies, or lead to increased risks of disease. Although predators or scavengers may not be attracted until after hatch of non-target avian species, predation of any flightless young or adults may increase. Nevertheless, such influences, if they occur, likely will be short-lived as carcasses disappear and become incorporated into local substrates and then, ideally, plant communities.

The Nutrient Replacement Option addresses ecosystem benefits of allowing nutrients locked up in goose carcasses eventually to return to damaged tundra substrates and vegetation. Consider that if all goose carcasses were transported back to communities, much of each goose consumed by people and most of the unconsumed parts will end up either in sewage lagoons or in community dumps, respectively. For example, 50,000 geese returned to Ekaluktutiak (Cambridge Bay) in Nunavut, for use by its ~1500 inhabitants would amount to 30-40 geese/resident and probably >200 geese/household - perhaps an overwhelming proposition considering that freezer space likely would be limiting. Furthermore, not all residents may be interested in goose consumption. On the other hand, further processing of feathers and down, pet food, bone meal, and dry meat for future human consumption may reduce the proportion of goose parts unused by people. The extent to which this occurs will depend on infrastructure for further processing available at communities. At least some communities in Nunavut, e.g., Ekaluktutiak (Cambridge Bay), already have plants for processing "country foods" such as Arctic Char, Muskox, and Caribou for local consumption or export to markets outside of communities nearest to target colonies, either in other communities in Nunavut, or outside of Nunavut. Perhaps, processing and marketing of plucked, packaged and frozen snow geese could proceed in this way under the Complete Removal Option (see below). Additional costs of further distribution of processed geese beyond the nearest communities are not considered in this report, as this would require a separate detailed analysis of the availability of such infrastructure.

Complete removal option

If all dead geese are returned to communities for distribution or further processing, costs become considerably higher. For example, it would require 98 Twin Otter flights with a payload capacity of 1270 kg (i.e., 508 geese/flight, average goose weight = 2.5 kg) to transport 50,000 geese from target colonies to nearest communities. Moreover, if Hunting crews are expected to continue harvesting to achieve target levels, an additional Gathering crew is required to pick up dead geese and transport them to a central gathering point, where aircraft can land and take off to transport geese back to communities. Gathering crews have additional capital costs associated with additional equipment requirements (see below) to expedite collection and ground transport of geese within target colonies. Complete removal would require that at least one Twin Otter essentially be dedicated to the program and remain on stand-by for 3-4 weeks. If 98 flights are required to transport all geese over 20 days, this means 5 flights per day would be necessary. Although logistically possible if target colonies are <150 km from the nearest communities with fuel, and if two crews are available (because of Ministry of Transport regulations governing the amount of time that pilots can fly/day due to fatigue), unpredictable weather conditions that prevent flight make it very unlikely that all geese could be removed in 20 days. Even with 2 dedicated aircraft on standby, a round trip flight of even 100 km (flight time = 1 hr, return) would probably require an additional 1 to 1.5 hour at the base for unloading geese and refueling. Unless 2 or 3 Twin Otters, each with replacement crews, remain fully committed to the control program, it is effectively impossible to transport 50,000 geese in 20 days. If 2 or 3 aircraft are available, frequent landings may severely damage habitat in areas without a firm substrate, especially during nesting when melting snow further softens high clay soils.

Harvest Efficiency at Nesting Colonies

Compared to transportation and how dead geese are to be used, more uncertain is the efficiency (e.g., number geese/day) with which geese can be killed both at breeding colonies and on brood-rearing areas. This has a large influence, not so much on deploying people to harvest geese, but on costs expended/goose harvested. Efficiency was entered in our model as the average number of minutes between each goose harvested. We assumed that use of .223 calibre rifles with jacketed or solid point rounds would be most effective in harvesting adults because of (1) greater effective range (up to 200 m), thereby minimizing the need to travel on foot between shooting locations and maximizing numbers of geese harvested at each shooting location, (2) low wounding rates, and (3) low weight of ammunition compared to shotgun shells, thereby leaving travel by, and resupply of, hunters relatively easy. Use of silencers which are available for .223 rifles (M. Johnson, pers. comm.) may improve daily harvest rates because geese not targeted immediately would remain undisturbed. Efficiency of harvest likely would increase from egg-laying to hatch as nesting adults become more apt to remain on or near nests. On the other hand, the negative feedback associated with shooting large numbers of animals day after day likely would reduce the daily rate of geese harvested/hunter.

Numbers of geese that could be killed in a single day likely vary directly with nesting densities. There is considerable variation in density of nesting geese within and among colonies. Regional density was calculated by dividing estimated number of breeding geese by the area (km^2, including water bodies) within local range of colonial geese. Ideally, waterbody area should be subtracted from total area as they support no nesting geese, and travel by hunting, gathering or processing crews (see below) would be on foot, or ATV. Although terrestrial area estimates are available for colonies in QMG, they were not for other regions.

In the central Arctic (e.g., Queen Maud Gulf Bird Sanctuary), colonies are small, insular, and some have very large numbers of nesting light geese (Ross's and Lesser snow geese). On the other hand, white goose colonies on Southampton and Baffin Islands support even larger numbers than in the central Arctic, but are very expansive such that densities are considerably lower (Figure 11). Variation in nesting density would have an unknown, but important influence on the efficiency with which adult geese could be shot during egg laying (see below).

Overall density of snow goose nests at the Karrak Lake colony in 1997 was 1221/km^2 (Alisauskas et al., in prep). Assuming an effective range of 200 m for a .223 rifle with silencer and scope and densities of 1221 snow goose nests/km^2 (i.e., 2440 snow geese/km^2), a hunter would have access to 307 snow geese/shooting location. If a goose is harvested every minute from this one shooting location, it would require about 5.1 hours. It seems reasonable to assume that one person, with additional firearms to allow cooling, may be able to harvest a goose every 30 seconds (allowing for reloading, switching firearms, adjusting position, allowing birds to settle down, etc.), but it is also unlikely that a person could sustain this for 2.6 hours without rest. Nevertheless, if this were probable, then three shooting locations might be visited / 8 to 9-hr working day allowing for travel on foot between camp and shooting areas. Thus under conditions of relatively high nesting densities, such as at Karrak Lake (Figure 11), individual hunters might harvest over 900 snow geese/day as an absolute maximum. If a snow goose was harvested only every 1.5 minutes, on average, then a crew of 8 hunters could harvest 2,560 geese/day or 51,200 geese over 20 days. We calculate costs, below, using two scenarios of high (1 goose/min; Table 1) and low harvest efficiency (1 goose/3 min; Table 2). With low harvest efficiency, a shooting crew could harvest only 1,280 geese/day or 25,600 geese in 20 days. Thus to achieve the objective of 50,000, 2 shooting crews would be required (Tables 2).

Travel distance would increase with each day, as hunters visit more distant shooting locations, thereby reducing the number of birds harvested/day, the number depending on ease of travel. The example from Karrak Lake likely represents a situation offering one of the highest potential harvest efficiencies/hunter/day. Most colonies, however support densities of nesting birds that are considerably lower (Figure 11; the discrepancy in the density estimate from Karrak Lake above and the one in the figure, is that the first estimate is based on density with only terrestrial habitat in the denominator, where in the figure, the denominator for density includes water bodies; this was necessary, as values for terrestrial habitat occupied was not available for colonies other than in Queen Maud Gulf). For example, at the largest colony on West Baffin Island, densities are only 422 snow geese/km^2 (including water bodies) compared to 1641 snow geese/km^2 (including water bodies) at Karrak Lake. Thus hunters on Baffin Island would spend more time traveling between shooting locations, and less time/day harvesting geese.

Topography is an important feature that likely influences not only efficiency of travel, but also efficiency of harvest from each hunting location. Compared to colonies with flat terrain, those with promontories from which geese could be harvested likely would increase the number of birds that could be shot from each location before moving to the next location.

Harvest Efficiency on Brood-rearing Areas

The most efficient means to mass-capture geese, in our view, is with helicopter assistance (Timm and Bromley 1976). To our knowledge, all previous helicopter-assisted mass capture of geese was for the purpose of marking birds with legbands, and in some cases, with additional neckbands. Such marking requires that great attention is directed at careful deployment of portable nets, so that handling effects on survival of birds are minimized. Moreover, marking extends the time that geese captured in individual drives are held, compared to a situation where geese so captured are to be killed. Finally, during banding operations, attention is normally focused on intermediate-sized flocks of no more than 400-500 snow geese. If geese mass-captured during brood-rearing are to be harvested, then considerably larger flocks of up to 1000 or 1500 geese per drive could be targeted. While it is difficult to envision the rate at which captured geese could be dispatched, we expect that, with the reduction in handling time/drive, more drives/day could be accomplished. Because costs of this kind of harvest are highly sensitive to the number of geese harvested/day, we propose that between 2000 (low efficiency) and 5000 (high efficiency) snow geese might realistically be harvested/day. Depending on nesting success and whether productive adults or nonbreeding flocks are captured, such numbers may include a substantial fraction (i.e., up to 50%) of goslings. Such dilution detracts from the objective of harvesting as many adults as possible. Also, cost-efficiency is sensitive to disposition of geese (Nutrient Replacement vs. Complete Removal).

Cost Estimates of Harvest at Nesting Colonies

Operating costs

Cost estimates were made for a minimal harvest of 50,000 nesting geese per target colony per year and include annual operating costs and capital costs in the first year for non-expendable supplies. Estimates were calculated based on distance of colonies (Figure 1) from nearest communities (Figure 2), number of hunting/gathering crews and harvest efficiency (see below). Greater harvest effort by increasing the number of crews increases total daily costs, but reduces the duration required to achieve harvest objectives. Furthermore, the number of crews deployed would increase the number of geese that could be harvested.

We assumed that hunting crews would travel through colonies on foot even though some colonies can cover >100 km². Many colonies are bisected by rivers or surround lakes and availability of boats might increase efficiency of travel but would increase capital and transportation costs and so was not considered in our budget. Depending on the disposition of dead geese (see above), gathering crews may also be required to pick up dead birds and transport them to central locations where the meat could be processed, or from where whole birds would be shipped by air back to nearest communities.

Equipment required per camp depends on the number of 10-person crews. Each crew member should be able to communicate with any other (hand-held radios), and each camp requires communication (satellite phone) with the air charter company for coordination of timely transportation of geese back to communities. Additionally, food, shelter and a power supply for communications equipment are required.

Community coordinator

To ensure that fuel is in place, aircraft is available, people are hired and outfitted, and scheduling is monitored, it is critical to have a coordinator at each community from which operations could be based. Although we suggest that allowances be made for a $20,000 contract for this work, we did not include this cost in our budgeting.

Hunting crews

Based on knowledge and speculation about efficiencies of payload, we suggest that an operation crew of hunters be composed of 10 people (1 coordinator, 1 camp cook/maintenance person, and 8 hunters). A hunting crew, with personal gear, plus all camp equipment for a stay of ~20 days at a colony would require 2-3 Twin Otter loads (payload about 1273 kg/load) from the nearest community to a target colony (we assumed that two Twin Otter loads/ hunting crew were adequate).

Options for including more than one hunting crew were considered. Most people, even those that subsist by harvesting and consuming wildlife, may find killing on such a scale distasteful or even unpalatable, and so recruiting adequate numbers to execute such a harvest program may be a problem. For example, note that we estimate it would require 100 persons to attempt to harvest 250,000 geese under the Nutrient Replacement Option and 200 persons under the Complete Removal Option (Table 1). We budgeted $200/person/hunting crew/day, and the number of days in the field depends on the number of hunting crews and harvest goals. We also budgeted for 2 days of salary before harvest and 2 days after to allow for transportation between settlements and target colonies, and camp set-up.

Transportation costs for hunting crews vary with distance from settlements to target colonies. All transportation to target colonies was assumed to be with Twin Otters ($1200/h at 200 km/hr), and there would be 4 flights required/hunting crew. We included $100 off-strip landing fee for each landing. For example, Twin Otter costs for a single hunting crew from Cambridge Bay to Karrak Lake (about 300 km) include 4 return flights (2 to deploy the crew at the target colony, and 2 to return the crew to Cambridge Bay) for a total cost of $14,800.

Gathering crews

Costs of gathering crews (1 coordinator, 1 cook, and 8 gatherers) would be in addition to costs of hunting crews and would be incurred under a Complete Removal option. Salaries/person would equal those of hunting crews (at $200/person/day), or $27,700 for gathering 50,000 dead geese over 13 days. Similarly, food would cost $3,900. We assumed that transport of gathering crews and their equipment (see below) would require 4 flights per crew. Thus Twin Otter costs for a single gathering crew from Cambridge Bay to Karrak Lake would be $29,600. We did not budget for purchase and transport of gasoline for ATVs (see below), as these costs would depend on gasoline consumption during gathering of geese. Therefore estimates of annual operating costs of gathering crews are biased low.

Removal of harvested geese

The following costs would be incurred under the Complete Removal option, not the Nutrient Replacement option and assume complete availability of aircraft and crews (see above). Costs of transporting geese back to communities for processing are highly sensitive to distances between target colonies and communities. We assumed that in all cases, Twin Otters could land near where gathering crews could deposit harvested geese in a central location, thereby removing the need to shuttling geese between target colonies and the nearest possible landing strip for Twin Otters. This assumption is likely faulty for most colonies, as, for example, there are no known terrestrial landing strips within 20 km of Karrak Lake, although landing on ice of a nearby deep lake is possible through the first half of June, in most years. Finding the nearest landing location for Twin Otters to each colony would require a case-by-case reconnaissance by aircraft charter companies, for which costs are unknown. We suspect that helicopter shuttling would be required at most colonies, but have ignored these costs because they are highly speculative.

With these caveats in mind, we simply assumed that the number of Twin Otter flights to move harvested geese to communities depended strictly on distance, and payload capacity of aircraft (1270 kg or 635 geese/load) assuming a mean body mass of 2 kg/snow goose. Body mass of female LSG is highly variable from early incubation (~2500 kg) to hatch (~ 1950 kg), and would influence the number of geese/load depending on incubation stage. Thus it would cost at least $292,300 to remove 50,000 whole geese 300 km from, e.g., Karrak Lake to Cambridge Bay, $580,900 to transport 100,000, and $1,457,800 to transport 250,000 whole geese.

Capital costs

Capital costs associated with each camp would only be incurred in the first year. Thus the option exits to outfit a single population reduction camp (possibly composed of >1 reduction crew) that would target different colonies in different years, or invest in more than one camp that would harvest geese at >1 target colony simultaneously.

Hunting crews

We assumed that hunting crews would travel through colonies on foot even though some colonies can cover >100 km². Many colonies are bisected by rivers or surround lakes and availability of boats and/or all terrain vehicles may increase efficiency of travel, acquisition of which would increase capital costs. We budgeted for 4 .223 rifles with scopes per hunter (total cost of $19,200/8 hunters), one satellite phone/camp ($5,000), one generator/camp, hand-held VHF radios for communication among all members of each crew ($10,000/crew), 3 Jutland tents/crew ($15,000/crew), and 1 kitchen/crew ($1,000). We did not include costs of bedding, clothing, footwear, and all personal effects, which we assume will be supplied by hired hunters. We also assumed one-time capital costs and made no allowance for repairing or replacing damaged equipment. Fixed capital costs were $55,200 for 1 hunting crew/camp, $80,200 for 2 hunting crews/camp, and $105,200 for 3 such crews/camp.

Gathering crews

Gathering crews would require the following equipment: hand-held VHF radios ($5,000/crew), 3 Jutland tents ($15,000/crew), kitchen ($1,000/crew), and 4 ATVs and trailers ($48,000/crew).

Cost Estimates for Variable Harvest at Specific Colonies

Using operating and capital costs above, we estimated cost of harvesting 50,000, 100,000, and 250,000 mid-continent LSG at major nesting colonies (Tables 1,2) under the Nutrient Replacement and Complete Removal options. Because of uncertainty about harvest efficiency, we also estimated costs assuming 1 goose harvested / min (high efficiency), compared to 1 goose harvested every 3 minutes (low efficiency). The nearest human communities to specific target colonies were chosen on the basis of distance, human population, and availability of jet fuel (Figure 10). While operating costs are highly variable, capital costs change only in relation to the number of crews and associated equipment. For example, to harvest 50,000 LSG from the west coast of Hudson Bay near McConnell River, a colony only 30 km from the nearest human settlement, would cost about $56,000 under the Nutrient Replacement option, but about $130,000 under the Complete Removal option assuming 1 goose harvested per minute (Table 1). If an average of 3 minutes is required to harvest a goose, then costs increase to about $126,000 and $342,000, respectively (Table 2). The difference in cost between the 2 options considered increases considerably with increasing distances between colonies and settlements (see Figure 13). With operations based out of Iqaluit, harvest of 50,000 at 1 goose/min from, e.g., west coast Baffin Island would cost about $73,000 for Nutrient Replacement, but about $511,000 for the complete removal option (Table 1). Reducing harvest efficiency to a more realistic rate for that area of 1 goose/3 min increases annual operating costs to about $159,000 and $775,000, respectively (Table 2). Under this last scenario, inclusion of capital costs increase first-year costs of operations at this site to ~$239,000, and ~$1,071,000, respectively (Table 2). By comparison, increasing harvest of LSG on west Baffin Island from 50,000 to 250,000 would cost ~$1,072,000 under Nutrient Replacement, and ~$7,334,000 under Complete Removal in the first year (Table 2). Subsequent annual operating costs there are predicted minimally at ~$792,000 and ~$6,985,000, respectively. An example of cost breakdown under the assumption of 50,000 nesting geese harvested at low harvest efficiency is presented in Appendix II for a colony 190 km from the nearest serviced community.

Cost estimates of harvest during brood-rearing

Methods generally consist of rounding up family groups into large flocks consisting of several thousand birds using crews assisted by helicopters. Birds are then driven into portable nets (Timm and Bromley 1976). We assumed that this method would be most likely. At some colonies, it may be possible to establish semi-permanent structures to facilitate round-up in successive years; because of unknown costs, we did not attempt to provide estimates for this approach.

Similar to harvest during nesting, costs of mass capture of geese is sensitive to distance from the nearest communities (Figure 5), and to the number of geese that could be captured/day. Compared to about 22 days of nesting, we assumed that geese could be captured for 30 days (after peak hatch) during brood rearing when adults are either behaviorally flightless when accompanying young, or incapable of flight due to primary molt. A breakdown of anticipated costs for a specific scenario is in Appendix III.

Information from previous pilot studies

There are approaches for predicting costs of harvest alternative to those of our preceding analyses, which were based on the presumptions for coordination and planning for large-scale harvest. Specifically, Canadian Wildlife Service initiated pilot studies for harvest of geese nesting near the communities of Sachs Harbour (on Banks Island, NWT) and Tuktoyaktuk (NWT) in Canada's western Arctic, and Coral Harbour (Southampton Island, NU) and Arviat (West Hudson Bay, NU) from 1999 to 2001. Costs from these studies of "facilitated hunts" were based on subsidizing individual hunting trips and such costs include harvest, transport and distribution of geese in communities (Table 5). Similar to our estimates, the cost/goose was highly variable ($8.60 to $19.90) and depended on colony location. Simple extrapolation of, e.g., $15/goose (Table 5) for harvest of 100,000 geese at Coral Harbour suggests a cost of $1,500,000 using the approach of "facilitated hunts." As a comparison, for the Complete Removal Option we estimated between $352,000 and $569,000 (for high harvest efficiency of goose/minute, Table 1) or $1,044,000 and $1,290,000 (for low harvest efficiency of 1 goose / 3 minutes, Table 2) depending on which colony near Coral Harbour is considered (Table 1). Thus, estimates from the Complete Removal Option range from 70% to 86% of those estimated from experience with "facilitated hunts."

Costs/goose incurred under "facilitated hunts" are most relevant specifically to relatively small-scale harvests (~1000 geese harvested) such as those attempted at Coral Harbour. Situations in which individual or small groups of hunters are paid to harvest geese independently of one another do not realize benefits associated with a large-scale effort that would require more intense planning and coordination, which likely lead to increased cost efficiencies; large-scale harvests are more cost-efficient due simply to economies of scale, and possibly are related to a difference in the specific goal of population reduction (rather than subsidy of hunting trips). Economies of scale likely explain part of the discrepancy in cost efficiency, above, from estimates for harvest of 100,000 geese based our large-scale analysis, and those from "facilitated hunts." Several factors could influence economies of scale. For example, lone hunters likely could not financially support the logistics (beyond aircraft) required to effect harvests on the scale necessary to reduce local population sizes of geese – particularly at colonies not easily accessible by land or by travel over ice. Estimates based on our large-scale analyses, and on information from "facilitated hunts" are both useful for estimating costs of harvesting geese in the Arctic, but each set of estimates likely is most pertinent to respective scales of harvest. Our large-scale approach was taken in consideration of what we judged to be the most cost-efficient means of harvesting large numbers of geese (>50,000) in as short a time as possible (a 20-day period during which opportunities for harvest of geese are constrained by their presence at colonies during egg-laying and incubation by geese).

THE NEED FOR EVALUATION

One of the objectives of the Direct Control Working Group included prediction of finances and projected response of snow goose populations to summer harvest in the Arctic. Any attempt at such an endeavor should also include (1) an assessment of harvest efficiency by carefully quantifying harvest, and (2) population estimation of nesting geese in each year of harvest and perhaps for 2-3 years after termination of harvest. The design and budgeting of this kind of evaluation is beyond the scope of this document; nevertheless, we feel that the effectiveness of Arctic harvest in reducing local goose populations can only be properly assessed through concurrent and subsequent monitoring of goose populations. Moreover, such an approach could provide an experimental framework for measuring the cost efficiency and biological effectiveness of Arctic harvest, as well as an opportunity to learn something about population response to large-scale management.

CONCLUSIONS

This exercise relied on several assumptions about population response of mid-continent LSG following large-scale harvest in the Arctic during both nesting and brood-rearing. Any large-scale harvest program with the goals of reducing mid-continent LSG populations and arresting damage to Arctic vegetation should not proceed without a complementary evaluation program. Some assumptions about logistics (e.g., availability of aircraft and crews, and accessibility of some sites with aircraft) were also relaxed because the feasibility of such an exercise has not been assessed previously, to our knowledge, let alone attempted on an even limited scale. Perhaps the most important uncertainty is the efficiency of harvest, even if all other logistical issues related to the constraints of geography, and especially topography, were relatively uncomplicated and did not limit access by hunters to geese. We estimated costs with this uncertainty in mind by considering a range in harvest efficiency. We recommend that greater weight be given to scenarios of less efficient harvest both during nesting (Table 2) and brood-rearing (Table 4). Even so, we propose that these costs are underestimated by an unknown amount because of (1) the simplifying assumptions used above, and (2) unanticipated issues or requirements. In review, the costs that we could not consider, short of guessing, are specifically for:

1. Increased aircraft and fuel costs since 1999,
2. Caching drummed jet fuel due to its unavailability at some communities near colonies,
3. Additional helicopter flights and fuel cache for helicopter, in situations where fixed winged aircraft could not land near target colonies,
4. Community coordinator to expedite logistics,
5. Additional hunters to meet any shortfall in availability of local hunters,
6. Capital replacement.

These short-comings in our estimation of costs could be improved with more careful study and analysis focused specifically on (1) topography and nesting density of snow geese at specific colonies, as well as on (2) availability of persons, fuel and other required infrastructure at communities nearest those colonies. In the latter regard, an important analysis might also include an assessment of the level of community support for such harvests in Nunavut, and of the willingness of individuals from those communities to assist in this kind of endeavor.

The sole method of testing whether some of these assumptions are relevant might be to conduct a pilot study on a relatively small colony with relatively free access to hunters. These might include colonies near Churchill, MB., Arviat, NU, or Coral Harbour, NU, which are accessible by ground. Important differences of such a pilot study from those done previously (Table 5) would be the scale of harvest, planning, coordination, level of funding and the objective of population reduction.

Despite the numerous caveats above, large-scale harvest of LSG in the Arctic is not an impossibility. Even though costs (in 1999 Canadian $) are acknowledged as minimal costs under ideal situations they are still very high, particularly when harvested geese are transported to communities for further processing (Figure 13). Harvest of mass-captured LSG after nesting is estimated to be about as costly as harvest during nesting (Tables 1-4, Figure 13). However, it is probably less efficient to harvest adult geese compared to harvest during nesting because an unknown fraction (up to a maximum of about 50%) of geese captured after nesting would be goslings. In comparison, harvest during nesting would remove both adults and their potential production of young from the population. Thus, if the objective is population reduction, then shooting snow geese during nesting has a higher likelihood of achieving goals of adult harvest than does mass-capture using helicopters during brood-rearing. Complete removal of harvested geese increases costs 5 or 6 fold over allowing carcasses to remain where they are harvested.

In long-lived species, adult survival will almost always show the highest elasticities as was demonstrated for LSG by Rockwell et al (1997). Their analyses provided the motivation for reduction of adult survival as the most efficient biological means to reduce growth rate in the mid-continent population. Some authors have recently cautioned against blind focus on parameters with the highest elasticities, e_{ij}, for management action (Nichols and Hines 2002, Heppel et al. 2000), because it ignores the efficacy of conducting management actions on changing specific vital rates, and it also ignores the costs of management alternatives. Given that $\lambda = S_a + F$, an analogous alternative to elasticities is to express the proportion of λ composed of S_a, such that $S_a/\lambda = \gamma$, whereby γ is referred to as seniority (Pradel 1996). Thus, the quotient represented by γ is analogous to elasticity (see Nichols et al. 2000) for λ with respect to the survival component, S, such that

$$e_{ij} = \frac{\partial \log \lambda}{\partial \log S_{ij}} \cong \gamma_{i+1} = \frac{\partial \log E(\lambda_i)}{\partial \log S_i} . \tag{15}$$

Nichols and Hines (2002) suggest the following metric as a conceptual guide to management actions:

$$m_{k,ij} = \frac{\partial \log \lambda}{\partial \log a_{ij}} \frac{\partial \log a_{ij}}{\partial x_k} \frac{\partial x_k}{\partial y_k} , \tag{16}$$

which explicitly considers not only elasticity of a particular vital rate, a_{ij}, but also weights elasticity by (1) the influence of a particular management action of type x_k (e.g., number of adult geese killed) on a_{ij}, and (2) the cost, y_k, (e.g., dollars) of management action x_k, i.e., of killing a particular number of geese. The greatest uncertainty in the use of this metric for population reduction of LSG pertains to values in the second term of eq. 16, i.e., the efficiency with which geese could be killed, and underscores our recommendation above for a pilot study, or perhaps some sort of dynamic optimization approach (Williams et al 2002). However, our cost estimates required for the third term in eq. 16 provide a minimum cost for harvest of LSG in the Arctic. The challenge remains to calculate and compare such metrics for each management alternative for population reduction of LSG covered in this report or elsewhere.

Should existing incentives that involve increased hunting opportunities during fall, winter, and spring fail to reduce population growth, then finances of Arctic harvest will need to be weighed against the intangible cost of continued degradation of Arctic ecosystems. Decisions about how to manage mid-continent LSG to arrest or reverse large-scale alteration of Arctic ecosystems need to consider all potential management options (cf. other chapters in this report). We view our analyses of large-scale harvest in the Arctic as a preliminary assessment of the level of harvest that would be required to induce population decline, and costs of doing that. Ultimately, we hope that policy makers in management agencies find this chapter useful in that regard.

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LITERATURE CITED

Abraham, K.F., and R.L. Jefferies. 1997. High goose populations: causes, impacts and implications. Pages 7-63 *in* B. D. J. Batt (ed.), Arctic ecosystems in peril: Report of the Arctic Goose Habitat Working Group. Arctic Goose Joint Venture Special Publication, U.S. Fish and Wildlife Service, Washington, D. C., and Canadian Wildlife Service, Ottawa, Ontario.

Alisauskas, R.T. 1998. Winter range expansion and relationships between landscape and morphometrics of mid-continent Lesser snow Geese. Auk 115:851-862.

Alisauskas, R.T. 2001. Nutritional ecology and population biology of Ross's Geese. Arctic Goose Joint Venture progress report, October 2001. Canadian Wildlife Service, Saskatoon, Saskatchewan. 9pp.

Alisauskas, R.T. 2002. Arctic climate, spring nutrition, and recruitment in mid-continent Lesser Snow Geese. Journal of Wildlife Management 66:181-193.

Alisauskas, R.T., S.M. Slattery, D.K. Kellett, D. Stern, and K.D. Warner. 1998. Spatial and temporal dynamics of Ross's and Snow Goose colonies in Queen Maud Gulf Bird Sanctuary, 1966-1998. Unpubl. progress report on numbers of geese and colonies, CWS Saskatoon, September 1998. 21pp.

Alisauskas, R.T., and K.L. Drake. 2001. Role of dispersal in local population dynamics of mid-continent Snow Geese. AGJV progress report. October 2001. 7 pp.

Alisauskas, R.T., and M.S. Lindberg. 2002. Effects of neckbands on survival and fidelity of white-fronted and Canada geese captured as nonbreeding adults. Journal of Applied Statistics 29:521-537.

Ankney, C.D. 1975. Neckbands contribute to starvation in female Lesser Snow Geese. Journal of Wildlife Management 39:825-826.

Brownie, C., D.R. Anderson, K.P. Burnham, and D. S. Robson. 1985. Statistical inference from band recovery data - a handbook. Resource Publication 156. U. S. Fish and Wildlife Service. 305pp.

Burnham, K.P., and D.R. Anderson. 1998. Model selection and inference: a practical information-theoretic approach. Springer-Verlag Press, N.Y., N.Y. 349pp.

Canada Flight Supplement. 2000. Canada and North Atlantic terminal and enroute data, effective 20 April 2000. Natural Resources Canada.

Cooch, E.G., R.F. Rockwell, and S. Brault. 2001. Retrospective analysis of demographic responses to environmental change: a Lesser Snow Goose example. Ecological Monographs 71:377-400.

Cooke, F., R.F. Rockwell, and D.B. Lank. 1995. The Snow Geese of La Pérouse Bay, Natural Selection in the Wild. Oxford, Oxford University Press.

Cooke, F., C.M. Francis, E.G. Cooch, and R.T. Alisauskas. 2000. Impact of hunting on population growth of mid-continent Lesser Snow Geese, pages 17-31 *in* H. Boyd., ed., Population modelling and management of Snow Geese. CWS Occasional Paper No. 102.

Eberhardt, L.L., and M.A. Simmons. 1992. Assessing rates of increase from trend data. Journal of Wildlife Management 56:603-610.

Flint, P.L, K.H. Pollock, D. Thomas, and J.S. Sedinger. 1995. Estimating prefledging survival: aslloing for brood mixing and dependence among brood mates. Journal of Wildlife Management 59:448-454.

Francis, C.M., M.H. Richards, F. Cooke, and R.F. Rockwell. 1992. Long-term changes in survival rates of Lesser Snow Geese. Ecology 73:1346-1362.

Francis, C.M. 2000. The relative impact of a spring hung on Snow Goose population dynamics. pages 6-16 *in* H. Boyd., ed., Population modelling and management of Snow Geese. CWS Occasional Paper No. 102.

Gauthier, G., R. Pradel, S. Manuy, and J.D. Lebreton. 2001. Seasonal survival of Greater Snow Geese and effect of hunting under dependence in sighting probability. Ecology 82:3105-3119.

Heppell, S., C. Pfister, and H. deKroon (editors). 2000. Elasticity analysis in population biology: methods and applications. Ecology 81:605-708.

Hestbeck, J. B. 1994. Survival of Canada geese banded in winter in the Atlantic flyway. Journal of Wildlife Management 58:748-756.

Kerbes, R.H. 1994. Colonies and numbers of Ross's Geese and Lesser Snow Geese in the Queen Maud Gulf Migratory Bird Sanctuary. Canadian Wildlife Service Occasional Paper Number 81.

LeShack, C.R., A.D. Afton, and R.T. Alisauskas. 1998. Effects of male removal on female reproductive biology in Ross's' and lesser snow geese. Wilson Bulletin 110:56-64.

Nichols, J.D., J.E. Hines, J.-D. Lebreton, and R. Pradel. 2000. Estimation of contributions to population growth: a reverse-time capture-recapture approach. Ecology 81:3362-3376.

Nichols, J.D., and J. E. Hines. 2002. Approaches for the direct estimation of λ and demographic contributions to λ, using capture-recapture data. Journal of Applied Statistics 29:539-568.

Pradel, R. 1996. Utilization of capture-mark-recapture for the study of recruitment and population growth rate. Biometrics 52:703-709.

Rexstad, E.A. 1992. Effects of hunting on annual survival of Canada geese in Utah. Journal of Wildlife Management 56:297-305.

Rockwell, R.F., E.G. Cooch, S. Brault. 1997. Dynamics of the mid-continent population of Lesser Snow Geese - Projected impacts of reductions in survival and fertility on population growth rates. Pages 73-100 *in* B. O. J. Batt, ed. Arctic Ecosystems in Peril: Report of the Arctic Goose Habitat Working Group. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario.

Rockwell, R.F., and C.D. Ankney. 2000. Snow Geese: Can we pay down the mortgage? pages 32-34 *in* H. Boyd., ed., Population modeling and management of Snow Geese. CWS Occasional Paper No. 102.

Timm, D.E. and R.G. Bromley. 1976. Driving Canada geese by helicopter. Wildlife Society Bulletin 4:180-181.

Trost, R.E., Malecki, R.A., Hindman, L.J. & Luszcz, D.C. (1986) Survival and recovery rates of Canada geese from Maryland and North Carolina 1963-1974. Proceeding of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 40: 454-464.

White, G. C., and K. P. Burnham. 1999. Program MARK: survival estimation from populations of marked animals. Bird Study 46:120-139.

Williams, B. K., J. D. Nichols, and M. J. Conroy. 2002. Analysis and management of animal populations. San Diego, Academic Press.

Table 1. Estimated costs (1999 Can $) of harvest of snow geese on specific colonies in Canada's central and eastern Arctic, by harvest level (50,000, 100,000 or 250,000 nesting adults) and disposition of carcasses (Nutrient Replacement vs Complete Removal options). Estimates assume high harvest efficiency (1 goose/min); also shown are number of crews required to achieve respective harvest goals during 20 days of incubation.

					Harvest[a]					
					Nutrient Replacement Option			Complete Removal		
	COLONY	COMMUNITY	DISTANCE (km)	Population Size	50,000	100,000	250,000	50,000	100,000	250,000
Number of crews					1	2	3	2	4	6
Annual O&M	East Bay	Coral Harbour	50	145,000	$56,750	$113,100	-[b]	$151,050	$352,200	-
	Harry Gibbons	Coral Harbour	150	552,000	$61,550	$122,700	$266,550	$260,250	$569,400	$1,478,550
	Great Plain	Iqaluit	380	1,766,000	$72,590	$144,780	$299,670	$511,410	$1,068,960	$2,665,350
	Karrak Lake	Cambridge Bay	300	388,000	$68,750	$137,100	$288,150	$424,050	$895,200	$2,252,550
	Colony 10	Cambridge Bay	354	318,000	$71,342	$142,284	$295,926	$483,018	$1,012,488	$2,531,190
	Colony 9	Cambridge Bay	360	109,000	$71,630	$142,860	-	$489,570	$1,025,520	-
	Colony 46	Cambridge Bay	325	153,000	$69,950	$139,500	-	$451,350	$949,500	-
	Colony 68	Cambridge Bay	160	83,000	$62,030	-	-	$271,170	-	-
	Colony 88	Cambridge Bay	310	132,000	$69,230	$138,060	-	$434,970	$916,920	-
	Other QMG Colonies	Cambridge Bay	300	41,000	$59,855	-	-	$365,215	-	-
	McConnell R	Arviat	30	154,000	$55,790	$111,180	-	$129,210	$308,760	-
	Henrietta Maria	Winisk	190	200,000	$63,470	$126,540	-	$303,930	$656,280	-
	La Perouse Bay	Churchill	20	66,000	$55,310	-	-	$118,290	-	-
One-time Capital					$55,200	$80,200	$105,200	$124,200	$149,200	$174,200

[a] Nutrient replacement Option requires only shooting crews (10 persons ea); Complete Removal Option requires shooting crews and gathering crews (10 persons ea).
[b] Harvest goal exceeds population size.

Table 2. Estimated costs (1999 Can $) of harvest of snow geese on specific colonies in Canada's central and eastern Arctic, by harvest level (50,000, 100,000 or 250,000 nesting adults) and disposition of carcasses (Nutrient Replacement vs. Complete Removal options). Estimates assume low harvest efficiency (1 goose/3 min); also shown are number of crews required to achieve respective harvest goals during 20 days of incubation.

					Harvest[a]					
					Nutrient Replacement Option			Complete Removal		
	COLONY	COMMUNITY	DISTANCE (km)	Population Size	50,000	100,000	250,000	50,000	100,000	250,000
Number of crews[a]					2	4	10	4	8	20
Annual O&M	East Bay	Coral Harbour	50	145,000	$126,950	$253,500	-[b]	$367,050	$1,044,200	-
	Harry Gibbons	Coral Harbour	150	552,000	$136,550	$272,700	$681,150	$490,650	$1,290,200	$5,566,550
	Great Plain	Iqaluit	380	1,766,000	$158,630	$316,860	$791,550	$774,930	$1,856,000	$6,985,190
	Karrak Lake	Cambridge Bay	300	388,000	$150,950	$301,500	$753,150	$676,050	$1,659,200	$6,491,750
	Colony 10	Cambridge Bay	354	318,000	$156,134	$311,868	$779,070	$742,794	$1,792,040	$6,824,822
	Colony 9	Cambridge Bay	360	109,000	$156,710	$313,020	-	$750,210	$1,806,800	-
	Colony 46	Cambridge Bay	325	153,000	$153,350	$306,300	-	$706,950	$1,720,700	-
	Colony 68	Cambridge Bay	160	83,000	$137,510	-	-	$503,010	-	-
	Colony 88	Cambridge Bay	310	132,000	$151,910	$303,420	-	$688,410	$1,683,800	-
	Other QMG Colonies	Cambridge Bay	300	41,000	$134,675	-	-	$578,175	-	-
	McConnell River	Arviat	30	154,000	$125,030	$249,660	-	$342,330	$995,000	-
	Henrietta Maria	Winisk	190	200,000	$140,390	$280,380	-	$540,090	$1,388,600	-
	La Perouse Bay	Churchill	20	66,000	$124,070	-	-	$329,970	-	-
One-time Capital					$80,200	$130,200	$280,200	$149,200	$199,200	$349,200

[a] Nutrient replacement and Complete Removal Option requires only helicopter capture crews (3 persons ea not including pilot);
[b] Harvest goal exceeds population size.

Table 3. Estimated costs (1999 Can $) of harvest of snow geese during helicopter-assisted capture on brood-rearing areas in Canada's central and eastern Arctic, by harvest level (50,000, 100,000 or 250,000 nesting adults) and disposition of carcasses (Nutrient Replacement vs. Complete Removal options). Estimates assume high harvest efficiency (5000 geese captured/crew/day); also shown are number of crews required to achieve respective harvest goals during 30 days of brood-rearing.

					Harvest[a]					
					Nutrient Replacement Option			Complete Removal		
	COLONY	COMMUNITY	DISTANCE (km)	Population Size	50,000	100,000	250,000	50,000	100,000	250,000
Number of crews[a]					1	1	2	1	1	2
Annual O&M	East Bay	Coral Harbour	50	145,000	$70,650	$133,850	-[b]	$222,489	$436,228	-
	Harry Gibbons	Coral Harbour	150	552,000	$82,950	$150,950	$451,600	$339,789	$661,528	$1,722,696
	Great Plain	Iqaluit	380	1,766,000	$111,240	$190,280	$593,740	$609,579	$1,179,718	$3,054,396
	Karrak Lake	Cambridge Bay	300	388,000	$101,400	$176,600	$544,300	$515,739	$999,478	$2,591,196
	Colony 10	Cambridge Bay	354	318,000	$108,042	$185,834	$577,672	$579,081	$1,121,140	$2,903,856
	Colony 9	Cambridge Bay	360	109,000	$108,780	$186,860	-	$586,119	$1,134,658	-
	Colony 46	Cambridge Bay	325	153,000	$104,475	$180,875	-	$545,064	$1,055,803	-
	Colony 68	Cambridge Bay	160	83,000	$84,180	-	-	$351,519	-	-
	Colony 88	Cambridge Bay	310	132,000	$102,630	$178,310	-	$527,469	$1,022,008	-
	Other QMG Colonies	Cambridge Bay	300	41,000	$91,420	-	-	$434,078	-	-
	McConnell River	Arviat	30	154,000	$68,190	$130,430	-	$199,029	$391,168	-
	Henrietta Maria	Winisk	190	200,000	$87,870	$157,790	-	$386,709	$751,648	-
	La Perouse Bay	Churchill	20	66,000	$66,960	-	-	$187,299	-	-
One-time Capital					$20,000	$20,000	$20,000	$20,000	$20,000	$20,000

[a] Nutrient replacement and Complete Removal Option requires only helicopter capture crews (3 persons ea not including pilot);
[b] Harvest goal exceeds population size.

Table 4. Estimated costs (1999 Can $) of harvest of snow geese during helicopter-assisted capture on brood-rearing areas in Canada's central and eastern Arctic, by harvest level (50,000, 100,000 or 250,000 nesting adults) and disposition of carcasses (Nutrient Replacement vs Complete Removal options). Estimates assume low harvest efficiency (2000 geese captured/crew/day); also shown are number of crews required to achieve respective harvest goals during 30 days of brood-rearing.

					Harvest[a]					
					Nutrient Replacement Option			Complete Removal		
	COLONY	COMMUNITY	DISTANCE (km)	Population Size	50,000	100,000	250,000	50,000	100,000	250,000
Number of crews[a]					1	2	5	1	2	5
Annual O&M	East Bay	Coral Harbour	50	145,000	$79,350	$179,600	-[b]	$231,189	$482,878	-
	Harry Gibbons	Coral Harbour	150	552,000	$91,650	$212,600	$785,750	$348,489	$725,878	$2,064,946
	Great Plain	Iqaluit	380	1,766,000	$119,940	$288,500	$1,139,720	$618,279	$1,284,778	$3,620,896
	Karrak Lake	Cambridge Bay	300	388,000	$110,100	$262,100	$1,016,600	$524,439	$1,090,378	$3,079,696
	Colony 10	Cambridge Bay	354	318,000	$116,742	$279,920	$1,099,706	$587,781	$1,221,598	$3,445,006
	Colony 9	Cambridge Bay	360	109,000	$117,480	$281,900	-	$594,819	$1,236,178	-
	Colony 46	Cambridge Bay	325	153,000	$113,175	$270,350	-	$553,764	$1,151,128	-
	Colony 68	Cambridge Bay	160	83,000	$92,880	-	-	$360,219	-	-
	Colony 88	Cambridge Bay	310	132,000	$111,330	$265,400	-	$536,169	$1,114,678	-
	Other QMG Colonies	Cambridge Bay	300	41,000	$95,280	-	-	$437,938	-	-
	McConnell River	Arviat	30	154,000	$76,890	$173,000	-	$207,729	$434,278	-
	Henrietta Maria	Winisk	190	200,000	$96,570	$225,800	-	$395,409	$823,078	-
	La Perouse Bay	Churchill	20	66,000	$75,660	-	-	$195,999	-	-
One-time Capital					$20,000	$30,000	$60,000	$20,000	$30,000	$60,000

[a] Nutrient replacement and Complete Removal Option requires only helicopter capture crews (3 persons ea not including pilot);
[b] Harvest goal exceeds population size.

Table 5. Preliminary information from facilitated harvest of geese in N.W.T., and Nunavut (source: Jim Hines, CWS – Yellowknife; Dave Duncan, CWS – Edmonton).

Location	Year	Number Harvested	Number of Hunters	Duration (days)	Annual Budget	Cost/ goose[a]
Sachs Harbour, NWT	1999	500	10	?	$9,950	$19.90
Sachs Harbour, NWT	2000	500	10	?	$9,950	$19.90
Sachs Harbour, NWT	2001	500	10	?	$9,950	$19.90
Tuktoyaktuk	1999	334	?	?	$4,300	$12.87
Tuktoyaktuk	2000	500	?	?	$4,300	$8.60
Coral Harbour, NU	2000	1000	?	?	$14,055 to $16,709	$14.06 to $16.71
Arviat, NU	2000	1000	?	?	>$10,000	>$10.00

[a] Includes cost of transporting and distributing harvested geese to nearby communities.

Appendix I. Communities near the breeding distribution of mid-continent Lesser snow geese showing coordinates, fuel and runway availability, and airport indicator (from Canada Flight Supplement, 20 April 2000).

English Name	Inuktitut Name	Longitude	Latitude	Fuel Availability	Airport Indicator
Aklivik	Aklivik	78.27	60.82	NO RUNWAY	-
Alert	Alert	61.70	82.49	MILITARY	CYLT
Arctic Bay	Tununirusiq	85.30	73.11	NO RUNWAY	CJX7
Attawapiskat	Attawapiskat	82.41	52.91	NO FUEL	CYAT
Baker Lake	Qamani'tuaq	96.33	64.24	JET B	CYBK
Bathurst Inlet	Kingaok	108.22	66.90	NO RUNWAY	-
Bay Chimo	Umingmaktok	107.94	67.65	NO FUEL	-
Broughton Island	Qikiqtarjuaq	63.36	67.51	JET A	CYVM
Cambridge Bay	Ekaluktutiak	105.05	69.09	JET A	CYCB
Cape Dorset	Kinngait	76.55	64.20	JET A	CYTE
Chesterfield Inlet	Igluligaarjuk	90.93	63.38	MOGAS	CYCS
Chisasibi	Chisasibi	79.10	53.90	NO FUEL	CSU2
Churchill	Churchill	94.23	58.79	JET A	CYYQ
Clyde River	Kangiqtugaapik	68.50	70.45	JET A	CYCY
Coral Harbour	Salliq	83.24	64.16	JET A	CYZS
Eastmain River	Eastmain	78.57	52.29	NO FUEL	CZEM
Eskimo Point	Arviat	94.08	61.21	JET B	CYEK
Eureka	Eureka	86.62	80.05	NO FUEL	CYEU
Fort Albany	Fort Albany	81.37	52.08	NO FUEL	CYFA
Fort Rupert	Fort Rupert	78.95	51.74	NO RUNWAY	-
Fort Severn	Fort Severn	87.52	56.04	NO FUEL	CYER
Georges River	Kangiqsualujjuaq	66.29	58.49	JET B	CYLU
Gjoa Haven	Oqsuqtooq	95.87	68.63	JET B	CYHK
Grise Fiord	Ausuittuq	83.03	76.44	JET A	CYGZ
Hall Beach	Sanirajak	81.30	68.76	JET A	CYUX
Igloolik	Iglulik	81.72	69.44	JET A	CYGT
Inukjuak	Inukjuak	78.10	58.46	JET A	CYPH
Iqaluit	Iqaluit	68.74	63.75	JET A	CYFB
Ivujivik	Ivujivik	77.88	62.45	JET A	CYIK
Kangirsuk	Kangirsuk	69.60	60.08	JET A	CYAS
Kuujjuarapik	Kuujjuarapik	77.89	55.24	JET A	CYGW
Kuujuaq	Kuujuaq	68.32	58.27	JET AB	CYVP
Lake Harbour	Kimmirut	70.06	62.79	NO FUEL	CYLC
Moosonee	Moosonee	80.45	51.34	JET B	CYMO
Nanisivik	Nanisivik	84.81	73.00	F 40	CYSR
Pangnirtung	Pannirtuuq	66.02	66.05	JET A	CYXP
Pelly Bay	Aqviligjuaq	89.97	68.58	DIESEL	CYBB
Pond Inlet	Mittimatalik	77.68	72.74	JET A	CYIO
Port Burwell	Port Burwell	64.81	60.38	NO RUNWAY	-
Povungnituk	Puvirnituq	77.55	60.18	JET AB	CYPX
Quaqtaq	Quaqtaq	69.60	61.07	NO FUEL	CYHA
Rankin Inlet	Kangiqsliniq	92.15	62.85	JET A	CYRT
Repulse Bay	Naujaat	86.29	66.54	DIESEL	CYUT
Resolute Bay	Qausuittuq	95.03	74.70	JET A	CYRB
Salluit	Salluit	76.07	62.23	JET A	CYZG
Sanikiluaq	Sanikiluaq	79.12	56.39	JET A	CYSK
Spence Bay	Taloyoak	93.78	69.44	F-40	CYYH
Wakeham Bay	Kangiqsujuaq	71.91	61.67	JET A	CYKG
Wemindji	Wemindji	78.86	53.03	NO FUEL	CYNC
Whale Cove	Tikiraqjuaq	92.67	62.21	NO FUEL	CYXN
Winisk	Winisk	84.91	55.27	NO RUNWAY	-
York Factory	York Factory	92.25	57.05	NO RUNWAY	-

Appendix II. Example of budget for harvesting snow geese during nesting. Shaded cells influence total cost and require input.

ASSUMPTIONS:		
	goose mass (kg)	2
	Twin Otter Payload (kg)	1270
	Geese/Twin Otter load	635
	Offstrip Landing fee	$100

	OPTION 1		OPTION 2	
	Nutrient Replacement		Complete Removal	
	O&M	Capital	O&M	Capital
INPUT DATA (shaded cells only)				
Distance from community(km)	190		190	
Number of Shooting Crews/camp	2		2	
Target Number of Geese	50,000		50,000	
Time required to kill one goose (min)	3		3	
Work Day (hrs)	8		8	
Geese/day/Shooting Crew	1,280		1,280	
Geese/day/camp	2,560		2,560	
daily salary	$200		$200	
Days required/crew to achieve target	40		40	
Days required/camp to achieve target	20		20	
Twin Otter hourly rate	$1,200		$1,200	
TOTAL COST	**$140,390**	**$80,200**	**$540,090**	**$149,200**
Cost/bird	$2.81	$1.60	$10.80	$2.98
"Maximum number of geese that could be harvested (20 day incubation constraint)	51,200		51,200	
10 person shooting crew				
Coordinator	$9,600		$9,600	
Cook	$9,600		$9,600	
8 Shooters	$76,800		$76,800	
Total Salary/Crew	$48,000		$48,000	
Total Salary/Camp	**$96,000**		$96,000	
Supplies for shooting crew				
.223 ammunition (cost/round)	$0.25		$0.25	
Rounds required	55,000		55,000	
Total Ammunition	$13,750		$13,750	
.223 Firearms+Scopes($600 ea) 4/hunter x 8 hunters		$19,200		$19,200
Short Wave Radio/Sat Phone/camp		$5,000		$5,000
Generator/camp		$5,000		$5,000
Hand-held radios ($10,000/crew)		$20,000		$20,000
3 Jutland tents ($15,000/crew)		$30,000		$30,000
Kitchen / crew		$1,000		$1,000
Food ($30/person/day)	$12,000		$12,000	
Total Supplies for Shooting Crew	**$25,750**	**$80,200**	**$25,750**	**$80,200**
Transport shooting crews to site				
Flight time (including return)	1.9		1.9	
Number of flights / crew	2		2	
Twin Otter/hour	$1,200		$1,200	
Total Twin Otter Cost to site	**$9,320**		**$9,320**	
Transort shooting crews to community				
Flight time (including return)	1.9		1.9	
Number of flights / crew	2		2	
Twin Otter/hour	$1,200		$1,200	
Total Twin Otter Cost to site	**$9,320**		**$9,320**	
10 person gathering crew				
Coordinator			$8,400	
Cook			$8,400	
8 Gatherers			$64,400	
Total Salary/Crew			$81,200	
Total Salary/Camp			**$162,400**	
Supplies for gathering crew				
Hand-held radios ($5,000/crew)				$ 5,000
3 Jutland tents ($15,000/crew)				$ 15,000
Kitchen / crew				$ 1,000
Food ($30/person/day)			$12,000	
4 ATV&trailer/crew				$ 48,000
Total Supplies for Gathering Crew			**$12,000**	**$ 69,000**
Transport gathering crews to site				
Flight time (including return)			1.9	
Number of flights / crew			4	
Offstrip landing fee			$100	
Twin Otter/hour			$1,200	
Total Twin Otter Cost to site			**$18,640**	

Transport gathering crews to community	
Flight time (including return)	1.9
Number of flights / crew	4
Twin Otter/hour	$1,200
Total Twin Otter Cost to community	**$18,640**
Transport Geese to Community	
Flight time (including return)	1.9
Number of flights / load	79
Twin Otter/hour	$ 1,200
Total Twin Otter Cost to airlift geese	**$188,020**

Appendix III. Example of budget for harvesting snow geese during brood-rearing.

ASSUMPTIONS:	goose mass (kg)	2		
	Twin Otter Payload (kg)	1270		
	Helicopter Slingload (kg)	454		
	Geese/Twin Otter load	635		
	Offstrip Landing fee	$100		
	OPTION 1 Nutrient Replacement		OPTION 2 Complete Removal	
	O&M	Capital	O&M	Capital
INPUT DATA (blue cells only)				
Distance from community(km)	190		190	
Number of Capture Crews/camp	1		1	
Target Number of Adult Geese	50,000		50,000	
Adult Geese/day/Capture Crew	2,000		2,000	
Geese/day/camp	2,000		2,000	
daily salary	$200		$200	
Days required/crew to achieve target	25		25	
Days required/camp to achieve target	25		25	
Twin Otter hourly rate	$1,200		$1,200	
Helicopter hourly rate	$900			
Beaver hourly rate	$600			
TOTAL COST	$96,570	$20,000	$395,409	$20,000
Cost/adult bird	$1.93	$0.40	$7.91	$0.40
Maximum number of geese that could be killed (30 day brood-rearing constraint)	60,000		60,000	
3 person Capture Crew				
Coordinator&Cook	$5,800		$5,800	
3 Netters	$7,400		$7,400	
Total Salary/Crew	$13,200		$13,200	
Total Salary/Camp	$13,200		$13,200	
Supplies for capture crew (+flight crew)				
Banding nets ($1000/crew)		$1,000		$1,000
Short Wave Radio/Sat Phone/camp		$5,000		$5,000
Generator/camp		$5,000		$5,000
Hand-held radios ($3,000/crew)		$3,000		$3,000
1 Jutland tents ($5,000/crew)		$5,000		$5,000
Kitchen / crew		$1,000		$1,000
Food ($30/person/day)	$4,500		$4,500	
Total Supplies for Capture Crews	$4,500	$20,000	$4,500	$20,000
Transport capture crews to site				
Flight time (including return)	2.4		1.9	
Number of flights / crew	3		3	
Total Beaver Cost to site/camp	$4,275		$4,275	
Transort capture crews to community				
Flight time (including return)	2.4		2.5	
Number of flights / crew	3		3	
Total Beaver Cost to site	$4,275		$4,275	
Helicopter capture costs				
Helicopter ferry to site (return)/crew	$3,420		$3,420	
Helicopter flight time (h/d/crew)	2		$2	
Helicopter flight costs/crew	$45,000		$45,000	
Helicopter flight costs/camp	$45,000		$45,000	
Helicopter fuel requirement (litres/camp)	5,000		$5,000	
Helicopter fuel (sealed drums/camp)	25		$25	
Helicopter fuel costs ($400/drum)	$10,000		$10,000	
Twin Otter to cache helicopter fuel	$11,900		$11,900	
Total Heli. Capture costs ($/camp)	$70,320		$70,320	
HeliTransport Geese to TO landing strip				
Helicopter ferry to site (return)/crew			$3,420	
Mean distance to landing strip (km)			30	
Number of geese/slingload			227	
Number of slingloads			220	
heli flight time (h)			83	
heli flight costs ($)			$74,339	
Helicopter fuel requirement (litres/camp)			8,260	
Helicopter fuel (sealed drums/camp)			41	
Helicopter fuel costs ($400/drum)			$16,400	
Twin Otter to cache helicopter fuel			$16,660	
Total helicopter cost of airlift geese			$110,819	
Tw. Ott. Transport Geese to Community				
Flight time (including return)			1.9	
Number of flights			79	
Total Twin Otter Cost to airlift geese			$188,020	

Figure 1. Communities and known snow goose colonies in the central Canadian Arctic surrounding Queen Maud Gulf showing Queen Maud Gulf Bird Sanctuary.

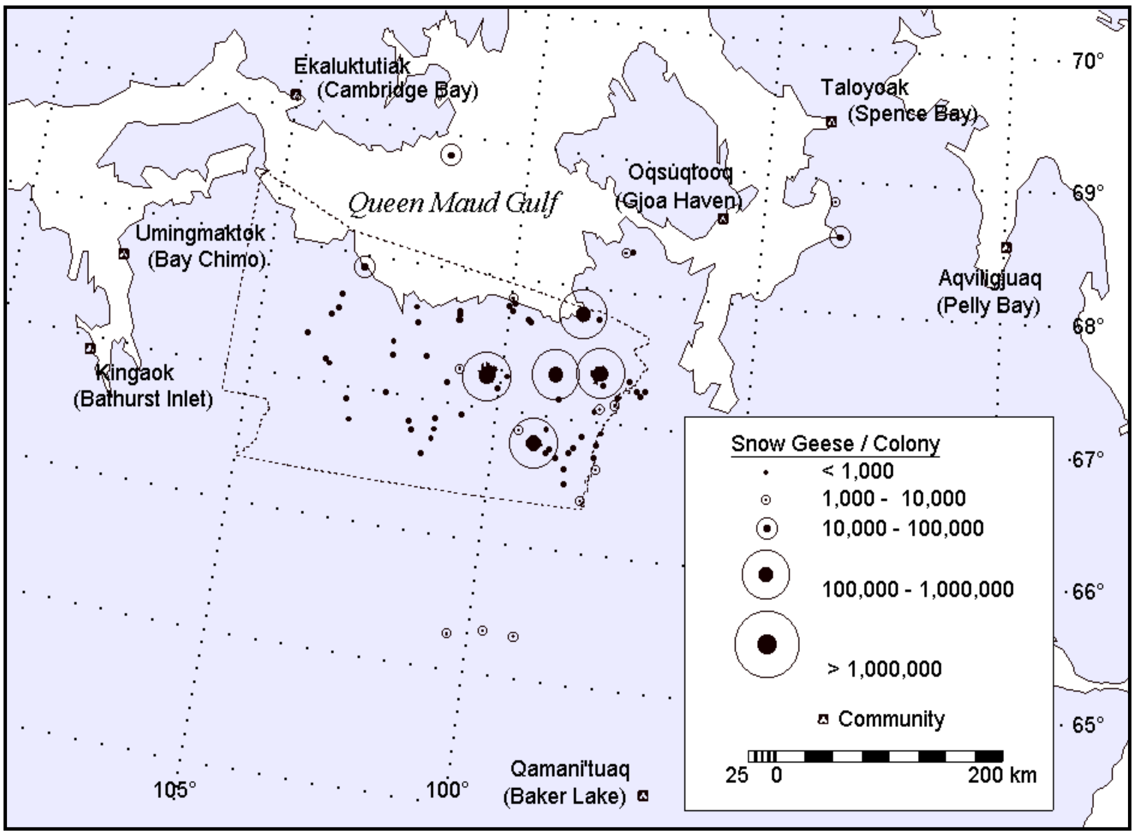


Figure 2. Communities and known snow goose colonies in the eastern Canadian Arctic surrounding Foxe Basin, showing Baffin Island and Southampton Island.

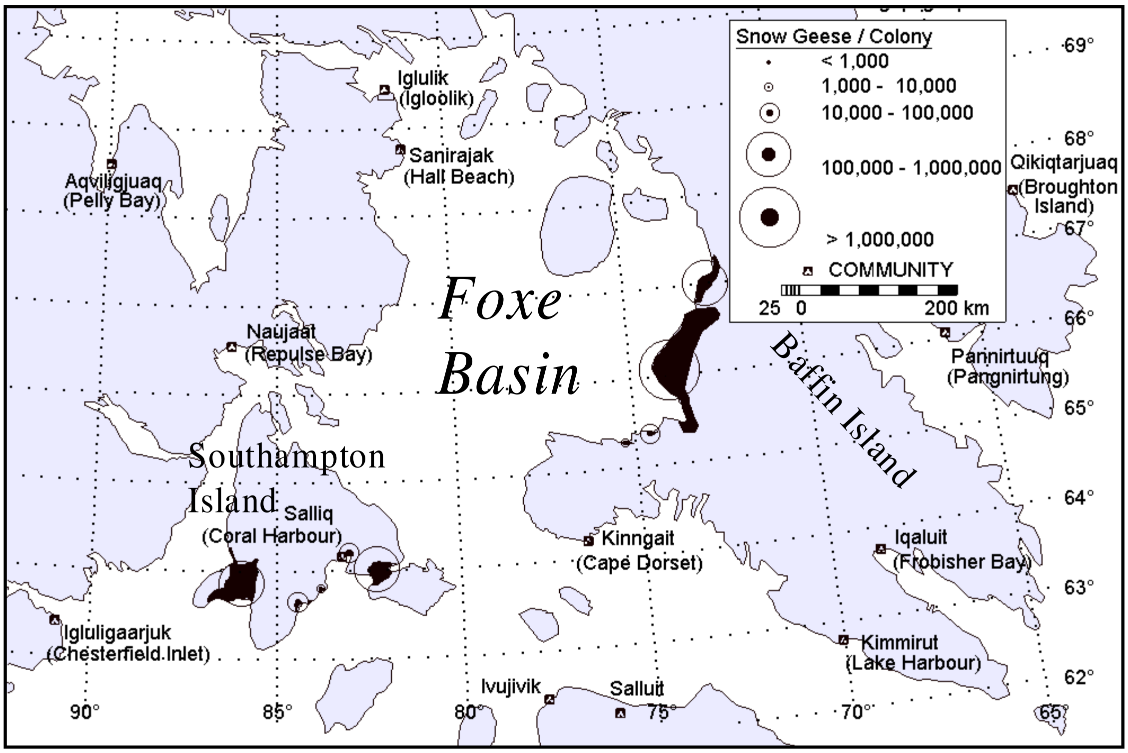


Figure 3. Communities and known snow goose colonies on the west coast of Hudson Bay.

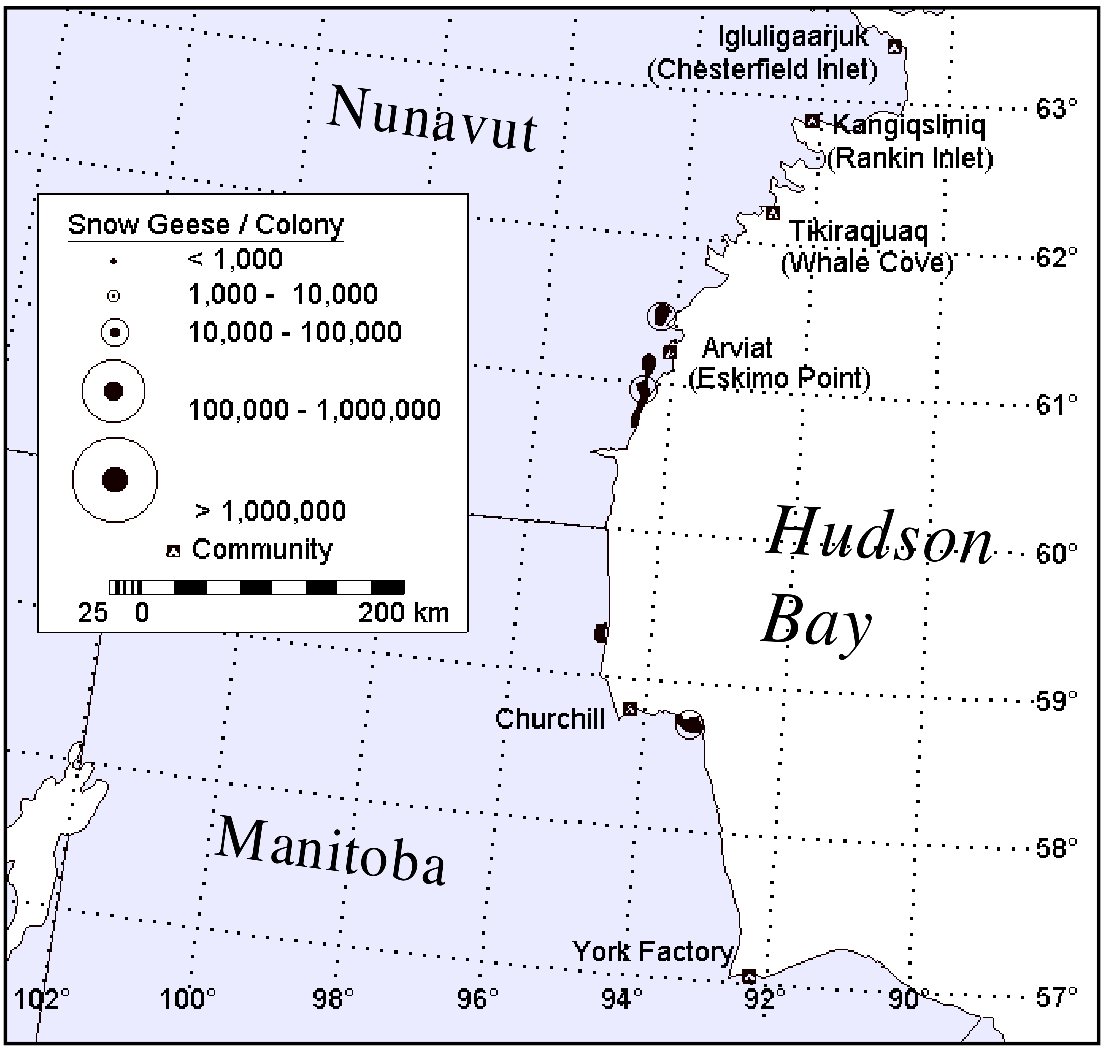


Figure 4. Communities and known snow goose colonies on the south coast of Hudson Bay and in James Bay.

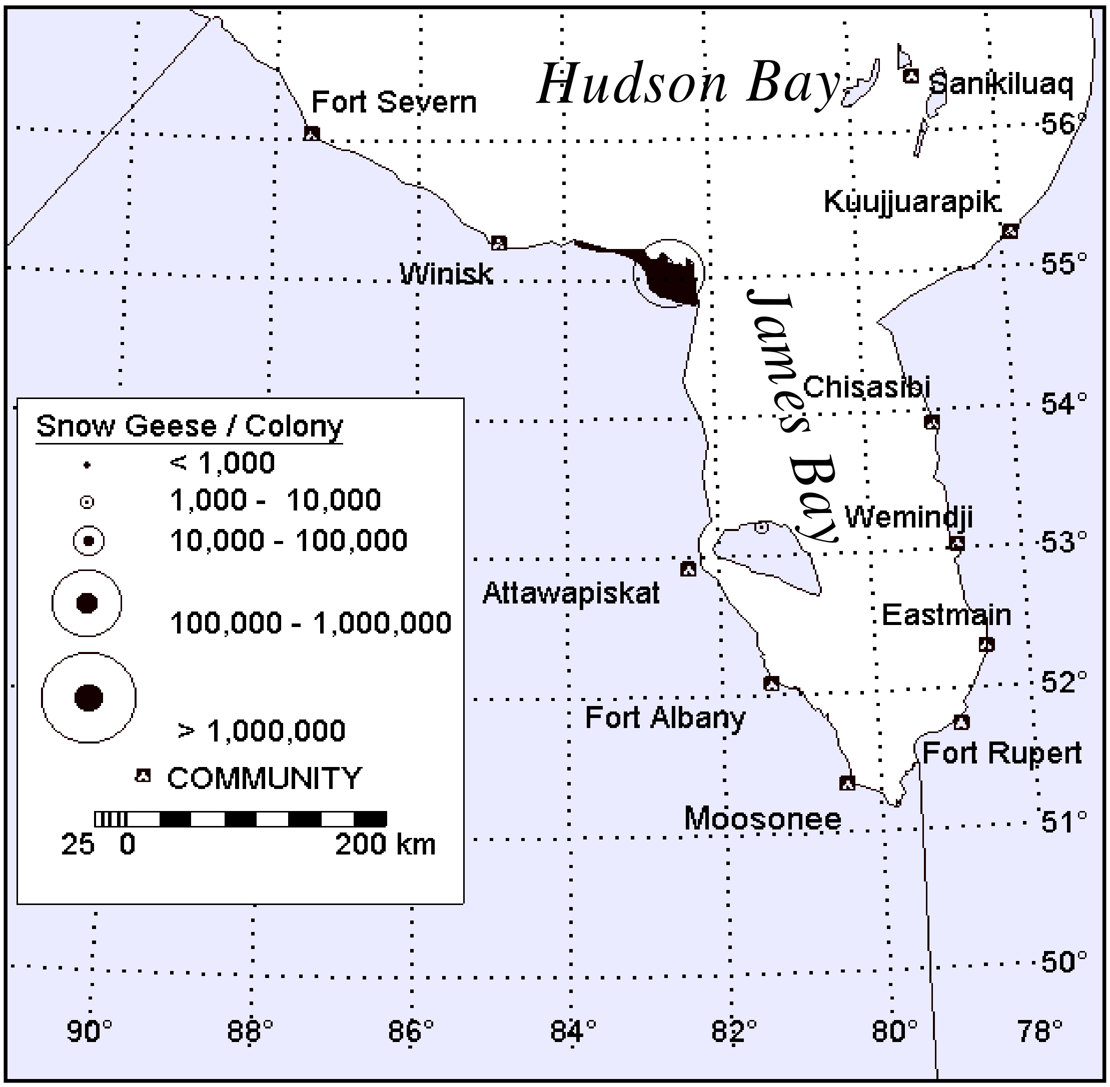


Figure 5. Distribution of communities and goose colonies over the breeding range of the mid-continent population of Lesser snow geese. Shown also are polygons which enclose an area around colonies that is closest to each colony.

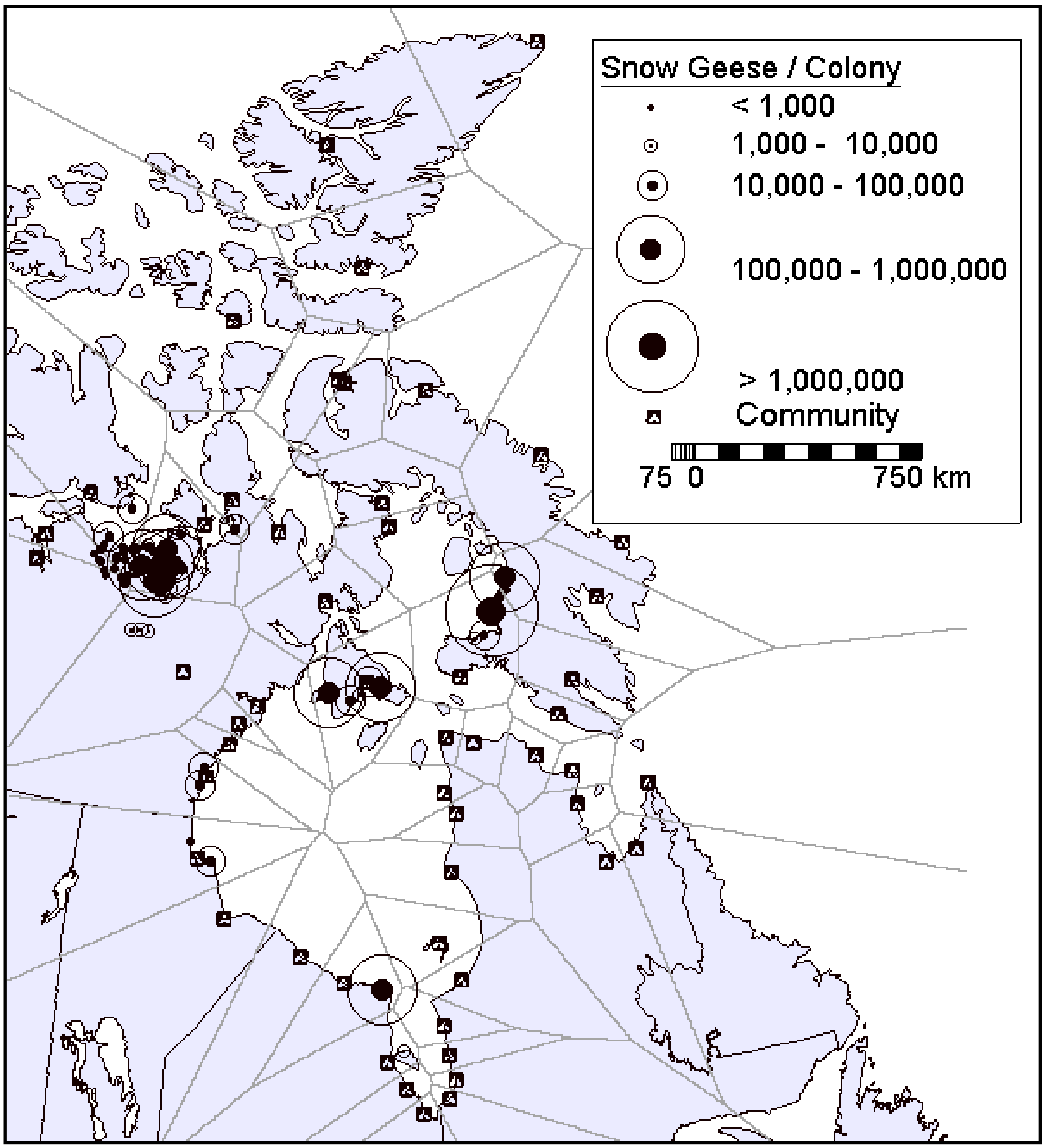


Figure 6. Ten year projections from deterministic population models of snow geese for colonies of 100,000 and 250,000 breeders. Also shown are populations of breeders and associated nonbreeders. Trajectories in each panel are with no harvest, and with harvests of 50,000 breeders consisting of 0%, 25%, 50%, 75%, and 100% females. Density dependence was not assumed.

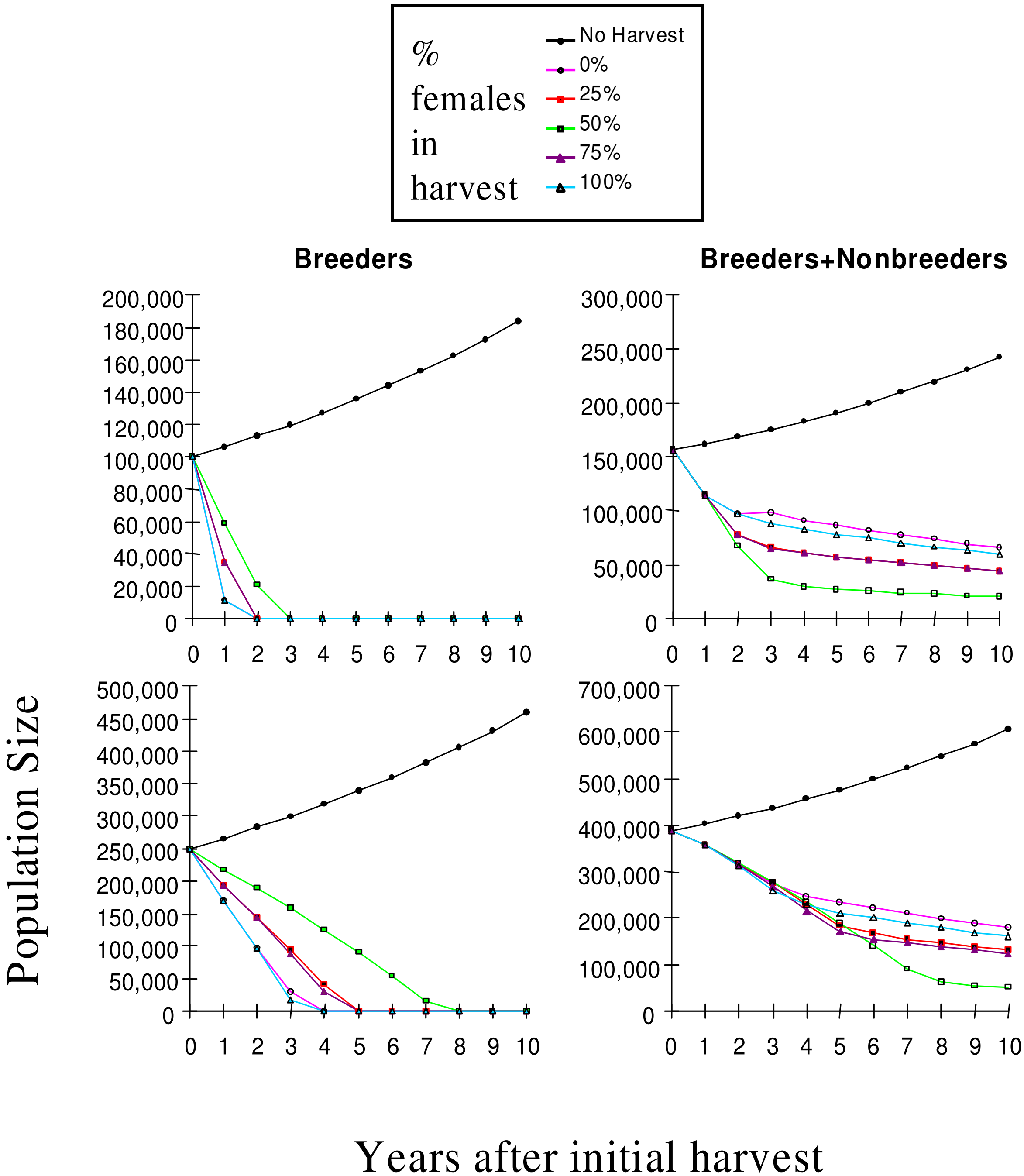


Figure 7. Ten year projections from deterministic population models of snow geese for colonies of 250,000, 500,000, and 1,000,000 breeders. Also shown are populations of breeders and associated nonbreeders. Trajectories in each panel shown are with no harvest, and with incremental increases in harvest of 50,000 breeders up to 250,000/year. Density dependence was not assumed.

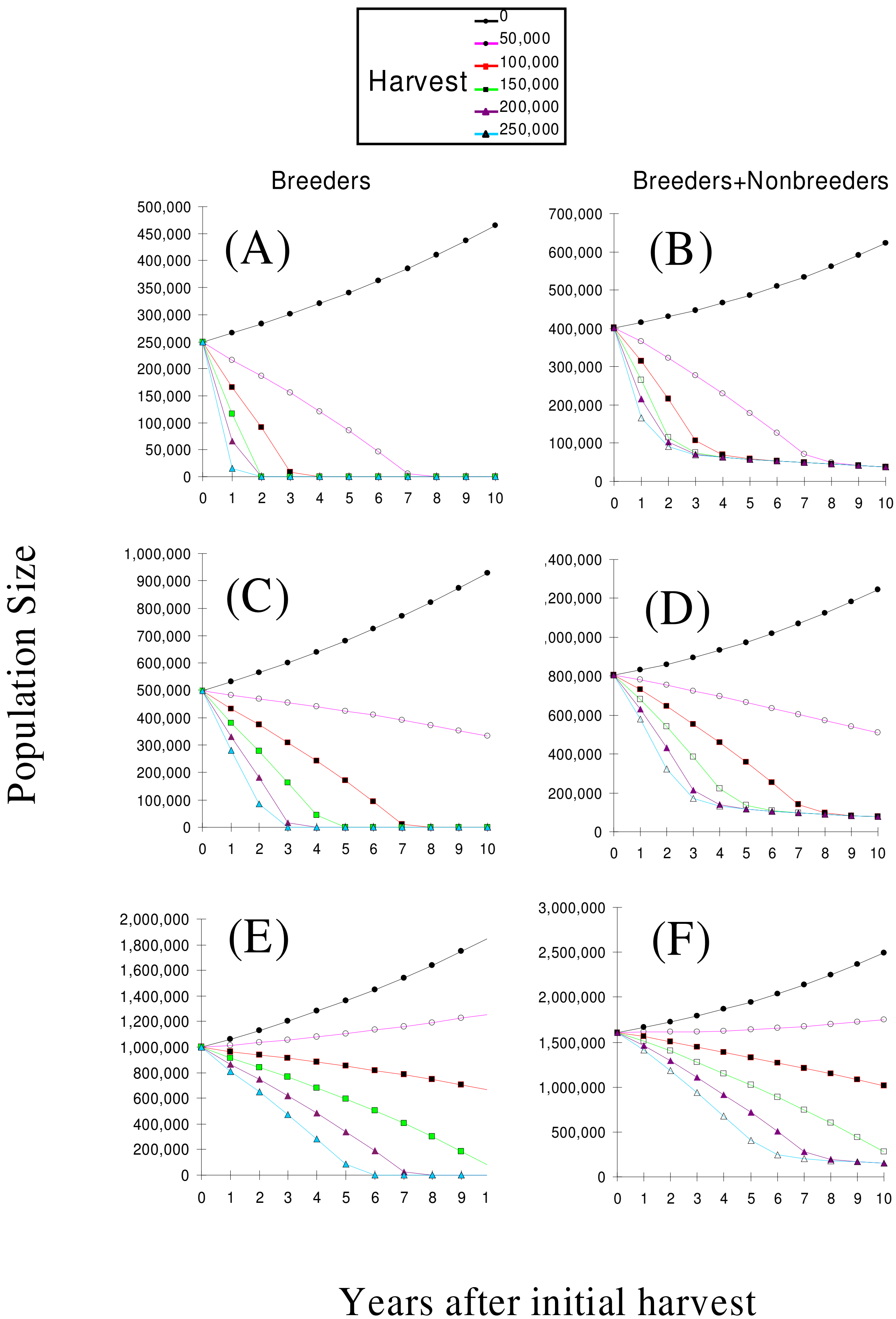


Figure 8. Ten year projections from deterministic population models of snow geese for colonies of 250,000, 500,000, and 1,000,000 breeders. Also shown are populations of breeders and associated nonbreeders. Trajectories in each panel shown are with no harvest, and with harvests of 50,000 breeders/year for 1, 3, 5, 7, and 9 sequential years.

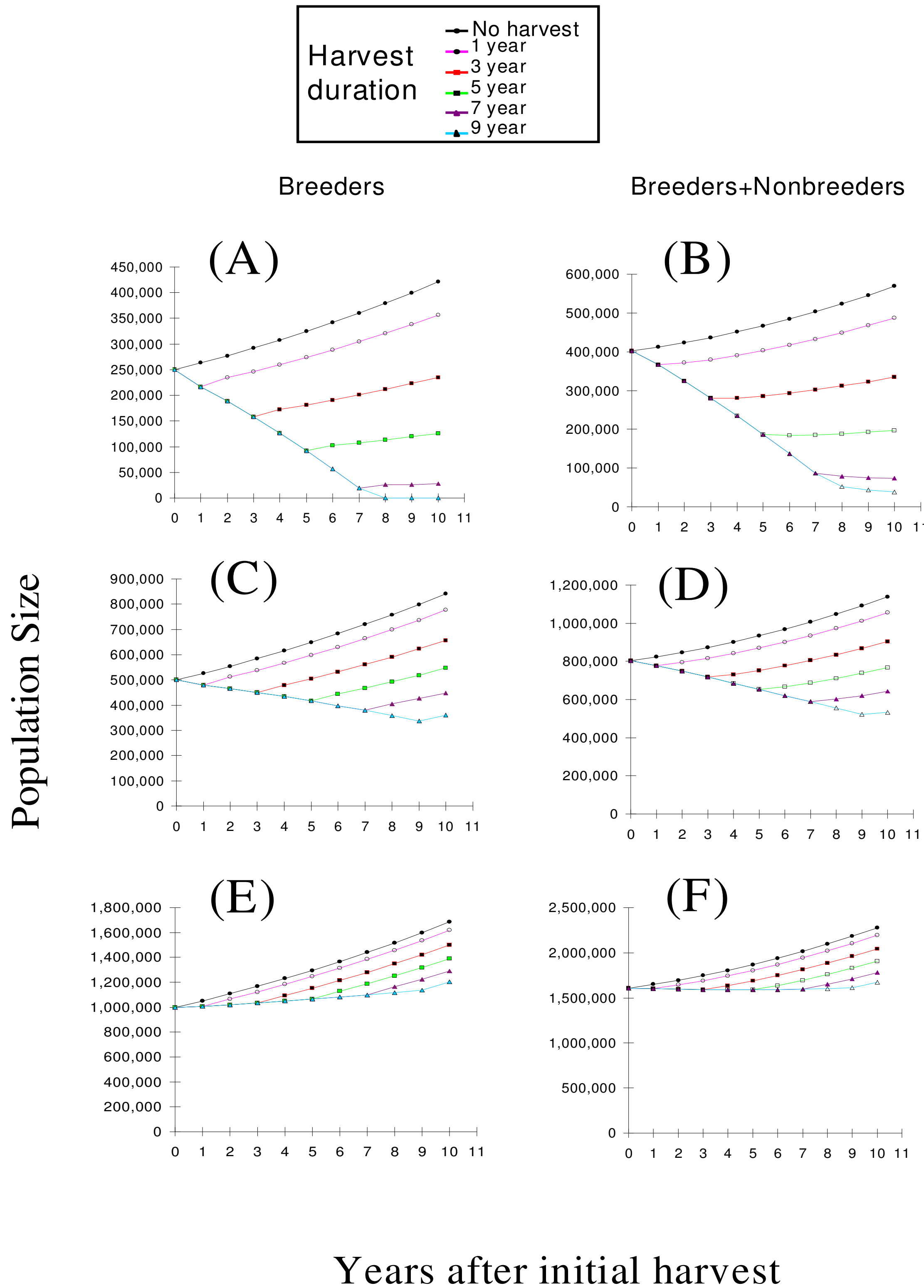


Figure 9. Ten year projections from deterministic population models of snow geese for a colony of 250,000 breeders with different survival probabilities of adults and juveniles. Also shown are populations of breeders and associated nonbreeders. Trajectories in each panel shown are with no harvest, and with incremental increases in harvest of 50,000 breeders up to 250,000/year. Density dependence was not assumed.

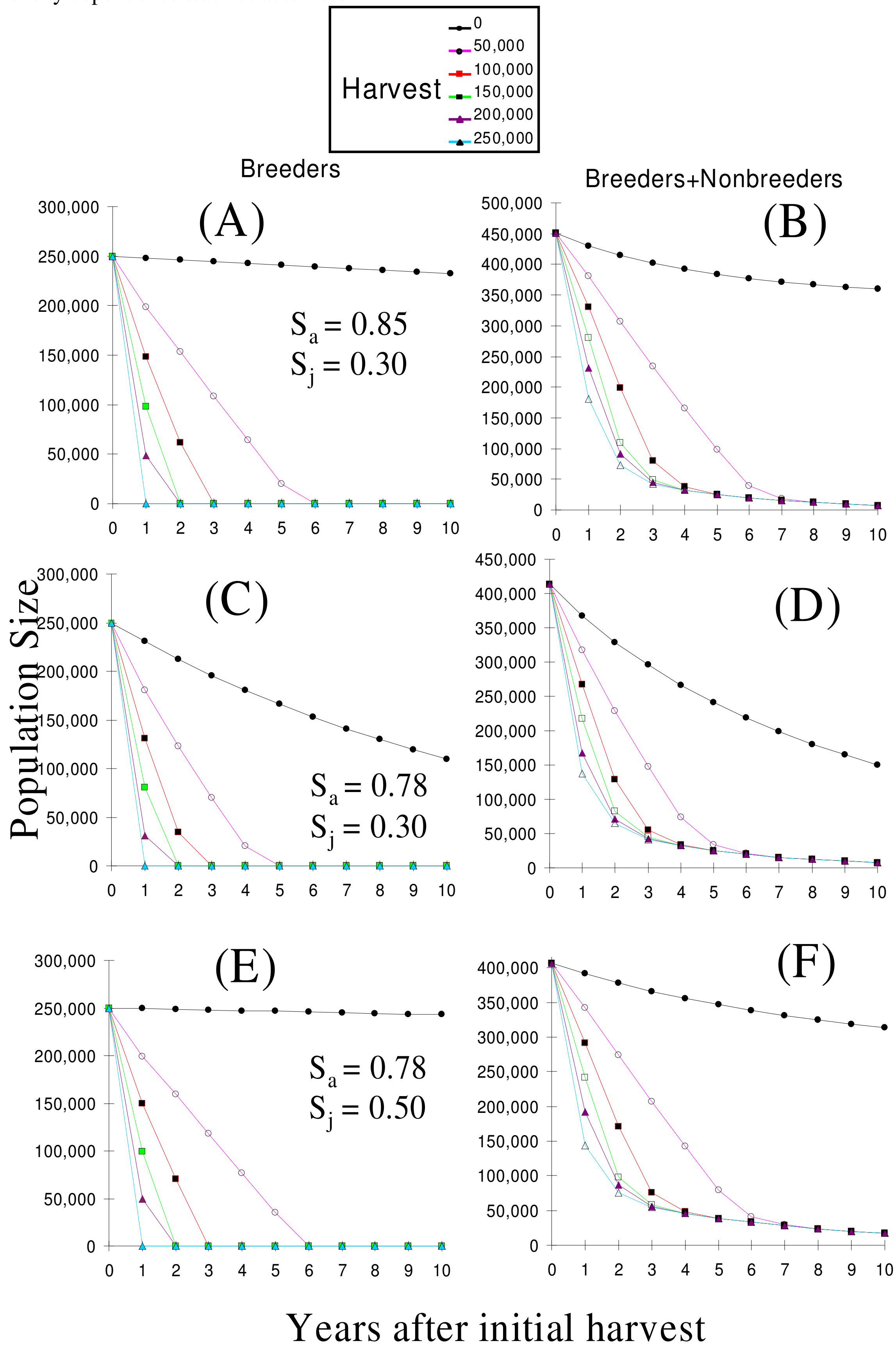


Figure 10. Availability of jet fuel near the breeding range of mid-continent snow geese. Shown also are polygons which enclose an area around colonies that is closest to each colony.

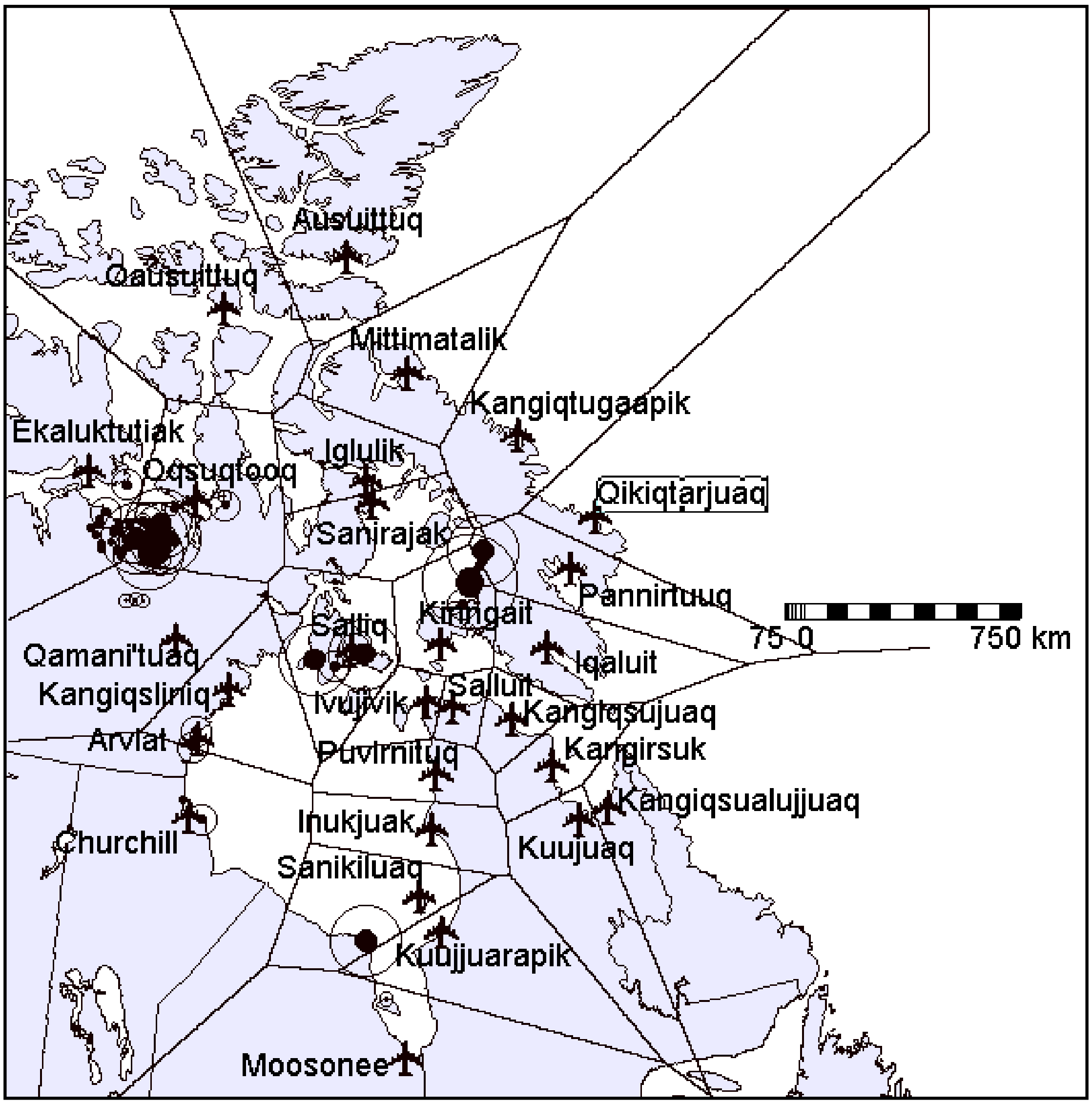


Figure 11. Nesting densities of mid-continent snow geese (geese/km^2) at specific colonies (R. T. Alisauskas, unpublished data, and R.H. Kerbes pers.comm.).

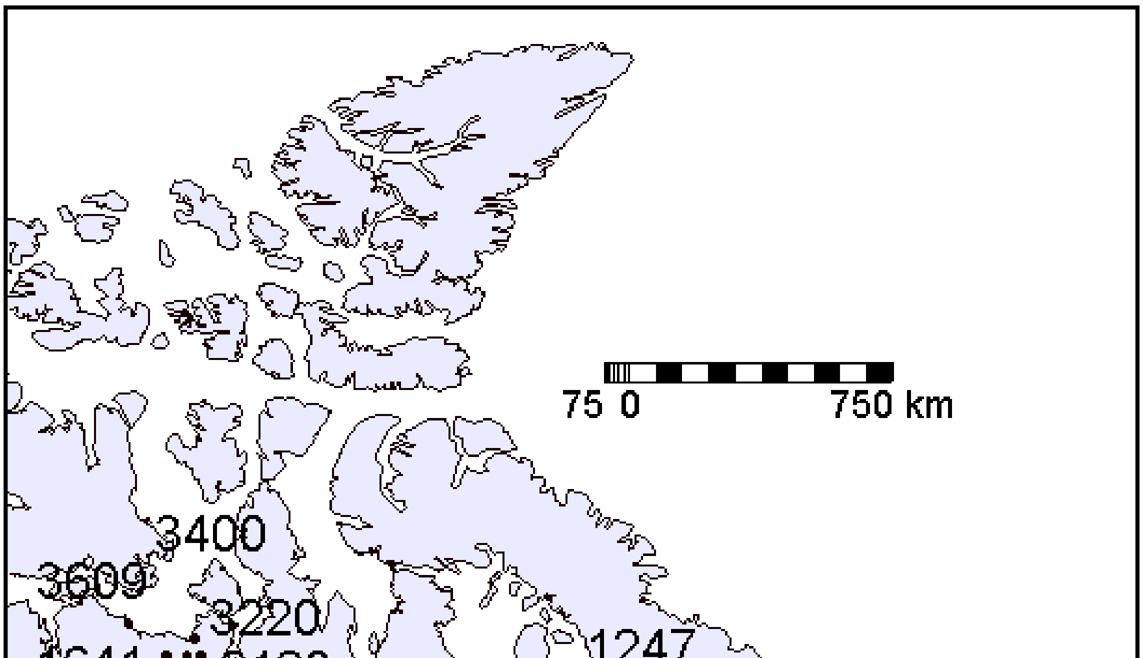
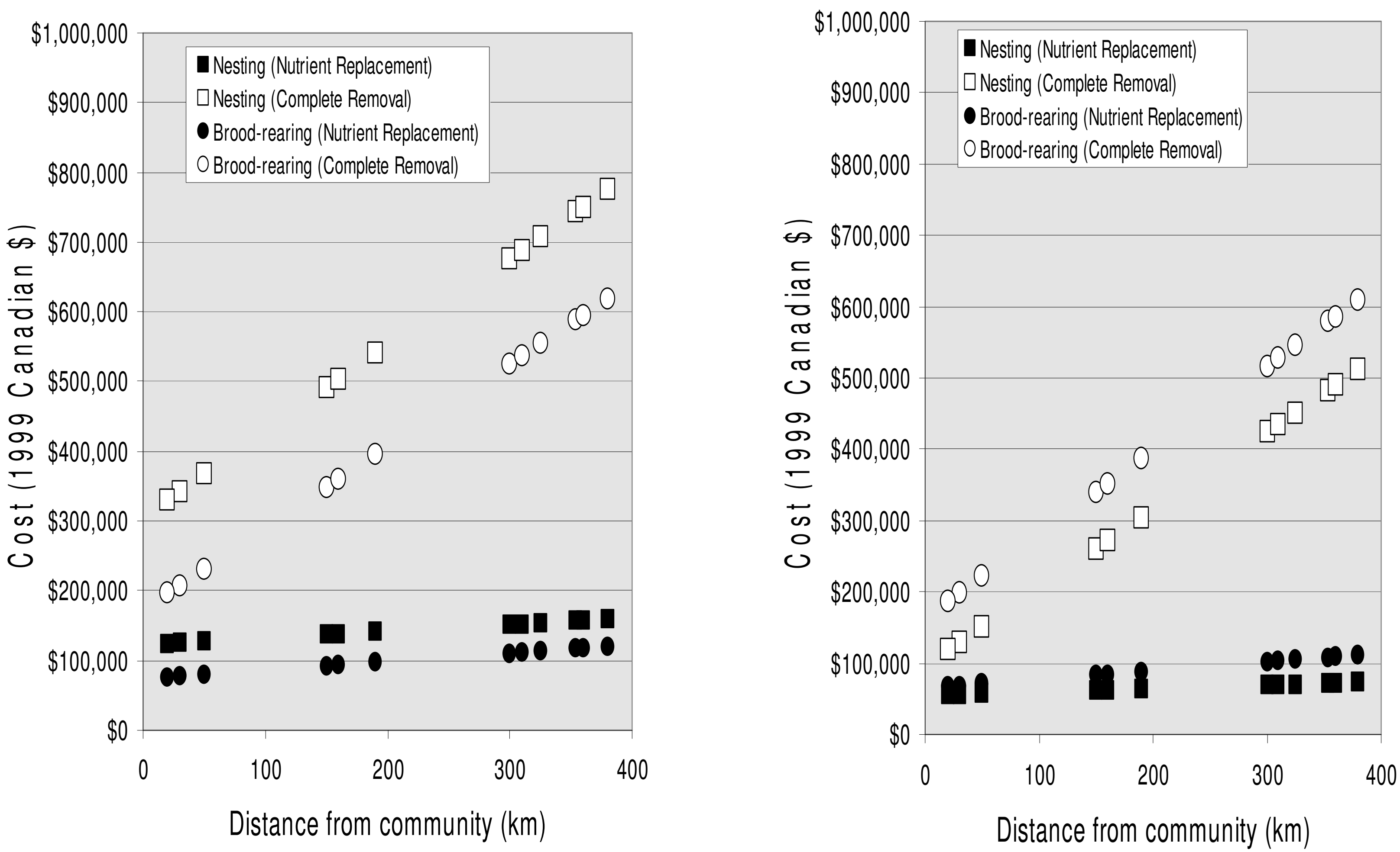


Figure 12. Arctic and sub-Arctic communities near the breeding range of mid-continent snow geese.

Figure 13. Cost of harvesting 50,000 snow geese as a function of distance from nearest serviced community, timing of harvest (nesting vs. brood-rearing), and disposition of geese (Nutrient Replacement vs. Complete Removal options) assuming (A) low harvest efficiency (1 nesting goose harvested / 3 min, or 2000 geese captured/day during brood-rearing) and (B) high harvest efficiency (1 nesting goose harvested / 1 min, or 5000 geese captured/day during brood-rearing). Note that geese harvested during nesting include only nesting adults, but geese captured during brood-rearing include both adults and goslings.



Part IV

TRAPPING AND SHOOTING LIGHT GEESE ON MIGRATION AND WINTERING AREAS

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INTRODUCTION

This section evaluates trapping and shooting (outside of hunting by the general public) light geese on migration and wintering areas, and considers methods and alternatives beyond those that might be implemented during regular and late-winter light goose hunting seasons and during special conservation harvests[1]. In accordance with the goal established by the Direct Control and Alternative Harvest Measures Working Group (Johnson and Ankney 2003) of maximizing use of light goose carcasses (preferably for human consumption), a primary advantage of trapping and shooting on migration and wintering areas is that birds are captured or killed close to human population centers in the United States and southern Canada, which facilitates transportation, processing, distribution, and consumption. The primary disadvantage of attempting direct population control during this portion of the annual cycle is that birds are wary, highly mobile, and congregate in large flocks, and consequently are more difficult to capture and kill than on Arctic breeding areas. These advantages and disadvantages appear to be reversed for capturing and killing light geese on Arctic breeding areas, where light geese are more easily captured or killed, but more difficult to process (Alisauskas and Malecki 2003).

TRAPPING

Rocket Netting

The advantages of using rocket nets to capture light geese are great and include (1) birds captured alive could be loaded into holding crates, transported to poultry processing facilities, and slaughtered like domestic fowl, producing food of the highest possible quality for human consumption (although some birds will contain previously embedded shot), (2) because birds would be captured alive, there would be complete control over the sex and age of birds to be killed, and (3) loss of non-target species would be minimized. An additional positive aspect of this technique is that crippling loss (i.e., waste) would be minimized.

Light geese have been captured with rocket nets set on grit-sites in southwestern Louisiana and coastal Texas (J. Walther, U.S. Fish and Wildlife Service, Sabine National Wildlife Refuge [NWR], retired, and J. Neaville, U.S. Fish and Wildlife Service, Anhauac NWR, pers. comms.), on wetland loafing sites in Nebraska (N. Lyman, Nebraska Game and Parks Commission, pers. comm.), and on wetland roosting sites in Delaware (Hill 1992). Hill (1992)

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[1] The term “Special conservation harvests” is used here to describe the “Conservation Order” and “Special Harvest Provisions during Regular Hunting Seasons” in the U.S. and “Special Conservation Measures” in Canada.

captured 113 greater snow geese (*Chen caerulescens atlantica*) in Delaware by rocket-netting unbaited roost sites, which required about 40 person-days of effort. Numbers of birds captured per rocket-netting event, often using multiple nets, typically ranged from 25 to 500 in the trapping efforts described above.

Attempts to use large quantities of bait (i.e., piled grain) to attract wintering snow geese to rocket-netting sites largely have been unsuccessful, either because bait attracted large numbers of undesirable species (e.g., blackbirds and grackles) or because light geese were not attracted to bait (e.g., Hill 1992). During spring 2000, two experimental efforts were made to attract light geese to bait for rocket netting. In the first effort, 250 kg of shelled corn was placed on a loafing site at Funk Waterfowl Production Area in the Rainwater Basins of Nebraska in late February. Snow goose diets during spring in Nebraska consist of >98% corn (aggregate percent dry mass; Cox, unpublished data). Estimated numbers of light geese using this area at the time were 1.25-1.75 million (J. Drahota, U.S. Fish and Wildlife Service, pers. comm.). In the second effort, two sites, adjacent to roosting areas, were baited with corn at Sand Lake NWR, South Dakota (Appendix). In both cases, light geese generally ignored bait, but ducks and Canada geese (*Branta canadensis*) used the sites. Also in both situations, too few light geese used the bait to justify the time and expense of setting rocket nets. Notably, however, neither of these efforts evaluated whether light geese could be attracted to bait placed in fields that were already being used by geese. In late January 2001, however, Ankney attempted to increase the number of snow geese using a shallowly-flooded rice field on the Mad Island Wildlife Management Area near Palacios, Texas. At the start of the trial, there were about 50 snow geese and 15 white-fronted geese using the field; there were at least 10,000 snow geese using other fields within 10 km. Over the course of five days, about 350 kg of rice were scattered in the field. The number of white-fronted geese using the field increased to about 250, but there was no increase in numbers of snow geese. Grackles (*Quiscalus* spp.) and blackbirds (*Agelaius* spp.), the numbers of which increased markedly, consumed most of the rice.

The major disadvantage of using rocket nets is high probability of failure to capture light geese at levels sufficient for population control (50,000 or 250,000). Success in attracting snow geese to grit sites has been demonstrated in only a few areas of extensive marsh in Texas and Louisiana where grit is believed to be limiting. Further, up to 5 years may be required for snow goose numbers to increase sufficiently at a site to make rocket netting feasible (J. Walther, pers. comm.). Failure to attract light geese to bait is the main impediment to rocket netting. However, limited success has been reported for attracting snow geese to sparsely baited sites in uplands (N. Lyman, Nebraska Game and Parks Commission, and J. Cummings, National Wildlife Research Center, pers. comms.). During fall of 1993-1995, Morez et al. (2000) successfully captured small numbers of greater snow geese on sparsely baited and unbaited sites in fields, but numbers captured on baited sites (n = 428) were not markedly larger than those captured on unbaited sites (n = 303). However, the Cap Tourmente study site of Morez et al. (2000) may be one of a very limited number of sites along the Saint Lawrence Seaway where capture of greater snow geese is possible (A. Reed, Canadian Wildlife Service, retired, pers. comm.). Sparse baiting of pea fields during fall on major staging areas in prairie Saskatchewan and Manitoba may prevent light geese from "eating out" fields, and thus keep them using fields for longer periods. Leased fields could be baited in strips during midday or at night using trucks similar to those used to spread sand and salt on roads. It may be possible to concentrate geese on baited strips to make rocket netting more effective. During spring migration, snow geese become more hyperphagic as they move farther north, and they store large amounts of fat while in prairie Canada (Alisauskas 1988). Although corn is not abundant in prairie Canada, light geese there use corn extensively during spring, often flying long distances between roosts and cornfields (Alisauskas and Ankney 1992,

J. Leafloor, Canadian Wildlife Service, pers. comm.). Whether or not light geese could be concentrated (both in specific cornfields and within the range of rocket nets) by baiting in prairie Canada during spring is unknown. Further research is needed to determine the feasibility of baiting and capturing light geese with rocket nets during spring and fall in prairie Canada. Until such research is done, it will be impossible to assess the financial costs of reducing light goose populations using rocket nets.

OTHER CAPTURE METHODS

The only successful technique for capturing light geese during fall-spring has been rocket netting; consequently, other capture techniques discussed below are unproven and thus are highly speculative. Light traps have been used to capture blackbirds and European starlings (*Sturnus vulgaris)* on wetland roosts (Mitchell 1963). This technique involves constructing large nets near roosts. Powerful lights are used to temporarily blind roosting birds at night and portions of the birds are captured when they fly into the nets. It also may be possible to herd light geese into nets using model airplanes. The large body mass of light geese would require that nets be constructed to withstand considerable force.

Some forms of technology developed and used by the military may be amenable to capturing light geese. Launchers used to propel heavy ropes over great distances (e.g., between ships at sea) may be useful for capturing light geese if they can be adapted to propel light-weight entanglement nets over roost-sites or upland foraging areas. Entanglement nets set at the surface of open water also may be useful for capturing light geese as they return to roosts, typically well after sunset. Research on development and evaluation of new, innovative capture techniques should be conducted immediately.

SHOOTING

We believe that two approaches related to shooting, outside of hunting by the general public, warrant consideration for direct population control of light geese. These approaches are: (1) contracting of hunters to shoot light geese, and (2) use of remotely detonated shot-charge devices. These approaches are intended herein to be administered and delivered by the government, and not for use by the public at large.

Contractual Hunting

There is no recent history by which to evaluate the potential effectiveness of hiring or contracting professional hunters (hereafter called “contractual hunters”) to shoot light geese. However, a possible advantage of this alternative is that it is likely that contractual hunters could be recruited who are more effective at harvesting light geese than are average hunters, as measured by number of geese harvested per hunter or per unit time. Additional advantages are (1) a higher proportion of adult light geese might be harvested as compared to normal harvest if hunters are paid more for harvesting adults than for juveniles, and (2) harvested birds could be consumed by humans.

There are disadvantages to this approach. First, potential for conflicts between public hunters and contractual hunters is high. If contractual hunters simply were hired to hunt light geese, then competition between contractual hunters and public hunters for access to land likely would occur. If contractual hunters were allowed exclusive access to areas closed to public hunters, such as refuges, then disgruntlement among public hunters might occur because they were not afforded similar access. Second, not all harvest by contractual hunters would be additive to that of public hunters. Many of the most experienced (and likely most effective) light goose hunters are individuals who regularly hunt light geese anyway (without being paid). Furthermore, contractual hunters operating on land (public or private) available to public hunters would replace at least some of the harvest by public hunters. Consequently, this alternative must be evaluated only in terms of numbers of light geese harvested *in addition to* what would have been harvested without hunters being compensated. Third, some mortality of non-target species would occur from contractual hunters, possibly at a higher rate than by public hunters if monetarily motivated contractual hunters were more likely to flock-shoot light geese when non-target species are present. A final negative aspect of this approach is that some crippling would occur from contractual hunters, as with public hunters. We estimate that contractual hunters would need to be paid a minimum of $10.00 (U.S.) per goose to motivate them to kill large numbers of geese. Costs of processing carcasses for human food ($6.00 [U.S.] per bird [Maier et al. 2003]) would be additional to that paid to contractual hunters.

Remotely Detonated Shot-charge Devices

Direct population control would be considered only if harvest during the present nine-month-long hunting seasons and special conservation harvests prove insufficient at reducing populations. Thus, direct population control can be viewed accurately as an extraordinary measure. Consequently, we believe it is important to identify a method that has a high probability of rapidly achieving population reductions of up to 250,000 total birds. Remotely detonated shot-charge devices, with the capability to instantaneously and directionally propel large amounts (measured in kg, not g) of shot, could be in the form of modern remotely fired punt guns (which, with barrels up to 4.5 cm diameter, currently are legal in many parts of Europe, including Great Britain [Owen et al. 1986]), batteries of shotguns (e.g., up to 50 10-gauge shotguns fired simultaneously via electronics), or other devices which essentially function as large shotguns. Claymore mines, in particular, are above-ground, directional, remotely detonated shot-charge devices that appear to be highly suited for killing large numbers of light geese. Claymores are not to be confused with land mines, which are buried and pressure-activated. Claymore mines are compact devices that contain 500 steel balls (about the size of #4 buckshot) that travel in a 60^{o} arc when detonated with an effective range of 50 m. Multiple claymores could be deployed quickly and electrically detonated simultaneously from remote locations. These devices would be deployed only by wildlife professionals properly trained in their safe use, probably with military experts on site to supervise. Key refuges, closed to public access in primary staging areas during spring migration (or possibly in winter), could be targeted for this activity. Ancillary benefits to population control from this activity might be moving birds off refuges and consequently increased harvest by public hunters.

An advantage of using remotely detonated shot-charge devices is that birds could be used for human consumption. Another is that this technique would remove adults proportionately from the population, as opposed to hunting which removes juveniles disproportionately from populations (Rockwell et al. 1997, Alisauskas and Malecki 2000). However, the main advantage is that this approach has a high probability of rapidly achieving population reduction with a high level of efficiency and cost-effectiveness. A disadvantage of this approach is that use of remotely detonated shot-charge devices would result in some loss of non-target species. A final negative aspect of remotely detonated shot-charge devices is that some crippling loss would occur. However, it may be possible to develop alternative shot types or shapes with crippling rates lower than that of spherical nontoxic shot.

CONCLUSION

Our findings suggest that live capture of light geese would be preferable to other alternatives considered herein because of its many advantages. However, our review casts serious doubt on the effectiveness of live capture in achieving population reduction goals. Consequently, it is important that research on the feasibility and effectiveness of capturing light geese via rocket nets and other methods on migration and wintering areas begin immediately. Development of capture techniques is required before cost schedules can be estimated. If new and innovative techniques to capture light geese can be developed, they could have marked implications for future use in wildlife research. Our findings suggest that contracting of hunters will lead to competition between contractual and public hunters, and, consequently, to dissatisfaction among public hunters.

Remotely detonated shot-charge devices have great potential for rapidly achieving population-reduction goals during migration and winter. If live capture of light geese via rocket nets or other means proves unfeasible or ineffective, our review indicates that this alternative be given priority consideration in the event that direct population control on migration and wintering areas becomes necessary. Two of the negative aspects of this alternative, loss of non-target species and crippling, already occur during current light goose harvest periods. Although actual rates are not known, it is plausible that rates of crippling and loss of non-target species would be lower with wildlife professionals using these devices than typically occurs with public hunters. Preliminary polling of the public to assess potential level of opposition to such an approach, given that direct population control becomes necessary, would help guide future management decisions.

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LITERATURE CITED

Alisauskas, R.T. 1988. Nutrient reserves of lesser snow geese during winter and spring migration. Ph.D. dissertation, University of Western Ontario, London.

Alisauskas, R.T., and C.D. Ankney. 1992. Spring habitat use and diets of mid-continent adult lesser snow geese. Journal of Wildlife Management 56:43-54.

Alisauskas, R.T., and R.A. Malecki. 2003. Direct control methods for population reduction of light geese in the Arctic. Pages 43-86 *in* Johnson, M. A. and Ankney, C. D., editors. Direct control and alternative harvest strategies for North American Light Geese. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario.

Cooke, F., R.F. Rockwell, and D.B. Lank. 1995. The snow geese of La Perouse Bay: natural selection in the wild. Oxford University Press, New York.

Hill, M.R.J. 1992. Movements and habitat use by wintering greater snow geese (Chen caerulescens atlantica) on the Delmarva Peninsula. Thesis, Eastern Kentucky University, Richmond, USA.

Johnson, M.A. and C.D. Ankney. 2003. Introduction and background. Pages 7-21 *in* Johnson, M.A. and Ankney, C.D., editors. Direct control and alternative harvest strategies for North American Light Geese. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario.

Maier, A.,N. Clark and M.A. Johnson. 2003. Human food, processing, marketing, food programs, and other products. Pages 105-117 *in* Johnson, M. A. and Ankney, C. D., editors. Direct control and alternative harvest strategies for North American Light Geese. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario.

Mitchell, R.T. 1963. The floodlight trap: a device for capturing large numbers of blackbirds and starlings at roosts. U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife Special Scientific Report Wildlife 77.

Morez, V., G. Gauthier, and A. Reed. 2000. Effect of body condition on vulnerability of greater snow geese to hunting and capture. Journal of Wildlife Management 64:875-886.

Owen, M., G.L. Atkinson-Willes, and D.G. Salmon. 1986. Wildfowl in Great Britain. Cambridge University Press, Cambridge, Massachusetts.

Padding, P.I., E.M. Martin, and B.H. Powell. 1999. Age and sex composition of ducks and geese bagged in the 1998 hunting season in comparison with prior years. U.S. Fish and Wildlife Service, Office of Migratory Bird Management Administrative Report.

Rockwell, R., E. Cooch, and S. Brault. 1997. Dynamics of the mid-continent population of lesser snow geese - projected impacts of reductions in survival and fertility on population growth rates. Pages 73-100 *in* B. D. J. Batt, editor. Arctic Ecosystems in Peril: Report of the Arctic Goose Habitat Working Group. Arctic Goose Joint Venture Special Publication. U. S. Fish and Wildlife Service, Washington, D. C. and Canadian Wildlife Service, Ottawa, Ontario.

Appendix. Report on light goose trapping during spring 2000 at Sand Lake National Wildlife Refuge, South Dakota.

SPRING SNOW GOOSE CAPTURE ATTEMPT

Sand Lake National Wildlife Refuge

Spring 2000

During the spring of 2000, Sand Lake National Wildlife Refuge personnel attempted to capture and band snow geese as they migrated through the area. This attempt was made at the request of Michael Johnson, Waterfowl Biologist with the North Dakota Game & Fish, and Bobby Cox, Northern Prairie Wildlife Research Center. The objective of the project was to evaluate the feasibility of capturing snow geese with rocket nets as a direct population control method in the future.

We decided that we would attempt to attract snow geese to two banding sites on Sand Lake NWR. One is located along the west side of Mud Lake, and the other site is located on the west side of Sand Lake. These sites are currently used during pre-season duck banding.

During the last week of February, refuge personnel spent approximately 2 days mowing cattail and grass, and cutting several Russian olive trees near the Mud Lake site to further "open up" the site and tie it in with agricultural fields near the site. We decided to wait until snow geese began to use the bait before we put out the rockets and nets.

The snow geese began to move into the refuge on March 3, and by March 5, there were 500,000 snow geese using the refuge. Most of these birds were standing on the ice in Mud Lake and Sand Lake, feeding west of the refuge. Both banding sites were wet and muddy from rain and the frost coming out of the soil, so we had to wait for the temperature to drop below freezing and bait the sites right away in the morning before the temperature rose. The two sites were baited with approximately 20 bushels of corn per site on the morning of March 6. These birds remained on the refuge and in the area until March 8. On March 9, most of the snow geese went back south due to snow and cold weather. Only several thousand remained in the refuge area until the 14th, although up to 75,000 were seen flying over during this time. On the 14th, 150,000 snows moved into the refuge. By the 15th, several hundred thousand snows were using the refuge again. The Mud Lake site had to be re-baited on the 14th (25 bushels) and on the 16th (20 bushels). Numbers remained near 200,000 through March 22. Numbers dropped to 25,000 by the 25th. Flocks of 10,000 to 30,000 moved through the refuge area off and on the rest of the month. Bait was on both sites through the 25th.

No snow geese were observed on the bait. Snow geese were observed flying over the bait as they came back into the refuge, but they made no attempt to use it. Canada geese and ducks were observed on the Mud Lake site. The corn at the Mud Lake site was nearly cleaned up by the 14th. Up to 100 Canada geese and 100 ducks were observed on this site on the 11th and 12th. Nothing had been observed or was using the site on the west side of Sand Lake. Approximately 25 bushels of corn was added to the Mud Lake site on the 14th, and another 20 bushels on the 16th. Only Canada geese and ducks used the bait.

In summary, although there were many snow geese using the refuge this spring, they showed no interest in feeding on the bait. Only Canada geese and ducks were seen feeding on the corn. Wet and muddy conditions on the sites hampered baiting the sites and would have made interesting conditions for banding the geese. From what we saw and observed this spring, this method does not show a lot of promise for capturing snow geese during the spring migration at Sand Lake NWR.

Expenses

Preparation of banding sites: $242.00

Bait: 85 bushels corn @ $1.80/bu. = $153.00 (not an actual expense-had the corn on hand)

Monitor banding sites: $200.00

Total cost - $595.00

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Sand Lake National Wildlife Refuge

Part V

POTENTIAL CHEMICALS TO MANAGE LIGHT GOOSE POPULATIONS

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INTRODUCTION

Over-abundant light geese are having long-term negative effects on the Arctic tundra ecosystem. Significant damage to native plants, increases in soil degradation and impacts on bird communities are likely to be the main consequences (Batt 1998). The extent of which over-abundant light geese reduce food and cover for other wildlife on wintering grounds and migration routes is not well documented, although anecdotal observations suggest that light geese could compete with wintering waterfowl for food, i.e. Louisiana rice fields (J. L. Cummings, National Wildlife Research Center, personal observation).

Successful management of over-abundant light goose populations suggests the development of a strategic plan that identifies clear objectives in terms of desired population numbers, management techniques and monitoring. The plan needs the support of various local, state, federal and provincial governmental agencies and private organizations. The success of any light goose management action will require an integrated approach at various locations on the breeding and wintering areas and migration routes, and depend on the expertise and motivation of the personnel involved. These professionals must have an understanding of the problem, the biology of light geese, and the proposed management strategies.

There are various management strategies that could potentially be used to manage over-abundant light goose populations on the breeding and wintering areas and along migration routes (Johnson 1997). The goal of managing over-abundant light geese should be to reduce light goose populations to numbers that will lessen the impacts on the Arctic tundra habitat, other breeding bird species and competition with other wildlife for resources such as food and roosting sites. One approach that could potentially affect thousands of light geese in a relative short time period is the use of chemical avicides at key staging areas on migration routes. Since light geese forage in sizable flocks, up to 20,000 birds (Mark Zaunbrecher, Sweet Water Land Company, personal observation), an effective avicide could potentially affect thousands of birds with one application.

DIRECT CONTROL METHODS

Currently, there are three registered avicides that could potentially be modified and used for light goose population management: 3-chloro-4-methyl benzenamine HCl (Denver Research Center (DRC)-1339) , 4-aminopyridine (Avitrol) and alpha chloralose (AC). Factors affecting the use of these avicides for light goose management are registration issues, environmental factors, non-target and/or threatened and endangered species, animal welfare concerns and bait acceptance.

3-chloro-4-methyl benzenamine HCl (DRC-1339)

Description

DRC-1339 (Chemical Abstracts (CAS) #774-89-3) is a slow-acting avicide that is registered with the Environmental Protection Agency (EPA) for control of several species of pest birds, including blackbirds, starlings, rock doves, crows, ravens, magpies and gulls. The product was developed jointly by Ralston Purina and the National Wildlife Research Center. Registrations are maintained by PM Resources, Inc. and the U.S. Department of Agriculture (USDA), Wildlife Services (WS). The effectiveness of DRC-1339 as a lethal management tool is largely due to its differential toxicity. It is acutely toxic to a narrow range of avian species, primarily birds that often cause pest problems, such as starlings, blackbirds, rock doves, crows and ravens. The median acute lethal dose $_{50}$ (LD_{50}) for these species ranges from 1 to 14 mg/kg. The LD_{50} is the amount of chemical it takes to cause 50% mortality to a test population. For other species, such as raptors, DRC-1339 is moderately toxic (LD_{50} exceeds 300 mg/kg). It is estimated that the LD_{50} for waterfowl is between 17-48 mg/kg (Hudson et al. 1984; Eisemann and Pipas 2002). Light geese would probably fall within this range. Once ingested, most DRC-1339 is metabolized and excreted from the bird within 4-6 hours. The mode of action of DRC-1339 in birds consuming a lethal dose is irreversible kidney and heart damage; a quiet and apparently painless death normally occurs 1-3 days following ingestion (USDA 1995).

Currently DRC-1339 is used under an EPA Staging Area label to manage blackbird populations that damage agriculture crops (Cummings et al. 1992; Cummings et al. 2002). In these management programs, DRC-1339 baits are diluted 1:25 with untreated bait and applied to areas where target birds congregate with an all terrain vehicle (ATV) equipped with a 25-kg bait spreader. The baits are applied directly to the ground at a rate of 50-100 kg/ha. The amount of treated bait applied to each site is about 75% of the amount of untreated bait taken during a 3 to 5- day pre-baiting period. This procedure assures that all treated baits will be consumed.

DRC-1339 could be used to manage light geese. The selectivity of DRC-1339 for light geese could be enhanced by: (1) pre-baiting with untreated bait and ensuring that light geese are the only species taking the baits, (2) using baits that are most preferred by light geese, (3) using the minimal concentration of chemical to cause mortality, and (4) applying baits to prime feeding locations. The use of DRC-1339 would be most effective at staging areas on wintering areas and along migration routes. It would only be effective on breeding grounds if geese staged in large numbers before dispersing to nest sites. Once geese were on nesting territories, the logistics and costs associated with baiting individual geese would be prohibitive.

There is evidence that traditional baits and baiting techniques used to attract waterfowl and Canada geese to bait sites might not be effective for light geese (Robert Cox, United States Geological Survey, personal communication). However, observational data collected in Louisiana during January, February and March suggest that light geese will feed on whole corn and brown rice that is lightly scattered at sites they are currently using. For example, during January 2001 in Louisiana, light geese foraging in rye grass fields consumed 25-kg of whole corn from a bait site 4 x 20 m and 150-kg of whole corn that was scattered over a 1 ha bait site. In addition, flocks of >10,000 light geese have been observed feeding on waste grain in corn stubble as they migrate from wintering areas in the central and Mississippi flyways. This information demonstrates that bait placement and/or application timing may be key factors for bait acceptance by light geese.

Cost-benefit estimate

DRC-1339 costs about $0.77/g (Pocatello Supply Depot, United States Department of Agriculture). Based on a LD_{50} of 48 mg/kg or 163 mg of DRC-1339 per goose, an estimated lethal dose would cost $0.12. The logistics and manpower to locate and bait light goose staging areas (wintering areas and migration routes) that would result in removal of 50,000 or 250,000 light geese would cost about $2.96/goose (Table 1). Each person would operate individually and be equipped accordingly. One person could manage up to six bait sites in an area where light geese are staging. Each bait site would be used until light goose numbers were reduced or light geese abandoned the site. Since death occurs from 1-3 days following ingestion, recovery of light geese would be from the bait site only.

The following cost estimates are for removal of 50,000 or 250,000 light geese from wintering areas, along migration routes and/or on the breeding grounds before geese disperse to nesting sites.

Table 1. Estimated program costs to remove 50,000 or 250,000 light geese with DRC-1339 from wintering areas, along migration routes and/or on the breeding grounds before geese disperse to nesting sites.

Average flock size of 3,000 geese per bait site

Time period: December-April

Light geese	50,000	250,000
Personnel	3	15
Salaries	$30,000	$150,000
Travel/per diem	$18,000	$90,000
Equipment		
Vehicles (3 and 15)	$66,000	$330,000
ATV's (3 and 15)	$18,000	$90,000
Bait mixers (3 and 15)	$900	$4,500
Miscellaneous	$2,500	$12,500
Supplies		
Chemical	$7,500	$37,500
Bait	$1,000	$5,000
Fuel	$3,000	$15,000
Miscellaneous	$1,500	$7,500
TOTAL	$148,400	$740,000

Use of birds

Light geese that are collected on and around baits sites could not be used as human or animal food because of potential chemical residues in edible tissues. However, feathers and down could have some economic value and could be collected if a viable market exists. The carcasses of light geese following removal of feathers would have to be disposed of by burial or incinerated.

Problems

The use of this product would depend on approval from PM Resources and USDA. The conventional baiting technique described earlier requires a pre-baiting period prior to the application of treated baits. During the migration period, light geese could potentially leave bait sites before treated baits are applied. Bait type, acceptance and application may present some problems. There is evidence that blackbirds, crows and ravens avoid treated baits due either to the bait carrier or chemical degradation of DRC-1339. There is some potential for non-target species to be affected. Since DRC-1339 is a slow-acting toxicant, light geese could move to other locations before death which prevents recovery of all affected light geese. Light geese could not be used as a food resource because of potential chemical residues in tissues. Baiting operations would be limited to areas where light geese congregate and the potential non-target hazard is low. Under the current EPA label for DRC-1339, no crops could be planted on bait sites for 365 days.

Information needs

Determine optimal baiting techniques, dose levels, application rates, bait carrier, and dilution rates. Evaluate the preference for various bait types by geographic area and time period. Determine specific areas where light geese congregate on wintering areas and along migration routes. Determine the types of permits needed by local, state, federal and provincial governments for baiting with DRC-1339. Determine the potential non-target hazards associated with baiting in different geographical areas.

4-aminopryidine (Avitrol)

Description

Avitrol, a bird management chemical registered with the EPA by Avitrol Corporation, is used as a flock-frightening agent, or at a higher chemical concentration and lower dilution rate a toxicant (Lucid 1980). It is a restricted use avicide that can be used only by certified applicators. Avitrol is an acutely toxic chemical that affects the nervous system in a manner similar to that of organophosphates and carbamates but it is not a cholinesterase inhibitor. Birds and mammals appear equally sensitive to Avitrol. It is usually formulated on grain baits, and LD_{50} levels are generally less than 10 mg/kg for target species, such as blackbirds, pigeons and gulls. For geese, the LD_{50} is 4.3 mg/kg. Treated bait is diluted with untreated bait so that the desired control of a bird population can be achieved. In most cases, Avitrol will affect birds in less than 20-30 minutes. Before dying, affected birds emit distress cries and/or perform visual displays that often frighten the other birds in the flock which causes them to leave the area. Avitrol has been used successfully to lower pigeon and gull populations in a number of situations without any adverse affects to non-target species. In field tests with blackbirds, it was noted that birds reacted about twice as fast to the chemical when they ingested 2-3 times the normal dose (Knittle et al. 1988). Avitrol could be used to manage light geese following the same criteria outlined for DRC-1339.

Cost-benefit estimate

Avitrol costs about $0.55/g (Avitrol Corporation). Based on a LD_{50} of 4.3 mg/kg or 13.7 mg per goose, an estimated lethal dose would cost $0.007. Chemical application, manpower and logistical support for baiting sites would be similar to those described under the DRC-1339 section. The only difference would be a reduction in the chemical cost. It is estimated that a program for removal of 50,000 or 250,000 light geese from the population would cost about $141,400 or $705,000, respectively or about $2.82/goose.

Use of birds

Light geese that are collected on and around baits sites could not be used as human or animal food because of potential chemical residues in edible tissues. However, feathers and down could have some economic value and could be collected if a viable market exists. The carcasses of light geese following removal of feathers would have to be disposed of by burial or incinerated.

Problems

The use of this product would depend on Avitrol Corporation approval and the use of their data to support a registration. Avitrol baits present similar problems as those of DRC-1339. However, some non-target species are more sensitive to Avitrol. Laboratory tests indicate that Avitrol does not pose a secondary hazard to non-target species such as raptors, except if birds consume treated baits directly from the esophagus or gizzard of the target species. Collected light geese could not be used as a food resource because of potential chemical residues in body tissues. Baiting operations would be limited to areas where light geese congregate and the non-target hazard is low. The EPA label for Avitrol would have to be modified for this type of use.

Information needs

Determine optimal baiting techniques, dose levels, application rates, bait carrier, and dilution rates. Evaluate the preference for various bait types by geographic area and time period. Determine specific areas where light geese congregate on wintering areas and along migration routes. Determine the types of permits needed by local, state, federal and provincial governments for baiting with Avitrol. Determine the potential non-target hazards associated with baiting in different geographical areas.

Alpha Chloralose (AC)

Description

Alpha chloralose (AC) is a narcotic and therefore acts by anesthetizing rather than killing (Agricultural Chemicals Board 1977). It is registered in England, Germany and France to capture and kill birds. Since 1992, it has been used by USDA, Wildlife Services for the capture of pigeons, coots, and waterfowl under an Investigational New Animal Drug authorization from the Food and Drug Administration (FDA). Currently, the use of AC in the United States is not authorized during, or 30 days prior, to hunting seasons that involve Canada geese or waterfowl.

Application of AC is by certified applicators or under the direct supervision of a certified applicator. AC can be incorporated on bread or whole corn baits at about 30 mg/kg for geese. It takes from 30 to 90 minutes for birds to be completely immobilized and about 8 to 24 hours to recover. Target birds that are captured by AC are usually relocated or euthanized.

AC could be used to manage light geese following the same criteria outlined for DRC-1339. The estimated immobilizing dose and LD_{50} for a light goose is 96 mg and 288 mg, respectively.

Cost-estimate benefit

AC costs about $2.90/g (Pocatello Supply Depot, United States Department of Agriculture). Based on an immobilizing dose of 96 mg per goose or a LD_{50} of 288 mg, an estimated immobilizing dose would cost $0.27 and a lethal dose would cost about $0.81. Chemical application, manpower and logistical support for baiting sites would be similar to those described under the DRC-1339 section. The costs related to chemical, manpower for retrieving affected light geese, euthanizing affected light geese and burial or incineration of affected light geese would cost about $8.34/goose (Table 2). However, additional costs would be incurred if light geese will be salvaged for human consumption. In this case, the costs of chemical, retrieving the affected birds and housing them for a period of 30 days or more to eliminate AC residues from the body would increase the overall cost of the program by 40-50%.

Cost estimates for removal of 50,000 or 250,000 light geese from wintering areas, along migration routes and/or on the breeding grounds before light geese disperse to nesting sites are shown in Table 2. Costs are based on an immobilizing dose only, and assume that light geese would not be used for human or animal consumption after capture.

Use of birds

Light geese that are collected on and around baits sites could not be used as human or animal food because of potential chemical residues in edible tissues unless held in captivity for a minimum of 30 days. However, feathers and down could have some economic value and could be collected if a viable market exists. The carcasses of light geese following removal of feathers would have to be disposed by burial or incinerated. If light geese are held for a minimum of 30 days, they could be processed and used for human or animal consumption.

Problems

The use of this product would depend on Food and Drug Administration approval. AC baits may present some non-target hazards should those species forage on bait sites. The time to immobilization (30-90 minutes) could allow light geese to move off site before the chemical takes effect. Light geese could not be used as a food resource unless held a minimum of 30 days in captivity. Housing and feeding light geese would require large bird trailers, large holding pens, extensive maintenance and a method to determine if geese are chemical free before processing. If light geese were not retrieved, there could be the potential for secondary effects (immobilization or poisoning) to non-target species.

Table 2. Estimated program costs to remove 50,000 or 250,000 light geese with alpha-chloralose from wintering areas, along migration routes and/or the breeding grounds before geese disperse to nesting sites.

Average flock size of 3,000 birds per bait site

Time Period: December-April

Light geese	50,000	250,000
Personnel	9	45
Salaries	$90,000	$450,000
Travel/per diem	$36,000	$180,000
Equipment		
Vehicles (9 and 45)	$198,000	$990,000
ATV's (9 and 45)	$54,000	$270,000
Bait mixers (3 and 15)	$900	$4,500
Miscellaneous	$10,000	$50,000
Supplies		
Chemical	$17,000	$85,000
Bait	$1,000	$5,000
Fuel	$8,000	$40,000
Miscellaneous	$3,000	$15,000
TOTAL	$417,400	$2,087,000

Information needs

Determine optimal baiting techniques, dose levels, application rates, bait carrier, and dilution rates. Evaluate the preference for various bait types by geographic area and time period. Determine specific areas where light geese congregate on wintering areas and along migration routes. Determine the types of permits needed by local, state, federal and provincial governments for baiting with AC. Determine the potential non-target hazards associated with baiting in different geographical areas. If light geese will be used for human or animal consumption, an existing method will need to be modified to detect the concentration levels of AC in edible tissues.

Discussion/Research Needs

At this time there are no avicides currently registered or labeled for control of light geese. Such a product would be regulated by the U. S. Environmental Protection Agency (EPA) under the Federal Insecticide and Rodenticide Act (FIFRA). The act requires that all pesticides used in controlling or repelling organisms in the United States be approved and registered by EPA. In addition, a selected chemical avicide should be species selective, safe, effective, humane and economical. The registration of a new chemical to reduce light goose populations on wintering and/or breeding grounds or along their migration routes could take a minimum of 5 years of data collection and review at an estimated cost of $3-5 million.

The alternative to developing and registering a new chemical for light goose management is to take an existing chemical such as DRC-1339, Avitrol or AC that are currently registered with EPA for another target species or situation and amend the label to include the management of light geese. Under FIFRA, EPA can issue a variety of permits to allow the use of a registered chemical for a non-labeled use. This could be accomplished under a Section 24C registration or Section 18 Specific Exemption. Under a Section 24C a State can request an additional use of a federally-registered product to meet a Special Local Need, however this registration is subject to all normal EPA data requirements. Under a Section 18, EPA can exempt State and Federal agencies from any provision of FIFRA, if emergency conditions exist which require an exemption. There are four types of emergency exemptions: Specific, Quarantine, Public Health and Crisis. The light geese problem would fall under a Specific Exemption. This exemption may be authorized in an emergency to avert a significant economic loss or a significant risk to the environment, such as damage to the Arctic tundra. Thus, it is feasible that a permit for DRC-1339, Avitrol or AC could be approved by EPA for use on light geese under a Section 24C or Section 18.

Research Needs

Research has provided much of our understanding of light goose biology, movement patterns, migration routes and wintering/spring staging areas. Our discussion needs to focus on what research is needed to effectively use one of the potential chemicals, and where and when chemical management of light geese would be most effective and socially acceptable. We know that each chemical, DRC-1339, Avitrol and AC, can be formulated on bait that if ingested by light geese will cause death. However, we need first to determine the type of bait light geese would prefer at various geographic locations in their wintering areas, along migration routes and on breeding grounds before they disperse to nesting sites. This could be accomplished within one season by conducting a simple bait preference study in the laboratory and at various geographic locations where light geese are feeding or staging. The field portion of this study would be designed to address three objectives, the first to determine light goose preference for various baits, such as corn, wheat, mixed grains, etc. on a typical light goose feeding or staging area. The second objective would determine consumption of preferred bait. The third objective would determine non-target species use of typical bait sites and their bait preference. Cost for this type of study is estimated at $25,000.

We need to develop a single dose bait that will cause >90% mortality to light geese. This could be accomplished by conducting a laboratory dose response test of DRC-1339, Avitrol and AC with light geese. This type of test would take about 8 weeks and cost about $20,000.

The final step in bait development would be to conduct a pilot field test to evaluate potential baits, dilution rates, and application rates at 2 sites on light goose wintering areas, along migration routes and on breeding grounds before they disperse to nesting sites. This type of test would take about 8-10 weeks and cost about $15,000.

Field application of baits will require development of baiting methodologies and techniques not normally used. However, current methodologies and techniques used by the United States Department of Agriculture (USDA), Wildlife Services (WS) Program to manage blackbirds with DRC-1339 in the Central and Mississippi flyways could be adapted for light goose management (Cummings et al. 1992). USDA guidelines already exist for blackbird baiting programs that address handling chemical baits, mixing baits, bait application with ATV's, non-target hazards, and estimating take. Limited modifications of these guidelines could adapt them for light goose management.

Bait sites would need to be identified on wintering grounds, along migration routes, and on the breeding grounds that meet the following criteria: control over baiting, disturbances, access, and low non-target use. The question that arises is when will baiting be most effective and where will bait sites be located. Baiting light goose populations when densities are low, late winter/early spring would greatly improve effectiveness, economy and humaneness of the management effort. Bait site locations are numerous but getting access to sites may require a considerable effort. The general public, hunters, farmers and land owners will influence the extent to which a local or regional approach to managing light geese populations with chemicals will be successful. Access to areas where light geese could be baited will be also influenced by animal welfare issues, the fact that light geese are an economic resource, and the ignorance of the damage that over-abundant light geese pose to the Arctic tundra.

In summary, we feel that in less than 2 years and at a cost of under $100,000 that one of the chemical bait discussed could be developed to manage light goose populations at locations in their winter areas, along north migration routes and before they disperse to nesting sites. The success of the chemical baiting program will depend on developing effective baiting methodology and the acceptance of the program by the public.

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LITERATURE CITED

Agricultual Chemicals Board. 1977. Alpha-chloralose for bird control. Information Services, Ministry of Agriculture and Fisheries, Wellington. 12 pp.

Batt, B.D.J., editor. 1998. The Greater Snow Goose: report of the Arctic Goose Habitat Working Group. Arctic Goose Joint Venture Special publication. U. S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario. 88pp.

Cummings, J.L., J E. Glahn, E.A. Wilson, J.E. Davis, Jr., D.L. Bergman and G.A. Harper. 1992. Efficacy and non-target hazards of DRC-1339 treated rice baits used to reduce roosting blackbird populations of depredating blackbirds in Louisiana. Bird Section Research Report No. 481. National Wildlife Research Center, Fort Collins, Colorado. 136pp.

Cummings, J.L., J.E. Glahn, E. Allen Wilson, and J.E. Davis. 2002. Potential hazards of DRC-1339 treated rice to non-target birds when used at roost staging areas in Louisiana to reduce local populations of depredating blackbirds. International Biodeterioration and Biodegradation 49: 169-173.

Hudson, R.H., R.K. Tucker, and M.A. Haegele. 1984. Handbook of toxicity of pesticides to wildlife. U.S. Department of Interior, Fish and Wildlife Service, Resource Publication 153, Washington, D.C. 90pp.

Johnson, M.A. 1997. Management strategies to address the mid-continent Lesser Snow Goose overpopulation problem. Pages 101-112 *in* B. D. J. Batt, ed. Arctic Ecosystem in Peril: Report of the Arctic Goose Habitat Working Group, Arctic Goose joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario.

Knittle, C.E., J.L. Cummings, G.M. Linz, and J.F. Besser. 1988. An evaluation of modified 4-aminopyridine baits for protecting sunflowers from blackbird damage. Vertrebrate Pest Conference, 13: 248-253.

Lucid, V.J. 1980. Handbook of bird management and control. U.S. Department of Commerce, National Technical Information Service. 185pp.

U.S. Department of Agriculture. 1995. DRC-1339. Tech Note, USDA, APHIS. 2pp.

Part VI

HUMAN FOOD, PROCESSING, MARKETING, FOOD PROGRAMS, AND OTHER PRODUCTS

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INTRODUCTION

This chapter examines the potentials, problems and issues involved in making use of light geese taken under various direct control and alternative harvest strategies as detailed in Johnson and Ankney (2003). Both Batt (1997) and Johnson and Ankney (2003) stressed the desire and importance of using geese taken to control population numbers. However, making use of large numbers of geese taken by direct control methods presents problems different than those in making use of geese taken by hunters. Direct control is defined as a purposeful removal of large numbers of birds in a short period of time. Direct control actions are different than special conservation harvests and other hunting strategies that have been implemented thus far to control light goose numbers (Federal Register 64 (30): 7517-7529). The nature of the possible direct control techniques, numbers of birds involved, and location where birds are captured or killed could make it difficult to use birds for human consumption or other purposes. Direct control actions may not be conducive to easy retrieval of birds, transporting them to processing facilities, or in converting carcasses to safe and palatable human food. Although uses of light geese for purposes other than human food are also possible, there are legal and logistical issues that must be addressed before that can be done.

The topic of "waste" is frequently one of the first considerations in discussions about making use of light geese killed for conservation purposes. It is often said, "We do not want to waste the birds." These discussions quickly become philosophical as the meaning of the term "waste" is debated. Is it wasteful if killed birds are recycled into the environment from which they came? Must all killed birds be used for human consumption? What about non-edible parts? Is consumption of light geese by organisms other than humans wasteful? It seems obvious that the definition of waste, in the context of the management strategies being considered, is much a matter of personal opinion. The range of individual opinions and desires on this topic is understandably broad. In the minds of some, birds would be "wasted" if they were not consumed by humans. Other believe that "not wasting" birds simply means that they are used for some purpose, such as animal food, fertilizer or some other product(s) that would be beneficial to society. Still others believe that under some conditions, at least, the best and most appropriate action is to ensure that birds are efficiently recycled into the environment. All are legitimate positions and must be considered in any future actions. Clearly, the ultimate decision on what to do with large numbers of birds taken to control a burgeoning light goose population will depend on several considerations including cost, logistics, human health and safety, feasibility, time, and legal, political and social considerations.

Beyond all of this, it is explicit opinion and desire of the Direct Control and Alternative Harvest Measures Working Group (Johnson and Ankney 2003) to strive to make use of birds killed by direct control. The guiding principles developed by the working group addresses this issue:

> Statement of Principles
>
> "We will consider all techniques that have the potential to directly control light (snow/Ross's) goose populations and preserve/restore the integrity of Arctic and other ecosystems and light geese. Our goal is to find one or more humane methods for killing many light geese in a short time in a way that maximizes subsequent use of the birds or, at least, minimizes waste of the birds and has minimal negative impacts on other wildlife. We will use the best available science and expertise to accomplish our goal" (emphasis added).
>
> These uses could be prioritized into the following general categories as follows:
>
> 1. Human food
>
> 2. Food for animals that provide human food
>
> 3. Food for other domestic or captive animals
>
> 4. Uses other than food that benefit humans
>
> 5. Recycled into Arctic habitats and other environs as a fertilizer

We believe that all of the uses listed above are far superior to burning carcasses or disposing of them in a landfill.

There are two potential sources of geese, (1) birds obtained through alternative harvest strategies as detailed by Johnson (2003) and Johnson (1997), and (2) birds obtained through direct control strategies as detailed by Alisauskas and Malecki (2003), Cox and Ankney (2003) and Cummings and Poulos (2003). Also, there are two general geographic areas and time periods where these actions could take place, the Arctic breeding grounds in the spring and summer and the wintering and migration areas in the fall, winter and spring. Each strategy or technique and each geographic location and time period presents unique challenges, opportunities and difficulties, both in taking birds (as detailed by the authors above) and in attempting to make use of the birds as we will describe.

HUNTER-KILLED BIRDS

Birds killed by hunters are those that have been shot, generally with non-toxic shot. This occurs on migration and wintering areas in Canada and the United States. Hunters also take some birds each year in the far north, primarily through subsistence hunting. Hunters took approximately 1.5 million light geese in the United States and Canada in 1999-2000 (Sharp et al. 2001 and Sharp 2001). This number does not include birds taken by subsistence hunters in the north. For the most part, birds killed by hunters are retrieved, processed and consumed by the hunters themselves, their families, friends and associates. Assuming an average of 5.1 pounds whole body weight per bird taken and a 30.9 percent yield of lean edible meat (Marchello 1982) this amounted to over 2.4 million pounds of food for people in the United States and Canada in 1999-2000.

U.S. and Canadian laws require that hunters retrieve any bird shot (or make a "reasonable effort" to retrieve such birds) and that retrieved birds be included in the hunter's daily bag and possession limits. However, federal laws in the United States and Canada do not require that harvested birds be consumed or even retained for possible consumption. But, some states have much more restrictive laws regarding the disposition of harvest birds. For example, Montana requires that the breast, thighs and wings must be retained from any bird larger than the size of a mallard. It is legal in the United States and Canada for hunters to give their birds to other individuals. In United States, this transfer of ownership must occur at the domicile of the donor or donee, unless the birds have tags attached signed by the hunter and including his address, the total number and species taken and the date taken. These laws allow hunters to harvest additional birds without exceeding a possession limit, while, at the same time, increasing the likelihood that harvested birds will be consumed by someone. Note: at the current time there are no possession limits on light geese in the United States.

Despite the above, a major constraint that limits the number of birds taken by many hunters is the opportunity to dispose of birds without wasting them. Most hunters are inherently conservationists and do not want to waste birds. Thus, they limit their take to what they can use or, at least, to what they can store, process, and transport. Consequently, it seems apparent that finding new outlets for birds taken by hunters would facilitate increased harvest of light geese. Among such outlets are food shelters, charitable organizations, or other entities that could process birds and give nutritious meat to people who need and want it. A good example of such a program is the loosely formed network of "Hunters for the Hungry" organizations that does this with venison and other game taken in many states and provinces (e.g. Michigan, Texas, Virginia, Ontario and Alberta). These organizations have worked with local, state and federal government wildlife agencies and food and health regulators to establish protocols and procedures for handling, processing and donating wild game to needy individuals and families.

BIRDS KILLED VIA DIRECT CONTROL ON BREEDING AREAS

Birds killed or captured in the north offer a unique set of problems in trying to convert them to human use. Alisauskas and Malecki (2003) present a detailed discussion of these problems. Because of the remoteness, difficulty in access and the associated high costs, converting large numbers of geese in the Arctic to human food would be very expensive. Nonetheless, it could be done, if desired by management agencies. Birds taken by shooting or molting birds captured live in drive traps could be processed for food for First Nation communities in the north or used by them for dog food. Live birds would be captured during the molting period, in July, and would have little or no fat and breast muscles would be atrophied in adults and minimal in goslings (Ankney 1979). Thus, these birds would be much less desirable for use as human food and it is questionable First Nation communities would want them except, perhaps, as dog food. Birds taken during the nesting season would be fairly fat and in reasonably good condition, especially if shot in the head with a rifle. Shot birds would have to be collected soon after being killed and then transported to a central processing facility where they would be cleaned, packaged and prepared for transport to final destinations.

BIRDS KILLED AND/OR CAPTURED VIA DIRECT CONTROL ON MIGRATION AND WINTERING AREAS

Birds killed on migration and wintering areas are much easier to get to people for consumption than birds killed in the far north because the logistics of transportation and moving people to do work is considerably cheaper and easier. Birds could be obtained either live or dead on migration and winter areas. Cox and Ankney (2003) detailed several possibilities for taking light geese either through killing or capturing them live. Cummings and Poulos (2003) identified strategies that would allow the take of light geese with chemicals both alive and dead. The condition of the bird (live or dead) affects what can and cannot be done to convert it to human food. A major advantage of capturing live birds on migration and wintering areas is that they will be in better condition than live (molting) birds captured in the far north. Based on the work by Cox and Ankney (2003), however, it is unlikely that large number of geese could be live-captured in the United States or southern Canada using current technologies. Regardless, it is useful to consider what opportunities and limitations there may be for handling and processing live-captured birds on migration and wintering areas because new ways to live-capture geese may be developed (and see Cummings and Poulos 2003).

It seems that the chances of using chemically captured or killed birds for human food are slight. Birds captured or killed with DRC-1339 or Avitrol are not suitable for human or animal consumption (Cummings and Poulos 2003). Although birds captured with alpha-chloralose are safe for human or animal consumption if they have been held for 30 days, we cannot envision that this would happen because public acceptance of eating birds captured by chemicals would be very low.

HUMAN FOOD

Light geese are a tremendous food resource that can provide nutritional benefits to humans. The meat of light geese is highly nutritious. Marchello (1982) reports that snow goose breast muscle is 22.7 percent protein and 3.6 percent fat compared to 22.0 percent protein and 6.5 percent fat for USDA Choice Beef and 22.3 percent protein and 4.9 percent fat for pork. Snow goose breast muscle contains one of the highest levels of cholesterol (142mg per 100g of muscle tissue) of all meats tested (Marchello 1982). This cholesterol level is high relative to other domestic meats and many other game species. However, it is lower than that of other waterfowl species regularly consumed by humans, such as pintail (158mg), shoveler (189mg), redhead (194mg), canvasback (176mg) and wigeon (153mg) and about the same as mallard (140mg) (M. Marchello, pers. comm.). Raw, trimmed, lean snow goose meat also has the highest level of energy (Kcal/100g) of all the waterfowl meats tested (M. Marchello, pers. comm.).

Birds killed by direct control actions could be processed and used as human food. The Migratory Bird Treaty[1] prohibits most sales of migratory birds, but does not prohibit the donation of migratory game birds. The Bill Emerson Good Samaritan Food Donation Act (see Food Banks below) facilitates such donations. Donated food is not subject to the same inspection requirements as food sold or shipped in interstate or international commerce. Thus, birds killed by direct control actions could be processed into food for humans and donated to charitable

[1] The international treaty between the U.S. and Great Britain (for Canada) was signed in 1916 and amended in 1999 by the governments of Canada and the U.S. This agreement is termed the Migratory Bird Convention in Canada and the Migratory Bird Treaty in the U.S. For simplicity, this agreement is referred to as the "Migratory Bird Treaty" or "Treaty" throughout this paper.

organizations without constraints of inspection. A major consideration under this scenario would be how to retrieve, handle, store and ship large numbers of bird carcasses so that they remain safe and palatable for human food. One option would be to establish portable processing facilities (see below under Custom Exempt Facilities) that could be moved to a direct control location. This would eliminate long transportation times and the chances for spoilage and would help to produce a superior product.

Processing geese for human food would entail considerable cost for food banks and charitable organizations, which may deter them from accepting dead birds from hunters. If all or part of this cost could be covered from outside sources, such as government grants or private contributions, charitable organizations may be willing to accept more birds.

It is possible, although we think unlikely, that some light geese killed under direct control would be carrying contaminant burdens, e.g., pesticides or heavy metals. We are not aware of any testing of light geese that has found this, so we cannot further address the issue here. We can report, however, that Canada geese examined in the Twin Cities showed no contaminant levels of concern for human consumption (Cooper 1995 and Cooper and Keefe 1997). If light geese obtained through direct control activities were to be used in a human food program, an assessment of contaminant loads in at least a representative sample of birds should be considered.

FOOD INSPECTIONS

Although the Migratory Bird Treaty prohibits sale of migratory birds, it is still worthwhile to consider the option of sales. If it was decided that a large number of light geese would be taken by a direct control action, and if the public demanded that these birds be used for human consumption, then the Treaty could be amended to allow sale of migratory birds taken under such action. USDA regulations require that any bird shipped and sold as food in interstate or foreign commerce must be processed by a federally approved poultry inspection facility.

For a bird to be a federally or state inspected and approved food item, the bird must arrive at the processing facility alive and be killed on site as part of the processing procedure. Thus, live-captured birds would need to be held at the capture site until they could be loaded onto trucks for shipment to a processing facility. Presently, there are only two federally inspected slaughter/processing facilities in the United States set up to process geese. These are Schiltz Foods, Sisseton, South Dakota and Wenk Foods, Inc., Madison, South Dakota. Other poultry (chicken and turkey) plants cannot process geese without changes made in the operation because it takes a special picker and waxing operation for processing geese.

Wild animals slaughtered and/or processed under federal inspection, whether whole or in part, may be sold and shipped both in interstate commerce and exported to other countries. However, the Migratory Bird Treaty does not allow the sale of migratory birds. If such commerce were legalized, it would allow for maximum use of the entire bird, including the meat and other parts and products. For example, the down feathers could be collected and sold for use in clothing, pillows, and quilts. Native Americans and others in the United States, Canada and other countries could use other feathers to manufacture traditional crafts, attire, and other items. Additionally, other parts such as the feet, bones, and fat could be marketed to locations where they would be used. Dead, condemned birds (those not meeting inspection requirements) and remaining parts thereof could be sold or distributed to mink farms, fox farms and zoos. Both residue testing and metal detector devices could be used to assure maximum quality and safety of whole birds and their parts that are sold and distributed. State inspected products cannot be sold and transported in interstate commerce. However, "wild game" may be allowed depending on laws and regulations of individual states. There may be a fee for "voluntary inspection" of wild game within individual states, again depending on the laws and regulations of individual states.

Inspection Requirements

The Food Safety and Inspection Service (FSIS) of the U.S. Department of Agriculture is responsible for ensuring that meat and poultry products are safe, wholesome and accurately labeled. FSIS enforces the Federal Meat Inspection Act (FMIA) and the Poultry Products Inspection Act (PPIA), which require federal inspection of meat and poultry products shipped in interstate and foreign commerce for use as human food (Public Law 106-170, Amended December 17, 1999). According to Public Law 106-170:

> The term “poultry” means any domesticated bird, whether live or dead.
>
> The term "poultry product" means any poultry carcass, or part thereof; or any product which is made wholly or in part from any poultry carcass or part thereof, excepting products which contain poultry ingredients only in a relatively small proportion or historically have not been considered by consumers as products of the poultry food industry, and which are exempted by the Secretary from definition as a poultry product under such conditions as the Secretary may prescribe to assure that the poultry ingredients in such products are not adulterated and that such products are not represented as poultry product (Sect 4 (21 U.S.C. 453) e and f).

Under the scope of FSIS, states can operate their own state meat and/or poultry inspection program. Meat or poultry products produced under state inspection can be sold within that state only, and cannot be sold in interstate commerce. Processing plants not wanting to operate under any type of inspection program can operate under a program called Custom/Retail Exemption. Retail exemption requires the firm to purchase inspected products for further processing (e.g. a retail grocery store, retail meat market, etc.). Custom exemption operations are a service-orientated business (e.g. a farmer brings his animals or poultry to this firm for slaughtering and/or processing for personal use). Presently there are 29 states that are classified as “designated,” meaning they have no state inspection program. Plants in these states must operate under a grant of Federal Inspection in order to sell products in commerce or they can operate under the Custom/Retail Exemptions. The remaining states have adopted the FMIA for red meat and operate their own inspection program. Not all of these states adopted the PPIA for poultry, so FSIS requirements still apply.

Some of these State inspection programs operate under a cooperative program with USDA called the "Talmadge-Aiken Act" of September 28, 1962 (7 U.S.C. 450). Under this act, an administrator is authorized, under stated conditions, to use employees and facilities of any state in carrying out federal functions under the Poultry Products Inspection Act.

Another aspect of Federal Inspection is exemptions. Various poultry operations are exempt from inspection requirements depending on their operation and products being produced. Exemptions would have to be looked at and addressed on a case-by-case basis.

Because snow geese are wild game, the requirements of the FMI Act and regulations for inspection and processing of poultry and poultry products do not apply. However, most states have adapted the FDA food code of 1997, which requires that all meat products used in commerce, including wild game, must be inspected or come from an approved facility. Wild game can be slaughtered using Federal Inspection under a program call "Voluntary Inspection." Fees and charges for service under the regulations in this part shall be paid by the applicant for the service in accordance with this section, and, if required by the administrator (part 362.1, 362.2, 9 CFR). Presently this fee is about $35.00 per hour.

Custom Exempt Facilities

Throughout the entire United States each state has either federally permitted, state permitted or custom firms that could and would be interested in the slaughter/processing of these birds. Generally speaking a fee would be involved. Portable processing facilities are another option. This would allow the portable unit to be moved to various sites where these geese could be captured in large numbers for the purpose of slaughter/processing. This would best be done under the “exemptions” regulations but could also be done under either State or Federal inspection. In the state of Ohio, the Amish were allowed to use a portable slaughter/processing facility they moved from town to town. In Alaska, a portable unit has been used to process caribou. In South Dakota, the Sioux Indian Tribe received a grant and had one built to slaughter buffalo. Our understanding is that it has never been used. Research is needed on the potentials and problems of custom processing and portable processing facilities for light geese.

Another potential source of custom processing is through the Hutterian Brethren. They have colonies that are located in both United States and Canada, most of which are large farming operations. Each has about 15 families and 100 people total. Many of them contract the raising of large number of turkeys or chickens. A large number of them have their own slaughter and processing facilities and operate under the Poultry Exemptions. There are some that also operate under State or Federal Inspection. The number of colonies in the United States and Canada are as follows: British Columbia - 2, Alberta - 154, Saskatchewan - 56, Manitoba - 102, Ontario - none, Washington - 5, Montana - 48, North Dakota - 12, Minnesota - 18, and South Dakota - 108.

POTENTIALS FOR MARKETING BIRDS AND/OR BIRD PRODUCTS

If maximum use is to be made of birds taken through direct control strategies, an effective marketing system should be considered. Currently, the only people who regularly consume light geese are hunters and their families and associates. Beyond that, there is no tradition, interest or, apparently, desire to consume light geese among the general public. Thus, a major part of making use of large numbers of light geese for human consumption would be in creating the demand for such food. This would require advertising, marketing, product development and other strategies (that we, as administrators and biologists, know little about). One risk in doing this is that a long-term supply of geese may not be sustainable. How many geese would be available over what time period would depend entirely on the success of the program, the number of birds taken and the population trend of light geese.

Export markets could be developed for light geese, but only if the Migratory Bird Treaty were amended. We have recently learned of preliminary work being done to deliver eider meat from Greenland to markets in Germany (R. Rockwell, pers. comm.) Apparently, Europeans have an established demand for waterfowl meat. Although, under current law, birds could not be sold to foreign markets, or elsewhere, there may be donation possibilities or changes to the Migratory Bird Treaty could be pursued to allow this to happen. Perhaps, if the meat were donated to charitable organizations in Europe or Asia, we could find agencies or organizations that would be willing to subsidize processing and shipping costs.

Food Banks

Food banks are nonprofit organizations that receive donated food and other grocery products from manufacturers, distributors, wholesalers, retailers, and others. The food banks assist businesses in channeling unmarketable but usable grocery products to somewhere other than the landfill or incinerator. Rerouting this potential waste serves the food industry in an environmentally sound manner. Rather than allow these unmarketable products to incur disposal cost, the food bank system recovers and distributes it to nonprofit community agencies including soup kitchens, food shelves, etc. Another benefit of food banks is that large corporations have donated money for humanitarian aid purposes that could be used to offset the cost for the slaughter/processing, etc. The First Harvest Food Bank System is a national network of food banks. The Minnesota Food Bank Network is an association of eight Second Harvest Food Banks serving the entire state of Minnesota, parts of Wisconsin, and North Dakota.

Recent legislation in the United States has reduced the liability and risk associated with charitable food donations. The Bill Emerson Good Samaritan Food Donation Act became law on October 1, 1996. This Act:

> Encourages donations of food products to non-profit organizations for distribution to the needy.
>
> Protects individuals from liability when they donate to non-profit organizations.
>
> Protects individuals from civil and criminal liability should the product donated in good faith later cause harm to the needy recipient.
>
> Standardizes donor liability exposure. A donator's legal counsel no longer has to investigate liability laws in 50 states.

Dealing with migratory game birds, as compared to deer, in such a program would be more difficult because of the need to pluck or at least skin the birds makes the effort and cost per pound of meat much higher than compared to deer. Despite this, we think that using birds in charitable programs is feasible and that such use would be well received by the public. An example of the success of using migratory birds in a food program is that of the Minnesota Department of Natural Resources' (DNR) for dealing with resident Canada geese, wherein they used commercial contractors to process live-caught birds (Keefe 1996). The average cost of processing live Canada geese in an inspected facility was $7.50 to $8.00 in 1996, not including transportation, labeling and man-hours involved (Keefe 1997). Keefe concluded, "that processing Canada geese from the Twin Cities metro region for human food appears to be an economical, operationally feasible, and socially acceptable method for controlling nuisance goose populations." Thus, we conclude that there is great potential to expand the opportunities for hunters to share their harvest with non-hunters.

The Minnesota DNR was dealing with live-caught birds which is an entirely different problem than dealing with birds killed by hunters. Hunter-killed birds will have been subjected to various storage and handling situations, which may affect their quality and condition. Additionally, hunter killed birds will have wounds and associated tissue damage affecting carcass condition and the quantity of quality meat. Hunter killed birds will also have embedded pellets that affects the quality of the final product and present a risk of dental damage to the consumer. Live birds also can have embedded shot and Keefe (1996) recommended that metal detectors be used to locate embedded shot these during processing. While these are problems that need to be overcome, we are confident they are not insurmountable, and light geese taken by hunters could provide a significant food source for charities.

It also seems likely that work would have to be done to promote an acceptability of light goose meat by many food banks, food shelters and charitable organizations and institutions. Some experimental work has been done. In 1996, the Arviat Hunters' and Trappers' Organization (HTO) conducted a feasibility study on harvesting and distributing adult snow geese from their hunting region. During this study 500 adult geese were harvested in a two-day period. These geese were frozen whole in the traditional manner, and distributed to residents of regional communities that do not have access to geese. In 1997, a second proposal for 1000 geese was submitted and approved. The birds were again shipped to regional committees, where residents enthusiastically received them. It is the intent of the Arviat HTO, regulations permitting, to have this harvest become operational on a cost recovery basis, whereby residents would purchase the geese at cost, thereby negating the need for subsidy (Bromley et al. 1997).

OTHER USES

During this investigation, we learned that, beyond use as human food, there are many other potential uses of light geese. Edible parts of the birds could be processed for use as pet food, food for animals in zoos or for commercial animal farms (e.g., catfish, hog, mink or fox). Notably, commercial poultry processors make use of all parts of the birds not used for human food, i.e., nothing goes to "waste." Thus, if light geese were supplied to commercial processors for processing as human food, all of the parts, such as bones, entrails, feet, feathers and fat could be retained and used as, pet or animal food, fertilizer, millinery products or rendered into other products. For example, commercial processors currently sell domestic goose intestines and feet to foreign countries for human food. Further, all down and feathers are cleaned, processed, packaged and sold (in some cases, the feather products are worth as much as the meat products). Other parts and organs are rendered or sold for use in pet and animals foods, fertilizers and other uses. Fat is sold as yellow number 3 grease, an inedible oil, and bones are converted to bone meal. Additionally, feathers, fertilizers, grease and bone meal are potential uses for birds captured or killed with chemicals (see Cummings and Poulos 2003). It is our understanding that renderment, feathers and down, offal and condemned products and fertilizers produced from poultry are regulated by the FDA. Regardless, if it was determined that such use would be made of light geese, rather than all the non-meat parts simply disposed of in a landfill, issues of commercial sale of migratory game bird parts would have to be addressed. This would necessitate changing the Migratory Bird Treaty to allow for the sale of these parts.

RESEARCH NEEDS

Beyond our findings above, there is need for further investigation and research into many of the issues discussed. We know little about problems that would be encountered by commercial processors in handling live-caught or hunter-killed light geese. Hunters know that snow geese are difficult to pluck without ripping their skin. We need to live-capture several hundred light geese, transport them to a commercial goose processing facility and test their processing procedures on these birds. Processing of birds killed by hunters or by other means should also be tested. Research and development is needed on portable custom slaughter/processing facilities for waterfowl. We also need to investigate the problems and issues surrounding processing dead birds, including hunter-killed birds, for food donations including examination of the contaminant burdens of geese that would be used in such programs. We have little information on the opportunities and problems associated with such a program. Further, we need to investigate working with established organizations such as Hunters for the Hungry to use their energy, experience, skills and networks to help develop strategies for turning large number of hunter-killed or agency-taken light geese into human food.

FINDINGS

- Possible uses of light geese killed via direct control efforts range from human food to recycling nutrients into the environment.

- Light geese have a high nutritional content and birds killed via direct control or increased hunter harvest could be an important source of human food.

- There is need for resource management agencies to find new outlets where hunters could donate birds to charitable organizations. There is great opportunity for hunters to share their harvest with non-hunters, but this will require involvement and facilitation by resource management agencies.

- There is potential for marketing light geese as human food and food products. If there were a greatly expanded supply of these birds, there would need to be marketing to increase the demand for such foods. The Migratory Bird Treaty Act (1918) and the revised Migratory Bird Treaty prohibits the selling of migratory birds.

- There are limited possibilities to use geese killed on breeding areas for human food. This issue is covered in more detail in Alisauskas and Malecki (2003)

- A major advantage of capturing and killing birds on migration and wintering areas is the improved ability to process them into high quality food, but, it is unknown if large numbers of birds can be captured in those areas (see Cox and Ankney 2003)

- An advantage of birds taken via live capture is that they can be killed and processed as federally-inspected food. However, the Migratory Bird Treaty precludes the option of selling migratory birds.

- Birds killed by direct control action could be processed into human food and donated to charitable organizations without the constraints of inspection.

- It would be possible to export processed light geese to foreign charitable organizations, but this would likely require that processing costs be subsidized.

- It is unlikely that birds killed by chemicals would be or could be used as food for humans or animals.

- There are numerous ways that dead birds, including those killed by chemicals, can be used besides being processed into human food. For example, light geese and their parts could be used in animal food, pet foods or rendered into grease, bone meal, fertilizer, but the constraints of the Migratory Bird Treaty make most such uses problematic or impossible.

- Research should be considered to determine the ability of commercial processors to deal with both live and dead geese.

CONCLUSION

The information and issues presented in this paper stem mostly from our knowledge and experience in the United States. While many of the strategies and concepts we present are likely applicable to Canada, Canada's laws and regulations may differ from those in the United States Thus, additional work on the various aspects of using light geese for human food and other products in Canada is needed. There is no simple solution to making use of birds taken by direct control actions either in the far north or on migration and wintering areas. In the north, the birds can easily be killed or captured live in large numbers, but the logistics and costs of getting birds to those who want to use them may make it unfeasible to do so (Alisauskas and Malecki 2003). On migration and wintering areas, transportation of killed or captured birds to processing facilities is relatively cheap and easy (compared to the far north) but acquiring live birds suitable for processing into human food appears to be nearly impossible (Cox and Ankney 2003). Using birds killed by hunters in the United States and Canada as food donations may be the best that can be hoped for as far as using light geese for human food. The total market for this is unknown, but government agencies could facilitate the process of getting hunter killed birds into the hands of people who will use them. In any event, it will likely be a long time before any direct control program would be considered. Tests conducted in both the far north and on migration and wintering areas could provide additional information on the feasibility and costs of using light geese for human food.

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LITERATURE CITED

Alisauskas, R.T. 2002. Arctic climate, spring nutrition and recruitment in mid-continent lesser snow geese. Journal Wildlife Management 66:181-193.

Alisauskas, R.T. and R. Malecki 2003. Direct control methods for population reduction of light geese in the Arctic. Pages 43 – 86 *in* Johnson, M.A. and Ankney, C. D., editors. 2003. Direct control and alternative harvest strategies for North American Light Geese. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario.

Ankney, C.D. 1979. Does the wing molt cause nutritional stress in lesser snow geese? Auk 96:68-72.

Batt, B.D.J., editor. 1997. Arctic ecosystems in peril: report of the Arctic Goose Habitat Working Group. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario. 120pp.

Bromley, R.G., D. Aglukark and A. Carpenter. 1997. The role of aboriginal people in the co-management of over-abundant geese in northern Canada. Paper presented at the Symposium on Overabundant Goose Populations: An Emerging Challenge in Wildlife Conservation. The Wildlife Society 4th Annual Conference. September 23, 1997. Snowmass Village, Colorado.

Cooper, J.A. 1995. The potential health hazards of consuming metropolitan Twin Cities Canada geese. Unpublished report. 6pp.

Cooper, J.A. and T. Keefe. 1997. Urban Canada goose management: policies and procedures. Transactions North American Wildlife and Natural Resources Conference 62:412-430.

Cox, R.R., Jr. and C.D. Ankney. 2003. Trapping and shooting light geese on migration and wintering areas. Pages 87 - 94 *in* Johnson, M.A. and Ankney, C.D., editors. 2003. Direct control and alternative harvest strategies for North American Light Geese. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario.

Cummings, J. and P. Poulos. 2003. Potential chemicals to manage snow goose populations. Pages 95 – 104 *in* Johnson, M.A. and Ankney, C.D., editors. 2003. Direct control and alternative harvest strategies for North American Light Geese. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario.

Johnson, M.A. 1997. Management strategies to address the mid-continent lesser snow goose overpopulation problem. Pages 101-111 *in* Batt, B.D.J., editor. 1997. Arctic ecosystems in peril: report of the Arctic Goose Habitat Working Group. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario.

Johnson, M.A. and C.D. Ankney. 2003. Introduction and background. Pages 7 – 21 *in* Johnson, M.A. and Ankney, C.D., editors. 2003. Direct control and alternative harvest strategies for North American Light Geese. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario.

Keefe, T. 1996. Feasibility study on processing nuisance Canada geese for human consumption. Minnesota Department of Natural Resources report. 17pp.

Keefe, T. 1997. Processing Canada geese for human consumption – an operational report for 1996. Minnesota Department of Natural Resources report. 3pp.

Knudson, D. editor. No date. Snow goose cookbook. Arctic Goose Joint Venture. 40pp.

Marchello, M. 1982. Wild side of the menu, No. 1 care and cookery. North Dakota State University Extension Service pamphlet, HE124 (revised). 11pp.

Sharp, D.E. 2001. Central Flyway harvest and population survey data book. U.S. Fish and Wildlife Service Report. 126pp.

Sharp, D.E., K.L. Kruse and K. Gamble. 2001. Light geese in the Central Flyway. U.S. Fish and Wildlife Service Report, November 2001. 48pp.

Part VII

DISCUSSION AND CONCLUSIONS

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As a group, we are firmly convinced that increased harvest by hunters is the most desirable solution to the problem of any overabundant goose population. This solution, unlike direct control initiatives, involves relatively little cost to natural resource agencies in terms of time, effort, and money; harvest of geese by hunters also ensures that birds are put to human use (see below). Ensuring a sustainable hunter harvest was a major reason why governments undertook to manage migratory bird populations nearly a century ago. Such management should include a strategy for hunters to increase their harvest so as to keep populations at optimal levels equally as much as it has historically included restricting harvest for that purpose. Consequently, we have presented various techniques that would facilitate increased hunter harvest of geese (Johnson, 2003, see below). Some were previously described by Johnson (1997), whereas others are novel to this report.

We considered strategies for direct control (i.e., killing large numbers of birds in a short time period) in three categories: 1) Killing or capturing/killing birds on the breeding grounds, 2) Killing or capturing/killing birds on migration and wintering areas, and, 3) Killing or capturing/killing birds with chemicals. For each of these, we also examined the potential for converting carcasses into human food or for using them for other purposes. Whereas the original Migratory Bird Treaty only prohibited sale of migratory birds that were taken to control agricultural depredation, the latest revision (1996) of the Treaty, despite the plea in Johnson (1997:108), prohibits all sale, barter or exchange of migratory birds except within or between aboriginal communities. This revision effectively eliminated several ways to use geese taken via direct control methods or by non-aboriginal hunters (Maier et al. 2003)

Our statement of principles formed the basis for excluding some strategies for direct control that we considered to be socially, economically and/or biologically unfeasible. This included strategies that we thought were inhumane, too costly per bird killed, or would have had unacceptable negative affects on other species. We also excluded potential strategies for which we were unable to obtain sufficient information upon which to make sound judgments about their feasibility, etc.

INCREASING HUNTER HARVEST

Ankney (1996) noted that many hunters already harvested as many geese as they could either consume or readily give to others. Certainly, this “problem” is even more widespread now and it is a serious constraint on increasing hunter harvest beyond that obtained in 1999-2000. All of the birds that need to be harvested by hunters, so as to solve problems of overabundance, could be consumed easily by a small fraction of the people in the United States and Canada, yet nothing has been done by government agencies to enable this. In fact, some regulations, especially in Canada, make it unnecessarily difficult for hunters to consume and/or give away large numbers of light geese. There are two facets to this problem that require attention: (1) It is too difficult for hunters to provide harvested birds to people who want them for food, and (2) Current laws and regulations make it too difficult or even illegal for hunters to process birds (e.g., as sausage or other meat products) and then transport or ship or transfer possession of them. Below, we offer the following suggestions for solving the problem:

1. Government agencies could facilitate development of new outlets (e.g., food banks, Salvation Army, Indian Reservations in the United States, First Nation communities in Canada, church groups, etc.) that wish to receive geese taken by hunters. They could also help goose hunters take advantage of these outlets by providing information about such outlets including location, phone number, hours of operation, and whether unprocessed or only processed birds will be accepted (and see Recommendation 4, below).

2. In the United States, once geese have been plucked or otherwise processed by a commercial processing facility they can be transported, shipped or given away at any time <u>without</u> identifying parts, i.e., they do not need to have a fully feathered head or wing attached. In Canada, however, hunters cannot transport geese at any time or in any fashion without having a fully-feathered wing attached. Thus, they legally cannot have geese commercially processed into sausage or other meat products and then transport them or even transfer ownership of the processed meat to others. Therefore, Canadian regulations, at least as they relate to light geese, could be changed to be consistent with United States regulations relating to identification requirements for transportation of birds that have been commercially processed (see 50 CFR Part 20).

3. United States regulations could be changed so as to enable American hunters returning from Canada to import: (1) commercially processed light goose carcasses without an attached wing, and (2) commercially processed meat or meat products from light geese. Similar changes could be made to Canadian regulations.

4. Regulations in Canada allow Retriever Training Clubs to legally possess waterfowl in excess of normal possession limits. Similarly, regulations in the United States and Canada could ensure that groups, agencies, and organizations considered in Recommendation 1 (above) can legally possess as many light geese as are donated to them by hunters.

If the above recommendations to facilitate hunter harvest of birds are instituted, but subsequent harvest still falls short, then further action will be necessary to solve the problem of overabundant light geese. We recommend, however, that hunter harvest remain a part of the population control solution for reasons detailed above and in Batt (1997).

DIRECT POPULATION CONTROL

Note, we have not used the word "cull" in this report because a cull is defined "to selectively identify and remove ... something identified as inferior or worthless" (Webster's Ninth New Collegiate Dictionary, 1987). This differs from a population reduction wherein birds are removed randomly to reduce population size regardless of individual or quality.

We used our statement of principles to evaluate what must be done (i.e., is required) versus what is optional under the three strategies for direct population control as well as for increased hunter harvest (Table 1). The three direct control strategies provide options for either directly killing geese or for capturing and then killing them immediately or transporting them live for killing during processing for food. The capture option provides the best opportunity to selectively remove individuals by age and/or sex. Some shooting options could also provide opportunities to select for species and/or sex.

Table 1. Requirements and options for acquiring (killing-K and capturing and killing-C/K) and using light geese under four scenarios for increasing their mortality rate.

	Increased hunter harvest		Migration and winter		Arctic		Chemical	
	K	C/K	K	C/K	K	C/K	K	C/K
Technique for Acquiring Birds	R	NA	O	O	O	O	O	O
Retrieving/ Transporting/ Processing	R	NA	R	R	O	O	O	R
Distributing/ Consuming	R	NA	R	R	O	O	O	R

O - Optional; R - Required; NA - Not Applicable

In non-Arctic areas, birds captured and killed, or directly killed by non-chemical means, must be collected, transported, processed and used either for human food or for other purposes. The ultimate use of such geese (except those harvested by hunters) will depend on many factors including their suitability for use as food, demand for such food or for other products that can be obtained from them (see Table 2), and costs. We cannot, however, conceive of any circumstances under which it would not be possible for geese killed by non-chemical means to be used in some fashion (Maier et al. 2003). Most geese directly killed by chemicals, however, would not be easily recoverable because they may have dispersed from the application site before dying (Cummings and Poulos 2003).

The major rationale for declaring light geese to be “overabundant,” and for attempting to reduce their numbers, was to protect undamaged Arctic ecosystems and to restore those already damaged (Batt 1997). Such ecosystems are nutrient-poor, especially those that have been over-grazed by geese. Consequently, we think that allowing goose carcasses to decompose and thereby recycle nutrients into such ecosystems is an ecologically appropriate “use” of birds killed to reduce population size. Therefore, in locations or situations where geese cannot be converted to human or dog food or where there is not sufficient local demand to use all geese killed, then leaving dead birds where they lie may be an appropriate alternative. Before such an approach is used on a large scale, however, research should be done to determine the ecological consequences of scattering goose carcasses across an area of Arctic tundra. For example, it would be important to determine disease risks and the most appropriate and efficient techniques for recycling nutrients from goose carcasses.

Table 2. Relative ranks (1=easiest) for ease of acquiring, transporting, processing, and using a large number of light geese (e.g., 100,000).

Action	Increasing Hunter harvest	Migration/ winter	Arctic	Chemicals
Direct Kill	4	1	2	3
Catch & kill/ Retrieving	NA	4	1	3
Transporting	1	2	4	2
Processing for:				
human food	1	2	2	4
feathers	2	1	1	1
animal food	NA	1	2	4
fertilizer	NA	1	NA	1
rendering	NA	1	NA	1
Distributing as human food	1	2	3	4/NA

NA - Not Applicable

Notably, capturing and killing large numbers of light geese is easiest to do on Arctic breeding areas, but this strategy also presents, by far, the most difficulty in transporting and processing birds for human food or other uses (Table 2). However, given that the ultimate goal is to solve the problem of over-abundant geese, this may not be a serious constraint. Overall, it would be easiest to directly kill, collect, transport and process geese on migration and wintering areas (Cox and Ankney 2003, Maier et al 2003). This approach, however, may involve the greatest "social resistance." Regardless, it is beyond the scope of this Report to determine how much wildlife agencies are willing to spend in time, effort, and dollars to ensure that birds killed for population reduction are used for food or other purposes versus recycling them into the Arctic environment.

It was not a purpose of our Working Group to recommend one strategy over another, but we do note that killing geese at Arctic breeding colonies would allow the numbers killed to be directly related to colony size and severity of damaged/destroyed habitat, i.e., if everything else were equal, this approach would most closely satisfy the rationale behind a direct population control of light geese. Everything else will not be equal, however, so decisions about if and how to proceed must be made at the highest levels of wildlife agencies, and/or by the public through their elected representatives.

As an initial tool in the aforementioned decision-making process, we have summarized the relative difficulties and costs of converting light geese into human food in the Arctic as compared to migration/wintering areas (Table 3). We cannot assign real dollar estimates to these costs because appropriate data are unavailable for most of the steps that are required to turn a live goose in the wild into a processed goose in storage. Clearly, further research, especially in the Arctic, must be done if financial cost will be a critical variable in decisions about if, how, and where direct control of light geese is undertaken.

Table 3. Relative difficulty and cost per bird (including transportation costs) of converting light geese to inspected and non-inspected human food in the Arctic versus on non-Arctic (migration and wintering) areas. Note: Only live birds can be processed into Federally inspected food.

Inspected Food

Area	Capturing Birds Alive		Converting to Inspected Food	
	Difficulty	Cost	Difficulty	Cost
Arctic	Easy	Medium	Hard	Very High
Non-Arctic	Hard	High	Easy	Medium

Non-Inspected Food

Area	Killing Birds		Converting to Non-Inspected Food	
	Difficulty	Cost	Difficulty	Cost
Arctic	Easy	Medium/High	Hard	Very High
Non-Arctic	Easy	Low	Easy	Medium

Ultimately the fate of light goose populations lies in the hands of wildlife managers and the citizens of United States and Canada. We, obviously, believe that appropriate management actions should be taken to prevent an ecological disaster. How this may best be accomplished will be a very difficult decision and could involve high costs. We urge those involved to carefully consider the findings in this report, to begin tests and research recommended and begin planning for additional harvest measures should they become necessary. Of course, any implementation plan developed must include evaluation strategies to measure its effectiveness in reducing light goose populations and their impacts to Arctic habitats. Further, we suggest that increasing harvest by hunters is the most appropriate first step and that hunter harvest be continued in addition to any other strategies that may be employed.

LITERATURE CITED

Ankney, C.D. 1996. An embarrassment of riches: too many geese. J. Wildl. Manage. 60:217-223.

Batt, B.D.J., editor. 1997. Arctic ecosystems in peril: report of the Arctic Goose Habitat Working Group. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario. 120pp.

Cox, R.C. and C.D. Ankney. 2003. Trapping and shooting light geese on migration and wintering areas. Pages 87 – 94 *in* Johnson, M.A. and Ankney, C.D., editors. 2003. Direct control and alternative harvest strategies for North American Light Geese. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario.

Cummings, J.L. and P. Poulos. 2003. Potential chemicals to manage light goose populations. Pages 95 – 104 *in* Johnson, M.A. and Ankney, C.D., editors. 2003. Direct control and alternative harvest strategies for North American Light Geese. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario.

Johnson, M.A. 1997. Management strategies to address the mid-continent lesser snow goose operpopulation problem. Pages 101-111 *in* Batt, B.D.J., editor. 1997. Arctic ecosystems in peril: report of the Arctic Goose Habitat Working Group. Arctic Goose Joint Venture Special Pulication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wioldlife Service, Ottawa, Ontario.

Johnson, M.A. 2003. Alternative harvest strategies to increase the light goose harvest by hunters in the U.S. and Canada. Pages 23 – 42 *in* Johnson, M.A. and Ankney, C.D., editors. 2003. Direct control and alternative harvest strategies for North American Light Geese. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario.

Maier, A., N. Clark, and M.A. Johnson. 2003. Human food, processing, marketing, food programs, and other products. Pages 105 – 117 *in* Johnson, M.A. and Ankney, C.D., editors. 2003. Direct control and alternative harvest strategies for North American Light Geese. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario.

Appendices

Appendix A

Ad Hoc Committee on Alternative Management of Snow Goose

Report to the Arctic Goose Joint Venture
May 18, 1999

At their March 25, 1999 meeting in Burlingame, California, the Arctic Goose Joint Venture (AGJV) appointed an ad hoc committee to frame three issues related to the long-term management of mid-continent white geese:

1. Large-scale landscape changes
2. Non-lethal control
3. Direct population control

The original working group that prepared the *Arctic Ecosystems in Peril* considered these matters and concluded that they, either could not accomplish the objectives, or, should be in a second tier of practices for future development. The AGJV Management Board felt it was very important to conduct a more thorough review of these approaches to ascertain what could be accomplished by using them and to check the validity of the working group's assumptions. Due diligence requires that all possibilities are thoroughly examined as management agencies struggle to address all the political, practical, and ethical issues that are raised by the stewardship challenges that come with the light goose management problem.

Committee members appointed by the AGJV included:

Bruce Batt, Ducks Unlimited
Vernon Bevill, Texas Parks and Wildlife Department
David Case, D.J. Case & Associates
Dale Caswell, Canadian Wildlife Service
Evan Cooch, U.S. Fish & Wildlife Service
Mike Johnson, North Dakota Game and Fish Department
Jim Kelley, U.S. Fish & Wildlife Service
Bob Trost, U.S. Fish & Wildlife Service

The Committee met on March 29, 1999 in Burlingame (Evan Cooch and Jim Kelley had already left and were not able to attend) and then communicated on drafts of these recommendations via e-mail and telephone.

Recommendations

1. **Large-scale landscape changes**

Recommendation:	A working group be formed to address this issue (Landscape Working Group).
Members:	Co-chaired by Evan Cooch and Ray Alisauskas. The co-chairs will recruit additional members they feel represent the expertise needed.

Charge to working group:

1. Examine the landscape factors (e.g., ag. practices, reservoir creation, refuges, public and private hunting regulations) which may have contributed to the increase in snow geese.
2. Assess the possibilities for changing elements of the landscape that will reduce, or eliminate, population increases by affecting survival and recruitment parameters.

Timeline: Preliminary report from working group presented to AGJV at their November 30, 1999 meeting.

2. Non-lethal control

Recommendation: A working group be formed to address this issue (Non-lethal Control Working Group).

Members: Co-chaired by Don Rusch and Jim Kelley. Rocky Rockwell, Ed Hill (Denver Lab, ADC), and Charles Francis to consider as members. The co-chairs will recruit additional members they feel represent the expertise needed.

Charge to working group

1. Examine possible (current and potential future) non-lethal (i.e., non-hunting) control techniques for reducing snow goose populations.
2. Assess the possibilities for using non-lethal techniques to reduce snow goose populations based on social, political, biological and economic constraints and opportunities.

Timeline: Preliminary report from working group presented to AGJV at their November 30, 1999 meeting.

3. Direct population control

Recommendation: A working group be formed to address this issue (Direct Control and Alternative Harvest Measures Working Group)

Members: Members appointed to the ad committee on long-term management would serve on this working group. Co-chaired by Mike Johnson and Dave Ankney. The co-chairs will recruit additional members they feel represent the expertise needed.

Charge to working group	1.	Examine the possible direct control techniques for reducing snow goose populations
	2.	Assess the possibilities for using direct control techniques based on social, political, biological and economic constraints and opportunities.
Timeline:		Preliminary report submitted to the AGJV for review at their November 30, 1999 meeting.

The ad hoc committee believes there should be some central coordination of the activities and progress of the working groups recommended below. The ad hoc committee volunteers to serve in this role until the tasks assigned to the working groups are underway. This committee would assist primarily with the establishment of the working groups. Subsequently, each working group would report directly to the AGJV Management Board and the ad hoc committee would cease to exist.

Timelines for completing the final reports will be determined by the working groups and discussed at the November 30 AGJV meeting. It's the hope of the ad hoc committee that the working groups would complete their work by the end of 2000 at the latest.

The ad hoc committee also feels that communicating the purpose and formation of these working groups in a timely and accurate way is critical. To that end, the ad hoc committee recommends that, when accepted by the chairs, the AGJV forward this report to the appropriate people within the FWS, CWS, flyway councils, states/provinces, and NGOs. Communications in relations to these new working groups should emphasize:

1. Formation of these working groups in no way minimizes the importance of and commitment to the various land management and hunting related strategies that have been developed in the past two years.

2. These working groups are dealing with management actions that likely would be implemented years from now, if at all. It is prudent, however, to begin the methodical process of analysis and review as soon as possible to determine the potential of each approach in addressing the need to stabilize the light goose population at a more manageable level.

Appendix B

TERMS OF REFERENCE FOR AGJV ADHOC GROUP TO EXAMINE DIRECT CONTROL (CULL) METHODS
January 13, 2000

Complete an unfinished portion of "Arctic Ecosystems in Peril" and "Greater Snow Goose Report":

Purpose of this project: To provide a summary of options not being considered at this time for the reduction of mid-continent white goose populations. This summary of options will be important for people to understand the context of the regulatory steps now being taken, and provide background information for policy evaluations and environmental assessments. Another purpose of this project is to assist in the development of the U.S. Fish and Wildlife Service Environmental Impact Statement.

- Examine a range of options for methods to reduce the population of geese by cull (direct, non-hunting killing).
- Consider this according to two scenarios:

1. A very large mid-continent white goose population, growing despite other actions - in this scenario large culls would be required if they were to be effective (100,000s to millions)
2. Large mid-continent white goose populations stabilized with continued , unsustainable habitat destruction in near term (also large culls)

- Examine operational feasibility considering biology.
- Do not address issues of social acceptability as these go beyond the mandate of the report, and are not required at this stage. However, as noted below, it would be necessary to retain the concept that "wildlife would not be wasted" from the report.
- Do not make recommendations on the use of one method over another.
- Consider:
- cost
- safety
- operational logistics
- effect on other species and habitats
- wildlife should not be wasted
- scale and location of effort
- Use:
- necessary scientific and logistic expertise
- Report on:
- Cost, methods, locations, number of birds, side-effects, of the full range of feasible options.
- Dissemination of the report will be restricted to the AGJV Management Board for review prior to broader distribution.
- Timetable:
- Report by March, 2001 to AGJV Management Board.

(Not egging - part of the non-lethal group)