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MISSISSIPPI FLYWAY COUNCIL

A Management Plan for Mississippi Flyway Canada Geese

Prepared by the Mississippi Flyway Council Technical Section
Canada Goose Committee

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Executive Summary

Canada geese (*Branta canadensis*) are distributed across North America and the management of these important migratory birds is a responsibility shared among federal, state, provincial and First Nations (Indigenous Peoples) agencies, as well as non-governmental conservation organizations. The purpose of this plan is to promote and guide cooperative management of Canada geese and cackling geese (*Branta hutchinsii*) occurring in the U.S. states and Canadian provinces that comprise the Mississippi Flyway (MF). The Mississippi Flyway Council (MFC) was organized in 1952 to promote and help coordinate management of migratory game birds, and this plan was written under its direction and authority. Canada geese and cackling geese in the MF were formerly managed under 5 separate management plans and this plan unifies management goals and approaches for all stocks. The MFC now recognizes three distinct stocks associated with temperate-breeding, subarctic-breeding, and arctic-breeding areas and maintaining sustainable breeding populations and breeding distributions in each of these areas is fundamental to success of the plan. Although Canada geese have substantial economic, social, and ecological values, they can also cause conflicts and damage and so management strives to balance these benefits and costs. Recreational and subsistence hunting are important benefits of geese and the plan provides guidance about MF hunting season frameworks that allow states and provinces to meet local objectives for temperate breeding Canada geese without negatively impacting subarctic breeding Canada geese or cackling geese. Goose population monitoring is an essential component of harvest management and the plan includes objectives for monitoring changes in abundance, harvest rates and survival of geese in each of the breeding areas. Maintaining hunting participation is important to the success of the plan and research is needed to better understand reasons for declining hunting participation. The MFC strives to minimize human-goose conflicts and to maintain public support for Canada goose management; strategies to achieve these objectives include: focusing harvest on temperate breeding Canada geese, conducting surveys to better understand public perceptions and methods to communicate about reducing conflicts, and conducting research on efficacy of conflict control methods. The plan represents the current state of knowledge and management approaches resulting from over a century of Canada goose research and management in the MF and the plan will be periodically updated as new information suggests ways to improve management.

Acknowledgements

We appreciate the support of the Mississippi Flyway Council, Atlantic Flyway Council, the U.S. Fish and Wildlife Service, the Canadian Wildlife Service, and the states and provinces across the flyway for their long-term support of Canada goose management. Contributions to operational monitoring programs and research projects have provided the scientific basis for Canada goose management in our Flyway. We also thank the many agency staff, students and volunteers who have assisted in the operational monitoring and research programs. Many individuals across the waterfowl management community contributed suggestions to improve this plan and we thank all of them. Finally, we thank the hunters of the Mississippi Flyway who provide much of the funding for managing Canada geese and who make important contributions to harvest management by reporting recoveries of banded geese.

Contents

Introduction and Purpose

Canada geese (*Branta canadensis*) are distributed across North America and the management of these important migratory birds is a responsibility shared among federal, state, provincial and First Nations (Indigenous Peoples) agencies, as well as non-governmental conservation organizations. The purpose of this plan is to promote and guide cooperative management of Canada geese occurring in the U.S. states and Canadian provinces that comprise the Mississippi Flyway (MF: Fig. 1). The Mississippi Flyway Council (MFC) was organized in 1952 to promote and help coordinate management of migratory game birds, and this plan was written under its direction and authority. Migratory bird harvest in the United States is managed using Federal regulatory frameworks that provide for the maximum number of days, earliest and latest dates for hunting, and other regulations that affect hunter activities. The MFC provides an important venue for cooperatively developing season frameworks. Canada geese of the MF were previously managed with guidance from multiple management plans associated with birds originating from different breeding areas (Fig. 2; Appendices A and B) but this plan unifies management of Canada geese breeding in subarctic and temperate breeding locales as well as arctic-breeding cackling geese (*Branta hutchinsii*).

The management of MF Canada geese and cackling geese is complicated by the need to balance potentially conflicting objectives for birds originating from different breeding areas. However, holistic management needs to include maintenance of breeding distributions, ensuring sustainable populations, and consideration of multiple benefits and costs within social and economic tolerances. These goals can be difficult to accomplish when each population is considered in isolation, as has been the historic approach. Canada geese have gone from scarcity to great abundance over the past 50 years and now there are likely more Canada and cackling geese present in the MF than at any time in the last century (Figs. 3 and 4). Canada goose abundance was in decline in the late-1800s and early-1900s, reaching a critical low during the 1940s, when nearly all remaining Canada geese in the MF were affiliated with subarctic breeding areas (Fig. 5; see Appendix A for detailed history). Management planning, zone closures, harvest restrictions, and reintroductions of Canada geese into temperate breeding areas during 1960-2000 were successful in bolstering Canada goose abundance (Hine and Schoenfeld 1968, Dill and Lee 1970).

This plan represents the current state of knowledge and management approaches resulting from over a century of Canada goose research and management in the MF. Another purpose of this plan is to identify research and monitoring needs that will ensure continued future success in managing MF Canada and cackling geese. As the evolution in approaches and gaining of knowledge will surely continue, this plan will be periodically updated as new information suggests ways to improve management.

Figure 1. Mississippi Flyway administrative boundaries in relation to 3 other major North American Flyways defined for cooperatively managing migratory birds.

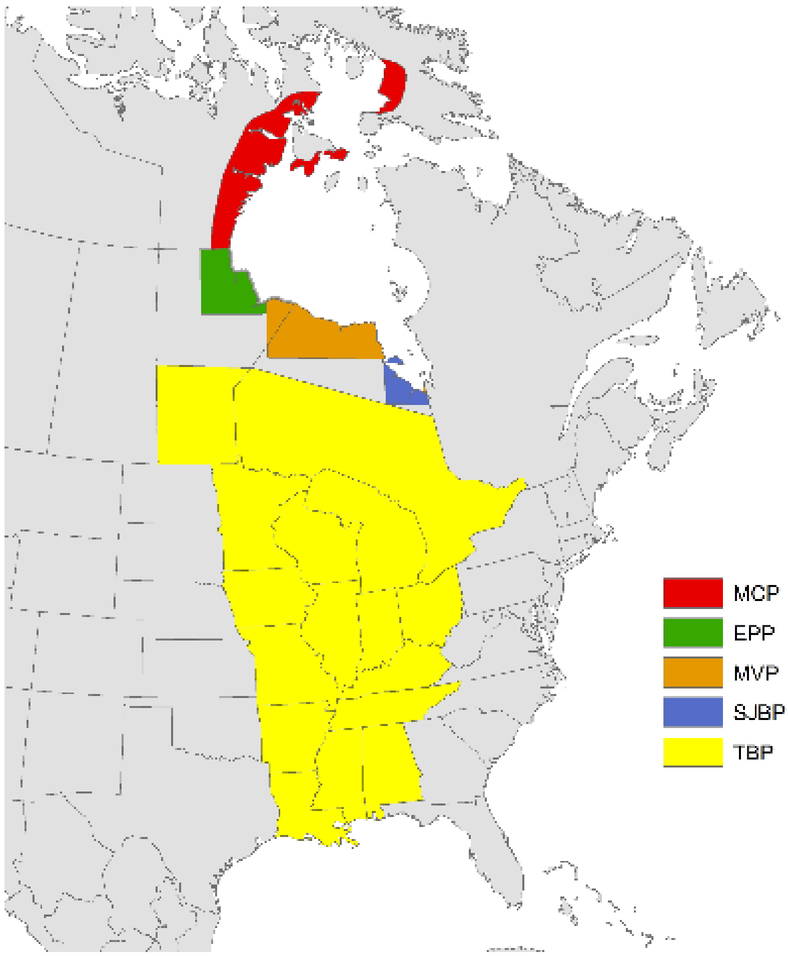

Figure 2. Approximate breeding areas historically defined for mid-continent cackling geese (MCP), subarctic-breeding Canada geese (EPP = Eastern Prairie Population, MVP = Mississippi Valley Population, and SJBP = Southern James Bay Population,) and Temperate-breeding Canada geese (TBP).

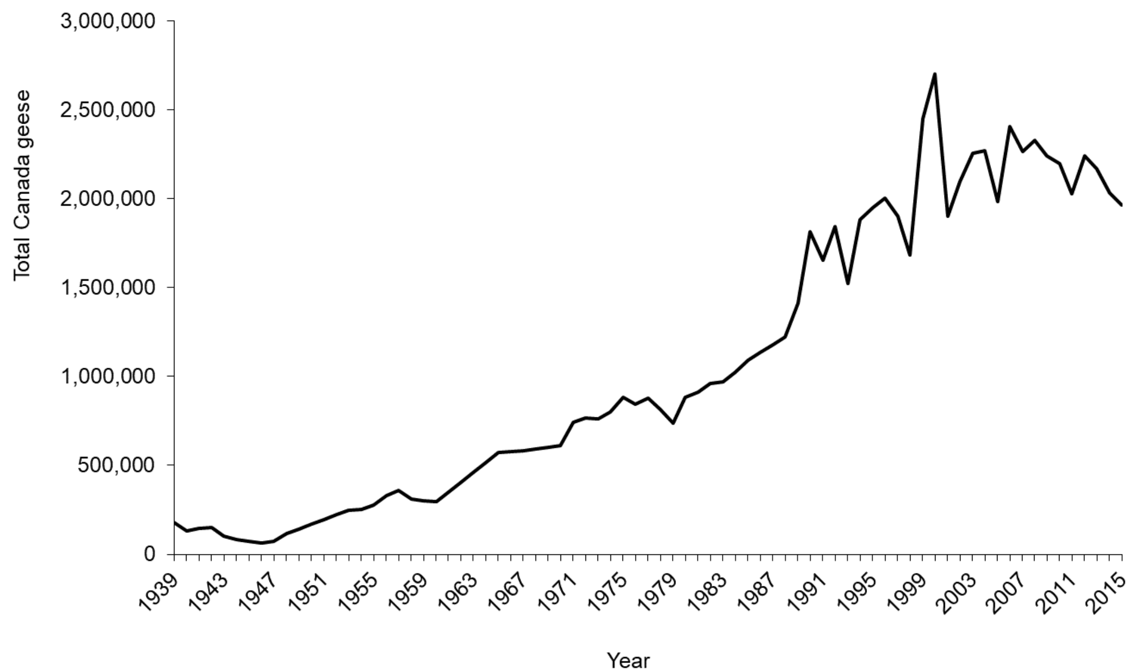

Figure 3. Total Canada goose abundance in the Mississippi Flyway, 1939-2015. Abundance estimates for subarctic-breeding geese prior to 1972 are based on winter counts and breeding population surveys were established later (EPP: 1972, MVP: 1989, SJBP: 1990). Estimates for temperate-nesting goose abundance for the period 1939-1992 assumes a 9% annual growth before and after 1963 when an estimate of 54,600 geese was made by Hanson (1997); temperate-breeding population abundance since 1993 was based on annual aerial surveys, ground counts or other information collected by MF agencies. Also, see Figure 5 for estimates of abundance by breeding area.

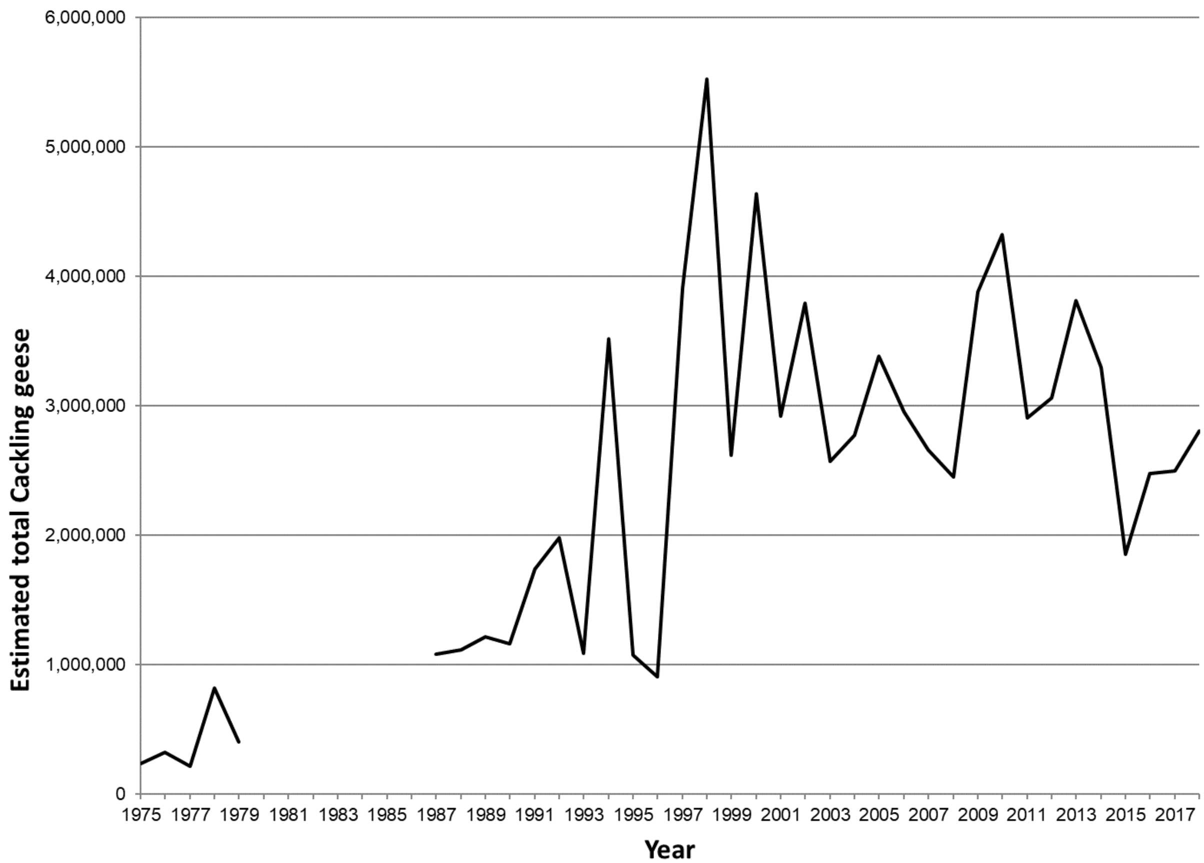

Figure 4. Estimates of mid-continent population cackling goose abundance (Mississippi Flyway Council Arctic Goose Committee 2013), 1975-2018.

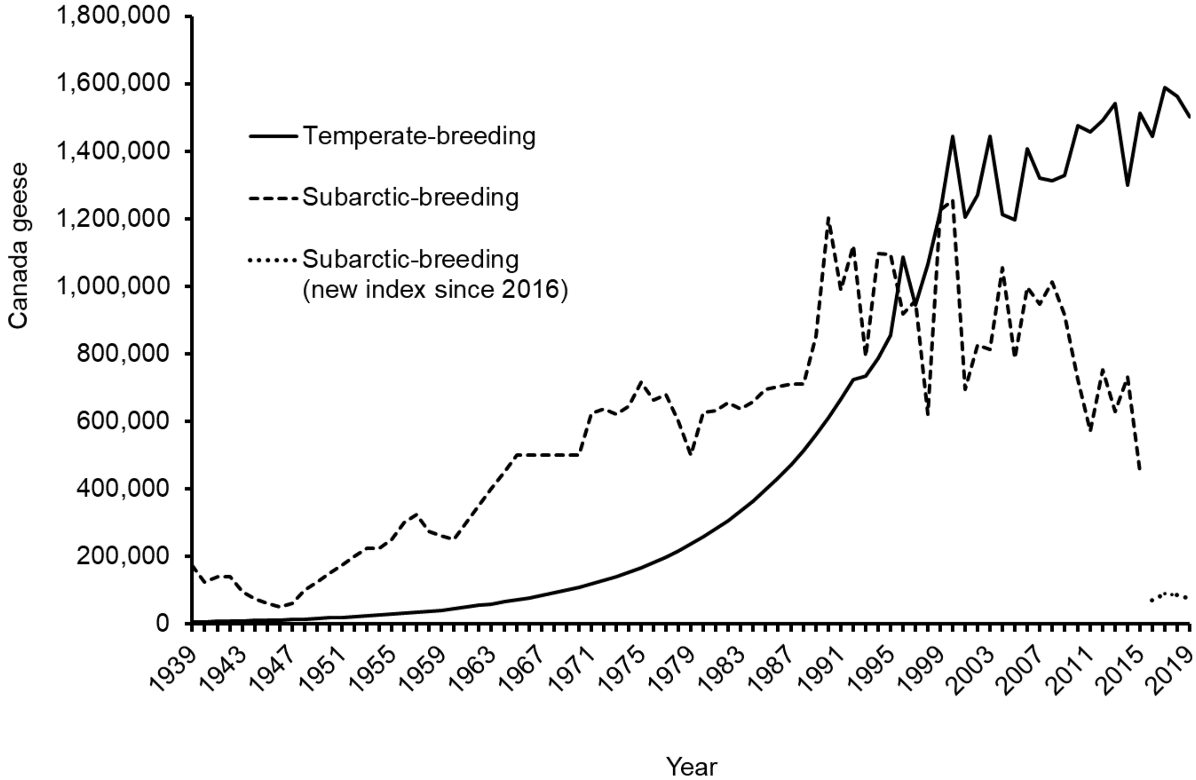

Figure 5. Abundance of temperate- and subarctic-breeding Canada geese in the Mississippi Flyway, 1939-2019. Abundance estimates for subarctic-breeding geese prior to 1972 are based on winter counts (all population combined) and breeding population surveys were established later (EPP: 1972, MVP: 1989, SJBP: 1990). In 2016, a new survey and index were developed for subarctic-breeding geese. Estimates for temperate-breeding goose abundance for the period 1939-1992 assumes a 9% annual growth before and after 1963 when an estimate of 54,600 geese was made by Hanson (1997); temperate-breeding population abundance since 1993 was based on annual aerial surveys, ground counts or other information collected by MF agencies.

Canada Goose Breeding Grounds and Plan Scope

Canada geese nesting in northern Ontario and Manitoba along the coasts of Hudson and James Bay and inland were previously managed as three discrete populations (Eastern Prairie Population, Mississippi Valley Population, and Southern James Bay Population) and separate management plans guided conservation of these birds (Abraham et al. 2008, Brook and Luukkonen 2010, MFC EPP Committee 2006). However, decades of banding studies and aerial surveys on subarctic breeding grounds do not support the concept of three spatially discrete breeding populations. Instead, nesting Canada geese occur in a continuum along the Hudson

Bay and James Bay coasts, and fall and winter band recovery distributions of geese banded on these breeding grounds follows a corresponding east-west continuum (Fig. 6).

Management of arctic- and temperate-breeding Canada and cackling geese has also been guided by separate management plans (Zenner 1996, MFC Arctic Goose Committee 2013). Unlike the plan for temperate-nesting Canada geese, the cackling goose plan is relatively new and will continue to guide management of these birds but the philosophical approach and management framework readily fits within this plan. Readers interested in detailed historic changes in breeding area definitions and management approaches are encouraged to consult these plans and Appendix A. The collective Canada goose and cackling goose breeding and wintering ranges within the MF identified in these plans constitute the geographic focal area for this plan. Initially, a refinement of the eastern boundary of the former Southern James Bay breeding area was considered such that MF would manage Canada geese nesting west of 80ºW and geese nesting east of this line would be affiliated with the Atlantic Flyway (Appendix B). After consultation with the Atlantic Flyway, the MFC agreed to retain the original eastern boundary of breeding range for subarctic-breeding Canada geese affiliated with the MF as the Ontario-Quebec border at 79º30'W. This decision can be revisited in the future in collaboration with the Atlantic Flyway and alternative boundaries could be evaluated as new information is gathered.

The SJBP Canada goose population was formerly managed under a plan co-signed by the Mississippi and Atlantic Flyway Councils (AFC) and the AFC contributed toward costs of monitoring this population. The SJBP plan used consultation to reach consensus on regulatory decisions for this group of Canada geese. It is the desire of the MF to consolidate and simplify regulation processes so that each Flyway independently manages a unique set of Canada geese. This is supported by data indicating there are few Canada geese nesting west of 80ºW that winter in the AF; there also are relatively few band recoveries and little harvest of Atlantic Population Canada geese (AP) in the MF (Appendix B). The MFC has no expectation that Atlantic Flyway states or provinces will take management actions (e.g., change hunting regulations) in response to changes in status of Canada geese affiliated with the MF; similarly, MF does not expect to take management actions in response to status of AP Canada geese.

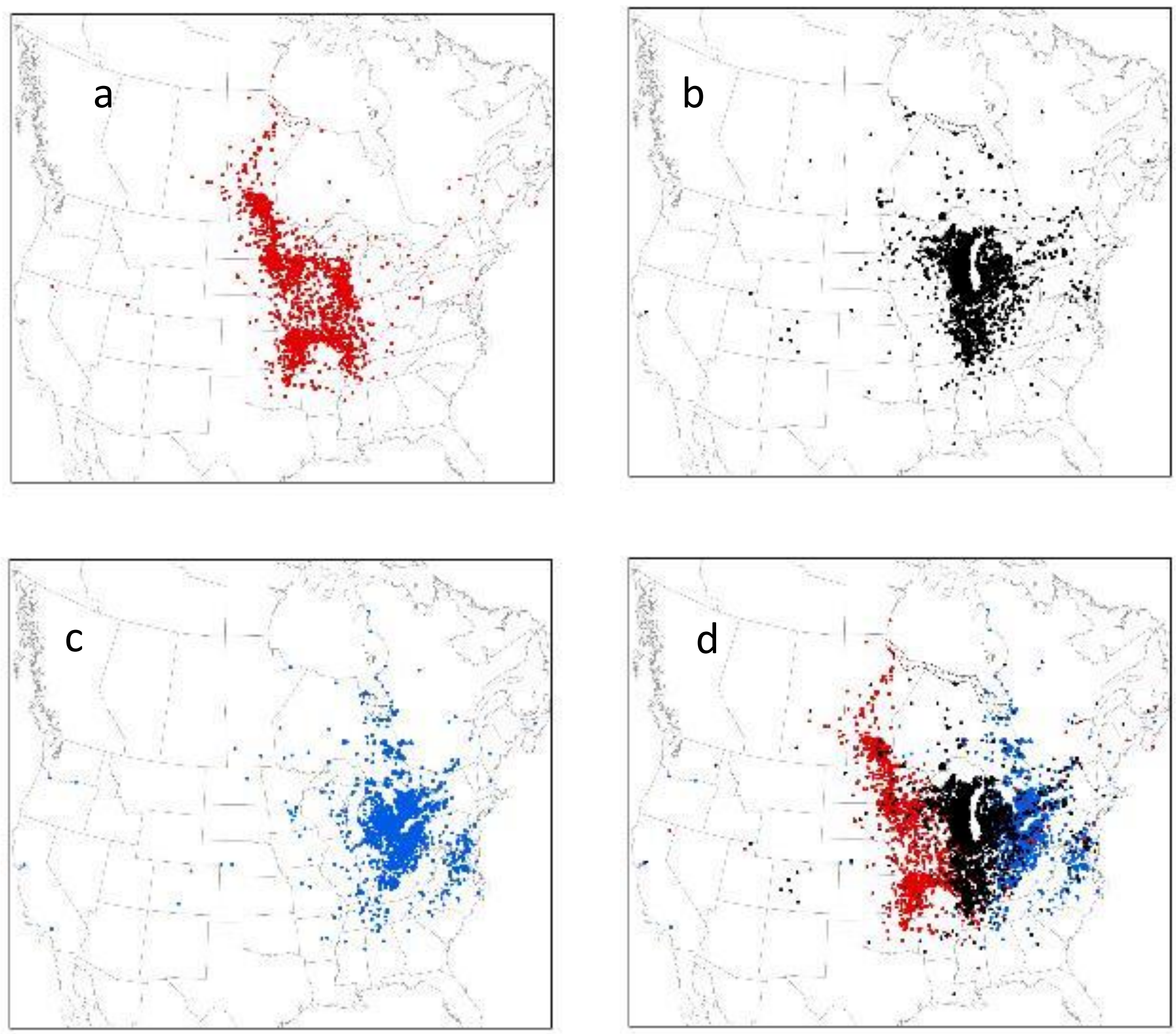

Figure 6. Distribution of Mississippi Flyway subarctic breeding Canada geese and associated recovery distributions of subarctic breeding geese banded along the Hudson Bay and James Bay coasts as indicated by the polygons; a: red=EPP, b: black=MVP, c: blue=SJBP), and d: a-c combined, 2000-2012. Data include direct and indirect recoveries of adult and hatch-year Canada geese shot by hunters.

Although maintaining capacity of habitats to support Canada geese is fundamental to achieving MF goals, this plan does not deal directly with strategies to manage habitat carrying capacity. We generally assume that Canada geese are kept below habitat carrying capacity via harvest and that breeding, migration and temperate wintering habitats will continue to support existing Canada and Cackling goose abundance throughout the next decade. The current abundance of agricultural foods available to geese during non-breeding periods supports this assumption (Fox and Abraham 2017). This is also consistent with available information and assumptions of some habitat Joint Ventures (e.g., Soulliere et al. 2007); however, we recommend continuing ongoing habitat monitoring in subarctic habitats as there are places like Akimiski Island in James Bay, Nunavut where breeding goose densities are high enough that competition for forage limits productivity (Leafloor et al. 2000, Brook et al. 2015). There may be other areas being impacted by goose grazing (snow geese and Canada geese) that may affect future carrying capacity and continued research on degradation of subarctic breeding habitats should be supported. Details of ongoing research and monitoring of habitats within the Hudson Bay Lowlands can be found at: http://research.amnh.org/~rfr/hbp/.

Benefits and Costs of Canada Geese

A fundamental assumption of goose management is that societal benefits and costs can be influenced through management decisions and actions that affect distribution and abundance of geese or that affect interactions between geese and people. Hunting and viewing are the two most quantifiable recreational and economic benefits to society associated with Canada geese in the MF. Readily quantifiable costs of abundant Canada geese are primarily associated with crop depredation, personal property damages, and injuries. Canada geese also have an ecological function and are important to the communities in which they reside. Canada geese are a widely distributed herbivore of both wetland and terrestrial environments in which they provide important ecosystem functions such as seed dispersal, nutrient cycling (Kitchell et al. 1999, Unckless and Makarewicz 2007, Buij et al. 2017), and as prey to a numerous predator species (Mobray et al. 2002). Territorial behavior during nesting may also influence local abundance of other nesting birds. Maintenance of Canada geese and Cackling geese across their historic MF breeding range is fundamental to the ecology of wetland ecosystems and to the success of management under this plan.

Waterfowl (particularly goose) hunting and other non-hunting related activities in the U.S. portion of the MF has substantial economic and recreational benefits. In 2006, there were an estimated 314,800 active goose hunters in the U.S. portion of the MF (U.S. Fish and Wildlife Service 2007) and 46,138 successful goose hunters in the Canadian provinces associated with the Mississippi Flyway (Gendron and Collins 2007). Since migratory bird hunters in the U.S. spent an average of $588 per hunter on hunting- related expenses in 2006 (U.S. Department of Interior 2006), the annual economic value of goose hunting in the U.S. portion of the Mississippi Flyway was estimated at $185 million (314,800 hunters x $588/hunter). More recently, the total industry output (direct and indirect) for waterfowl hunting in the U.S. was estimated at about $3 billion annually (Carver 2015); about 48% of U.S. waterfowl hunters were in the MF and so this is expected to have resulted in about a $1.44 billion impact for MF states. About 38% of the MF waterfowl hunting days in the U.S. were spent goose hunting and about 78% of the MF goose harvest was Canada geese in 2014 (Raftovich et al. 2015); assuming economic impact is proportional to days of hunting activity, the economic impact of goose hunting would have been about $547 million in the U.S. portion of the MF during the 2014-15 hunting season. Recreational and economic benefits of waterfowl watching are also substantial as 47.7 million U.S. residents participated in bird watching in 2006 and waterfowl were among the top three bird groups enticing people to make trips to watch birds (U.S. Department of Interior 2006).

The positive and negative impacts of Canada geese to society are often difficult to attribute to specific goose populations. For example, it is unlikely that many goose hunters recognize the subtle differences among the Canada goose taxa when they mix during migration and wintering. However, there are unique benefits and costs associated with birds originating from different areas. For example, the estimated costs of damages primarily associated with temperate-breeding Canada geese in the U.S. portion of the Mississippi Flyway grew from about $0.2 million in 1996 to over $2.2 million in 2000 (U.S. Department of Interior 2005). Temperate-breeding geese are largely responsible for conflicts during the breeding season, while damage caused by Canada geese during fall and spring migrations and winter may relate to geese from all breeding areas. Contributions of geese from different breeding areas to harvest varies among state and provinces, but temperate-breeding Canada geese have grown to dominate the MF harvest (Appendix C); Cackling geese maintain a long-distance migration and are relatively more important in the harvest of some southern states like Louisiana.

Economic values of geese from specific breeding areas were documented prior to high abundance of temperate breeding Canada geese numbers. For example, the positive economic impacts from Canada goose hunting and viewing in Wisconsin, Illinois and Kentucky were once attributed primarily to Mississippi Valley Population (MVP) Canada geese. An estimated 120,000-140,000 goose observers contributed over $2 million and goose hunters about $1.5 million to the local economy near Horicon National Wildlife Refuge, Wisconsin in 1986 (Heinrich 1988). In western Kentucky, it was estimated during the 1980s and early 1990s that over 30,000 visitors per year traveled to wildlife management areas to view large concentrations of Canada geese and Canada goose hunters contributed $3.4 million to the western Kentucky economy in 1994 (Pritchert 1995). Previous reports also mention costs to farmers from MVP Canada geese especially in Wisconsin (Rollins and Bishop 1998). Overall, almost one-half of the farmers in the Horicon NWR area had crop damage in two or more of the years from 1981-86, reporting these farmers' losses valued at $1.6 million, averaging $1,050 per farm (Heinrich and Craven 1998).

We also know that geese are economically important to both sport and subsistence hunters in Canada. While the economic benefit of goose hunting has not been formally quantified, best estimates indicate that resident and non-resident goose hunters (hunters who successfully harvest a goose) spent approximately $3.2 million and $1.3 million dollars, respectively, to hunt waterfowl in Ontario in 2012 (Canadian Wildlife Service, unpublished). A study of wildlife harvesting and the relationship to the economy of First Nations communities located in the Hudson Bay Lowlands of Ontario determined that waterfowl hunting (dominated by Canada and snow geese) had an 80% participation rate among the residents; this participation rate surpassed participation rates of other harvested animals such as small game (60%), fishing (56%), and moose (27%) (Berkes *et al.* 1994).

Canada geese provide a source of locally-harvested meat that is consumed by many people and each harvested Canada goose provides 1.7-2.4 kg of edible meat (Ashley 2002). The replacement value of waterfowl as a food source within northern Ontario communities was estimated at $2.4 million in 1990 dollars (Berkes *et al.* 1994). There are no estimates of economic value of wild waterfowl meat from recreational harvest in the U.S., but we know harvest of Canada geese in the U.S. portion of the MF increased greatly over the period 1962-2006 and has declined somewhat over the past 10 years (Fig. 7). Harvest of Canada geese in Canada has been increasing since the inception of harvest surveys in 1969 (Fig. 7). Growing Canada goose abundance and conflicts have prompted some states to round up and process geese as a human food source. There have been concerns about environmental contaminants in recreationally-harvested Canada geese as well as geese harvested from urban areas, but mean contaminant concentrations found in Canada goose muscle tissue were like those levels found in commercially raised poultry (Horak et al. 2014). Although the range of contaminant levels was greater in goose meat compared to commercial poultry, the risks to humans can be reduced by proper preparation (e.g., grinding and mixing meat from many animals; Horak et al. 2014).

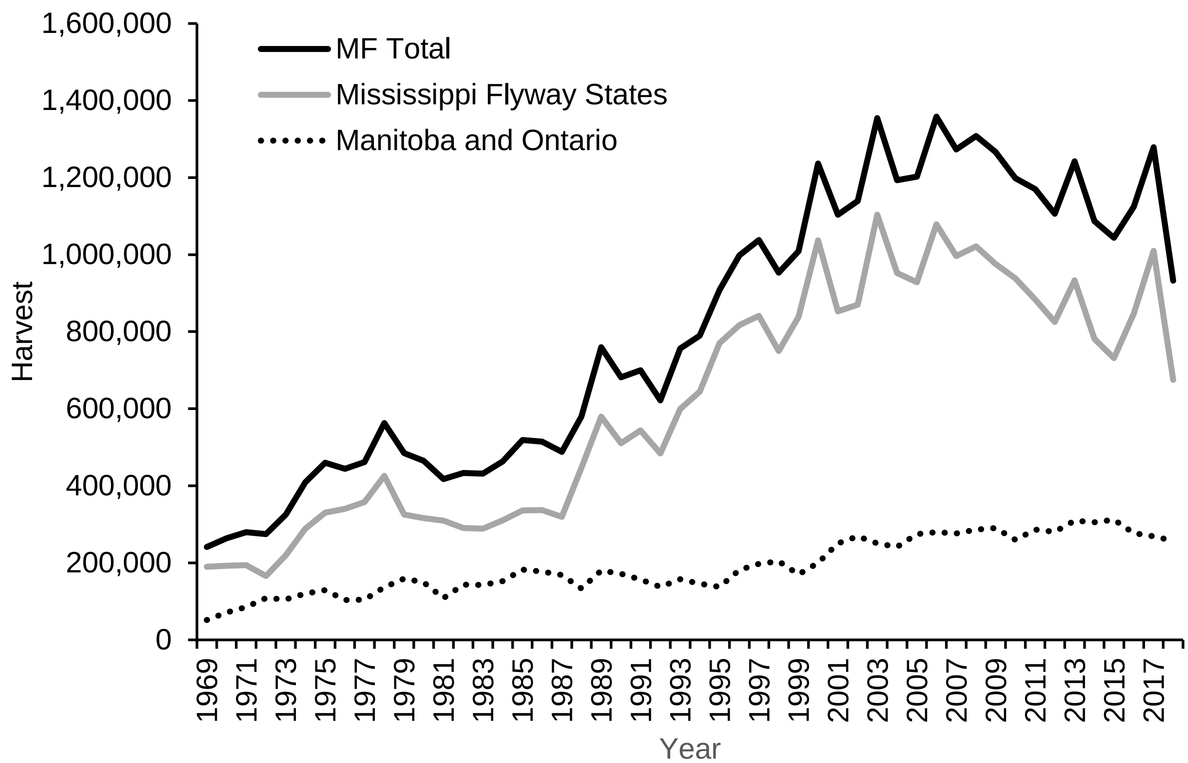

Figure 7. Annual harvest of Canada geese in Mississippi Flyway U.S. states and Canadian provinces (includes entire provinces of Manitoba and Ontario; Gendron and Smith. 2016), 1969-2018.

Management Philosophy

Canada goose economic, social, and ecological values were important in developing management plan goals and objectives. Management in the MF intends to enhance unique benefits while balancing potentially conflicting objectives for arctic, subarctic and temperate-breeding goose populations. These include maintaining breeding distributions, sustainable populations, and ecosystem functions as well as managing conflicts between geese and people within social and economic tolerances. There are significant benefits derived from maintenance of extant Canada goose breeding distributions; however, increased abundance and greater harvest of temperate breeding Canada geese has removed the imperative to maintain high abundance of subarctic-breeding geese (Appendix A). Additionally, we have learned that annual changes to hunting season frameworks are undesirable and inconsistent with biological and social goals, and detract from our ability to adequately assess impacts of regulation changes. These factors (in part) motivated the adoption of lower abundance thresholds in previous harvest strategies for subarctic-breeding Canada geese, which would trigger discussion and renegotiation of hunting season frameworks. Harvest strategies should strive for stabilized frameworks with infrequent regulation changes (e.g., 5 year intervals) to allow Canada goose population age-structure and hunter expectations to stabilize in response to change. Applications of these concepts was successful in guiding sustainable management of MF subarctic-breeding Canada geese. However, managing three separate groups of subarctic-breeding Canada geese had costs related to added regulation complexity, monitoring intensity and unsustainable growth of temperate-breeding Canada geese--these were important motivators for our current effort. In addition, there was a desire for over a decade to unify harvest management of Canada geese in the MF, but those efforts were complicated by "out of phase" adoption of management plans for geese affiliated with different breeding areas (i.e., EPP, MVP, and SJBP). Our current approach is intended to provide for unified management of Canada geese that allows for flexibility to adopt regulations that will better enhance long-term benefits of Canada geese to people in the MF.

Goals

- Maintain or grow goose hunting participation and support other sustainable non-consumptive uses of Canada geese.
- Balance costs and benefits of abundant temperate-breeding Canada geese.
- Maintain ecological and economic values as well as public support for Canada goose management.

Objectives and Strategies

Management objectives need to be measurable and have reasonable expectation that metrics of success can be influenced by management decisions. There is also an expectation that objectives are aligned with the primary objectives contained within the 2012 North American

Waterfowl Management Plan revision (NAWMP 2012), which lays out a framework for a balance between the objectives of waterfowl abundance, supporters and users of waterfowl and waterfowl habitats. Objectives and associated strategies are summarized here and later expanded to include justifications and monitoring approaches:

Objective 1: Maintain sustainable populations and breeding distribution

Strategy 1: Develop hunting season frameworks that provide flexibility for state and provincial agencies to adopt regulations that address local objectives for temperate-breeding Canada geese (for harvest rate, abundance and to address human-goose conflicts) while maintaining subarctic-breeding and cackling geese above minimum abundance thresholds without negatively impacting breeding distributions.

Objective 2: Maintain or grow goose hunter participation and harvest

Strategy 1: Conduct research on factors contributing to declining MF goose hunting participation.

Objective 3: Maintain or grow public support for sustainable populations of Canada geese and management, including management of conflicts between geese and people.

Strategy 1: Conduct and support surveys to better understand public perceptions and attitudes about Canada geese, and communicate values of Canada geese and methods of mitigating conflicts.

Strategy 2: Maintain harvest focus on temperate-breeding Canada geese to control abundance and help resolve human-goose conflicts.

Strategy 3: Conduct research to help resolve conflicts between geese and people in the Mississippi Flyway and monitor amounts and types of conflict control methods used.

Objective 1: Maintain sustainable populations and breeding distribution

Maintaining breeding distribution was not an explicit objective of past management plans or it was a means to achieve the fundamental objective of 'abundance.' However, maintaining breeding distributions is critical in the context of a Flyway-wide management plan to enhance unique values associated with geese among different breeding areas. Breeding distribution and abundance both contribute to sustainable populations, and appropriate monitoring is essential to ensure this objective is being met. Canada goose breeding distribution is considered at the scale of the breeding area (i.e., subarctic- and temperate-breeding areas) and at finer scales within breeding areas. Temperate-breeding Canada goose distribution is monitored at the state and provincial scale while subarctic-breeding Canada goose distribution can be resolved at the scale of individual transects along the coasts of Hudson Bay and James Bay (see indicators of sustainable populations below).

Population modeling and harvest management assume that non-hunting mortality is relatively stable and low, and that hunting mortality is additive to natural mortality (Rexstad 1992). Therefore, we assume harvest contributes to annual variation in abundance, although factors like weather and agricultural practices contribute to the annual migration pattern and contribute indirectly to annual variation in harvest. Therefore, tracking annual variation in abundance is less important than maintaining sustainable populations and monitoring longer-term population change. Experience suggests there is a weak linkage between annual harvest regulations and harvest rates; however, harvest regulation is still important for maintaining sustainable populations and breeding distribution as over (or under) harvest may negatively affect distribution and abundance. This is particularly true given the varying harvest potential of different goose stocks and the potential for harvest from one stock to compensate for lower harvest from other stocks in the total harvest, potentially protecting more vulnerable and less abundant stocks from unsustainable harvest.

Strategy 1: Develop hunting season frameworks that provide flexibility for state and provincial agencies to adopt regulations that address local objectives for temperate-breeding Canada geese (for harvest rate, abundance and to address human-goose conflicts) while maintaining subarctic-breeding and cackling geese above minimum abundance thresholds without negatively impacting breeding distributions.

Historically, management of subarctic-breeding Canada geese was guided by 3 separate management plans with different harvest strategies, resulting in hunting season frameworks that varied widely among MF states (Appendix A). Regulations also varied widely within states and provinces as zones were created to restrict harvest of subarctic Canada geese. Maintaining wintering and staging distribution was often included as an objective in previous management plans for subarctic-breeding stocks at smaller scales. However, it is now believed that there is very little that can be done using available management tools to influence broad-scale fall and winter distribution of subarctic-breeding Canada geese as these are thought to be primarily a function of weather and food availability. The historic approach also included emphasis on estimating harvest derivation (through band recovery or genetic analyses) to monitor distribution of subarctic Canada goose harvest. These management approaches attempted to allocate harvest of subarctic-breeding geese from separate breeding populations, resulting in complex harvest regulations across the MF. Harvest distribution was once largely tied to distribution and abundance of subarctic-breeding geese, but we now recognize that the complexity associated with allocating harvest geographically is not effective because variation in total Canada goose harvest among MF states is largely associated with abundance of temperate-breeding Canada geese in each respective state (Fig. 8). Therefore, complex regulations targeting subarctic-breeding Canada geese are unnecessary and ineffective due to abundance of temperate-breeding geese. Subarctic-breeding Canada and Cackling geese still help sustain significant harvest opportunities across the MF, and there are specific areas in the MF where these geese contribute a significant proportion of the harvest.

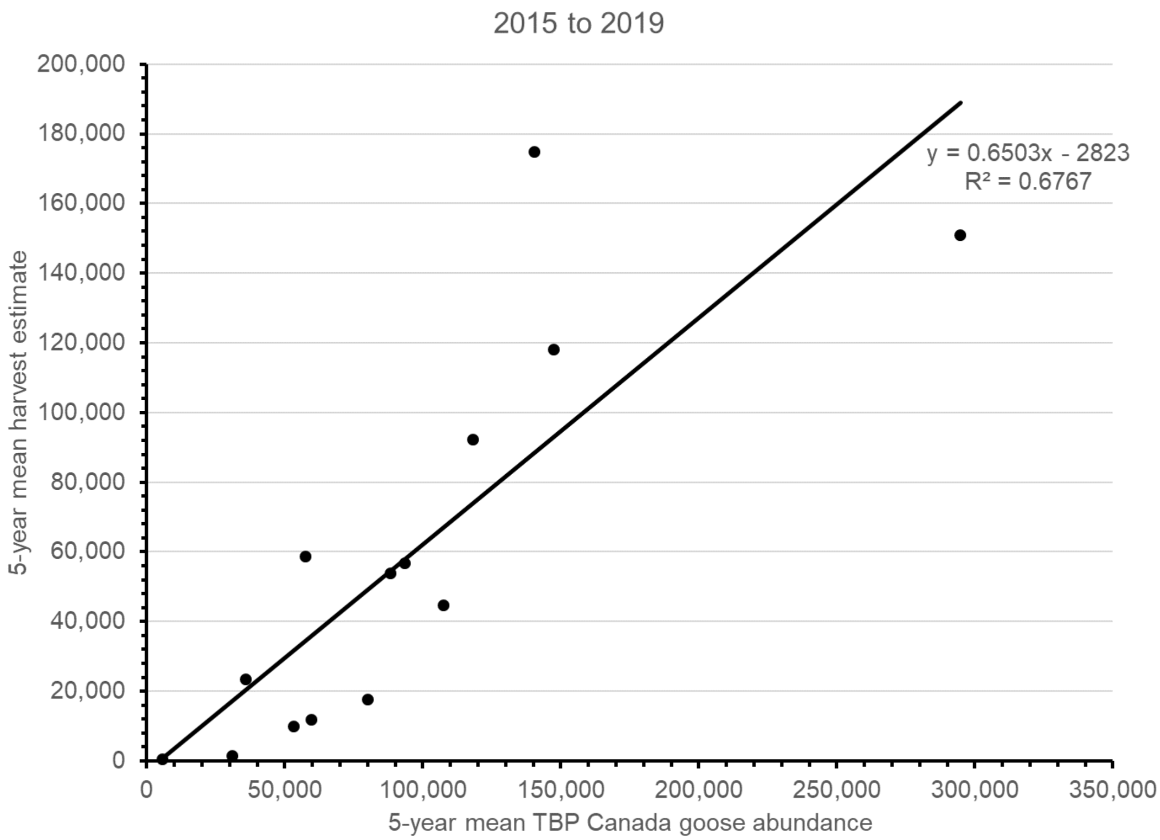

Figure 8. Five-year mean Canada goose harvest estimates in relation to state-specific temperate-breeding Canada goose abundance estimates among 14 Mississippi Flyway states, 2015-2019.

A decision strategy was developed to guide periodic assessment and modification of MFC's recommendations for Canada goose hunting seasons (Table 2). This strategy assumes harvest rates can be manipulated over longer periods by changing hunting regulations and that population growth will be supported when harvest rates are below equilibrium thresholds determined through population modeling (Table 3). Recommended state and provincial hunting season frameworks for the MF are also provided as a starting point for developing recommendations for framework changes on a 3-year decision timeframe (Table 2).

The intent of the different packages is to maintain harvest pressure on temperate-breeding geese while keeping harvest rates sustainable for all stocks. We are uncertain if the current liberal framework for states is too much like the moderate framework to detect differences in harvest rates or effects on temperate-breeding Canada goose abundance; however, the liberal framework will be reconsidered over the next 3 years and may be made more liberal if warranted (The liberal framework was modified in August 2020 with an increase in the daily bag limit from 3 to 5). The moderate package was utilized as the state framework prior to the current set of regulations and all indicators suggested these regulations were sustainable for subarctic-breeding Canada geese (although these regulations also allowed growth of temperate-breeding Canada goose abundance). The restrictive package is intended to promote population growth of all stocks. Despite population growth expectations, Canada goose abundance may increase or decrease independent of harvest rates, and in those cases, more detailed investigation of monitoring data and the underlying causes may be warranted to aid in formulating harvest recommendations.

Table 2. Recommended Canada goose harvest management decision framework for the Mississippi Flyway using the following thresholds: lower abundance threshold for temperate-nesting Canada geese is 1.2 million birds and upper abundance threshold is 1.4 million birds; lower threshold for subarctic-breeding Canada geese is > 15% average annual decline over 3 years (running mean), > 10% average annual decline over 6 years (running mean), or > 5% average annual decline over 9 years (running mean).

1. Decision thresholds and adult harvest rate objectives for U.S. Canada goose hunting season framework recommendations.
    a. If temperate- and subarctic-breeding geese are above abundance thresholds (Liberal framework) then:
        i. Temperate-breeding harvest rate objective: $\geq$ 0.15
        ii. Subarctic-breeding harvest rate objective: < 0.11
    b. If temperate-breeding geese are above and subarctic-breeding geese below abundance thresholds (Standard framework) then:
        i. Temperate-breeding harvest rate objective: $\geq$ 0.15
        ii. Subarctic-breeding harvest rate objective < 0.09
    c. If all Canada geese are below desired abundance (Restricted framework) then:
        i. Temperate-breeding harvest rate objective: < 0.15
        ii. Subarctic-breeding harvest rate objective: < 0.09
2. Recommended U.S. hunting season frameworks[a]
    a. Liberal
        i. 107 days of hunting, 5-bird daily limit 1 September 15 February. Splits: up to 4 segments.
    b. Standard
        i. 107 days of hunting, 5-bird daily limit 1-30 September; 2-bird daily limit 1 October – 15 February or 92 days and 3-bird daily limit 1 October – 15 February. Splits: up to 4 segments.
    c. Restricted
        i. 75 days of hunting, 5-bird daily limit 1-15 September, 2-bird daily limit 1 October – 31 January or 92 days, 2-bird daily limit 1 September – 31 January. Splits: up to 3 segments.
3. Recommended Canadian (MB and ON) hunting season frameworks
    a. Liberal
        i. 107 days of hunting, maximum 12-bird daily limit 1-24 September; maximum 8-bird daily limit 25 September–10 March.
    b. Standard
        i. Consider reductions to season length and/or daily limits.
    c. Restricted
        i. Consider reductions to season length and/or daily limits.

[a]U.S. frameworks represent maximums and states may choose more restrictive regulations.

Table 3. Harvest rate estimates, modeled equilibrium harvest rates, and population status of subarctic-breeding and temperate breeding Canada geese and arctic breeding cackling geese in the Mississippi Flyway.

Canada/Cackling Goose Breeding Area	Modeled Sustainable Adult Harvest Rate	Observed Adult Harvest Rates (2005-2014)	Population Trajectory (2005-2019)	Abundance in Relation to Goal
Temperate	0.14-0.15[a]	0.12-0.17	Increasing	Above range
Subarctic	0.095-0.11[a]	0.06-0.08	Stable	Within range
Arctic	0.096[b]	0.02-0.04	Stable	Within range

[a]Estimates of equilibrium harvest rates (assuming additive harvest mortality resulting in lambda = 1) based on simulations conducted with state-based matrix projection models (Brook and Luukkonen 2008).

[b]Estimate of maximum sustained yield based on a discrete logistic model fit to Lincoln-Peterson population indices (Zimmerman et al. 2013).

Indicators of sustainable populations

1. Distribution and abundance

Over the past 25-45 years, MF Canada geese in temperate- and subarctic-breeding areas were monitored via annual spring surveys. Historically, subarctic-breeding geese were monitored via separate breeding ground surveys for EPP, MVP, and SJBP Canada geese that provided annual population estimates. However, evolution in the management approach for Canada geese in the MF over the past decade raised the question of the value of monitoring three separate populations of subarctic-nesting geese. As part of the current planning process, the MF changed the monitoring program for subarctic breeding areas in 2016 to a unified survey focused on estimating annual (and longer term) changes in density within high-density breeding strata along the southern Hudson and James Bay coastlines (Appendix D).

The development of a new survey design for subarctic breeding Canada geese was driven by the change in Canada goose management in the MF. In short, the unprecedented abundance of Canada geese flyway-wide allows for monitoring and harvest management programs to be applied at larger geographic scales. Specifically, it is believed that this change in monitoring intensity more closely matches: 1) the decreasing relative importance of subarctic-breeding Canada goose abundance on harvest management decisions, and 2) the scale of management thought necessary to achieve Flyway objectives for Canada geese. These primary objectives spurred assessment of the value of monitoring three separate groups of subarctic breeding Canada geese, and resulted in amalgamation of the three formerly recognized groups into one Southern Hudson Bay Canada (SHB) goose population. It was also realized that breeding densities (i.e., Appendix D) and changes in abundance at finer spatial scales could be resolved using techniques such as kriging and this will serve to identify areas of potential concern that might warrant harvest restrictions at sub-MF scales (e.g., groups of states and/or provinces). A map of the estimated change surface (interpolated between survey transects using kriging) was incorporated into the annual SHB status report beginning in 2018.

To develop a unified survey that would meet current objectives, we used historical survey data to conduct simulations to evaluate how well a change in breeding density and distribution could be detected using different survey designs. We found that the historical surveys had relatively poor ability to detect annual changes in breeding density, particularly for low breeding density areas, which comprise most of the subarctic breeding range. To improve sampling and analytical efficiencies (two important objectives of the new survey design), we developed a systematic transect survey consisting of relatively short transects perpendicular to the coast with the intent of better measuring changes in breeding distribution and density. This redesigned survey also includes part of the breeding range never surveyed previously (between the ON-MB border and the mouth of the Nelson River). The length of each transect was determined by the extent of the estimated high density zone that was found to parallel the coasts of James and Hudson Bay. Across the range, this zone was determined by applying spatial analysis to the data from previous surveys (1989 to 2015) and it roughly conforms to the width of the historical higher density strata. By surveying only the higher density areas, we found the probability of detecting a 10% or a 15% annual change in the number of breeding pairs year-over-year was greatly increased (to 89% and 100% from an average 48% and 74%, respectively).

Two perceived shortcomings of this survey design include: 1) discontinuing monitoring of the low-density areas and, 2) breaking the population-specific time series. The new survey does not cover the large low density areas found throughout the breeding range and assumes that any change in this low-density area would also be reflected in changes in the high-density area (the surveyed portion).

The re-designed survey has cost and time efficiencies, and enables consistent methods to be employed across the breeding range of the SHB population. Importantly, only large changes in breeding population size, or a consistent trend in abundance over several years are to be used as a monitoring metric in addition to adult harvest rates. We are confident that this survey adequately fulfills the current and future objectives for Canada goose management in the MF.

Maintaining abundance above minimum thresholds was a goal in previous Flyway management plans. With the change in focus from estimating abundance to change detection, we have replaced this with an interim objective based on historical percent changes in subarctic-breeding Canada goose abundance (Fig. 9); the interim objective is to avoid an average annual decline in abundance of >15% over 3 years (running mean). This single interim objective may not protect SHB Canada geese from unsustainable harvest over periods longer than 3 years (i.e., a slow, chronic population decline), so similar thresholds of avoiding >10% decline in average annual abundance over 6 years (running means) and >5% decline over 9 years (running means) will be used to guide harvest management. Also, if annual surveys of breeding SHB detect areas of rapid decline on breeding grounds (i.e., from estimates of population change mapped via kriging in areas as large as the spatial scale of historic EPP, MVP, or SJBP), then additional analyses of band recovery and harvest data will be conducted to determine if excessive harvest is likely responsible for declines. Sub-flyway restrictions in harvest regulations can be enacted as needed to recover declines in segments of the SHB population. Abundance monitoring and objectives for subarctic breeding geese will be reconsidered after we gain more experience with the new survey results.

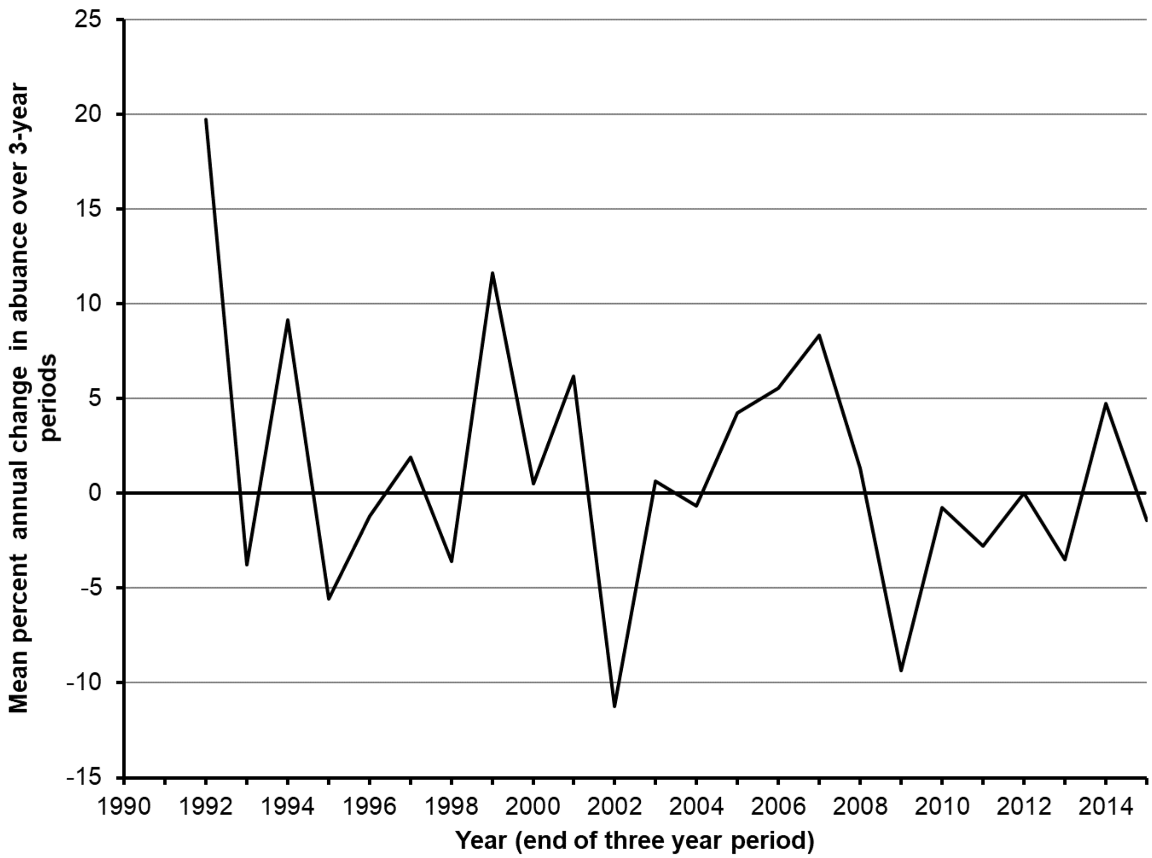

Figure 9. Mean percent annual change in abundance of Canada geese on Mississippi Flyway subarctic-breeding areas based on 3-year running means, 1992-2015.

The Mississippi Flyway Council Technical Section's Giant Canada Goose Committee has summarized spring population estimates for temperate-breeding geese from all states and provinces in the Flyway since 1993. State and provincial estimates are based on spring aerial surveys (helicopter plot or fixed-wing transect surveys), ground surveys, or agency assessment based on harvest and other information. Estimates are normally updated annually, but in some cases, estimates from previous years were used when current-year estimates were not available. Flyway-wide estimates are sums of all state and provincial estimates and since estimates of variances are not available for all individual state/provincial estimates, there is no estimate of annual precision provided on Flyway-wide estimates. (Fig. 10). The MF temperate-breeding Canada goose abundance objective range of approximately 1.2-1.4 million birds is based on the summation of objectives for individual states and provinces and approved by the MFC (Table 4). Arctic-breeding cackling goose abundance is estimated via Lincoln estimators derived from estimates of annual harvest and harvest rates (Fig. 4). State and provincial surveys of temperate-breeding Canada geese as well as banding of cackling geese (to provide Lincoln estimates of abundance) are important monitoring components of this plan and should be continued.

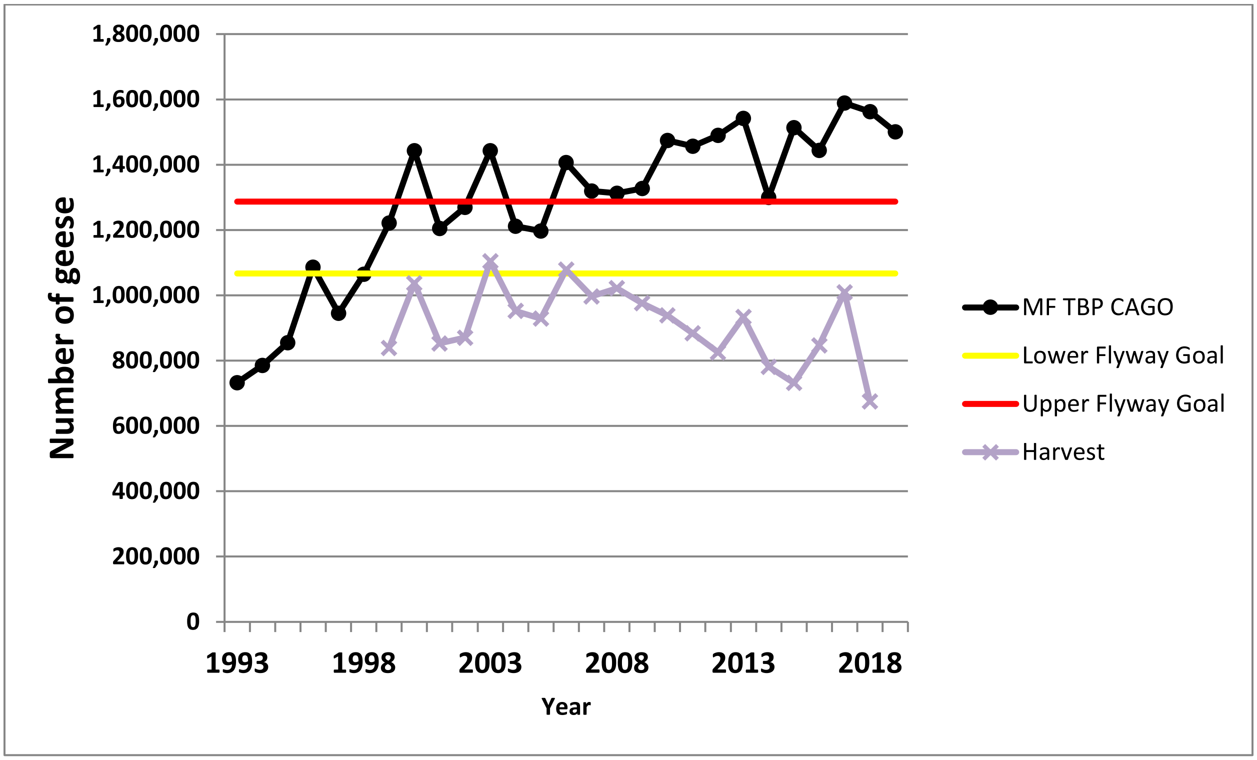

Figure 10. Abundance and harvest of temperate breeding Canada geese and goal range in the Mississippi Flyway, 1993-2019.

Table 4. Canada goose population objective ranges and 5-year mean breeding population estimates for temperate-breeding Canada geese in the Mississippi Flyway, 2015-2019.

State/Province	Population abundance objectives		Mean abundance
	Lower	Upper	
Alabama	25,000	25,000	59,800
Arkansas	25,000	25,000	53,257
Illinois	80,000	80,000	118,250
Indiana	80,000	80,000	107,487
Iowa	70,000	110,000	88,247
Kentucky	30,000	50,000	36,012
Louisiana	4,000	4,000	5,780
Manitoba	70,000	70,000	120,601
Michigan	175,000	225,000	294,740
Minnesota	135,000	135,000	140,392
Mississippi	20,000	20,000	30,800
Missouri	40,000	70,000	57,498
Ohio	60,000	120,000	93,642
Ontario	113,000	113,000	87,810
Tennessee	60,000	60,000	79,950
Wisconsin	80,000	100,000	147,231
Total	1,067,000	1,287,000	1,521,497

2. Harvest and survival rates

Banding is an essential component of the MF Canada goose monitoring program and state, provincial, and federal agencies share this responsibility. Annual banding operations and subsequent recovery and reporting of banded birds by hunters have provided a means to estimate harvest and survival rates of MF Canada geese. Responsibilities for funding banding programs for arctic-breeding and subarctic-breeding Canada geese are shared among the MFC, USFWS, and CWS through cooperative MF projects while state and provincial agencies conduct banding programs for temperate-breeding Canada geese (Table 5).

Table 5. Annual Canada goose banding targets to achieve monitoring objectives by breeding area.

Breeding Area	Responsible contributors	Flyway annual banding targets	Average annual Bandings (2014-2016)
Arctic	MFC, USFWS, CWS	3,500	2,357
Subarctic	MFC, USFWS, CWS	9,000	12,710
Temperate[a]	Minnesota	1,000	3,690
	Michigan	1,000	3,690
	Wisconsin	500	4,460
	Ohio	500	3,950
	Illinois	500	4,010
	Manitoba	500	950
	Indiana	500	1,930
	Tennessee	300	2,250
	Iowa	300	3,840
	Ontario	300	680
	Missouri	300	1,990
	Alabama	200	0
	Arkansas	200	1,340
	Kentucky	200	1,230
	Mississippi	100	0
	Louisiana	0	0

[a]Targets for temperate breeding geese are for Flyway-wide analyses and state and provinces with local monitoring objectives should review recommendations provided by Heller (2010).

Analyses of historic banding information indicates harvest rates of temperate-breeding Canada geese have been relatively high and stable over the past 25 years while harvest rates of adult subarctic-breeding birds increased during the late-1980s and has stabilized at a lower rate over the last 15 years (Figs. 11 and 12). The higher harvest rates during the 1985-1995 period for subarctic-breeding Canada geese may be a result of many adult birds being marked with neck collars in addition to leg bands causing them to be differentially targeted by hunters. This was discontinued by 2002. Harvest rates of adult subarctic-breeding geese have been in the 6-8% range over the last 10 years while harvest rates of adult temperate-breeding geese have been higher, in the 10-16% range (Figs. 11 and 12). Harvest rates of juvenile Canada geese are generally higher than harvest rates of adults, but this difference is not as pronounced in the last decade as in previous years (Fig. 11). Harvest rates of temperate-breeding Canada geese have been consistent between the Eastern and Western states of the MF over the last 15 years despite regional differences in harvest management strategies for subarctic-breeding Canada geese (Fig. 12). Higher harvest rates of temperate-breeding Canada geese compared to birds banded in other breeding areas suggests that relatively liberal hunting regulations, including special early and late seasons, have been successful in directing harvest toward temperate-breeding birds. However, relatively stable (or even slightly declining over the past 5 years) harvest rates of temperate-breeding Canada geese suggest that harvest may have only kept up with growth in abundance. High and growing abundance of temperate-breeding Canada geese may be responsible for declining harvest rates of subarctic-breeding Canada geese and cackling geese.

It is important to also periodically estimate survival rates for geese from all breeding areas to monitor impacts of harvest and other factors. Survival of adult subarctic-breeding Canada geese has been high with no long-term trend, but with annual variation (Fig. 13). Survival of juvenile subarctic-breeding Canada geese has been considerably lower than adults but has increased moderately over the last 15 years (Fig. 13). Survival estimates have been typically stable within jurisdictions for temperate breeding geese, but these estimates showed considerable variation among jurisdictions of the MF. However, survival estimation for temperate-breeding Canada geese is complicated by molt migration and potential for bias introduced into traditional band recovery models (Heller 2010). Harvest and survival rates of adult Canada geese have generally been inversely related, and these studies support our assumption that harvest is largely additive to natural mortality (Luukkonen et al. 2008, Iverson et al. 2013, R. Brook unpublished). Survival of temperate-breeding MF Canada geese can be higher in urban areas where birds are protected from hunting, but molt migration may expose some of these geese to subsistence and sport harvest (Luukkonen et al. 2003, Luukkonen et al. 2008, Dorak 2016); the same pattern of lower harvest and higher survival rates in urban compared to rural areas was observed in the Atlantic Flyway (Balkcom 2010, Beston et al. 2014).

Stage-based population projection models suggest higher sustainable harvest rates for temperate-breeding Canada geese and management of harvest should include consideration of sustainable harvest rates as well as Canada and cackling goose distribution and abundance trends (Table 3). Population models suggest that current harvest rates should be controlling population growth of MF temperate-breeding Canada geese, yet abundance has not completely stabilized (Table 3). Current parameter estimates may be underestimating the growth and harvest potential of temperate-breeding Canada geese. Alternatively, the banded sample of temperate-breeding Canada geese may not be completely representative of all population cohorts. Lower harvest rates of molt migrant temperate-breeding Canada geese as well as low susceptibility to harvest of birds breeding in urban refuges may be upwardly biasing estimates of harvest rates if birds in these groups are underrepresented in the banded samples used to estimate population harvest rates.

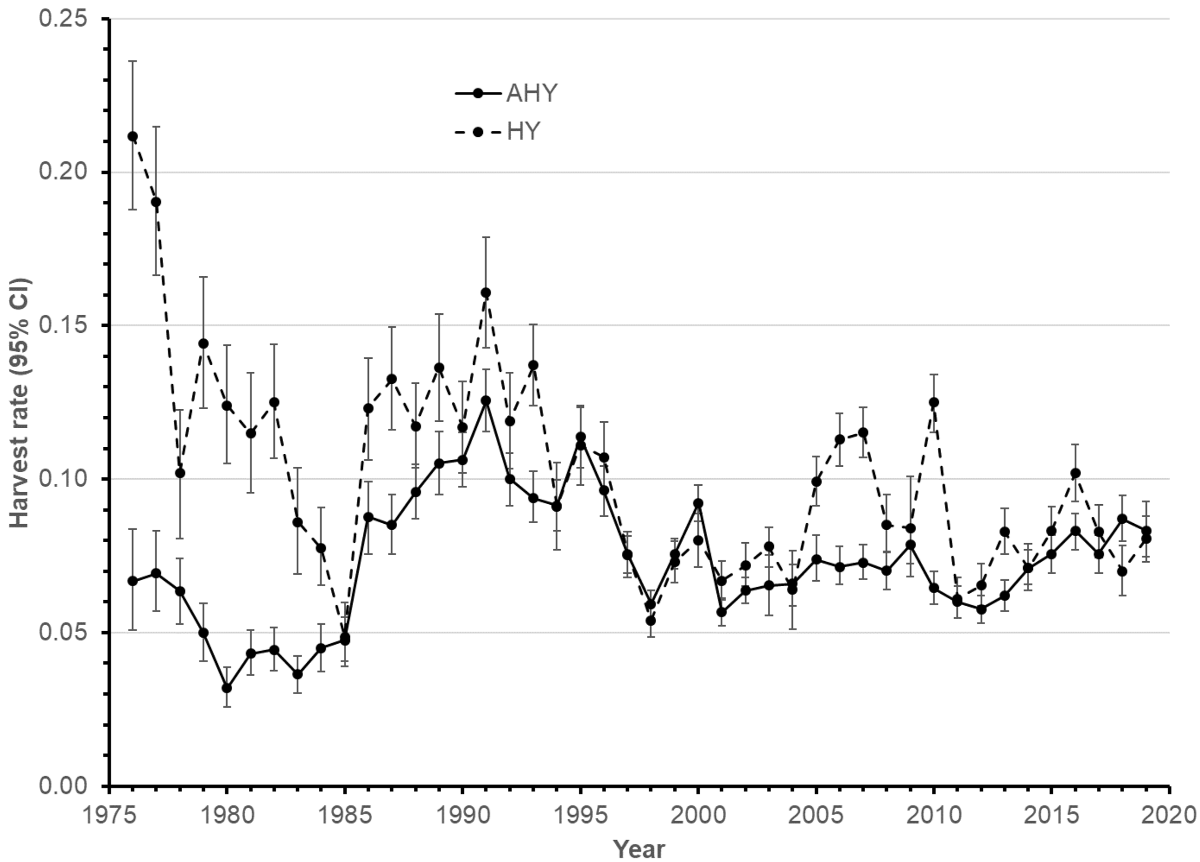

Figure 11. Harvest rate estimates of adult (AHY) and juvenile (HY) subarctic breeding Canada geese (±95% confidence interval) banded along the Hudson Bay and James Bay Coasts in the Mississippi Flyway, 1976-2019.

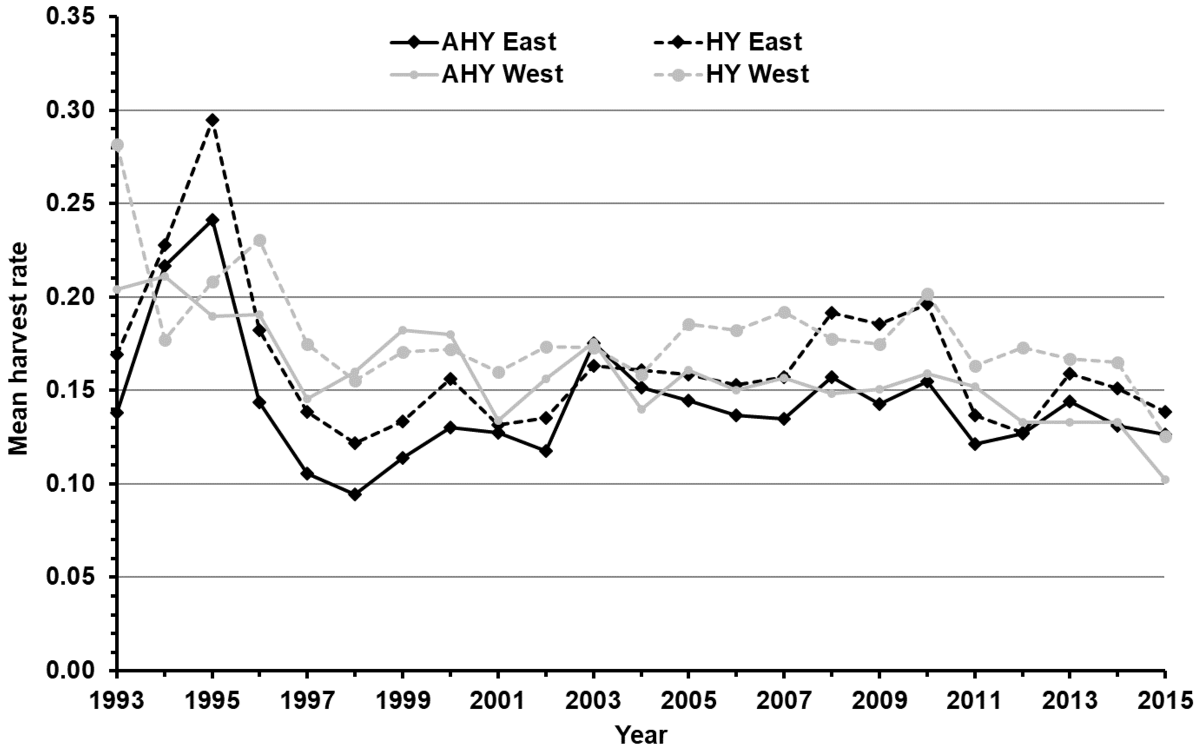

Figure 12. Harvest rate estimates of adult (AHY) and juvenile (HY) temperate breeding Canada geese by region where banded in the Mississippi Flyway, 1993-2015. Eastern states (East) are those affiliated with former SJBP and MVP planning and western states (West) are those affiliated with former EPP management planning. Regional harvest rate estimates were derived by weighting state and provincial harvest rate estimates in relation to estimates of proportional abundance of Canada geese.

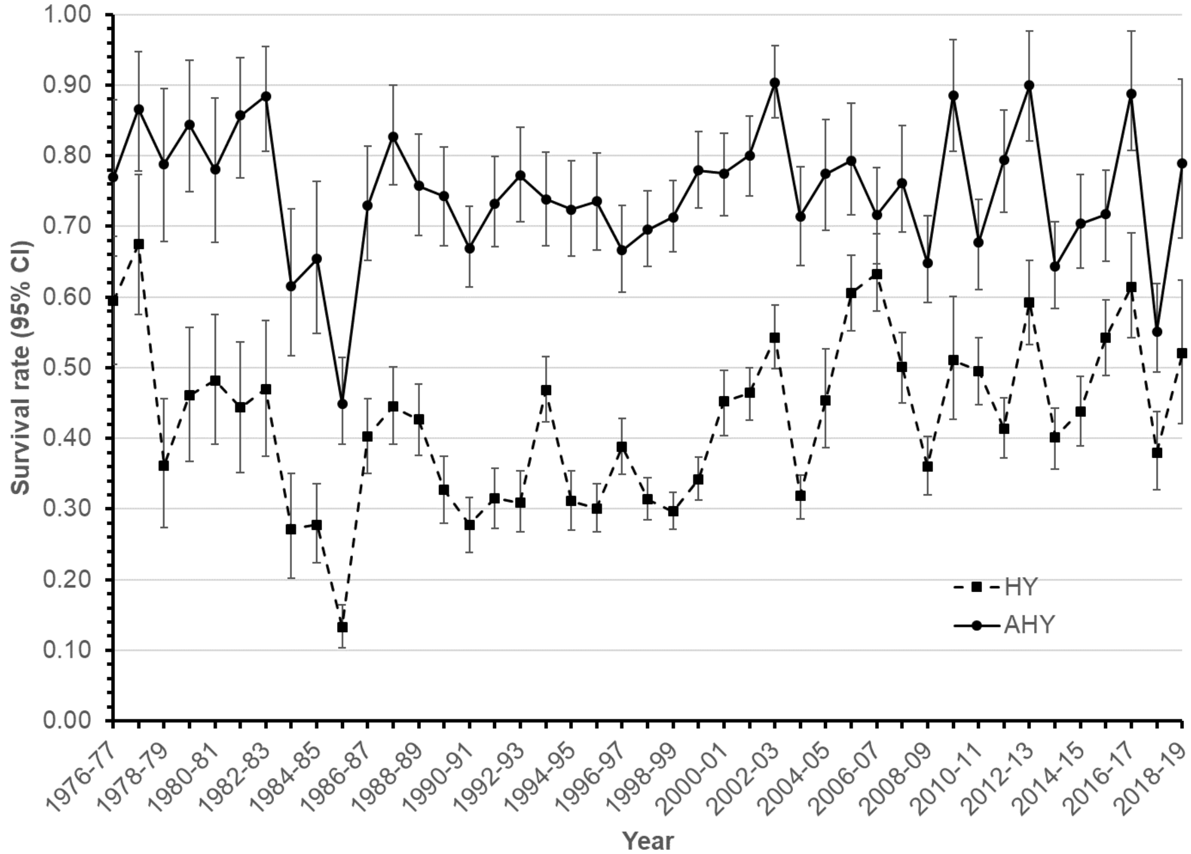

Figure 13. Survival rate estimates of adult (AHY) and juvenile (HY) subarctic breeding Canada geese (± 95% confidence interval) banded along the Hudson Bay and James Bay Coasts in the Mississippi Flyway, 1976-2015.

Objective 2: Maintain or grow goose hunter participation and harvest

This objective has many facets and is linked with the desire to: promote sustainable use of Canada geese, reduce conflicts between geese and people, and maintain public (both hunters and others) support for management. It combines agreement between the objectives of abundance (sustainable populations) and distribution with other human dimension objectives including hunter access, satisfaction and success. The goal is to balance sufficient abundance and distribution to satisfy users and maintain goose-human conflicts at acceptable levels. This considers the cultural and subsistence needs of Indigenous harvesters throughout the MF as well.

We recognize that high abundance of MF Canada geese and liberal hunting opportunities have not resulted in high hunter retention or recruitment. There are efforts underway through the implementation of the North American Waterfowl Management Plan (NAWMP 2012) to better understand the human dimensions of waterfowl hunting, and these efforts are supported by the

MF. However, much of the NAWMP emphasis has been on understanding duck hunter attitudes and desires, and there are reasons to also focus on differences or similarities in strategies needed to reverse the declining trend in goose hunting participation.

Strategy 1: Conduct research on factors contributing to declining MF goose hunting participation.

Although many factors likely influence harvest at state and provincial scales, the growth of temperate-breeding Canada goose abundance has likely been the most influential factor driving long-term growth in harvest. However, in recent years goose hunter numbers have declined in the MF despite unprecedented abundance of Canada, cackling, snow and Ross's, and white-fronted geese; successful goose hunter numbers peaked in the 1980s and declined thereafter in Ontario and Manitoba while MF U.S. hunters peaked around 2000 and have declined since 2003 (Fig. 14). Canada goose harvests have declined in concert with the decline in goose hunter numbers (Fig. 7).

Indicators of hunter participation and harvest

1. Federal harvest and effort surveys

Although many states and provinces of the MF conduct harvest and effort surveys, the USFWS and CWS national surveys provide a more consistent means to monitor distribution and level of goose harvest. In addition, parts collections allow separation of harvest by species (i.e., cackling and Canada goose harvests). This is particularly important for managing cackling geese as harvest data are used to estimate abundance via Lincoln estimators. Early season band recoveries and harvest estimates of Canada geese may provide a means to estimate abundance using Lincoln estimators, and this should be investigated as a supplement to current monitoring of temperate-breeding Canada geese. A disadvantage of the Federal harvest surveys is that there is no means to estimate Canada goose hunter numbers for the entire flyway because some hunters hunt in multiple states. In contrast, numbers of successful MF goose hunters can be estimated (Fig. 14).

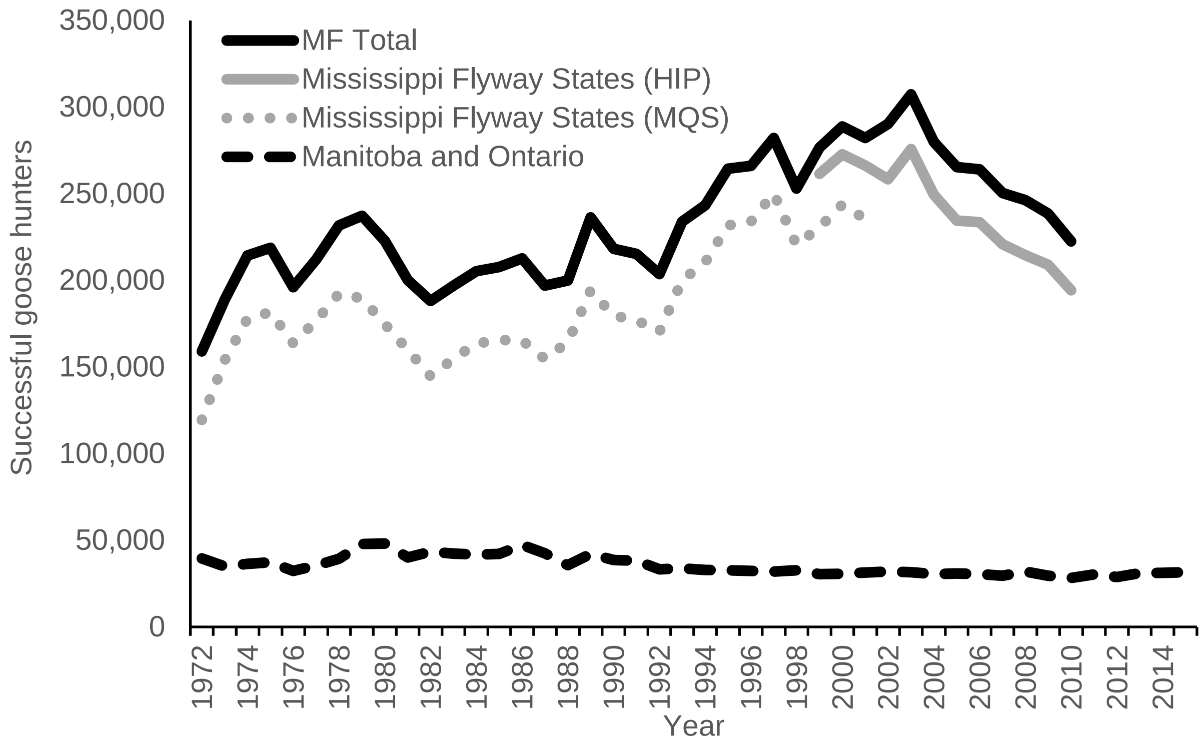

Figure 14. Number of successful goose hunters in the Mississippi Flyway with state estimates based on the U.S. Fish and Wildlife Service Mail Questionnaire Survey (MQS: 1972-2001) and Harvest Information Program (HIP: 1999-2010); successful goose hunters in Manitoba and Ontario based on the Canadian Wildlife Service estimates (Gendron and Smith, 1972-2015).

Objective 3: Maintain or grow public support for sustainable populations of Canada geese and management, including management of conflicts between geese and people.

Although Canada geese are valued greatly by many people, others experience significant conflicts and property damage. Understanding and responding to changing public attitudes about Canada geese, including conflicts between geese and people is critical for maintaining support for management programs. Although agencies may have well-established processes for public input from hunters about regulations and other issues, communication with other stakeholders will be essential in helping balance diverse opinions about how Canada geese are best managed.

Strategy 1: Conduct and support surveys to better understand public perceptions and attitudes about Canada geese, and communicate values of Canada geese and methods of mitigating conflicts.

Effective communication with wildlife management peers and the public is essential to maintain support for MF Canada goose management and agency credibility. Balancing desires of hunters and people experiencing conflicts with Canada geese requires understanding both perspectives. Managing conflicts with geese can be controversial (e.g., destroying nests, eggs, and adults) but the public is often supportive of agency activities when there is understanding about conflicts. Similarly, people are generally supportive of killing Canada geese via hunting or other means when birds are destined for human consumption (Fig. 15; Coluccy et al. 2001, Koval and Mertig 2004). Little is known about how management decisions change attitudes of the public about Canada geese or the effectiveness of agency communications about management. Agency surveys of hunters and other stakeholders can be coordinated among states and provinces to better understand geographic variation in attitudes and to provide for a more complete flyway-wide assessment. Canada geese are enjoyed and appreciated in non-consumptive activities as well as harvest, but we have little understanding of those values compared to values of harvest opportunity. Stakeholders such as Indigenous harvesters are not successfully surveyed through traditional mail survey techniques, so periodic meetings, special surveys or other forms of input are required to understand their unique perspectives and the values they associate with Canada geese.

Similarly, communication messages and other tools can be enhanced by sharing among agencies to ensure consistent messaging across the MF. One goal of shared communications should be overcoming past negative messaging about Canada geese (e.g., referring to geese as “sky carp”) and management (e.g., early goose seasons being referred to as “nuisance hunts”). An example of potentially unintended negative messaging is reference to temperate-breeding Canada geese as “resident geese” in some government publications. Although Canada geese sometimes remain relatively sedentary for most of the year in specific locations, the term “resident geese” obscures the more complex migratory nature of Canada geese from many areas. Further, it also suggests to the public that temperate-breeding Canada geese are not migratory birds and thus should not be managed under the same Federal framework as other migratory game birds. The MF has produced two communication pamphlets related to this plan, with one intended for biologists and agency staff and the other intended for the hunting public (Appendix E). The Flyways web page (https://flyways.us/) provides another opportunity to communicate with the public about Canada goose management. Improved communication with all stakeholders about the success of this plan may be facilitated with a “dash board” which summarizes current and desired conditions for Canada goose and cackling goose status indicators (Appendix E, Table 1).

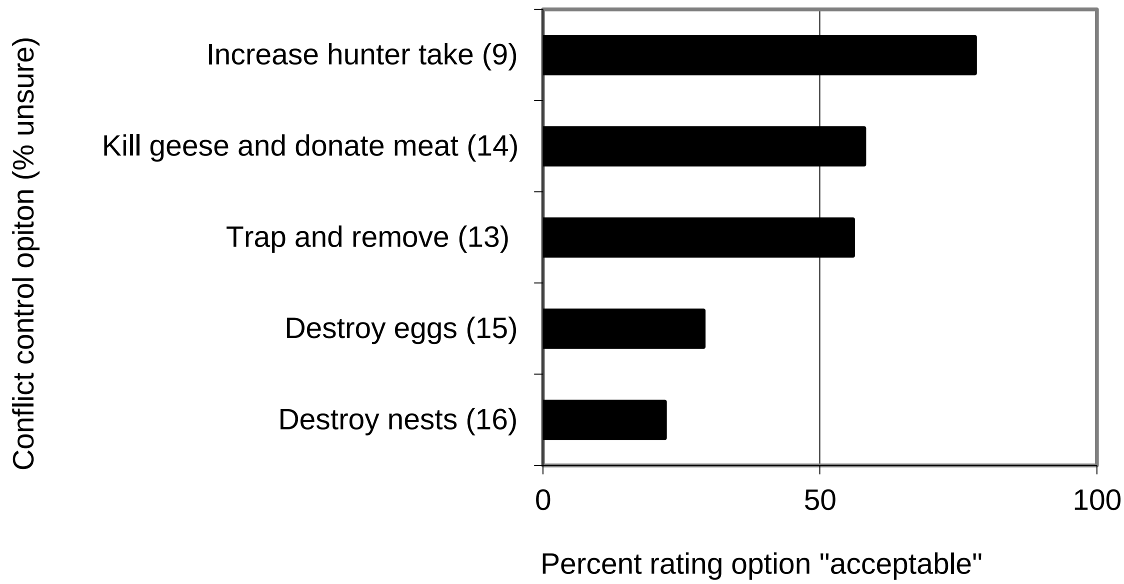

Figure 15. Percent support (% unsure in parenthesis) among a random sample of Michigan residents responding about options to control Canada goose conflicts in Michigan, 1999.

Strategy 2: Maintain harvest focus on temperate-breeding Canada geese to control abundance and help resolve human-goose conflicts.

Although many conflicts between Canada geese and people cannot be directly resolved through harvest, maintaining relatively high harvest rates on temperate-breeding Canada geese is desirable for those jurisdictions that want to control population growth and thus may indirectly help reduce conflicts. Human-goose conflicts with geese in urban settings are often in areas where hunting is prohibited by local ordinances or effectively prohibited due to safety concerns. In urban areas, it is often impractical or impossible to use traditional hunting techniques to take birds and help resolve conflicts. However, experience in states with high abundance of temperate-breeding Canada geese suggests that rural and agricultural damage by local Canada geese can be significant and may be affected by overall abundance. Each state and province has established goals for temperate-breeding Canada geese that reflect desired abundance. Hunting season frameworks can be used to allow states to modify harvest regulations relative to local objectives. For example, some states historically used more restrictive regulations than prescribed under federal frameworks to reduce harvest of birds in their states to maintain or recover Canada geese to objective levels. Also, states may choose daily limits during September that are more liberal than later in the season because early seasons can be effective in directing harvest toward temperate-breeding adults and their young without negatively impacting subarctic migrants.

Indicators of temperate-breeding Canada goose harvest derivation and harvest rates

1. Harvest derivations based on band recoveries.

The proportional contributions of Canada and cackling geese from different breeding areas in state and provincial harvests have been estimated using band recoveries weighted by population size or via genetic techniques. Because of the additional cost of genetic analyses of harvest samples, the band recovery method is generally preferred for operational monitoring: however, this technique has important assumptions such as representative banding of all cohorts of geese, which has not always been the case historically for subarctic-breeding Canada geese (Fritzell and Luukkonen 2003). Also, Canada geese nesting along the south Hudson Bay coast between the former EPP and MVP breeding ranges have not been banded recently and this might result in underestimates of the contributions of subarctic-breeding Canada geese in harvest areas south of this zone. Most recently, band recovery harvest derivations have been estimated for adult Canada and cackling geese using 5-year time periods (Appendix C; complete report not presented due to length of document). Temperate-breeding Canada geese made the largest contribution to Flyway harvest for the period 2011-2015, but there was variation among states and provinces in the magnitude of that contribution (Fig. 16).

2. Harvest rates from band recoveries (see Indicators of Sustainable Populations).

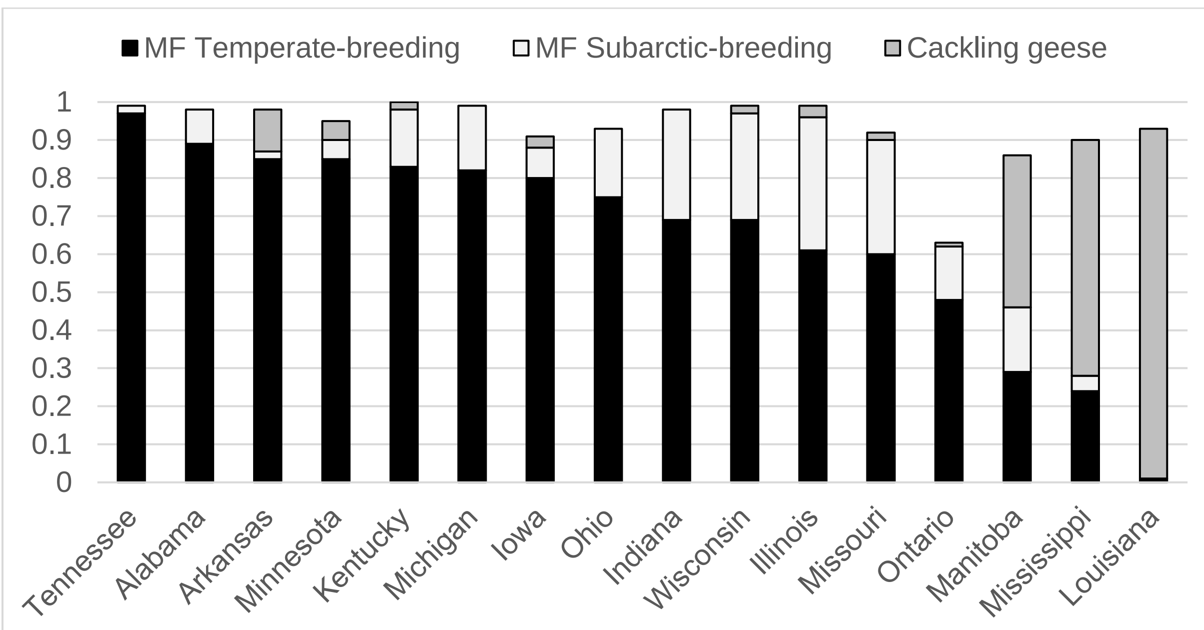

Figure 16. Proportional contribution of Mississippi Flyway temperate-breeding and subarctic-breeding Canada geese and cackling geese to state and provincial harvests in the Mississippi Flyway based on recoveries of adult geese, 2011-2015. States and provinces are ordered based on decreasing contribution of MF temperate-breeding Canada geese to total harvest. Harvest proportions do not sum to 1 for states and provinces that harvested birds from breeding areas outside of the Mississippi Flyway (Appendix C).

Strategy 3: Conduct research to help resolve conflicts between geese and people in the Mississippi Flyway and monitor amounts and types of conflict control methods used.

Indicators of conflict between geese and people in the Mississippi Flyway.

1. Trends in amount and level of control in the U.S. portion of the MF based on USFWS permit reporting.

Trends and amounts of conflict control activity should be regularly monitored; the last set of data available was for the period 1995-2012 (Fig. 17). Although conflicts increased over this period, there has been a reduction in numbers of birds relocated since 2002 and increases in numbers of nests and adults destroyed to help resolve conflict (Fig. 17).

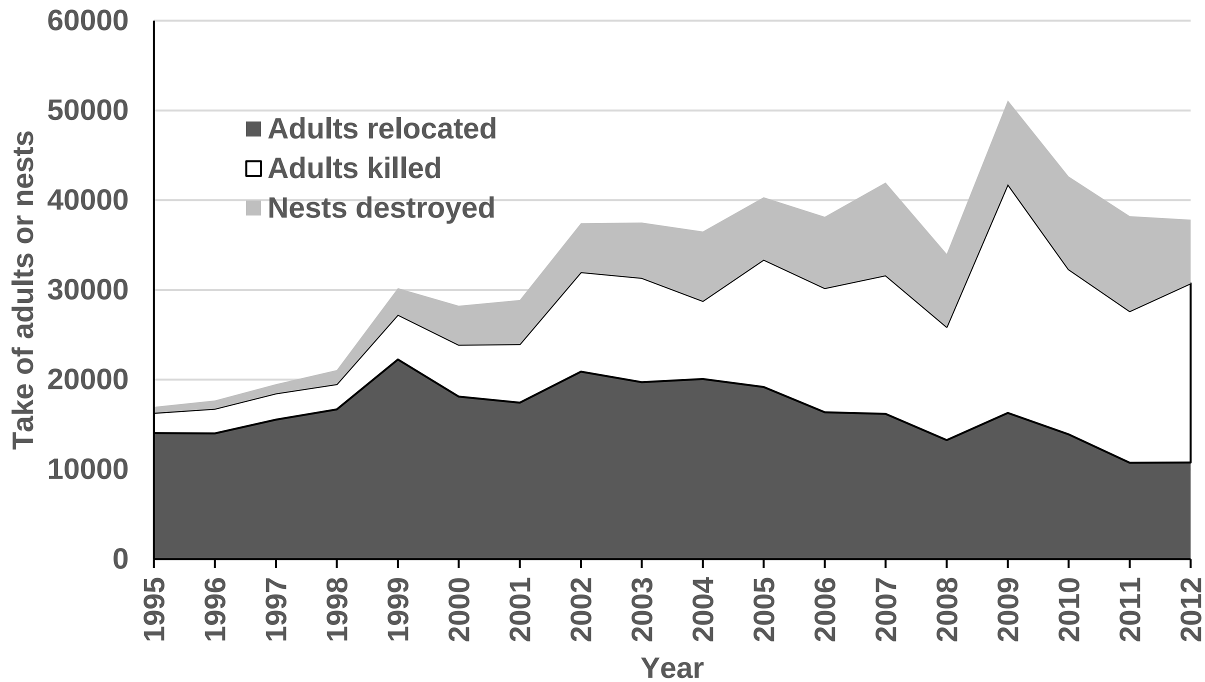

Figure 17. Number of adult Canada goose relocated or killed and number of nests destroyed in the U.S. portion of the Mississippi Flyway to help resolve conflicts between Canada geese and people, 1995-2012.

2. Proportion of states and provinces with populations of temperate-breeding Canada geese within goal range.

Currently, 11 of 16 states or provinces estimate higher temperate-breeding Canada goose abundance than desired based on established goal ranges (Table 4). Although many conflicts between geese and people cannot be resolved through harvest, this is the preferred method of maintaining Canada geese within acceptable abundance ranges whenever possible. Goal ranges need to be periodically assessed to ensure they remain relevant as abundance, stakeholder desires, and management experience changes over time.

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Appendices

Appendix A: History of MF Canada Goose Management

Jim Leafloor, Canadian Wildlife Service

The Early Years

The early history of Canada goose management in the Mississippi Flyway was described by Reeves et al. (1968), and is summarized in the following paragraphs. In the 1920s, hunting regulations for geese in what is now the Mississippi Flyway were relatively liberal. Seasons were open for 92-107 days, the bag limit was 8 birds per day with no possession limit, and baiting and the use of live decoys were still legal and widely used hunting techniques. Population monitoring programs did not exist at that time.

The Horseshoe Lake Refuge was established on an oxbow of the Mississippi River in southern Illinois in 1927, and this proved to be a defining moment in the history of Canada Goose management in the flyway. The provision of safe roosting habitat combined with an agricultural program to produce goose food quickly attracted Canada geese to the area, followed by large numbers of hunters. As numbers of Canada geese increased at Horseshoe Lake, commercialized hunting in surrounding lands became big business. It was not long before concerns arose over the numbers of geese that were being harvested, and federal restriction of bag limits occurred for the first time in 1929, when bag limits were cut to 4 Canada geese per day, with a possession limit of 8 birds. Following several years of drought conditions and continuing high harvests, season length was shortened to 30 days, the possession limit was dropped to 4 Canada geese, and baiting and the use of live decoys were finally banned in 1935. Even so, interest in Canada goose hunting continued, and hunter numbers continued to increase.

In early January of 1936, the first attempt at a census of wintering Canada geese occurred in the flyway, tallying just over 47,000 Canada geese. By 1939, survey coverage was thought to be more complete, and the counts tallied 175,000 Canada geese that year. Winter counts declined thereafter, reaching a low in 1946 of only 53,000 birds.

By the early 1940s, it was apparent that Canada goose populations had declined on some southern wintering areas, and that this was at least partly a result of concentration of Canada geese at refuges farther north. There was a debate about whether this was caused by “short-stopping” of geese, or was due to overharvest of southern-wintering cohorts, and this debate persisted in the flyway at least through the 1990s. Meanwhile, efforts to control harvest on concentration areas continued, but with little success. At Horseshoe Lake, this involved monitoring harvests at local hunting clubs, and closing the hunting season once a predetermined proportion of the flock was harvested. In 1944, hunting was closed after only 21 days of shooting; in 1945, after only 5 days; and in 1946, Canada goose hunting was closed in all of the Mississippi Flyway. In 1947, a Presidential Proclamation closed a 20,000 acre area around Horseshoe Lake to hunting. Outside of that area, the hunting season was opened for 30 days, with a daily bag and possession limit of only 1 Canada goose.

The closure of Canada goose hunting in 1946 was an important impetus for eventual establishment of the Mississippi Flyway Council, and for improvement of scientific databases on which to base management decisions. It also emphasized the importance of cooperative harvest management, and the need for conservative regulations to ensure the sustainability and equitable distribution of Canada goose populations in the face of high demand for hunting opportunities. The area closure around Horseshoe Lake remained in effect until 1953, when the closed area was reduced to 9,000 acres, and harvests again increased thereafter. However, the Canada goose population had increased under restrictive regulations, and even though periodic high harvests continued in the 1950s, the Canada goose population also continued to grow.

Canada goose harvests were controlled by quotas in the main concentration areas of many states, and seasons were supposed to be closed when quotas were reached. Though harvest controls on concentration areas were a major pre-occupation of state agencies and eventually the Flyway Council between the late 1930s and the 1960s, efforts to re-distribute Canada geese were also made, including an intensive hazing program to disperse the geese wintering at Horseshoe Lake in 1948 and 1949. Additional land was also purchased to provide alternative wintering sites for Canada geese, including at Swan Lake, Missouri (1937), Horicon Marsh, Wisconsin (1927 and 1941), and Union County and Crab Orchard, Illinois (1947), among other sites. Between 1953 and 1965, locally nesting Canada geese were transplanted from northern states to southern wintering areas in an effort to restore traditional migration patterns to southern states, and to establish new wintering flocks. Though these transplant efforts were considered to be mostly unsuccessful at the time (Hankla 1968), nesting Canada goose populations eventually became established in every state in the flyway.

A quota system was eventually implemented to control harvest in Wisconsin and Illinois in 1960. By then, many of the problems associated with large concentrations of Canada geese at Horseshoe Lake were also evident at Horicon Marsh in Wisconsin. By 1965, a population of 120,000 Canada geese had built up at Horicon Marsh, and the harvest quota in the Horicon Marsh zone was exceeded after only 12 days of hunting that year. In 1966 a hazing program was implemented in the weeks preceding the hunting season, in an attempt to force Canada geese to migrate, but instead it mainly succeeded in increasing the kill of Canada geese over a wider geographic area than usual. Hunting within the Horicon Marsh zone was curtailed after only two and a half days of hunting, and the harvest of Canada geese was nearly double the quota of 14,000 birds (MFCTS meeting minutes, April 1967). A year later, a monitoring system was implemented with mandatory tagging of each goose harvested in the Horicon Zone, despite considerable opposition from landowners near Horicon Marsh.

Development of Population Management of Canada Geese

Hanson and Smith (1950) were the first to delineate three populations of Canada geese that nested in the Hudson Bay Lowlands of northern Ontario and Manitoba and wintered mainly in the Mississippi Flyway (Eastern Prairie Population (EPP), Mississippi Valley Population (MVP), and the Southeast Population); they also described the South Atlantic Population that nested in northern Quebec and wintered in the Atlantic Flyway. The original population descriptions were mostly based on recovery distributions from birds banded in winter at Horseshoe Lake, Illinois, and during spring and fall migration at the Jack Miner Sanctuary in southern Ontario. The Eastern Prairie Population was thought to nest mainly in northern Manitoba, and overlapped with the Mississippi Valley Population somewhere between Fort Severn, Ontario, and Fort York, Manitoba. The Mississippi Valley Population was thought to nest inland of western James Bay and south of Hudson Bay in northern Ontario, and overlapped with the Southeast Population somewhere in southern James Bay (Hanson and Smith 1950). The Southeast Population was identified as a small population that nested in a narrow range at the southern tip of James Bay, and wintered in southeastern states of both the Atlantic (Virginia, North Carolina, South Carolina, Georgia) and Mississippi Flyways (Alabama). North of the Moose River in Ontario, the population was thought to merge with the Mississippi Valley Population, and east of the Nottaway River in Quebec, it merged with the South Atlantic Population. The narrow area between the Moose River and Nottaway River (an east-west distance of approximately 100 km, or 60 miles) was presumably considered to be the main nesting area of the Southeast Population (Appendix A *in* Hanson and Smith 1950).

The Southeast Population was later re-defined to include only those Canada geese that wintered in the Mississippi Flyway, and was called the Tennessee Valley Population (TVP; Mississippi Flyway Council 1958, Cummings 1973). The TVP breeding area depicted by Cummings (1973) included Akimiski Island and mainland areas of southwestern James Bay south of Attawapiskat, Ontario that were bounded in the east at approximately the Quebec-Ontario border. In 1974, TVP counts in the mid-December survey declined by 24% from the previous year, despite restrictive regulations being in effect in the Mississippi Flyway (bag limit of 1 bird per day, reduced season length). Coincidentally, some preliminary banding began on Akimiski Island, James Bay in the summer of 1974, and a relatively high number of direct recoveries was noted from the Pymatuning area of northwestern Pennsylvania (MFCTS meeting minutes, July 1975). This led to discussions between the Mississippi Flyway and Pennsylvania, with the aim of coordinating harvest management strategies for TVP geese across flyway boundaries.

These three wintering populations (TVP, MVP, and EPP) eventually formed the basis for harvest management of Canada geese in the Mississippi Flyway. A Canada Goose Committee was established by the Mississippi Flyway Technical Section in 1956, and shortly thereafter, the first waterfowl management plan for the flyway was published (Mississippi Flyway Council

1958). The plan contained the basic framework for population management of Canada geese, and emphasized the importance of reliable information about: (a) population indices that related specific breeding populations with their respective areas of harvest, (b) the numbers present in the harvest area, and the proportion taken by hunters, and (c) survival rates as a measure of the effectiveness of regulations. The plan specifically proposed ‘regulating the harvest of species or population segments in relation to their status and ability to maintain that status by either liberalizing or restricting in response to major status changes’.

In the early years of the Mississippi Flyway, goose population status was indexed by winter surveys that were conducted in mid-December or January each year. Beginning in the 1960s, Canada geese counted during winter surveys were assigned to one of the three populations described by Hanson and Smith (1950) based on their geographic location. From a harvest management perspective, there was no distinction made between temperate-nesting Canada geese and those nesting in subarctic regions that wintered in the same areas, though it was recognized that wintering populations usually included more than one subspecies of Canada goose (e.g., Bellrose 1976). Some wintering areas in the flyway were known to be inhabited by Canada geese that nested in the same areas, and early winter counts referred to these geese as ‘unassigned’ (Hanson, R. C. 1967-1969, unpublished reports on the December survey). Later, they were designated as ‘maxima’ (Hawkins, A. S., and R. C. Hanson. 1970. Report on the December 1969 inventory of Canada geese in the Mississippi Flyway. Unpublished report, 7 pages.), after the realization by Hanson (1965) that giant Canada geese (*B. c. maxima*) were not, in fact, extinct. Nevertheless, harvest management recommendations in most areas of the flyway were still mainly based on the status of EPP, MVP, and TVP Canada geese. This focus on subarctic migrant populations would have important repercussions two decades later, when unprecedented growth of Canada goose populations in the southern portions of the flyway led to increasing human-goose conflicts, and calls for increased harvest opportunities to help control population growth of temperate-nesting Canada geese.

The Rise of Giant Canada Geese and the Advent of Special Seasons

The re-discovery of the giant Canada Goose (*Branta canadensis maxima*; Hanson 1965), a subspecies thought by some authorities to be extinct by the early 1950s (e.g., Delacour 1954), was another event of historical significance to Canada Goose management in the Mississippi Flyway. It led to widespread efforts to restore and protect this subspecies across the flyway, including re-introduction programs and conservative harvest management policies aimed at increasing population sizes of temperate-nesting (giant) Canada Geese in localized areas. Earlier concerns remained about equitable distribution of harvests and potential overharvesting on concentration areas, so Canada goose hunting regulations remained relatively conservative. In fact, regular season frameworks for Canada geese were 70 days, with a maximum of two birds per day (70/2), from 1956 until 1989. Despite these federal frameworks, hunting regulations for Canada geese were often much more restrictive than the frameworks allowed, as states attempted to encourage growth of locally nesting Canada geese or reduce harvest of migrants that were perceived to be in decline based on previous winter counts. For example, Canada goose seasons in Minnesota, Iowa, and much of Missouri were only 9, 23, and 21-30 days long, respectively in 1971 and 1972, and the season remained closed in Arkansas and Louisiana. At the same time, statewide harvest quotas for MVP Canada geese were only 28,000 birds in both Wisconsin and Illinois (compared to a quota of 100,000 in each state by 1982).

Under such restrictive regulations, mid-December counts of Canada geese increased steadily between 1969 and 1977 (Figure 1), and Canada goose harvests also increased from 1972 to 1978 (Figure 2). The high winter count of 1977 was followed by declining counts through 1981 before another long period of increase that continued through 1989 (Figure 1). Harvests remained relatively flat between 1979 and 1987, before a prolonged period of increasing harvest began that continued into the 2000s (Figure 2). Overall, both numbers and harvests of Canada geese increased under conservative harvest management policies that were in place from the early 1970s through at least the mid-1980s.

Winter counts were still being divided into population components based on geographic criteria in 1987, when there were 1,341,500 Canada geese tallied during the mid-December goose survey. Of these, giant Canada geese were thought to make up only 18.8%; MVP 54.8%; EPP 13.8%, and TVP 12.7% of the total. (By comparison, 2015 spring survey estimates totalled 2,121,532 Canada geese that were ~76% giant, 12% MVP, 9% EPP, and 3% SJBP Canada geese). Though giant (temperate-nesting) Canada geese were thought to make up a relatively small proportion of the flyway's Canada goose population at the time, they still increased more than seven-fold between 1969 and 1994 (Figure 3).

Federal hunting season frameworks for geese in the Mississippi Flyway usually stipulated that seasons must occur within the period between the Saturday nearest October 1 and mid- to late January, and were not to exceed 70 days in length. The first attempts to control temperate-nesting Canada geese through 'special seasons' began with extended seasons around urban areas of southeastern Michigan in 1977. Following a 50-day regular season that was concurrent with the duck season, Canada geese in these zones could be harvested between December 21 and February 15, with a 3-bird bag limit. In 1983, Michigan requested that these extended seasons be expanded to include southwestern portions of the state, but there were concerns over potential harvest of migrants, and the Flyway requested that an evaluation of existing long seasons be provided before further expansion of such experimental seasons was allowed. Meanwhile, winter counts of temperate-nesting Canada geese continued to increase across the flyway (Figure 3).

The first early September hunting seasons aimed at increasing harvest of temperate-nesting Canada geese in the Mississippi Flyway were initiated in Michigan in 1986, and other states soon followed suit. In 1987, the flyway developed evaluation guidelines to ensure that incidental harvest of migrant geese during special early seasons aimed at temperate-nesting geese did not add appreciably to regular season harvests. Early seasons with liberal bag limits continued to expand in almost every state and both provinces in the flyway, but regular seasons remained conservative, and protection of southern migrant cohorts remained a concern through the 1990s. Though regulations necessarily became more complex, harvests increased sharply after 1987 until they ultimately peaked in 2003 (Figure 2).

Monitoring Canada Geese on the Breeding Grounds

By the late 1980s, Flyway biologists were increasingly uncomfortable with their ability to differentiate migrant populations from locally nesting Canada geese during winter surveys. Babcock et al. (1990) pointed out that giant Canada geese were a rapidly increasing component of the flyway population of Canada geese, and that increasing management complexity required better information about population status of all populations. They recommended that breeding grounds surveys be refined, standardized, and expanded to include all populations in the flyway in order to obtain better population-specific estimates of abundance. Babcock et al. (1990) also suggested that too much emphasis had been placed on maintaining 'traditional' wintering distributions of migrant populations, and not enough attention had been paid to controlling populations of giant Canada geese that could potentially offer additional hunting opportunity. Their calls and others led to a fundamental shift in the focus of Canada goose management from a wintering ground to a breeding ground perspective. This entailed development of spring surveys that would take place when Canada goose populations were thought to be geographically discrete, and these eventually replaced winter counts as the main monitoring approach for all populations by the mid-1990s.

Surveys of EPP Canada geese on the breeding grounds were developed in the early 1970s (Malecki et al. 1981), and continued along with winter counts for many years before other breeding grounds surveys were developed. Population estimates from EPP spring surveys were similar to winter counts, or at least similar enough that they did not cause concerns at the time (Figure 4). The same was true for MVP Canada geese, i.e., when spring surveys of that population began in 1989, they were very similar to preceding winter counts (Figure 4; Tacha et al. 1998). At this point, switching from winter to spring monitoring seemed like it would be a straightforward transition. The first spring surveys of TVP Canada geese coincided with the re-definition of the population based on its breeding distribution, becoming the Southern James Bay Population (SJBP; Abraham et al. 2008; Appendix 1). However, population estimates of SJBP Canada geese in 1990 were significantly lower than expected based on counts in preceding winters, and did not increase much in subsequent years as the survey coverage was expanded (e.g., Leafloor et al. 1996; Rusch et al. 1996).

Coordinated state and provincial surveys of temperate-nesting Canada geese in the Mississippi Flyway began in the spring of 1993, and this led to another surprising result. Preliminary estimates were more than double the preceding winter surveys, and they continued to increase as survey efforts expanded and improved over the course of the next few years (Figure 4). Thus, it became clear by the mid-1990s that temperate-nesting Canada geese made up a much larger proportion of the flyway population than had been thought previously. At the same time, it was evident that mid-winter counts of SJBP Canada geese had in fact overestimated the size of that population (Leafloor et al. 1996). Overall, switching survey emphasis from wintering to breeding areas in the early 1990s led to an improvement in knowledge about the composition of the flyway population, which was increasingly dominated by temperate-nesting Canada geese.

Regulatory Complexity in the Face of Conflicting Objectives

Faced with the competing objectives of controlling growth of abundant Canada goose populations in the south, while conserving smaller migrant populations in the north, the 1990s were marked by increasing complexity of regulations in the Mississippi Flyway (reviewed by Leafloor et al. 2004). While there was a near continuous expansion of hunting opportunities during early and late special seasons aimed at harvesting more temperate-nesting geese, the regular season remained tightly regulated to control the harvest of subarctic migrants.

Besides lower than expected population estimates for SJBP Canada geese in the spring of 1990, the population experienced several years of low productivity in the early 1990s, and goslings banded on Akimiski Island had very low recovery rates, suggesting high mortality of goslings in late summer (Leafloor et al. 1996). This led to a decade of very restrictive regulations for SJBP Canada geese due in part to a perceived population decline or the realization the SJBP was much smaller than previously thought. Despite conservative regular season hunting regulations in SJBP harvest states, the population on Akimiski Island continued to decline, and habitat loss on Akimiski Island was ultimately implicated as the cause (Hill et al. 2003, Brook et al. 2015).

In MVP harvest states, an annual fall forecast model was used to estimate the “harvestable surplus” beginning in the early 1990s, and states were allocated an allowable harvest quota each year (Tacha and Thornburg 1998). The MVP quota system required more information, and more timely information, from the breeding grounds to permit calculation of fall flights on an annual basis. This system of harvest management also relied on having annual population-specific harvest estimates and a means to close the season when the quota was reached. Though considerable effort was put into improving harvest derivations, in the long run quotas and in-season harvest monitoring added significant cost and complexity to MVP harvest management, particularly in the high harvest states of Illinois and Wisconsin. In addition, the inherent variability of spring population surveys resulted in large annual fluctuations in fall flight forecasts, which in turn caused large year-to-year variation in harvest quotas. MVP quotas of ~100,000 birds in 1982 rose to 260,000 in 1988, 364,000 in 1989, and 500,000 in 1990, then fluctuated between 175,000-500,000 between 1991 and 2006. At the same time, there were suggestions that fall flight estimates could be biased high (Leafloor and Abraham 2000). All of this put a strain on the flyway, both economically and in terms of communication and the regulatory process in the United States. Thus, this attempt to manage harvest using quotas, as opposed to managing hunting opportunity, resulted in unstable regulations over much of the period from 1990 to 2006, when the MVP quota system was finally abandoned (Brook and Luukkonen 2010).

In 1990, the population objective for EPP Canada geese was raised from 200,000 to 300,000 birds in response to the fact that the population had grown over time. Efforts to maintain higher numbers, combined with indications of poor production in some years in the early 1990s, led to regular season harvest restrictions aimed at reducing EPP harvests by 25-50% in the western portions of the Mississippi Flyway. Hunting regulations varied from ‘baseline’ (70/2 in most areas during the regular season) to more restrictive throughout the 1990s until the mid-2000s.

By the early 2000s, most options for trying to control increasing numbers of temperate-nesting Canada geese through increased harvest had been exhausted, and still the population continued to increase. Most states in the flyway had very liberal early season bag limits for the first 2-3 weeks of September, and several had liberal bag limits during late seasons, but regular season regulations remained relatively restrictive to protect stocks of subarctic-nesting migrants from the Southern James Bay, Mississippi Valley, and Eastern Prairie Populations. Although these measures were successful in shifting harvest pressure toward temperate-nesting Canada geese, and increasing harvests overall, Canada goose harvest in the Mississippi Flyway eventually peaked at about 1.1 million birds in 2003, before declining through 2015 (Figure 2). Meanwhile, hunting regulations for Canada geese in much of the United States and southern Canada remained most restrictive when populations were at their peak, and when the largest number of waterfowl hunters was active in each state, i.e., during the regular season.

Simplifying Canada Goose Management

More than 50 years of growth in numbers of temperate-nesting Canada geese inevitably led to increasing conflicts between people and geese, particularly in urban areas (USFWS 2005), and prompted biologists to re-think Canada goose management in the Flyway. In addition to increasing numbers, there was increasing recognition that temperate-nesting geese overlapped with subarctic-nesting migrant populations during most of the year. Molt migrations to subarctic nesting areas involved geese from virtually every state and province in the flyway (e.g., Abraham et al. 1999), and Luukkonen et al. (2008) estimated that more than half of the population of temperate-nesting Canada geese in the Mississippi Flyway could undergo molt migrations in any given year. Thus, molt migrants from temperate nesting areas likely made up a substantial proportion of the fall flight in most years, further complicating attempts to separately manage subarctic- and temperate-nesting geese, particularly during the regular season.

By the early 2000s, it was recognized that attempts to maintain subarctic populations of Canada geese at relatively high levels came at the cost of less hunting opportunity during the regular season, reduced ability to control growth of temperate-nesting Canada geese, and annual hunting regulations that were necessarily more complicated and variable as a result. This led to a gradual change in philosophy for managing Canada geese in the Mississippi Flyway, and management plans for subarctic-nesting Canada geese were subsequently modified to make regular season hunting regulations more simple, liberal, and stable. This shift in management approach entailed changes to population objectives for subarctic-nesting Canada geese, and was at least partly aimed at testing the notion that increased numbers of temperate-nesting geese in the fall might effectively buffer migrant populations from overharvest if regular season regulations were made more liberal (e.g., Abraham et al. 2008; Brook and Luukkonen 2010). Instead of objectives aimed at maintaining or increasing subarctic populations, the flyway adopted minimum threshold objectives, which allowed hunting regulations to be liberalized, as long as subarctic populations remained above those thresholds. The thresholds were nominally based on the lowest population sizes that had been observed during the history of spring surveys, with the idea being that subarctic populations had continued to thrive despite experiencing such low levels in the past.

Among the first changes enacted to simplify regulations was the elimination of MVP harvest quotas in 2006, in favor of harvest management through changes in season length and bag limits in MVP harvest areas. In addition, concentration areas that were previously identified as SJBP, MVP, and EPP harvest zones were eliminated across the flyway, allowing consistent regulations to be applied over larger geographic areas within states. Gradual liberalizations of regular season regulations were also enacted in concert with periods of stabilized regulations in order to facilitate analysis of potential impacts on migrant Canada geese. EPP harvest states were the first to allow bag limits of 3 Canada geese per day during the regular season in 2009, and to date the population has remained stable. Likewise, moderate changes to regulations in SJBP and MVP harvest areas have not had any obvious deleterious effects so far, and overall harvests have actually declined in recent years, despite regular season liberalizations (Figure 2).

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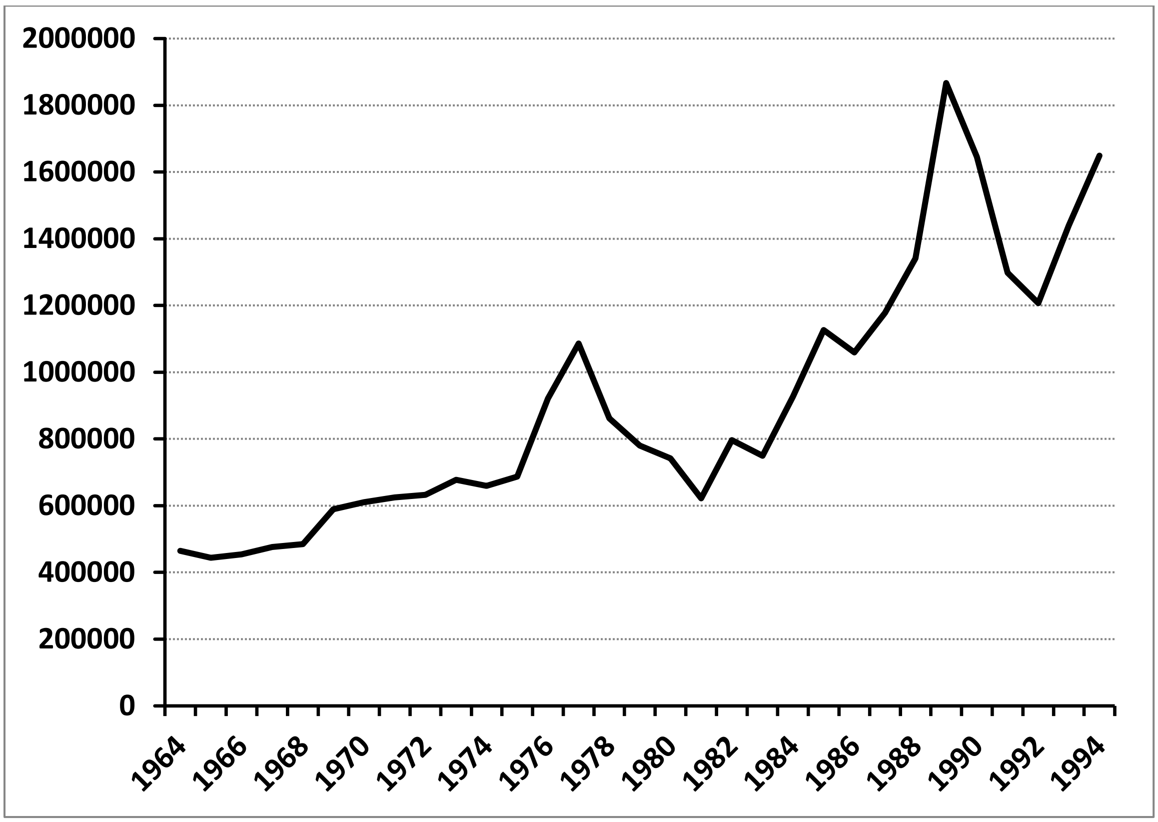

Figure 1. Midwinter counts of Canada geese in the Mississippi Flyway, 1964-1994.

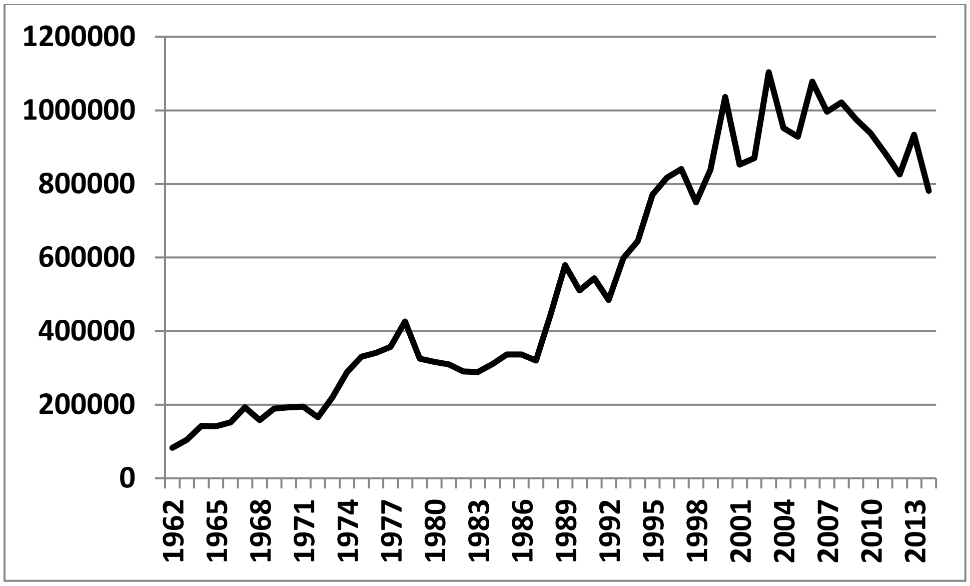

Figure 2. Estimates of annual harvest of Canada geese in the Mississippi Flyway, 1962-2014.

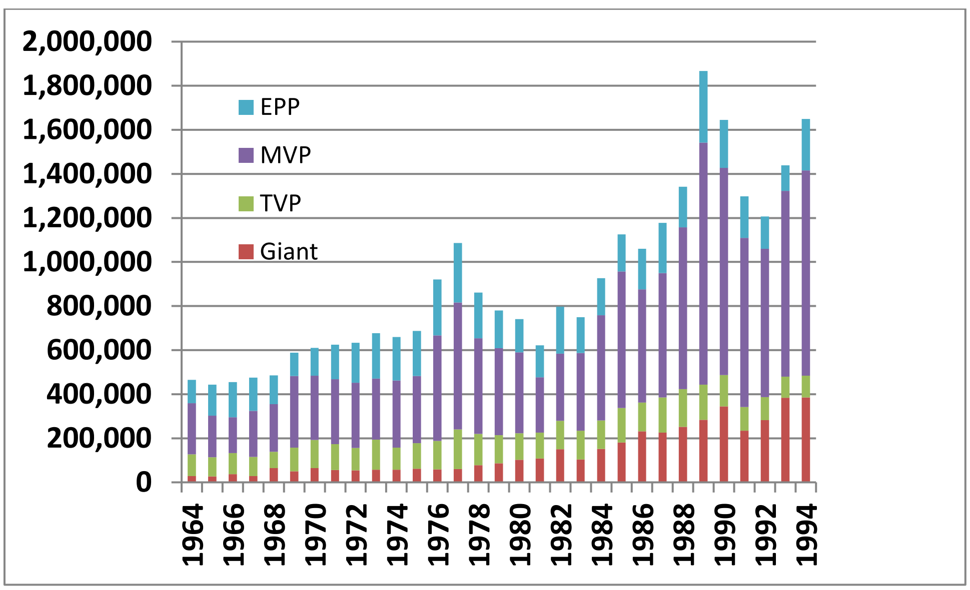

Figure 3. Population composition of mid-December counts, 1964-1994.

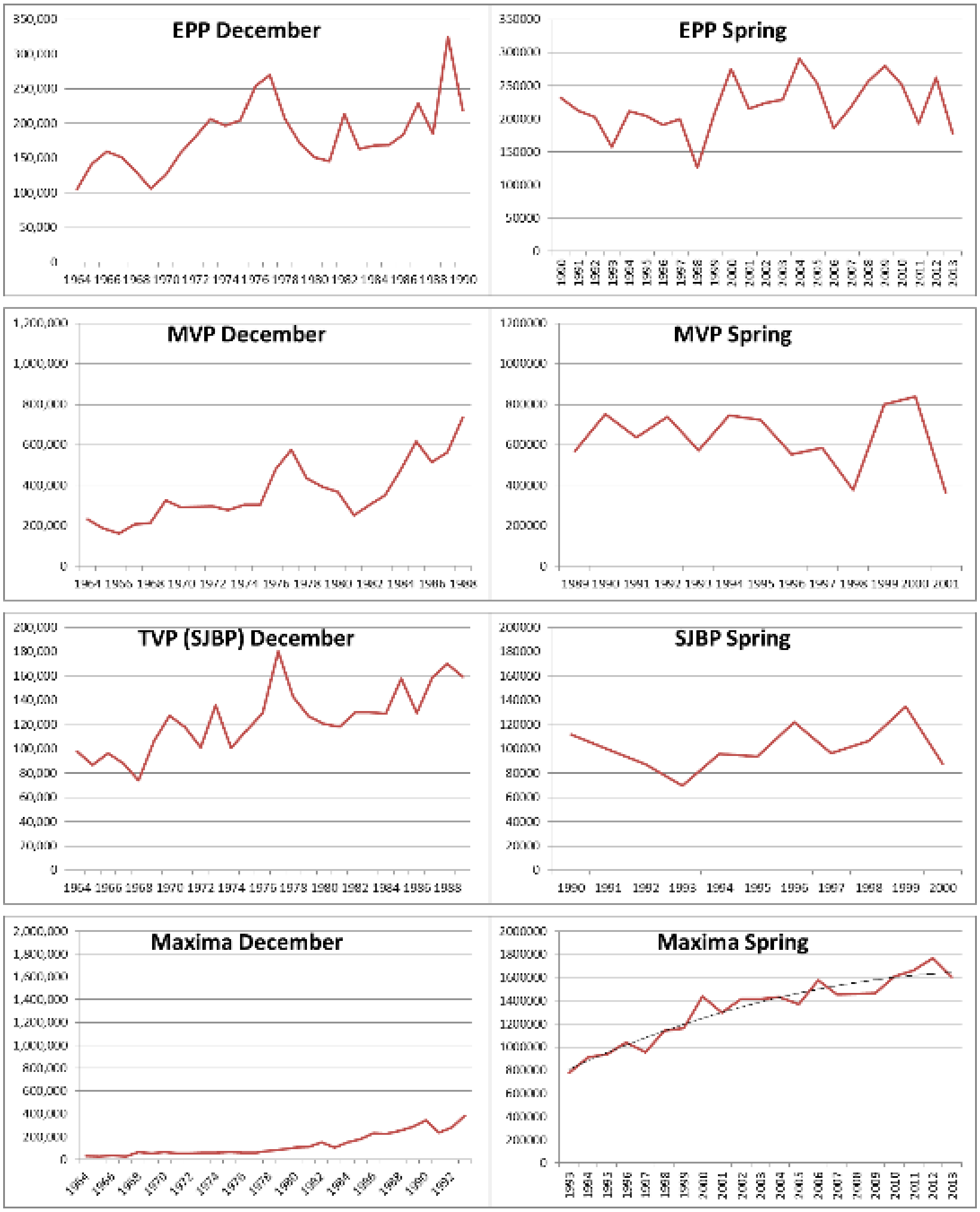

Figure 4. Comparison of winter counts to spring population estimates for (from top to bottom) EPP, MVP, SJBP, and giant (temperate-nesting) Canada geese.

Appendix B: Refinement of the Breeding Range Boundary Between SJBP and AP Canada Geese

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February 12, 2016

Hanson and Smith (1950) were the first to delineate two populations of Canada geese that nested in the Hudson Bay Lowlands of northern Ontario and Manitoba and wintered mainly in the Mississippi Flyway [i.e., the Eastern Prairie Population (EPP), and Mississippi Valley Population (MVP)]. They also described the South Atlantic Population that nested in northern Quebec and wintered in the Atlantic Flyway, and the Southeast Population that wintered in southern portions of both flyways. The Southeast Population was identified as a small population that nested in a narrow range at the southern tip of James Bay, and wintered in southeastern states of both the Atlantic (Virginia, North Carolina, South Carolina, Georga) and Mississippi Flyways (Alabama). North of the Moose River in Ontario, the population was thought to merge with the Mississippi Valley Population, and east of the Nottaway River in Quebec, it merged with the South Atlantic Population. The narrow area between the Moose River and Nottaway River (an east-west distance of approximately 100 km, or 60 miles) was presumably considered to be the main nesting area of the Southeast Population (Hanson and Smith 1950; Appendix A).

Consistent with population management that was based on a wintering ground perspective, the Southeast Population was later re-defined to include only those Canada geese that wintered in the Mississippi Flyway (Cummings 1973), and was called the Tennessee Valley Population (TVP; Mississippi Flyway Council 1958). Most analyses to support the new delineation were based on winter banding data from states in the Mississippi Flyway, and perhaps not surprisingly, recovery data provided little evidence of interchange between the Atlantic and Mississippi Flyways. Recovery data from Canada geese banded on Akimiski Island showed that for those that were banded between 1955 and 1959, ~22% of recoveries occurred in the Atlantic Flyway, mostly in Virginia and North Carolina. By contrast, only ~3% of direct recoveries from birds banded in 1971 on Akimiski Island occurred in the Atlantic Flyway, all of them in Pennsylvania (2) and Maryland (1). Combined, these data were still considered corroborative to those from winter-banded geese in the Mississippi Flyway, i.e., that most band recoveries from Akimiski Island occurred in the Mississippi Flyway. The TVP breeding range depicted by Cummings (1973) was also based on band recoveries from winter banding, and included Akimiski Island and mainland areas of southwestern James Bay south of Attawapiskat, Ontario that were bounded on the east side of Hannah Bay, at approximately the Quebec-Ontario border. Curiously, a few additional recoveries occurred north and east of there in northern Quebec, but these were considered AP Canada geese and were ignored. Likewise, 3-4% of winter recaptures and recoveries in the core TVP wintering range of the Mississippi Flyway came from birds banded in the Povungnituk region of northern Quebec, but these were considered to be ‘wondering (sic) non-breeders of the TVP’, and were also ignored. The proportion of cross-flyway recoveries evidently was not considered a significant impediment to independent harvest management by the Atlantic and Mississippi Flyways at that time.

In 1974, TVP counts in the mid-December survey declined by 24% from the previous year, despite restrictive regulations being in effect in the Mississippi Flyway (bag limit of 1 bird per day, reduced season length). Coincidentally, additional banding had been conducted on Akimiski Island in the summer of 1974, and 29 direct recoveries (representing ~16% of direct recoveries) were noted from the Pymatuning area of Pennsylvania (MFCTS meeting minutes, July 1975). Bednarik and Lumsden (1977) later evaluated banding data from Akimiski Island for the years 1971, 1974, and 1976, and found that Pennsylvania accounted for 20% of direct recoveries; the rest of the Atlantic Flyway accounted for only ~3.5% of direct recoveries. This represented a significant change in distribution of recoveries from the 1950s, and corresponded with declining numbers of migrant geese on southern wintering areas in both flyways (e.g., Orr et al. 1998). Bednarik and Lumsden (1977) recommended that harvest be reduced in the major harvest areas (Ontario, Pennsylvania, and Michigan), which together accounted for ~67% of band recoveries from Akimiski Island. At the same time, a draft management plan for TVP Canada geese that was appended to their report made no mention of Canada geese harvested in any portion of the Atlantic Flyway, and regarded all recoveries that occurred east of 79ºW longitude as belonging to the 'South Atlantic' harvest area. Importantly, the TVP harvest area illustrated in the plan was west of 79ºW, and included the Pymatuning area in northwestern Pennsylvania.

Trost et al. (1998) examined recoveries from 1971-1987 bandings that occurred on the southern James Bay mainland and offshore islands, and found that Pennsylvania accounted for 14% of direct recoveries from Akimiski Island, while the rest of the flyway accounted for about 4% of recoveries from there. They noted that recovery distributions from mainland bandings north of the Moose River to Fort Albany were similar to those from Akimiski Island, but that those from islands (i.e., Charlton and Twin Islands) and mainland areas in southeastern James Bay were mainly associated with the Atlantic Flyway. Trost et al. (1998) concluded that the original description of the Southeast Population by Hanson and Smith (1950) still applied, and recommended that the geese nesting on Akimiski Island be re-named as the Southern James Bay Population to reflect a shift toward management of Canada geese from a breeding ground perspective. They made no specific recommendations about population boundaries on the mainland or with respect to other offshore islands in southern James Bay, but recommended additional surveys and banding aimed at further refinement of the population boundaries (Trost et al. 1998). [Note: Though published in 1998, this paper was written in 1990 for the 1991 Canada Goose Symposium in Milwaukee, WI, and followed the re-naming of TVP to SJBP at a special meeting in Lansing, MI in 1989.].

When spring surveys of SJBP Canada geese were initiated in 1990, the survey area included mainland areas south of the Attawapiskat River, westward to 84ºW longitude, southward to 50ºN latitude, and eastward to the Ontario-Quebec border at approximately 79º30'W (Leafloor et al. 1996; Figure 1). Geese nesting north of the Attawapiskat River belonged to the Mississippi Valley Population, and it was noted that most geese (~85%) banded in the area near the Quebec-Ontario border were recovered in the Atlantic Flyway, though no actual recovery data were presented (Leafloor et al. 1996). Likewise, Trost et al. (1998) indicated that most recoveries from birds banded (east of 80ºW) on Charlton and Twin Islands, and on the mainland near the Quebec-Ontario border, occurred in the Atlantic Flyway, but no data were included. Nonetheless, this was in stark contrast to the proportion of geese from

Akimiski Island that were recovered in the Atlantic Flyway (~18%) between 1971 and 1987, and the vast majority of those recoveries occurred in northwestern Pennsylvania (Trost et al. 1998). In summary, most geese banded west of 80ºW longitude in southern James Bay were recovered in the Mississippi Flyway, while most geese banded east of 80ºW were recovered in the Atlantic Flyway. Though such discrepancies in band recovery distributions have been noted previously, there has never been a formal evaluation to determine an appropriate east-west boundary to separate SJBP from AP Canada geese. Based on the fragmentary evidence available, we suggest that the breeding range boundary between AP and SJBP Canada geese would be better placed at 80ºW, and not at the Ontario-Quebec border (79º30'W).

We used the most current 5-year period of banding and hunter recovery data to determine flyway affiliation of breeding geese by 10-minute block of banding. We excluded Canadian recovery data from the analysis, and used all available recovery data (i.e., both direct and indirect recoveries) for birds banded between 2010 and 2014 on the SJBP breeding range, and from the Atlantic Population (AP) breeding range west of 73ºW longitude. For each 10-minute block, we calculated the proportion of band recoveries from each flyway, and estimated the Euclidian distance between recoveries in each pair of blocks (Gower and Legendre 1986). We then conducted a cluster analysis using the Ward method (Ward 1963), and constructed a dendrogram (Figure 2) and a cluster diagram (Figure 3) based on 2 potential clusters (i.e., one for each flyway). Results confirmed that band recoveries from birds banded in 10-minute blocks east of 80ºW clustered with those dominated by AP band returns from the Atlantic Flyway, and those to the west (including Akimiski Island) clustered with the Mississippi Flyway. There was one exception where a 10-minute block just south of the Moose River (Figure 3) resulted in 100% Atlantic Flyway band returns for the period; however, that result was based on only 4 band returns in the 5-year period.

The Mississippi Flyway Council Technical Section is in the midst of overhauling its approach to population management of Canada geese. The exercise is aimed at managing Canada geese on a larger geographic scale in order to reduce regulatory complexity and improve efficiency of monitoring programs. As part of this undertaking, three subarctic populations of Canada geese (EPP, MVP, and SJBP) will be combined into a single entity that will be managed within the Mississippi Flyway. This presents some challenges, because the Southern James Bay Population is currently managed jointly by the Atlantic and Mississippi Flyways. In order to reduce complexity in promulgating annual regulations, we propose that the mainland boundaries between SJBP and AP Canada geese be moved westward from 79º30'W to 80ºW, a distance of <40 km. This would allow each flyway to regulate Canada goose harvests independently, without jeopardizing the welfare of Canada geese in each flyway. We expand on our rationale below.

Canada geese nesting east of 80ºW should be considered as part of the Atlantic Population (AP), and should be managed independently by the Atlantic Flyway. Though a small number of Canada geese that nest east of this boundary are harvested in the Mississippi Flyway, they are insignificant to the status of AP Canada geese, and should be ignored. Of the SJBP Canada geese banded west of 80ºW from 2010-2014, ~93% of direct recoveries occurred in the Mississippi Flyway (Table 1). About 11% of direct band recoveries from Canada geese banded on Akimiski Island occurred in the Atlantic Flyway from 2010-2014 (Table 1), and we suggest that these should be ignored also, because they represent relatively few geese. Numbers of Canada geese on Akimiski Island declined from about 76,000 in 1985 (Leafloor et al. 1996) to fewer than 10,000 in 2015, and this decline was most likely due to habitat loss that reduced recruitment (Brook et al. 2015), and not due to excessive harvest. In spring 2015, there were an estimated 9269 adult Canada geese on Akimiski Island (Brook and Badzinski 2015), about 1100 of which would be expected to migrate to the Atlantic Flyway with their goslings. By comparison, the 2015 spring population index for AP Canada geese was 864,000 birds, including at least 161,000 breeding pairs (Harvey et al. 2015), and AFRP Canada geese numbered close to 1 million birds (Roberts and Padding 2015). Attempting to manage harvest of SJBP Canada geese in the Atlantic Flyway would be akin to managing AP harvest in the Mississippi Flyway, and does not appear to be justified, especially if the proposed boundary at 80ºW is adopted. Most of the shared range between AP and SJBP Canada geese occurs on the breeding grounds or during migration at the Ohio-Pennsylvania border, and not during winter. Therefore, harvest management in the Mississippi Flyway is unlikely to affect the status of Canada geese that originate in James Bay and winter in the Atlantic Flyway.

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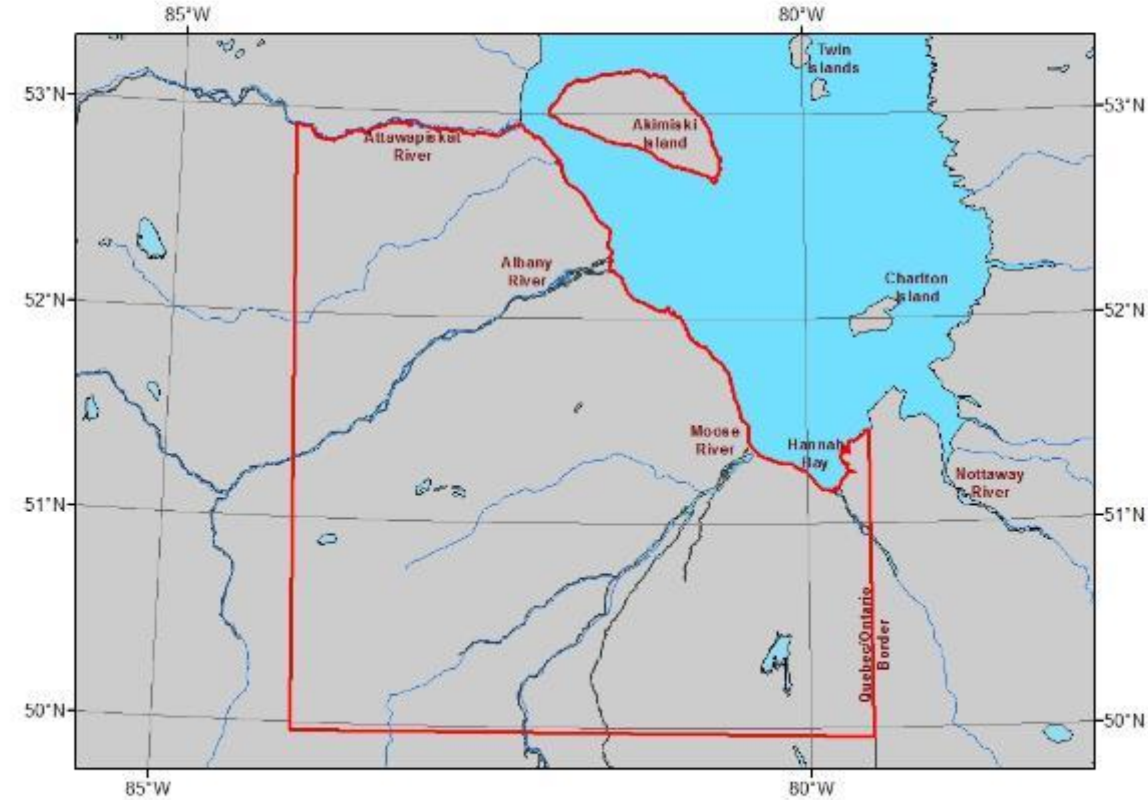

Figure 1. Breeding survey area (outlined in red) and assumed breeding range of the Southern James Bay Population of Canada geese in 1996 (Leafloor et al. 1996).

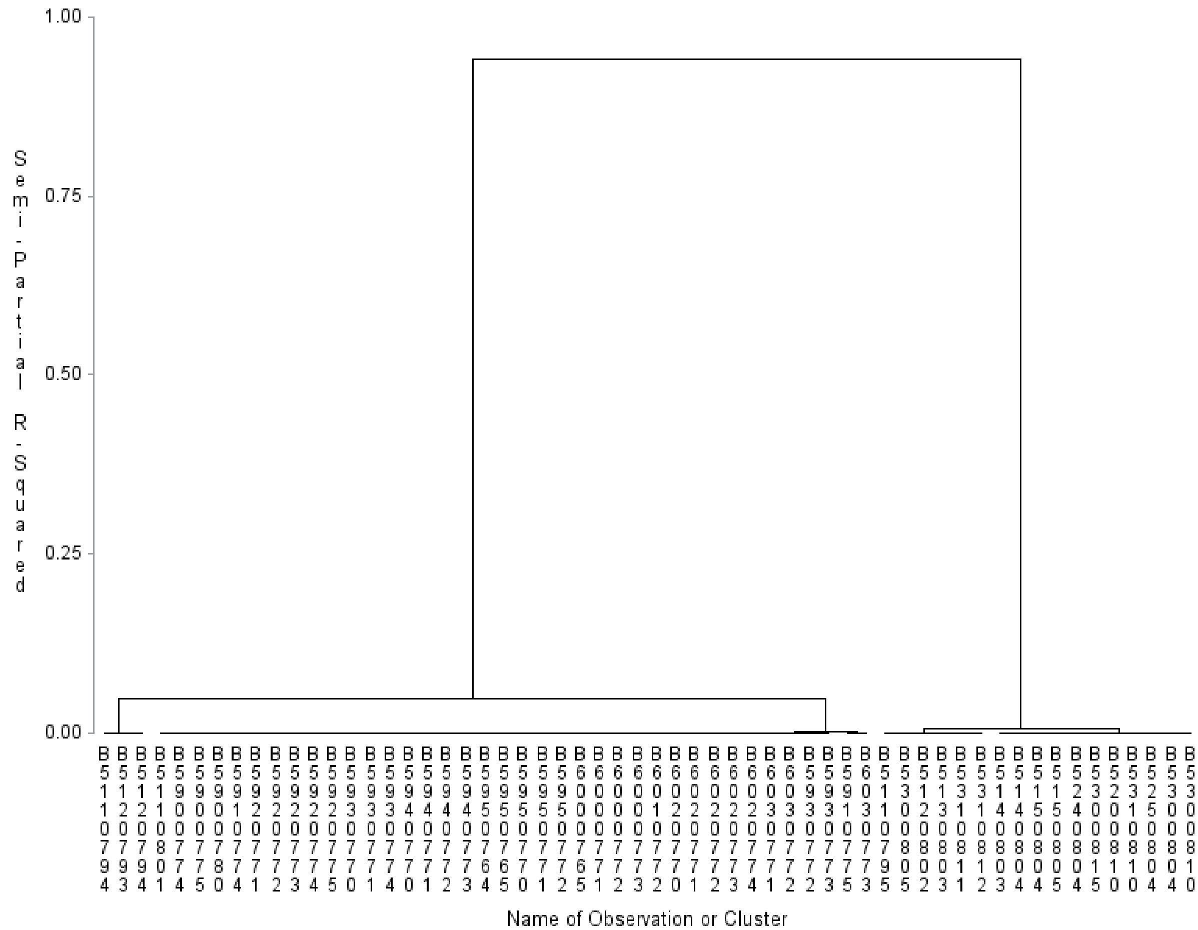

Figure 2. Dendrogram depicting clusters of band recoveries in the Mississippi and Atlantic Flyways for Canada geese banded in 10-minute blocks from Ungava, Quebec, the southern James Bay mainland in Ontario, and Akimiski Island, Nunavut regions. Blocks starting “B59…” or “B60…” are in Ungava, and blocks starting “B53…” are on Akimiski Island. Except for B5110801, all other 10-minute blocks on the mainland of southern James Bay (B5110794, B5120793, B5120794) clustered more closely with Ungava blocks than with Southern James Bay blocks. Canada goose densities are very low in most mainland areas, and B5110801 had only 4 band recoveries in the 5 years considered.

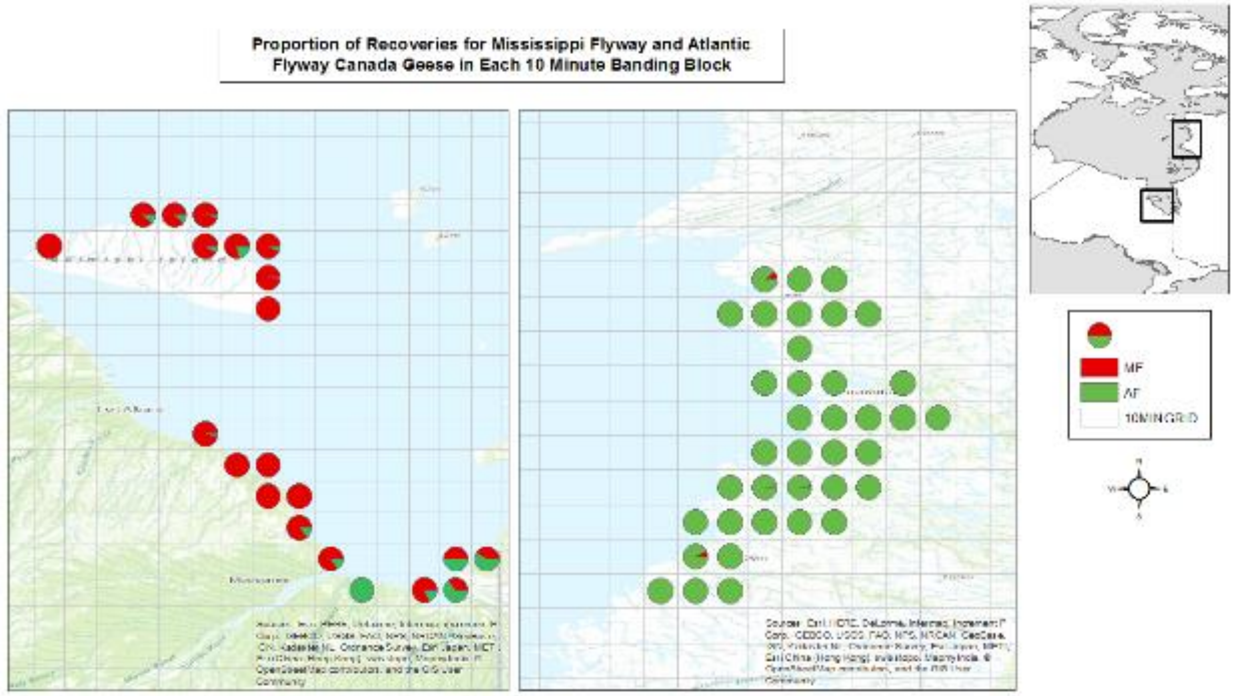

Figure 3. Proportion of band recoveries from the U.S. portion of the Mississippi and Atlantic Flyways by 10-minute block of banding on SJBP and AP breeding areas for the period 2010 to 2014. Atlantic Flyway recoveries are represented in green, Mississippi Flyway recoveries in red.

Table 1. Number of total and direct recoveries by state of Canada geese banded in the southern James Bay mainland of Ontario and on Akimiski Island, Nunavut from 2010-2014, inclusive.

Recovery region	Total recoveries	Direct recoveries
Akimiski Island		
Maryland	22	9
New York	10	3
North Carolina	4	2
Pennsylvania	45	19
South Carolina	6	6
Virginia	11	1
West Virginia	4	1
Alabama	2	0
Illinois	5	3
Indiana	8	4
Kentucky	23	5
Michigan	210	96
Ohio	486	216
Wisconsin	3	1
TOTAL	**839**	**366**
% MF recoveries	**88**	**89**
Southern James Bay East of 80 Degrees		
Maryland	8	1
New York	10	6
North Carolina	1	0
Pennsylvania	13	3
Virginia	5	1
West Virginia	1	0
Michigan	5	4
Ohio	22	7
Wisconsin	1	0
TOTAL	**66**	**22**
% MF recoveries	**42**	**50**
Southern James Bay West of 80 Degrees		
New York	2	0
North Carolina	1	1
Pennsylvania	14	1
Virginia	2	1
West Virginia	2	2
Indiana	9	3
Kentucky	6	3
Michigan	62	33
Ohio	68	29
Wisconsin	2	1
TOTAL	**168**	**74**
% MF recoveries	**88**	**93**

Appendix C: Mississippi Flyway Canada Goose Harvest Derivation

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August 19, 2016

Harvest derivation analyses combine abundance and banding data to estimate the proportion of various stocks in the overall harvest. This information can aid managers in developing harvest regulations and evaluating their impact. This is an important consideration for goose harvest in the Mississippi Flyway (MF), which is composed of temperate, sub-arctic, and Arctic geese. The last comprehensive MF Canada goose (CAGO) harvest derivation analysis was completed in 2010 (Moser 2010), and there was interest to have updated information. To this end, I conducted a harvest derivation analysis with primary focus on the Mississippi Flyway. Methodologies and population delineations differ between this analysis and Moser (2010), and any discrepancies should be considered within that context. Below is a description of the methods used for this analysis.

I used banding records obtained from the USGS Bird Banding Lab (BBL) from 1960 to 2015 and recoveries of these geese through the 2015 hunting season (i.e., the 2015–2016 hunting season; herein referenced by the first year). As general filters for banding records (i.e., see below for additional filters per population), I used all Canada/Cackling goose AOU species codes (i.e., 1720, 1721, 1722, 1723, and 1729), known age (i.e., juvenile or adult), known or unknown sex (male, female, or unknown), only summer bandings during May–Aug, and only original banded, normal wild, and standard and control metal band only records (i.e., no reward bands, no transmitters, no other markers, etc.). I used only shot or found dead recoveries during Sep–Feb and fall/winter/hunting seasons; inexact month or year encounters were excluded. Direct recoveries were geese shot during the first hunting season after banding. Indirect recoveries were geese shot after the first hunting season after banding.

MF breeding populations were defined as follows (F. Baldwin, R. Brook, and J. Leafloor pers. comm.):

1) *Midcontinent Cackling Geese (MC_Cack):* In Canada above 60N and only AOU species code 1729 (i.e., small Canada geese); this follows delineation of K. Dufour (CWS, [unpubl. data]), and Lincoln population estimates using this delineation were used for band weighting (see more below).

2) Eastern Prairie Population CAGO (EPP): In Manitoba between 57.3–60.0N and 92.4–97.2W; an additional date filter (only included bandings during 25 July–30 Aug during the 1980s and 1990s) was used to exclude non-breeding geese that were banded during that time period (F. Baldwin, pers. comm).

3) *Mississippi Valley Population CAGO (MVP):* North of Attawapiskat in Ontario to the Nelson River in Manitoba (i.e., broken into two segments: [52.9-57.3N; 82.07-87.0W] and [54.4-57.3N; 87.0-92.4W]).

4) *Southern James Bay Population CAGO (SJBP):* Ontario mainland between 50-52.9N and 79.5-82.5W plus Akimiski Island (i.e., broken into three segments: [52.6-53.3N; 80.5-81.5W], [52.81-53.3N; 81.5-82.0W], and [52.92-53.21N; 82.0-82.17W]).

5) *Ontario Mississippi Flyway Giant CAGO (MFG_ON):* In Ontario south of 50N.

6) *Manitoba Mississippi Flyway Giant CAGO (MFG_MB):* In Manitoba south of 51N.

7) *Mississippi Flyway Giants in U.S. States:* The entire state boundary was used. State abbreviations were used for nomenclature or *MFG_STs* or *MFG_STs_MB_ON* when pooled. Pooled estimates for EPP, MVP, and SJBP were also presented and the nomenclature Hudson Bay Population (*HUDP*) was used.

Additionally, all Atlantic (AF) CAGO populations and the Central Flyway (CF) temperate CAGO population were included in the analysis, which represent nearly all direct and indirect recoveries that occurred within the MF and AF. Delineation of AF populations generally followed Klimstra and Padding (2012) except as noted:

8) *North Atlantic Population CAGO (NAP)*: all of Newfoundland and Labrador and portion of Quebec between 48.0–52.0N and east of 66.0W (i.e., no species code 1729 – small Canada geese).

9) *Atlantic Population CAGO (AP)*: portion of Quebec north of 52.0N and between 48.0–52.0N and west of 66.0W (i.e., no species code 1729 – small Canada geese). Included as a single population, whereas Klimstra and Padding (2012) used two separate groupings for AP CAGO (i.e., Hudson Bay and Ungava Bay).

10) *Atlantic Flyway Resident Population CAGO (AFRP)*: all AF States and the Provinces of Quebec, New Brunswick, Prince Edward Island, and Nova Scotia south of 48.0N.

11) *Central Flyway Resident Population CAGO (CFRP)*: all CF States (i.e., using jurisdictional boundaries for West-Tier Split States [not BBL Flyway Code]) and the Provinces of Alberta and Saskatchewan south of 51.0N.

Recovery regions were defined as individual states for the MF and as aggregate for Pacific Flyway (PF), CF, and AF lower 48 states (i.e., *PF_Sts*, *CF_Sts*, and *AF_Sts*). For Canada, MB and ON were defined separately, and remaining portions of Canada, excluding MB and ON, were divided east and west of 101.0W (i.e., *CAN_E101_woutMB_ON* and *CAN_W101_woutMB_ON*). All other recovery regions were defined as “Other”.

Analysis output was provided per five year period from 1961–2015 (*due to length, only some output was included in this Appendix*). For all year periods, banding and recovery maps and a table of direct recovery rates (drr = direct recoveries/# bands), harvest rates (dhr = drr/reporting rate), and max kill rates (dkr = dhr/[1-crippling loss]) of juveniles and adults (separate and combined) were provided. For reporting rates during 1961–2000, I averaged the annual estimates provided by K. Dufour (CWS, unpubl. data for Midcontinent Cackling Geese) and R.

Alisauskas (CWS unpubl. data for midcontinent white-fronted geese), which were derived from model-based approaches or taken from other source material. For 2001–2015, I used an overall reporting rate estimate of 0.74 based upon Flyway-wide estimates from the reward band study of Zimmerman et al. (2009; e.g., AF = 0.737, MF = 0.742, CF = 0.749; PF = 0.745; Canada = 0.706). For all year periods, I also included a direct and indirect+direct recovery summary table of each population and for each recovery region.

For 1996–2015, I included tables of adult harvest derivation for recovery regions of all MF States, ON, MB, AF States (as one group) and Eastern Canada (as one group). Harvest derivation was based on adult recoveries (i.e., adult direct recoveries+all indirect recoveries) during a given time period, a pre-breeding total population size during spring/summer, and a band weighting factor. For a given year range, I calculated the band weighting factor as the average adult population size divided by the average number of available adult bands in the population per year. The number of available adult bands in the population was calculated as the total number of adult direct recoveries+indirect recoveries divided by the adult direct recovery rate. This weighting follows similar methodology of Moser (2010), except restricted only to adults and pre- breeding spring/summer populations estimates (i.e., similar to Klimstra and Padding [2012]). Prior MF derivation analyses used a band weighting based on a 3-year summation of predicted fall population sizes (i.e., based on the spring/summer population estimate and various measures of productivity) divided by the total estimated number of bands in the population (i.e., total direct and indirect recoveries of juveniles and adults divided by the overall direct recovery rate; Moser 2010). In an initial analysis, I included a band weighting based only on adult direct recoveries following Klimstra and Padding (2012). However, use of direct recoveries did not represent overall harvest well for Manitoba and Ontario, which included a substantive number of indirect recoveries of geese banded in MF States as well as some indirect recoveries from geese banded in AF and CF states. For most MF States, particularly those with large banding and recovery sample sizes, recovery distribution of different populations was rather proportional between direct and indirect recoveries, and the percent harvest derivation was similar between the two weighting schemes. For MF and AF population estimates, I used the pre-breeding total population size estimates included in Fronczak (2015) or USFWS (2015), except for Midcontinent Cackling Geese which were based on Lincoln estimates (K. Dufour, CWS, [unpubl. data]). Lincoln estimates were reduced by half to make them more comparable to count survey indices (J. Leafloor, pers. comm.). Comprehensive annual estimates for CF resident/temperate Canada geese were not available. Estimates during 1990–2000 were based on Gabig (2000), and the most recent estimate of ~1 million geese was used for subsequent years. Comprehensive population estimates for Mississippi Flyway Giant CAGO started in 1994, so I was unable to do similar harvest derivation estimates for preceding year ranges.

Also of note, Moser (2010) restricted the breeding populations of Midcontinent Cackling geese (i.e., formerly just Tall-Grass Prairie) and MF Giant Canada geese in Ontario and Manitoba to the longitudinal ranges that coincided to recoveries primarily within just the MF. As noted above, I included broader delineations for these populations and expanded the analyses to include other populations in the AF and CF as well as other recovery regions. Also, Moser (2010) used a weighting based upon juveniles and adults, and applied the calculated percent harvest derivation to the annual Canada goose Federal harvest estimates to derive the total harvest of each population. I did not include these same estimates. If doing so, the percent harvest derivation was only calculated for adults and consideration should be given as to whether juvenile percent harvest estimates similarly approximate the adult percent harvest estimates as well as the potential bias of the Federal harvest estimate (see Padding and Royle 2012). For MF and AF States, ON, MB, and Eastern Canada recovery regions, essentially all direct and indirect recoveries were from the populations defined in the analyses. Population delineation and inclusion was incomplete for the CF, PF, and Western Canada recovery regions (thus, not included in harvest derivation analyses), and an expanded analysis that incorporates additional CAGO populations may be worth considering in the future. Additionally, for all populations, a general, Flyway-wide reporting rate was used to derive harvest estimates, and harvest rate estimates could be further enhanced with inclusion of additional population- or harvest region-specific reporting estimates.

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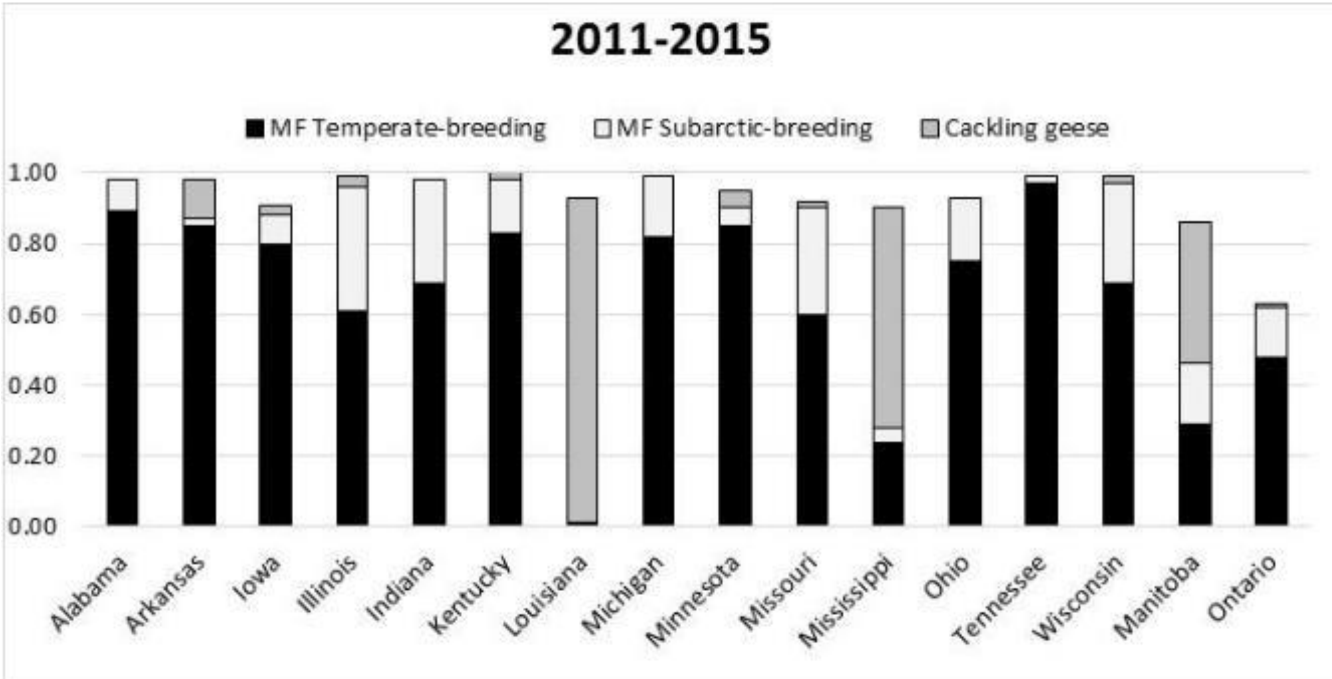
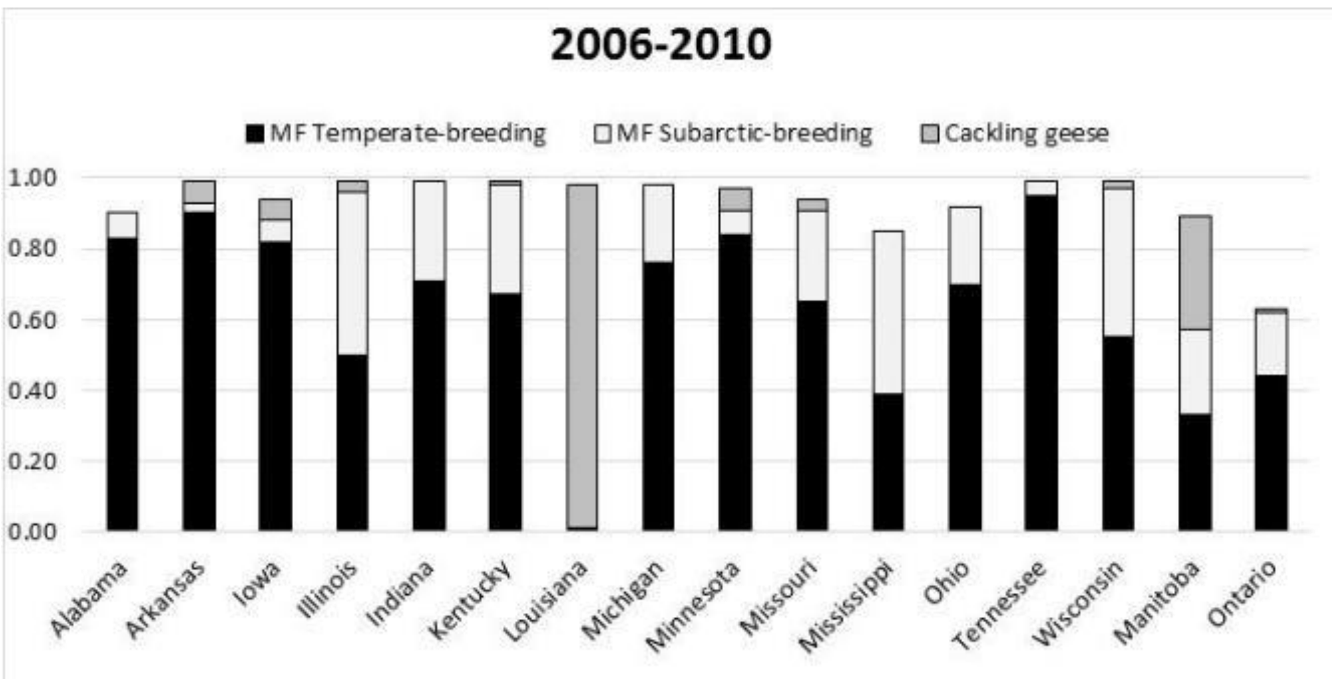
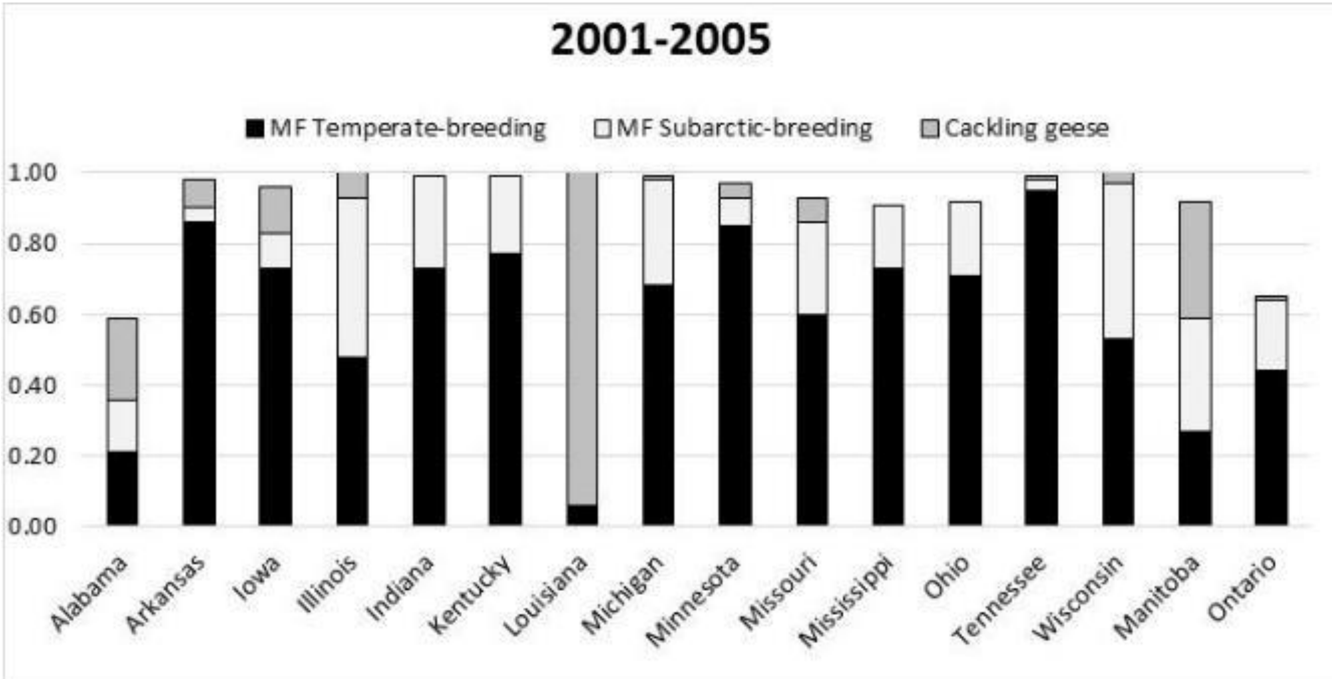

2011-2015
MF Temperate-breeding
MF Subarctic-breeding
Cackling geese
1.00
0.80
0.60
0.40
0.20
0.00
Alabama
Arkansas
Iowa
Illinois
Indiana
Kentucky
Louisiana
Michigan
Minnesota
Missouri
Mississippi
Ohio
Tennessee
Wisconsin
Manitoba
Ontario


2006-2010
MF Temperate-breeding
MF Subarctic-breeding
Cackling geese
1.00
0.80
0.60
0.40
0.20
0.00
Alabama
Arkansas
Iowa
Illinois
Indiana
Kentucky
Louisiana
Michigan
Minnesota
Missouri
Mississippi
Ohio
Tennessee
Wisconsin
Manitoba
Ontario



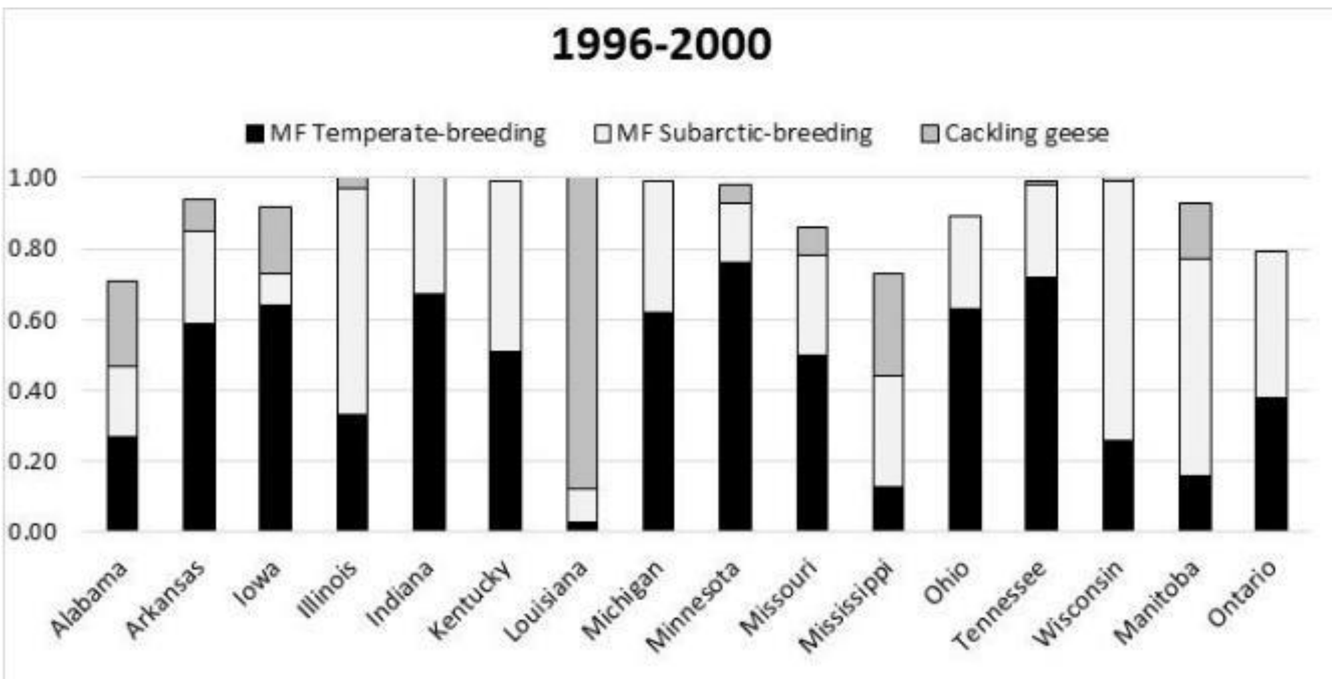
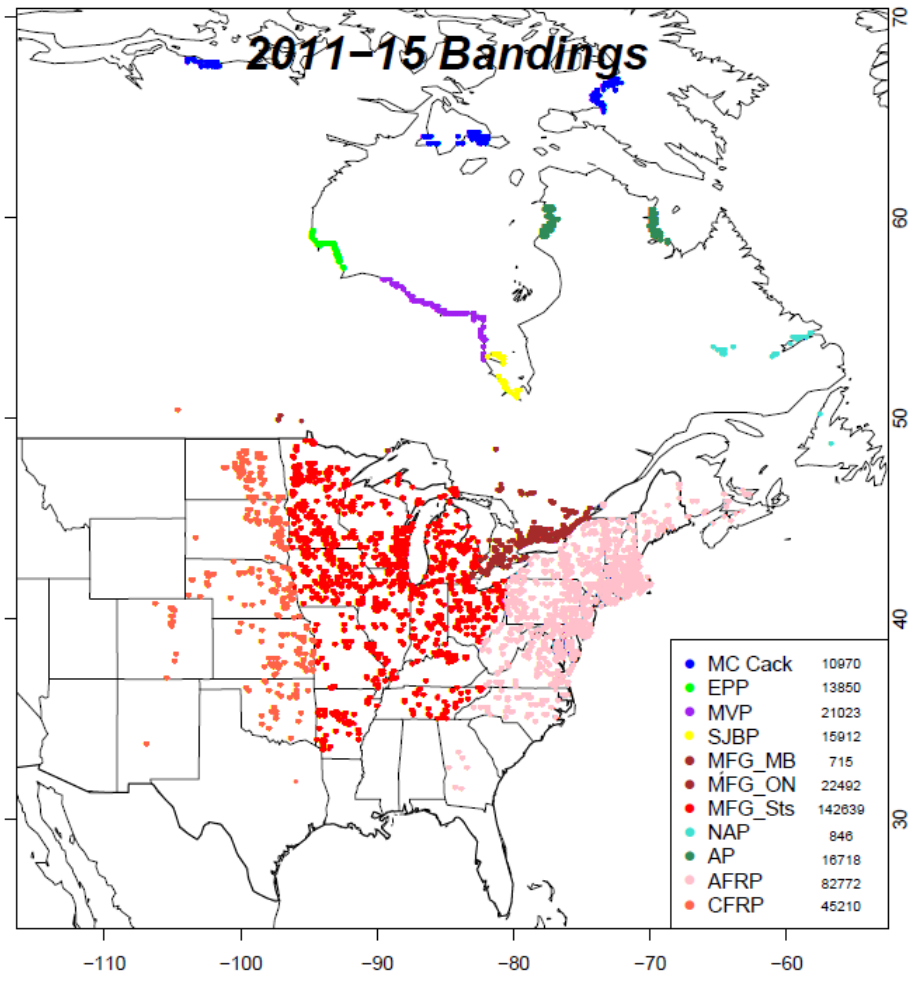
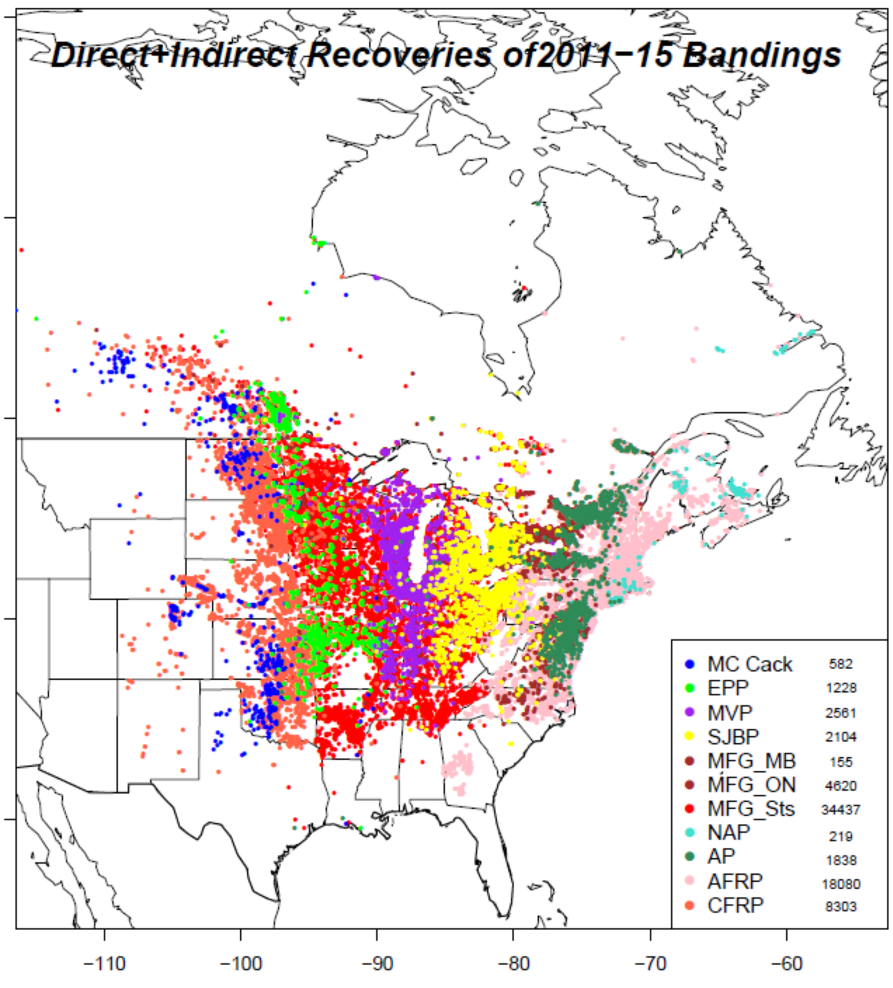


Figure 1. Proportional contribution of Mississippi Flyway temperate- and subarctic-breeding Canada geese and cackling geese to state and provincial harvests in the Mississippi Flyway based on recoveries of adult geese, 1996-2015 by five year period. Harvest proportions do not sum to 1 for states and provinces that harvested birds from breeding areas outside of the Mississippi Flyway.

Supplemental Figures. Mississippi Flyway harvest derivation analysis output for 2011–2015.





2011−15 Bandings − Direct Recovery Harvest Summary

Number Bandings (NBand), Number direct recoveries (Ndrec), direct recovery rate (drr), direct harvest rate (dhr), and direct kill rate (dkr)

all = all bandings; juv = juvenile; ad=adult

Population	Nband_all	Ndrec_all	drr_all	dhr_all	dkr_all	Nband_juv	Ndrec_juv	drr_juv	dhr_juv	dkr_juv	Nband_ad	Ndrec_ad	drr_ad	dhr_ad	dkr_ad
MC_Cack	10970	245	0.02	0.03	0.04	2085	10	0.00	0.00	0.00	8885	235	0.03	0.04	0.05
EPP	13850	728	0.05	0.07	0.09	9733	521	0.05	0.07	0.09	4117	207	0.05	0.07	0.09
MVP	21023	1395	0.07	0.09	0.12	12436	881	0.07	0.09	0.12	8587	514	0.06	0.08	0.11
SJBP	15912	1073	0.07	0.09	0.12	7210	325	0.05	0.07	0.09	8702	748	0.09	0.12	0.16
HUDP	50785	3196	0.06	0.08	0.11	29379	1727	0.06	0.08	0.11	21406	1469	0.07	0.09	0.12
MFG	165846	17774	0.11	0.15	0.20	99443	11789	0.12	0.16	0.21	66403	5985	0.09	0.12	0.16
MFG_STs	142639	15785	0.11	0.15	0.20	83282	10345	0.12	0.16	0.21	59357	5440	0.09	0.12	0.16
MFG_MB	715	66	0.09	0.12	0.16	533	53	0.10	0.14	0.19	182	13	0.07	0.09	0.12
MFG_ON	22492	1923	0.09	0.12	0.16	15628	1391	0.09	0.12	0.16	6864	532	0.08	0.11	0.15
AL	0	0	0.00	0.00	0.00	0	0	0.00	0.00	0.00	0	0	0.00	0.00	0.00
AR	6627	491	0.07	0.09	0.12	1022	50	0.05	0.07	0.09	5605	441	0.08	0.11	0.15
IA	17697	1654	0.09	0.12	0.16	12235	1236	0.10	0.14	0.19	5462	418	0.08	0.11	0.15
IL	15930	1892	0.12	0.16	0.21	10827	1424	0.13	0.18	0.24	5103	468	0.09	0.12	0.16
IN	11221	817	0.07	0.09	0.12	3166	263	0.08	0.11	0.15	8055	554	0.07	0.09	0.12
KY	6135	468	0.08	0.11	0.15	765	44	0.06	0.08	0.11	5370	424	0.08	0.11	0.15
LA	0	0	0.00	0.00	0.00	0	0	0.00	0.00	0.00	0	0	0.00	0.00	0.00
MI	16761	2038	0.12	0.16	0.21	12115	1473	0.12	0.16	0.21	4646	565	0.12	0.16	0.21
MN	17518	2602	0.15	0.20	0.27	13677	2131	0.16	0.22	0.29	3841	471	0.12	0.16	0.21
MO	9327	568	0.06	0.08	0.11	3606	197	0.05	0.07	0.09	5721	371	0.06	0.08	0.11
MS	0	0	0.00	0.00	0.00	0	0	0.00	0.00	0.00	0	0	0.00	0.00	0.00
OH	12374	1286	0.10	0.14	0.19	8478	914	0.11	0.15	0.20	3896	372	0.10	0.14	0.19
TN	7726	777	0.10	0.14	0.19	754	74	0.10	0.14	0.19	6972	703	0.10	0.14	0.19
WI	21323	3192	0.15	0.20	0.27	16637	2539	0.15	0.20	0.27	4686	653	0.14	0.19	0.25
NAP	846	108	0.13	0.18	0.24	650	92	0.14	0.19	0.25	196	16	0.08	0.11	0.15
AP	16718	1030	0.06	0.08	0.11	9502	664	0.07	0.09	0.12	7216	366	0.05	0.07	0.09
AFRP	82772	8761	0.11	0.15	0.20	33720	3627	0.11	0.15	0.20	49052	5134	0.10	0.14	0.19
CFRP	45210	3884	0.09	0.12	0.16	21795	2057	0.09	0.12	0.16	23415	1827	0.08	0.11	0.15

drr = Ndrec/Nband

dhr = drr/0.74; ~0.74 reporting rate

dkr = dhr/0.75; ~0.25 crippling rate

2011−15 Bandings − Direct+Indirect Recovery Summary

Breeding Population (POP) Number of direct+indirect recoveries (Nrec) of juveniles and adults (all) within each recovery region

Population	POPNrec_all	MB	ON	AL	AR	IA	IL	IN	KY	LA	MI	MN	MO	MS	OH	TN	WI	AF_Sts	CF_Sts	PF_Sts	CAN_E101_woutMB_ON	CAN_W101_woutMB_ON	Other
MC_Cack	582	84	2	0	5	1	4	0	2	1	0	18	0	0	0	0	2	2	392	0	0	69	0
EPP	1228	464	4	0	6	73	103	1	3	1	0	150	259	0	1	2	27	0	131	0	0	3	0
MVP	2561	8	60	4	0	4	796	271	54	0	496	12	3	0	36	13	792	9	1	0	2	0	0
SJBP	2104	1	661	3	0	0	6	58	62	0	398	2	0	0	685	0	6	202	0	0	20	0	0
HUDP	5893	473	725	7	6	77	905	330	119	1	894	164	262	0	722	15	825	211	132	0	22	3	0
MFG	39212	632	3770	71	1123	3231	5177	1981	1261	2	3699	4640	1725	15	2860	1355	5215	1377	862	0	151	64	1
MFG_STs	34437	563	721	71	1122	3223	5119	1941	1243	2	3562	4585	1713	15	2739	1354	5140	336	848	0	79	61	0
MFG_MB	155	66	0	0	0	8	2	0	0	0	1	48	11	0	0	0	1	0	14	0	1	3	0
MFG_ON	4620	3	3049	0	1	0	56	40	18	0	136	7	1	0	121	1	74	1041	0	0	71	0	1
AL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AR	1116	1	0	0	1069	0	3	0	0	0	1	4	9	6	0	17	0	1	5	0	0	0	0
IA	4312	184	3	0	7	2764	286	2	4	0	7	500	236	0	0	0	75	0	217	0	0	27	0
IL	4116	112	16	0	4	86	3403	46	19	0	14	181	20	4	4	9	175	0	19	0	0	4	0
IN	2090	6	34	27	0	5	64	1504	161	1	124	11	1	0	29	6	64	44	5	0	3	1	0
KY	1028	0	13	3	0	1	16	25	880	0	22	3	2	0	15	25	5	9	1	0	8	0	0
LA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MI	4250	4	335	0	6	0	40	159	101	0	3161	3	1	0	256	5	82	61	0	0	36	0	0
MN	5023	128	7	0	0	252	234	4	2	0	6	3408	311	0	0	2	99	0	546	0	0	24	0
MO	1611	65	1	2	34	36	144	3	3	1	5	122	1113	5	2	3	34	0	38	0	0	0	0
MS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OH	3115	0	278	0	0	1	5	28	14	0	164	0	0	0	2427	1	11	156	0	0	30	0	0
TN	1444	0	6	39	1	1	7	6	36	0	2	0	0	0	1	1274	3	63	4	0	1	0	0
WI	6332	63	28	0	1	77	917	164	23	0	56	353	20	0	5	12	4592	2	13	0	1	5	0
NAP	219	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	103	0	0	116	0	0
AP	1838	0	178	0	0	0	0	1	0	1	3	0	0	0	0	0	1	1344	2	0	308	0	0
AFRP	18080	0	403	1	1	0	2	1	2	0	29	1	0	0	175	3	6	15884	4	0	1568	0	0
CFRP	8303	226	2	0	2	70	15	0	1	0	2	130	113	2	0	1	19	0	7569	12	0	139	0

2011−15 Bandings − Direct Recovery Summary

Breeding Population (POP) Number of direct recoveries (Ndrec) of juveniles and adults (all) within each recovery region

Population	POPNdrec_all	MB	ON	AL	AR	IA	IL	IN	KY	LA	MI	MN	MO	MS	OH	TN	WI	AF_Sts	CF_Sts	PF_Sts	CAN_E101_woutMB_ON	CAN_W101_woutMB_ON	Other
MC_Cack	245	38	2	0	2	1	4	0	1	1	0	12	0	0	0	0	2	0	152	0	0	30	0
EPP	728	314	1	0	2	40	45	0	1	1	0	88	144	0	1	1	9	0	79	0	0	2	0
MVP	1395	0	29	2	0	1	418	126	25	0	306	4	0	0	18	8	456	1	1	0	0	0	0
SJBP	1073	0	340	1	0	0	4	24	32	0	220	1	0	0	339	0	3	98	0	0	11	0	0
HUDP	3196	314	370	3	2	41	467	150	58	1	526	93	144	0	358	9	468	99	80	0	11	2	0
MFG	17774	24	1382	26	502	1554	2665	917	611	0	1717	1972	807	9	1423	762	2551	485	361	0	4	1	1
MFG_STs	15785	2	77	26	502	1552	2639	894	600	0	1687	1936	803	9	1381	761	2521	37	357	0	1	0	0
MFG_MB	66	22	0	0	0	2	0	0	0	0	0	33	4	0	0	0	0	0	4	0	0	1	0
MFG_ON	1923	0	1305	0	0	0	26	23	11	0	30	3	0	0	42	1	30	448	0	0	3	0	1
AL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AR	491	0	0	0	477	0	0	0	0	0	0	0	2	3	0	8	0	0	1	0	0	0	0
IA	1654	0	0	0	2	1376	105	1	0	0	0	22	114	0	0	0	0	0	34	0	0	0	0
IL	1892	0	1	0	2	1	1850	15	6	0	0	2	2	3	0	5	4	0	1	0	0	0	0
IN	817	0	0	13	0	0	8	702	71	0	15	0	0	0	3	1	1	2	1	0	0	0	0
KY	468	0	0	0	0	0	7	17	429	0	0	0	0	0	1	14	0	0	0	0	0	0	0
LA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MI	2038	0	66	0	3	0	23	70	53	0	1664	0	1	0	129	0	28	1	0	0	0	0	0
MN	2602	1	0	0	0	147	116	2	1	0	0	1815	176	0	0	0	28	0	316	0	0	0	0
MO	568	1	0	2	17	0	40	0	0	0	0	5	496	3	0	2	0	0	2	0	0	0	0
MS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OH	1286	0	10	0	0	0	0	2	5	0	8	0	0	0	1248	0	0	13	0	0	0	0	0
TN	777	0	0	11	1	0	1	0	19	0	0	0	0	0	0	722	0	21	1	0	1	0	0
WI	3192	0	0	0	0	28	489	85	16	0	0	92	12	0	0	9	2460	0	1	0	0	0	0
NAP	108	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	53	0	0	55	0	0
AP	1030	0	99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	734	1	0	196	0	0
AFRP	8761	0	63	0	1	0	0	0	0	0	0	1	0	0	55	0	0	8218	2	0	421	0	0
CFRP	3884	0	0	0	1	24	3	0	0	0	0	7	67	0	0	0	2	0	3766	3	0	11	0

2011−15 Bandings − Direct+Indirect Recovery Summary

Recovery Region (RecReg) Number of direct+indirect recoveries (Nrec) of juveniles and adults (all) of each breeding population

RecReg	RecRegNrec_all	MC_Cack	EPP	MVP	SJBP	HUDP	MFG	MFG_STs	MFG_MB	MFG_ON	AL	AR	IA	IL	IN	KY	LA	MI	MN	MO	MS	OH	TN	WI	NAP	AP	AFRP	CFRP	OutsideDerivPops
MB	1418	64	464	8	1	473	632	563	66	3	0	1	184	112	6	0	0	4	128	65	0	0	0	63	0	0	0	226	3
ON	5081	2	4	60	661	725	3770	721	0	3049	0	0	3	16	34	13	0	335	7	1	0	278	6	28	0	178	403	2	1
AL	80	0	0	4	3	7	71	71	0	0	0	0	0	0	27	3	0	0	0	2	0	0	39	0	0	0	1	0	1
AR	1137	5	6	0	0	6	1123	1122	0	1	0	1069	7	4	0	0	0	6	0	34	0	0	1	1	0	0	1	2	0
IA	3380	1	73	4	0	77	3231	3223	8	0	0	0	2764	86	5	1	0	0	252	38	0	1	1	77	0	0	0	70	1
IL	6103	4	103	796	6	905	5177	5119	2	56	0	3	286	3403	64	16	0	40	234	144	0	5	7	917	0	0	2	15	0
IN	2313	0	1	271	58	330	1981	1941	0	40	0	0	2	46	1504	25	0	159	4	3	0	28	6	184	0	1	1	0	0
KY	1385	2	3	54	62	119	1281	1243	0	18	0	0	4	19	161	880	0	101	2	3	0	14	38	23	0	0	2	1	0
LA	5	1	1	0	0	1	2	2	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0
MI	4627	0	0	496	398	894	3699	3562	1	136	0	1	7	14	124	22	0	3161	6	5	0	184	2	56	0	3	29	2	0
MN	4953	18	150	12	2	184	4640	4585	48	7	0	4	500	181	11	3	0	3	3408	122	0	0	0	353	0	0	1	130	0
MO	2100	0	259	3	0	262	1725	1713	11	1	0	9	236	20	1	2	0	1	311	1113	0	0	0	20	0	0	0	113	0
MS	17	0	0	0	0	0	15	15	0	0	0	6	0	4	0	0	0	0	0	5	0	0	0	0	0	0	0	2	0
OH	3757	0	1	36	685	722	2880	2739	0	121	0	0	0	4	29	15	0	258	0	2	0	2427	1	5	0	0	175	0	0
TN	1374	0	2	13	0	15	1355	1354	0	1	0	17	0	9	6	25	0	5	2	3	0	1	1274	12	0	0	3	1	0
WI	6068	2	27	792	6	825	5215	5140	1	74	0	0	75	175	64	5	0	82	99	34	0	11	3	4502	0	1	6	19	0
AF_Sts	18921	2	0	9	202	211	1377	336	0	1041	0	1	0	0	44	9	0	61	0	0	0	156	63	2	103	1344	15884	0	0
CF_Sts	9178	392	131	1	0	132	882	848	14	0	0	5	217	19	5	1	0	0	546	38	0	0	4	13	0	2	4	7569	217
PF_Sts	3373	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	3361
CAN_E101_woutMB_ON	2165	0	0	2	20	22	151	79	1	71	0	0	0	0	3	8	0	38	0	0	0	30	1	1	116	308	1568	0	0
CAN_W101_woutMB_ON	585	69	3	0	0	3	64	61	3	0	0	0	27	4	1	0	0	0	24	0	0	0	0	5	0	0	0	139	310

2011−15 Bandings − Direct Recovery Summary

Recovery Region (RecReg) Number of direct recoveries (Ndrec) of juveniles and adults (all) of each breeding population

RecReg	RecRegNdrec_all	MC_Cack	EPP	MVP	SJBP	HUDP	MFG	MFG_STs	MFG_MB	MFG_ON	AL	AR	IA	IL	IN	KY	LA	MI	MN	MO	MS	OH	TN	WI	NAP	AP	AFRP	CFRP	OutsideDerivPops
MB	376	38	314	0	0	314	24	2	22	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
ON	1916	2	1	29	340	370	1382	77	0	1305	0	0	0	1	0	0	0	66	0	0	0	10	0	0	0	99	63	0	0
AL	29	0	0	2	1	3	26	26	0	0	0	0	0	0	13	0	0	0	0	2	0	0	11	0	0	0	0	0	0
AR	508	2	2	0	0	2	502	502	0	0	0	477	2	2	0	0	0	3	0	17	0	0	1	0	0	0	1	1	0
IA	1621	1	40	1	0	41	1554	1552	2	0	0	0	1376	1	0	0	0	0	147	0	0	0	0	28	0	0	0	24	1
IL	3139	4	45	418	4	467	2865	2839	0	28	0	0	105	1850	8	7	0	23	116	40	0	0	1	489	0	0	0	3	0
IN	1067	0	0	126	24	150	917	894	0	23	0	0	1	15	702	17	0	70	2	0	0	2	0	85	0	0	0	0	0
KY	670	1	1	25	32	58	611	600	0	11	0	0	0	6	71	429	0	53	1	0	0	5	19	16	0	0	0	0	0
LA	2	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MI	2243	0	0	306	220	526	1717	1687	0	30	0	0	0	0	15	0	0	1664	0	0	0	8	0	0	0	0	0	0	0
MN	2085	12	88	4	1	93	1972	1936	33	3	0	0	22	2	0	0	0	0	1815	5	0	0	0	92	0	0	1	7	0
MO	1018	0	144	0	0	144	807	803	4	0	0	2	114	2	0	0	0	1	176	496	0	0	0	12	0	0	0	67	0
MS	9	0	0	0	0	0	9	9	0	0	0	3	0	3	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
OH	1636	0	1	18	339	358	1423	1381	0	42	0	0	0	0	3	1	0	129	0	0	0	1248	0	0	0	0	55	0	0
TN	771	0	1	8	0	9	762	761	0	1	0	8	0	5	1	14	0	0	0	2	0	0	722	9	0	0	0	0	0
WI	3023	2	9	456	3	468	2551	2521	0	30	0	0	0	4	1	0	0	26	26	0	0	0	0	2460	0	0	0	2	0
AF_Sts	9589	0	0	1	98	99	485	37	0	448	0	0	0	0	2	0	0	1	0	0	0	13	21	0	53	734	8218	0	0
CF_Sts	4429	152	79	1	0	80	361	357	4	0	0	1	34	1	1	0	0	0	316	2	0	0	1	1	0	1	2	3766	67
PF_Sts	1799	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1796
CAN_E101_woutMB_ON	687	0	0	0	11	11	4	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	1	0	55	196	421	0	0
CAN_W101_woutMB_ON	80	30	2	0	0	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	36

2011−15 Adult Recoveries & Adult Geese per Adult Band

Number of adults (N_ad) based on spring/summer population counts/estimates; Direct recovery rate of adults (drr_ad)
Number of adult recoveries during year range (Ndrec_ad.NIndrec; adult direct recoveries and all indirect recoveries)
Number of adult bands available in population during year range (NTOTbandavail_ad) and per year (NPERYRbandavail_ad) [Ndrec_ad.NIndrec/drr_ad]
Weight (wt_NPERband_ad) for calculating % harvest derivation (i.e., how many adult geese a band represents [N_ad/NPERYRbandavail_ad]

Population	N_ad	Ndrec_ad.NIndrec	drr_ad	NTOTbandavail_ad	NPERYRbandavail_ad	wt_NPERband_ad
MC_Cack	1859485	1416	0.03	47200	9440	197.0
EPP	212714	1349	0.05	26980	5396	39.4
MVP	362977	2952	0.06	49200	9840	36.9
SJBP	81130	3099	0.09	34433	6887	11.8
MFG_MB	99070	404	0.07	5771	1154	85.8
MFG_ON	87033	5152	0.08	64400	12880	6.8
AL	48360	0	0.00	0	0	0.0
AR	44651	1686	0.08	21075	4215	10.6
IA	87213	5633	0.08	70412	14082	6.2
IL	107130	5007	0.09	55633	11127	9.6
IN	92042	3533	0.07	50471	10094	9.1
KY	32865	1483	0.08	18538	3708	8.9
LA	3980	0	0.00	0	0	0.0
MI	249010	4986	0.12	41550	8310	30.0
MN	320112	6388	0.12	53233	10647	30.1
MO	59466	2603	0.06	43383	8677	6.9
MS	30800	0	0.00	0	0	0.0
OH	135811	4492	0.10	44920	8984	15.1
TN	84998	2174	0.10	21740	4348	19.5
WI	141183	6757	0.14	48264	9653	14.6
NAP	175751	183	0.08	2288	458	383.7
AP	882159	3086	0.05	61720	12344	71.5
AFRP	979105	23829	0.10	238290	47658	20.5
CFRP	1000000	8302	0.08	103775	20755	48.2

2011−15 Adult Recoveries & Weighted % Adult Harvest Derivation

Recovery Region (RecReg) Number of adult recoveries during year range (Ndrec_ad.Nindrec; adult direct recoveries and all indirect recoveries)
Weighted total (wtTOT) goose harvest (adult direct recoveries * population wt [adult geese/band]);
Proportion of total harvest (prop.h) of adults ['pop'_wtTOT/TOT_wtTOT]

RecReg	Ndrec_ad.Nindrec	MC_Cack	EPP	MVP	SJBP	HUDP	MFG	NAP	AP	AFRP	CFRP	MC_Cack_wtTOT	EPP_wtTOT	MVP_wtTOT	SJBP_wtTOT	HUDP_wtTOT	MFG_wtTOT	NAP_wtTOT	AP_wtTOT	AFRP_wtTOT	CFRP_wtTOT	TOT_wtTOT	MC_Cack_prop.h	EPP_prop.h	MVP_prop.h	SJBP_prop.h	HUDP_prop.h	MFG_prop.h	NAP_prop.h	AP_prop.h	AFRP_prop.h	CFRP_prop.h
MB	1940	192	384	24	1	409	1062	0	0	0	277	37824	15130	886	12	16028	28045	0	0	0	13351	95248	0.40	0.16	0.01	0.00	0.17	0.29	0.00	0.00	0.00	0.14
ON	6462	3	3	78	936	1017	4518	2	325	594	3	591	118	2878	11045	14041	46663	767	23238	12177	145	97622	0.01	0.00	0.03	0.11	0.14	0.48	0.01	0.24	0.12	0.00
AL	117	0	0	3	5	8	107	0	0	2	0	0	0	111	59	170	1626	0	0	41	0	1837	0.00	0.00	0.06	0.03	0.09	0.89	0.00	0.00	0.02	0.00
AR	1734	12	11	2	1	14	1704	0	0	1	3	2364	433	74	12	519	17943	0	0	20	145	20991	0.11	0.02	0.00	0.00	0.02	0.85	0.00	0.00	0.00	0.01
IA	4014	7	82	10	0	92	3835	0	0	1	79	1379	3231	369	0	3600	34551	0	0	20	3808	43358	0.03	0.07	0.01	0.00	0.08	0.80	0.00	0.00	0.00	0.09
IL	6947	18	118	908	8	1034	5872	0	4	7	12	3546	4649	33505	94	38248	67245	0	286	144	578	110047	0.03	0.04	0.30	0.00	0.35	0.61	0.00	0.00	0.00	0.01
IN	3541	0	1	349	95	445	3085	0	7	4	0	0	39	12878	1121	14038	33161	0	500	82	0	47781	0.00	0.00	0.27	0.02	0.29	0.69	0.00	0.01	0.00	0.00
KY	1959	2	5	60	85	150	1802	0	1	3	1	394	197	2214	1003	3414	19235	0	72	62	48	23225	0.02	0.01	0.10	0.04	0.15	0.83	0.00	0.00	0.00	0.00
LA	8	5	0	0	0	0	2	0	1	0	0	985	0	0	0	0	16	0	72	0	0	1073	0.92	0.00	0.00	0.00	0.00	0.01	0.00	0.07	0.00	0.00
MI	5657	2	0	474	575	1049	4542	0	10	52	2	394	0	17491	6785	24276	119364	0	715	1066	96	145911	0.00	0.00	0.12	0.05	0.17	0.82	0.00	0.00	0.01	0.00
MN	7004	51	206	35	3	244	6553	0	0	2	154	10047	8116	1292	35	9443	157448	0	0	41	7423	184402	0.05	0.04	0.01	0.00	0.05	0.85	0.00	0.00	0.00	0.04
MO	2943	5	337	19	0	356	2500	0	0	0	82	985	13278	701	0	13979	28015	0	0	0	3952	46931	0.02	0.28	0.01	0.00	0.30	0.60	0.00	0.00	0.00	0.08
MS	27	3	0	1	0	1	21	0	0	0	2	591	0	37	0	37	230	0	0	0	96	954	0.62	0.00	0.04	0.00	0.04	0.24	0.00	0.00	0.00	0.10
OH	5096	0	1	41	1065	1107	3736	0	2	251	0	0	39	1513	12567	14119	58920	0	143	5146	0	78328	0.00	0.00	0.02	0.16	0.18	0.75	0.00	0.00	0.07	0.00
TN	2082	0	6	18	4	28	2048	0	1	4	1	0	236	664	47	947	39197	0	72	82	48	40346	0.00	0.01	0.02	0.00	0.02	0.97	0.00	0.00	0.00	0.00
WI	6784	14	40	893	8	941	5799	0	2	6	22	2758	1576	32952	94	34622	84942	0	143	123	1060	123648	0.02	0.01	0.27	0.00	0.28	0.69	0.00	0.00	0.00	0.01
AF_Sts	24974	2	0	25	281	306	1645	86	2288	20647	0	394	0	922	3316	4238	17502	32998	163592	423264	0	641988	0.00	0.00	0.00	0.01	0.01	0.03	0.05	0.25	0.66	0.00
CAN_E101_woutMB_ON	3061	5	0	4	32	36	231	95	443	2251	0	985	0	148	378	526	3277	36452	31674	46146	0	119060	0.01	0.00	0.00	0.00	0.00	0.03	0.31	0.27	0.39	0.00

Appendix D: SHB Survey Report

Ontario

Environment Canada / Environnement Canada
Canadian Wildlife Service / Service canadien de la faune

25 November 2019

MEMORANDUM TO: Interior Canada Goose Population Co-operators, Mississippi Flyway

SUBJECT: 2019 Survey Results for Interior Canada Geese

Please find the 2019 estimates of the breeding population index for Interior Canada Geese below. This is the fourth year using a redesigned survey which was based on an in-depth analysis of previous survey data (2010 to 2014, Figure 1). Although not directly comparable with previous surveys (prior to 2016), the redesign assumes that processes that affect abundance and distribution of breeding Interior Canada Geese are similar for both high- and low-density areas. With a focus on coastal regions where the highest breeding pair densities occur, the redesigned survey has improved change detection ability and cost efficiency.

The survey was flown using a Twin Otter aircraft and was timed to coincide with the expected mid-incubation period. Consequently, the southern and northern parts of the Lowlands were flown during two separate periods due to differences in spring phenology and timing of nest initiation. The southern portion of the survey was flown on 22 May and Akimiski Island was flown on 23 May under good conditions. The northern portion was flown from 5 to 6 June under fair conditions. No changes were made in 2019 to the survey design; however, three transects were skipped at the request of the Weenusk First Nations as it was felt the flights would interfere with the later than usual youth hunt. Also, the coastal ends of a few transects could not be completed due to fog. Observers were Rod Brook (right side) and Shannon Badzinski (left side).

Spring phenology across the entire breeding area in 2019 was later than average but was like that of 2016 and 2017. The snow pack throughout most of the Hudson Bay Lowlands in winter 2018-19 was well above average with records set in some areas and melt was protracted due to below freezing spring temperatures (Figure 2, 3), especially on the Hudson Bay coast in Ontario and at Cape Churchill. Indigenous hunters on both the James Bay and Hudson Bay coasts noted that goose migration was later than normal. According to those hunters, migration was also interrupted by stretches of poor weather. Hunters were still out on the Hudson Bay coast until the first week of June in 2019; later than in a normal year.

With the larger than normal snow pack to melt and poor drying conditions through June, the Lowlands were wetter than normal during the nesting period. Wet conditions continued through July (the brood rearing period) with July having above average precipitation and poor drying conditions punctuated by below normal temperatures. There were far fewer forest fires in the Hudson Bay lowlands in 2019 than there has been during the last few dry years.

During our banding operation in late July, goose productivity varied geographically. Productivity in Southern James Bay was average, while on Akimiski Island the adult to gosling age ratio appeared just below average but numerous brood flocks were observed. On the Hudson Bay coast, productivity was average and above. Evidence from Canada Goose nest monitoring at Burntpoint Creek suggests that the later spring phenology was not particularly detrimental as there appeared to be average or better nest success; much higher than in 2018. Productivity was assessed more thoroughly using age ratios calculated from flock data of Canada Geese captured during banding in late July and reported in the Canada Goose banding report (Bennett et al. 2019).

Distribution, density and abundance of Interior Canada Geese breeding within the surveyed area was estimated from spatial statistics (Empirical Bayesian Kriging [EBK], Krivoruchko 2012) using counts and locations of breeding birds (indicated breeding pairs x 2) observed during the survey (Table 1, Figure 4). Estimates for this and previous years using the new survey design are slightly different than those previously reported because we continue to refine the parameters used for the spatial analysis as we learn what methods work best and are least biased. The four years (2016-2019) reported here were all analysed using the same method to facilitate annual comparisons. The estimated 2019 breeding bird mainland index was statistically lower than that of the three year mean (2016 – 2018) and Figure 5 indicates the spatial change in density when compared to the mean.

Akimiski Island had statistically similar counts for all years. Estimates for all years in this analysis assumed a single stratum for Akimiski Island. The 3-year average EBK estimate for the mainland was 70,617 breeding birds and 11,032 for Akimiski Island. We also generated design-based ratio estimators of density appropriate for unequal-area transect surveys (Stehman and Salzer 2000) for comparison. From these, estimates for Akimiski Island and for the Mainland were not statistically different than their three-year mean based on overlapping 90% confidence limits. We are concerned that the error estimates from EBK may be biased small and feel that the confidence limits estimated using the ratio method are likely more representative for the design of this survey.

We previously explored other methods, including double Kriging and a design-based estimation of density from transect counts. The double Kriging approach (Sun et al. 2003), used to address the zero inflated nature of the data (e.g., Wang et al. 2015), appeared to produce overly biased results. We found that abundance estimates were sensitive to the analytical approach, including parameterizations, such as the choice of the semivariogram model used during the Kriging process (e.g., Arétouyap et al. 2015, Arétouyap et al. 2016). These observations raise uncertainty as to the sensitivity of population estimates to the choice of analytical methods and highlighted the need for more investigation into the most appropriate course. Another analysis option could be to use a regression style model-based approach (e.g., Entezari et al. 2018) to help account for potential sources of variation such as survey timing relative to phenology or to account for variability in density among habitat types. This method may provide finer scale change detection and allow us to also make improved inference about the spatial distribution of breeding Canada Geese in the Lowlands. Given the primary purpose of this survey continues to be detection of temporal and spatial change rather than simple comparison of annual total population estimates, we will continue to explore analysis methods that best meet this objective.

Please contact us if you have any questions about the survey or the results.

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Table 1. Comparison of estimates from the Kriging spatial analysis of surveys for interior Canada geese nesting in the Hudson Bay Lowlands of Ontario and Manitoba. Surveys of total breeding birds extrapolated from indicated breeding birds counted in spring each year.

Area	Year	Est. Breeding Birds	SE	Lower 90% CL	Upper 90% CL
Mainland	2016	59,773	1,263	54,820	64,726
Mainland	2017	77,403	1,695	70,757	84,049
Mainland	2018	74,676	1,749	67,821	81,531
Mainland	2019	63,826	1,571	57,669	69,983
Mean	2016-18	70,617			
Akimiski Isl.	2016	9,810	400	8,240	11,380
Akimiski Isl.	2017	12,296	682	9,623	14,970
Akimiski Isl.	2018	10,990	555	8,814	13,166
Akimiski Isl.	2019	10,627	787	7,542	13,712
Mean	2016-18	11,032			

Figure 1. An Interior Canada Goose breeding pair density surface based on an average from aerial surveys flown between 2010 and 2014 inclusive.

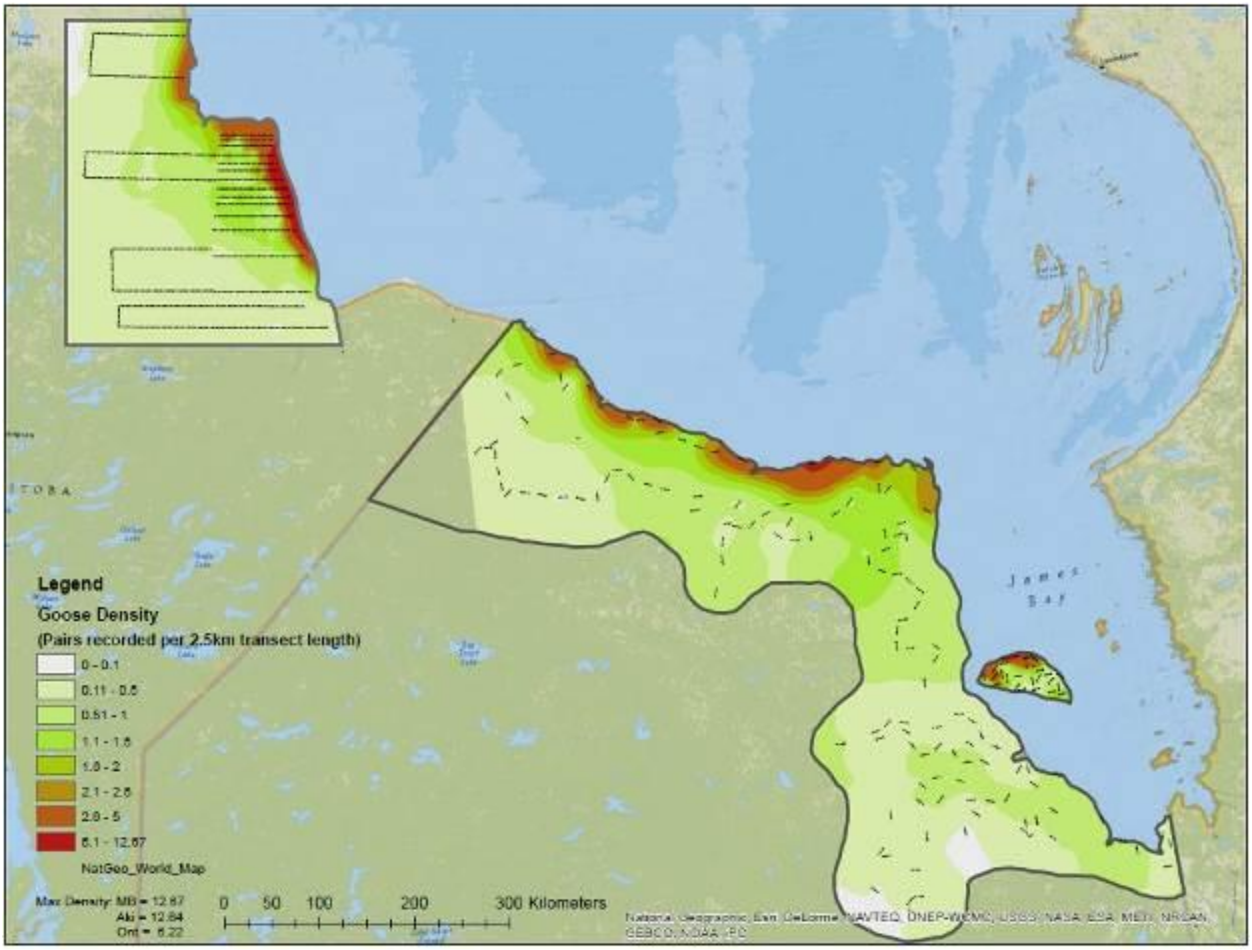


Figure 2. Relative snow melt pattern at the Burntpoint Creek weather station (N55.23750, W84.32000) in Ontario from 2009 to 2019. Snow depth measurements from the Burntpoint Creek weather station are not available for 2016 due to bear damage to the station. 2019 data are highlighted with date of snow melt second only to 2009.

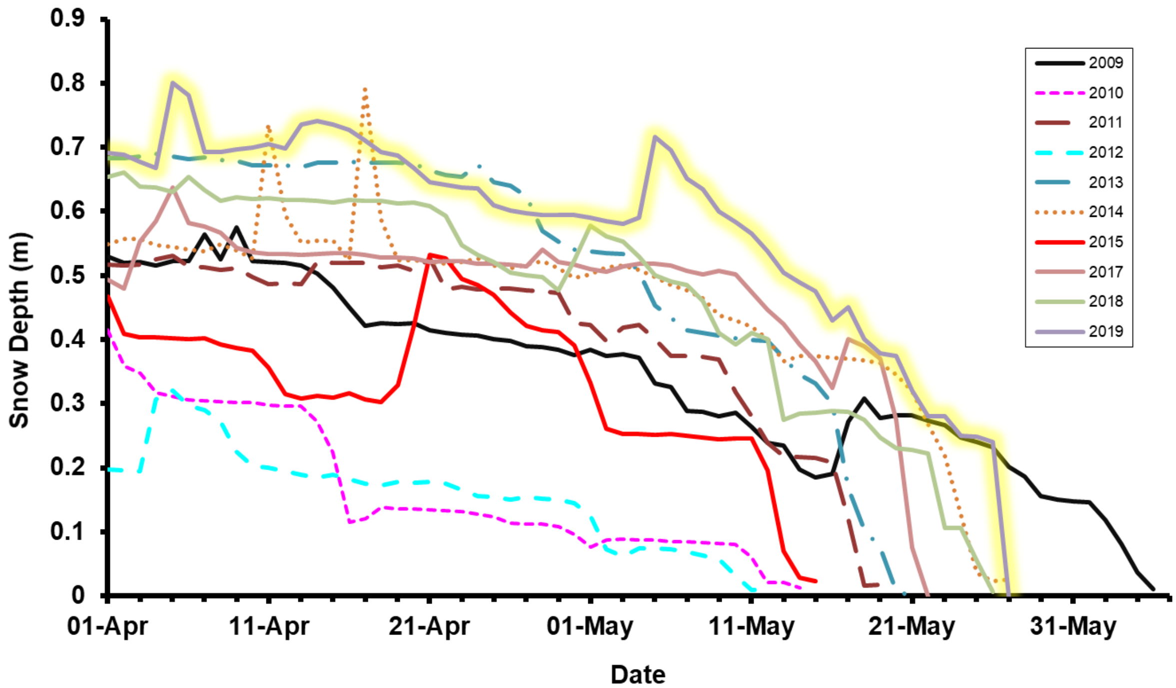
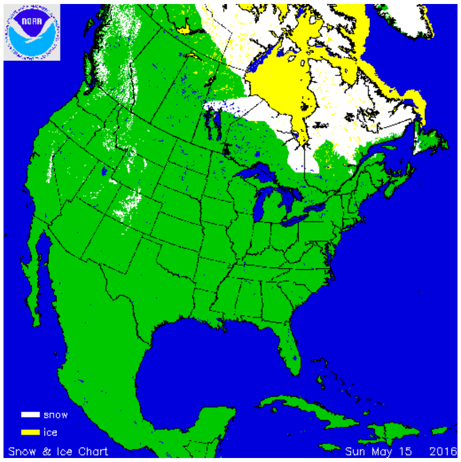
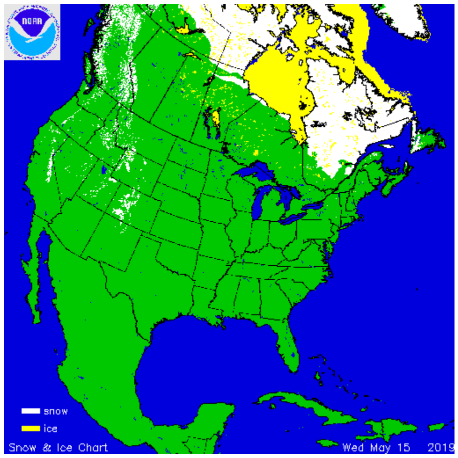


Figure 3. Snow cover extent in North America on 15 May for 2016 to 2019. Data from the U.S. National Ice Center (www.natice.noaa.gov). May15 is the median Canada Goose nesting initiation date for Burntpoint Creek research station.

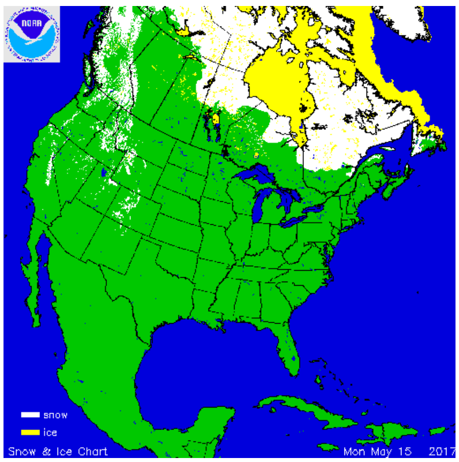
2016



2019



2017



2018

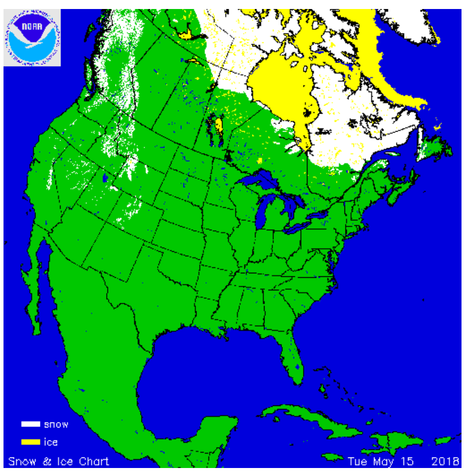


Figure 4. The average density and relative distribution of breeding Interior Canada Geese (indicated breeding birds) surveyed using aerial survey techniques, 2016 to 2019. The red line indicates the division between the southern and northern portion of the survey; flown about a week apart to account for differences in spring phenology.

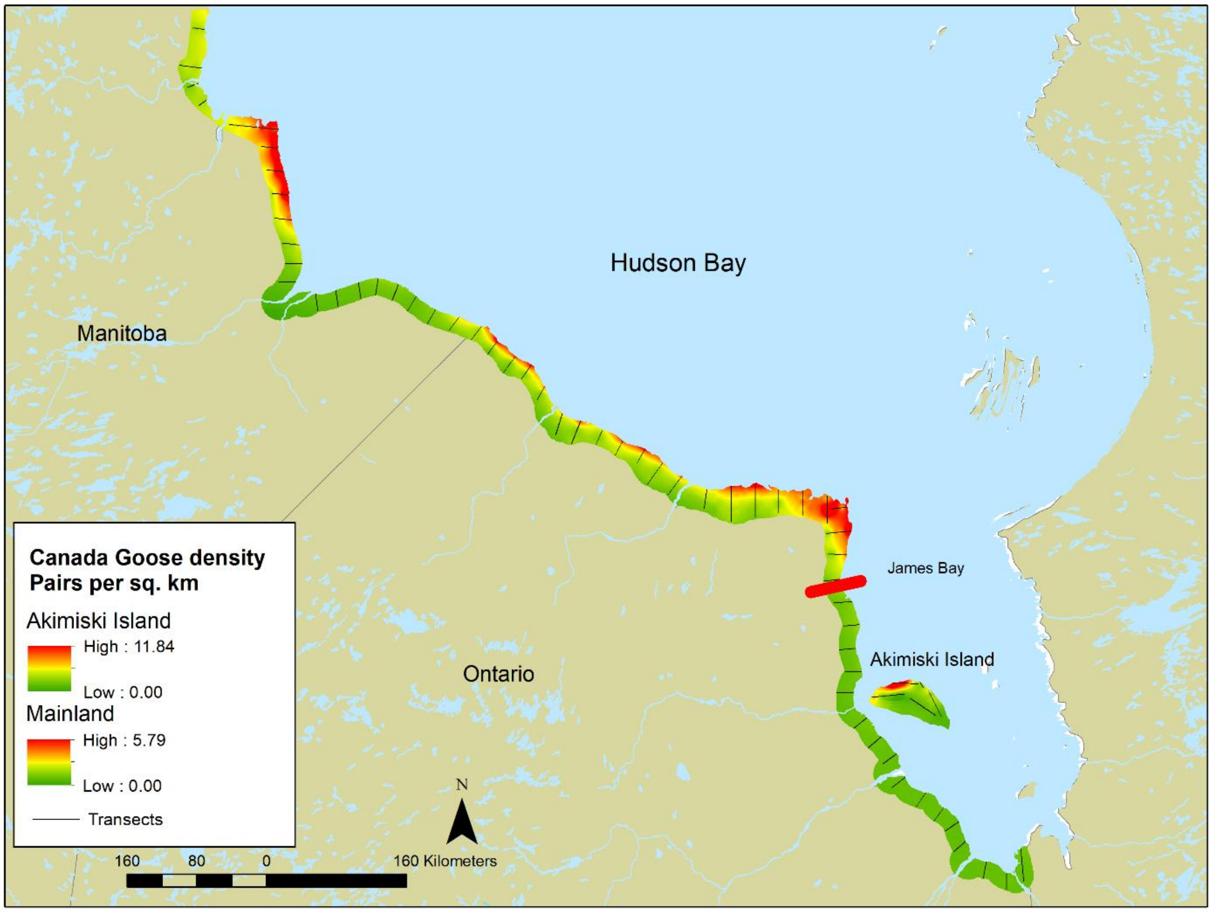
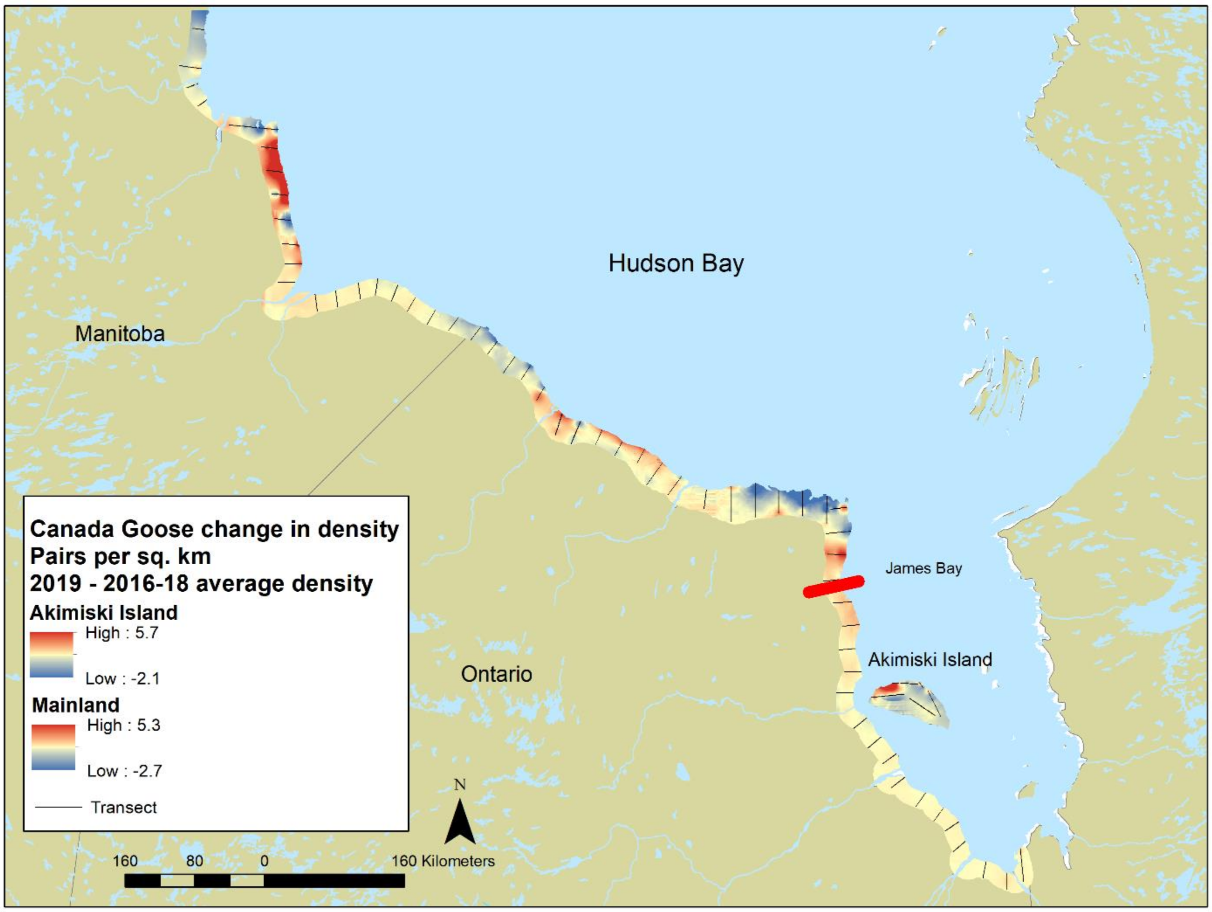


Figure 5. An indication of change in the density and relative distribution of breeding Interior Canada Geese (indicated breeding birds) surveyed using aerial survey techniques, 2016 to 2019. Colour indicate the estimated change of the 2019 density from the average density (2016 to 2018). The red line indicates the division between the southern and northern portion of the survey; flown about a week apart to account for differences in spring phenology.



Appendix E: Communications tools

This link provides a pamphlet for communicating about changing management of MF Canada geese to wildlife biologists:

http://www.michigandnr.com/ftp/wildlife/LuukkonenD/MFC%20CAGO%20Management%20Plan%20Pamphlet%20FINAL2.pdf

This link provides a pamphlet for communicating about changing management of MF Canada geese to goose hunters:

http://www.michigandnr.com/ftp/wildlife/LuukkonenD/MFC%20CAGO%20Management%20Plan%20Pamphlet%20Hunter%20Version.pdf

Table 1. Mississippi Flyway Canada and cackling goose management indicators with current (2012-2016) and desired conditions.

Indicator	Breeding area	Current condition	Desired condition
Breeding distribution	Arctic	Stable	Stable
	Subarctic	Stable	Stable
	Temperate	Expanding	Stable
Abundance	Arctic	Increasing	Not declining
	Subarctic	Stable	Not declining
	Temperate	Increasing	Declining
Jurisdictions near local objectives	Temperate	5 of 16	16 of 16
Survival rate	Arctic	Increasing	Not declining
	Subarctic	Stable	Not declining
	Temperate	Stable	Decreasing
Harvest rate	Arctic	Stable	Not increasing
	Subarctic	Stable	Not increasing
	Temperate	Stable	Increasing
Hunter numbers	NA	Declining	Stable/increasing
Human-goose conflicts	NA	Increasing/high	Decreasing