Arctic Ecosystem Research in the Queen Maud Gulf Migratory Bird Sanctuary

Annual Report

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A pair of snow geese with Karrak Lake Research Station in the background.

Project Summary and Objectives

Long-term research on the population ecology of arctic-nesting waterfowl, specifically lesser snow (*Chen caerulescens*, hereafter, snow), Ross's (*Chen rossii*), white-fronted (*Anser albifrons*) and cackling geese (*Branta hutchinsii*), king eiders (*Somateria spectabilis*) and long-tailed ducks (*Clangula hyemalis*), has occurred annually in Queen Maud Gulf Migratory Bird Sanctuary (QMGMBS) since 1991. The primary field sites are (1) Karrak Lake, the site of one of the largest (currently estimated at just under 1 million birds) known snow and Ross's goose (collectively referred to as light geese) nesting colonies in the Sanctuary, and (2) Perry River. Every year, the abundance of each of the above-mentioned species nesting in the Karrak Lake area is estimated, and/or metrics associated with population dynamics, such as clutch size, egg survival, nest survival, and adult survival. These metrics are crucial for addressing management concerns of harvested species, both within Canada and internationally within North America. Further, factors thought to influence reproductive ecology, such as spring chronology, meteorological conditions, and small mammal abundance, are monitored in order to explain annual variation in productivity.

From a conservation aspect, burgeoning populations of light geese are a priority research focus in North America. High populations have caused alteration of arctic vegetation in arctic and subarctic regions, and concern exists for the potential impact habitat alteration may have on other species, and research in QMGMBS is addressing these concerns. In addition to habitat surveys within the nesting colony at Karrak Lake and the Sanctuary, surveys of small mammals, passerines, and shorebirds are conducted to determine if abundance and occupancy differs between intact tundra habitats and those that have been converted to exposed peat by removal of vegetation by geese. Research on population ecology of arctic fox is also conducted, as well as less-intensive studies on gulls, arctic terns, loons, shorebirds, and passerines. In collaboration with Dr. Emily Jenkins (University of Saskatchewan) and Dr. Kirsty Gurney (Environment and Climate Change Canada), dynamics of various pathogens in arctic foxes, small mammals, and geese, and contaminants in several species of waterbirds (including eggs) are investigated.



Jim Leafloor and Ray Alisauskas at Perry River (left), the main cabin at Karrak Lake Research Station in March (middle), and a bull caribou resting near Camp (right).

Results and Discussion

To date, over 70 publications and theses have resulted from this research, and in addition to the highlights from the 2016 field season, a few of the most recent publications and results presented at scientific conferences are listed and briefly summarized in this report. We welcome interest in all aspects of our research, and will gladly provide scientific publications or additional information upon request.



Snow and Ross's geese nesting at Karrak Lake (left), field crew measuring eggs at a nest plot (middle), and Ross's geese in flight (right).

Snow and Ross's geese: abundance and spatial size of the nesting colony at Karrak Lake

The amount of terrestrial habitat (water not included) occupied by nesting snow and Ross's geese has grown substantially over time (Fig. 1), as has the number of nesting geese (Fig. 2). Until 2006, the proportion of snow and Ross's geese nesting at Karrak Lake were about equal, but since that time, Ross's geese have outnumbered snow geese.

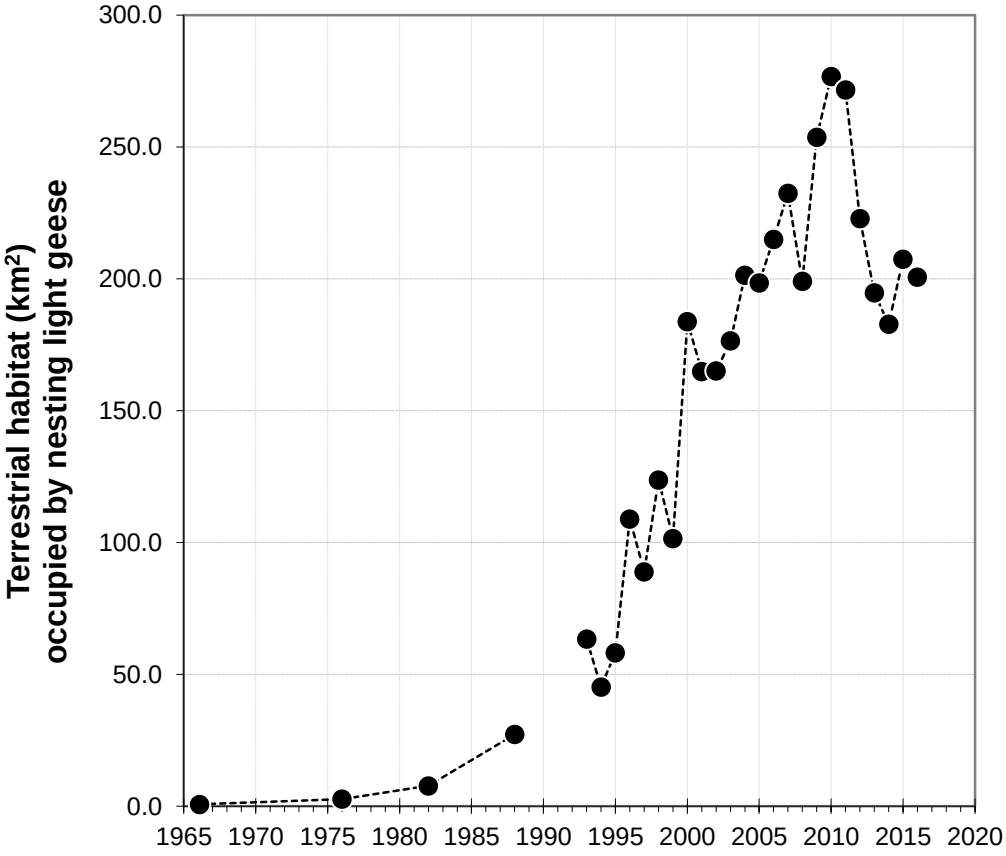

Figure 1. Terrestrial habitat (square kilometers) occupied by nesting snow and Ross's geese at the Karrak Lake colony, 1966-2016.

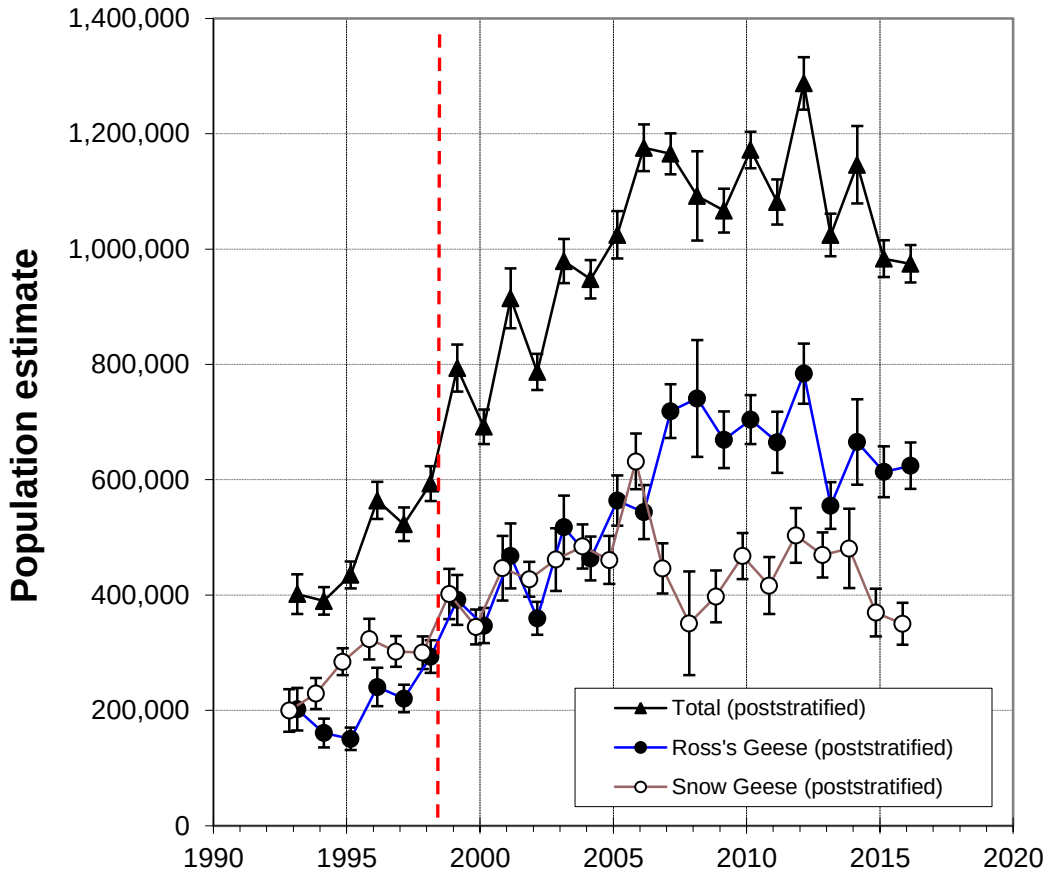

Figure 2. Estimated numbers of snow and Ross's geese nesting at the Karrak Lake colony, 1993-2016. The red dotted line indicates the start of the Conservation Order, which included liberalized harvest regulations aimed at reducing abundance of light geese.

Snow geese with goslings departing the nesting colony at Karrak Lake.

Within the colony boundary, 226 nest plots were sampled in 2016, from which nest initiation date, clutch size, nest success, and nesting population size were estimated. The spatial size of the colony and the number of nesting birds was approximately the same as in 2015, with the latter currently estimated at 974,300 light geese. Nest success of both species at Karrak Lake exhibits annual variation (Fig. 3), but is typically high (long-term means (1991-2016) were 77% and 83% for snow and Ross's geese, respectively). In 2016, estimates of nest success for both species were less than the long-term average, at 70% and 80% for snow and Ross's geese, respectively (Fig. 3).

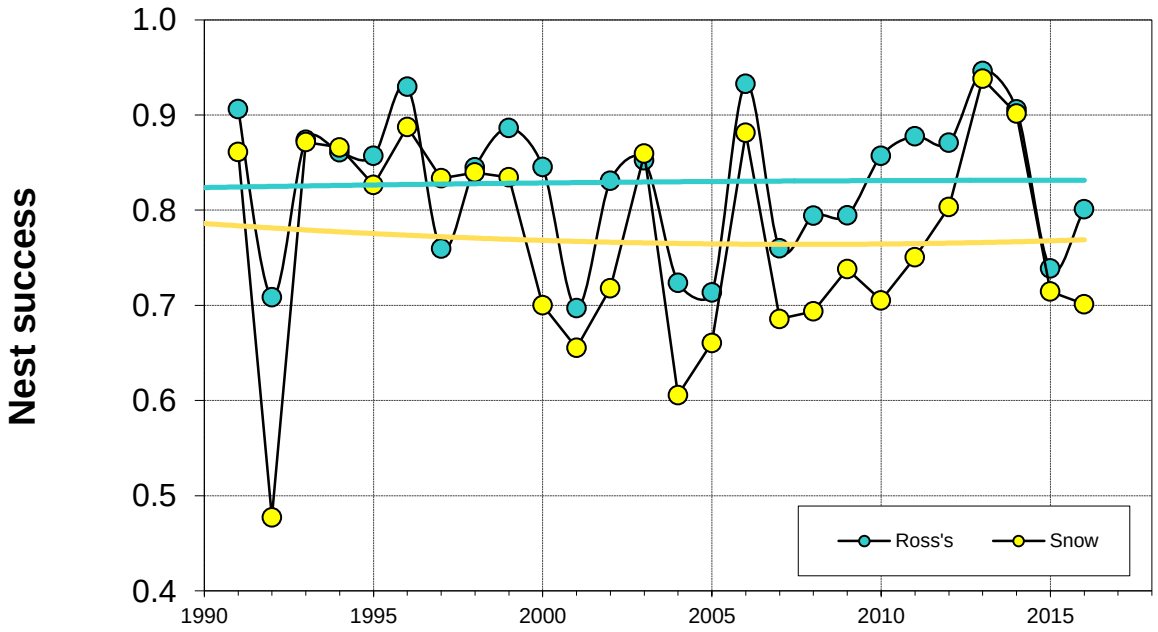

Figure 3. Estimated apparent nest success (number of successful nests divided by total number of nests) of snow and Ross's geese nesting at the Karrak Lake colony, 1991-2016.

The rate of population growth at Karrak Lake appears to have attenuated over the last decade, but did not stabilize or decline immediately following the implementation of the Conservation Order, which included liberalized hunting regulations beginning during the 1998-1999 hunting season. Instead, the decline in number of nesting snow geese in 2007 appeared to be related most to the lateness of snow melt and nesting delays in that year, and for a few years following 2007. Snow geese at Karrak Lake tend to have poorer nest success than Ross's geese, and seem to be more negatively influenced by late springs. Overall, numbers of both species nesting at Karrak Lake have stabilized

since 2005, and this most likely is due to reduced recruitment into the Karrak Lake nesting population. Recent analyses demonstrated that decline in recruitment is due to nutritional deficiencies of pre-breeding female geese stemming from density dependence as a result of increasing populations, and phenological mismatch between gosling hatch and peak forage quality. Annual production of goslings was reduced when the mass of nutrient reserves of pre-breeding females arriving on nesting areas was also reduced, likely as a result of competition for resources on pre-breeding staging areas north of the prairies. Further, reduction in gosling production occurred when the time gap ("mismatch") between gosling hatch and peak forage quality (as inferred by remote-sensing) was wider; over the 23-year study period, this mismatch has increased, due to an advance in vegetation phenology without a congruent advance in goose breeding phenology.

Light geese in capture net (left) and walking towards net (middle), and fuel caching (including digging out empty drums) by twin otter in late winter to support all field operations in QMGMBS (right).

Snow, Ross's, greater white-fronted, and cackling geese: capture-mark-recapture/recovery

To date, over 268,000 geese have been marked with uniquely-identifiable leg bands in QMGMBS during 1989-2016. Many of these individuals have been recaptured in subsequent years, or recovered by hunters throughout North America. This continues to be unique and important data critical for evaluation of management practices of these harvested species, and in particular, for evaluation of efforts implemented to reduce midcontinent lesser snow goose populations. For example, the results presented above identifying causes of reduced recruitment in light geese are only possible with long-term breeding and population ecology data sets such as those collected in QMGMBS.

In August 2014, GPS satellite transmitters were deployed on 10 snow and 10 Ross's geese in QMGMBS, and locations (up until late December 2014 when most transmitters ceased to function) are depicted in Figure 4a. Snow and Ross's geese departed tundra regions on 9 September ± 3 days, used taiga habitat until 13 September ± 3 days, and arrived in prairie Saskatchewan on 11 September

± 3 days. The average departure date from southern Saskatchewan and was 12 November ± 3.4 days, with mean arrival in the Mississippi Alluvial Valley on 13 November ± 3.8 days, where birds settled for at least a portion of the winter in either Arkansas or Mississippi. To summarize, birds used the following habitats during fall migration (beginning 1 August): 42.2 days in the arctic, 2.4 days in taiga, 0.4 days in boreal, and 59 days in prairie habitat. Coastal marsh habitats along Hudson Bay were not used. The most time on the prairies was spent in Canada, with very little spent in the northern U.S. (North and South Dakota). Geese relied heavily on agricultural lands in prairie Canada and the Mississippi Alluvial Valley. Use of arctic habitats was important before southward migration to the prairies, while boreal and taiga habitats were little used.

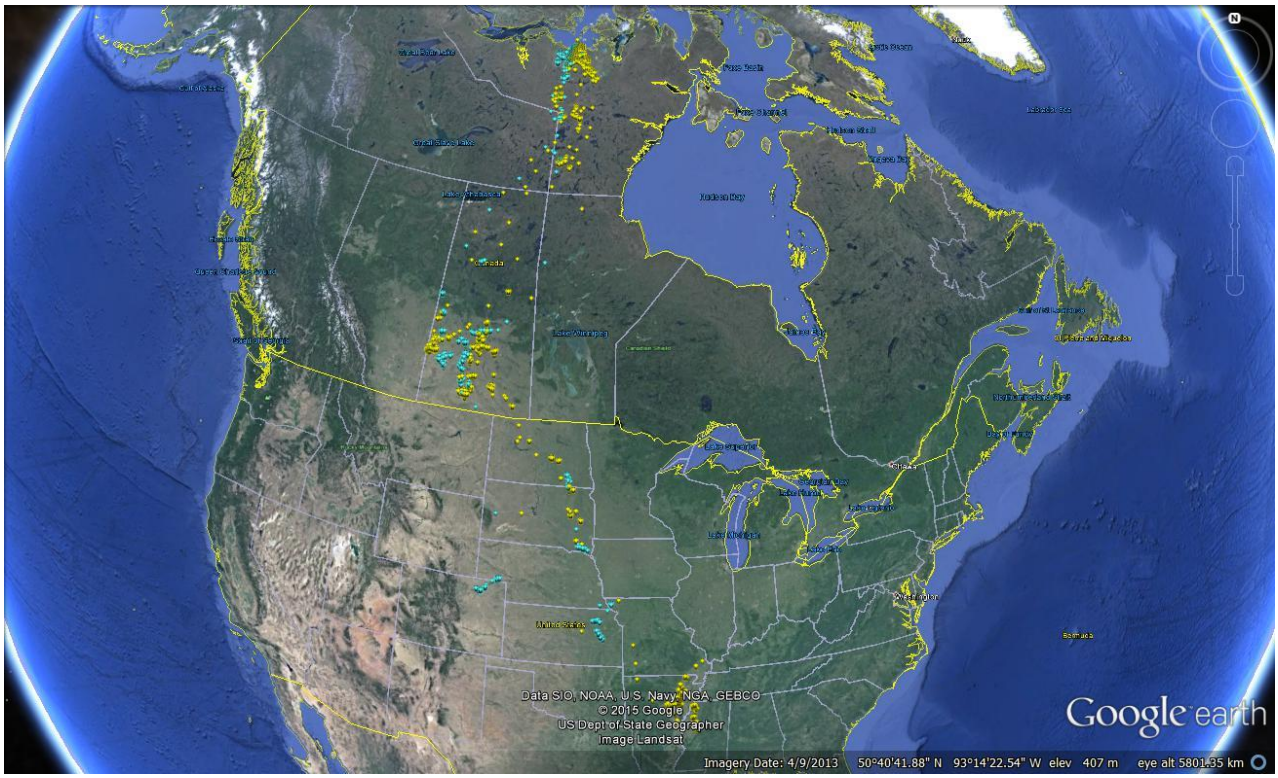

Figure 4a. Locations of snow geese (yellow circles) and Ross's geese (blue circles) generated by GPS satellite transmitters deployed in QMGMBS in August 2014.

In January 2016, GPS satellite transmitters were deployed on 10 and 9 snow geese in Louisiana and Arkansas, respectively, and locations up until August 2016 are depicted in Figure 4b. Similar to southward migration in the fall, birds did not use boreal habitats during spring migration.

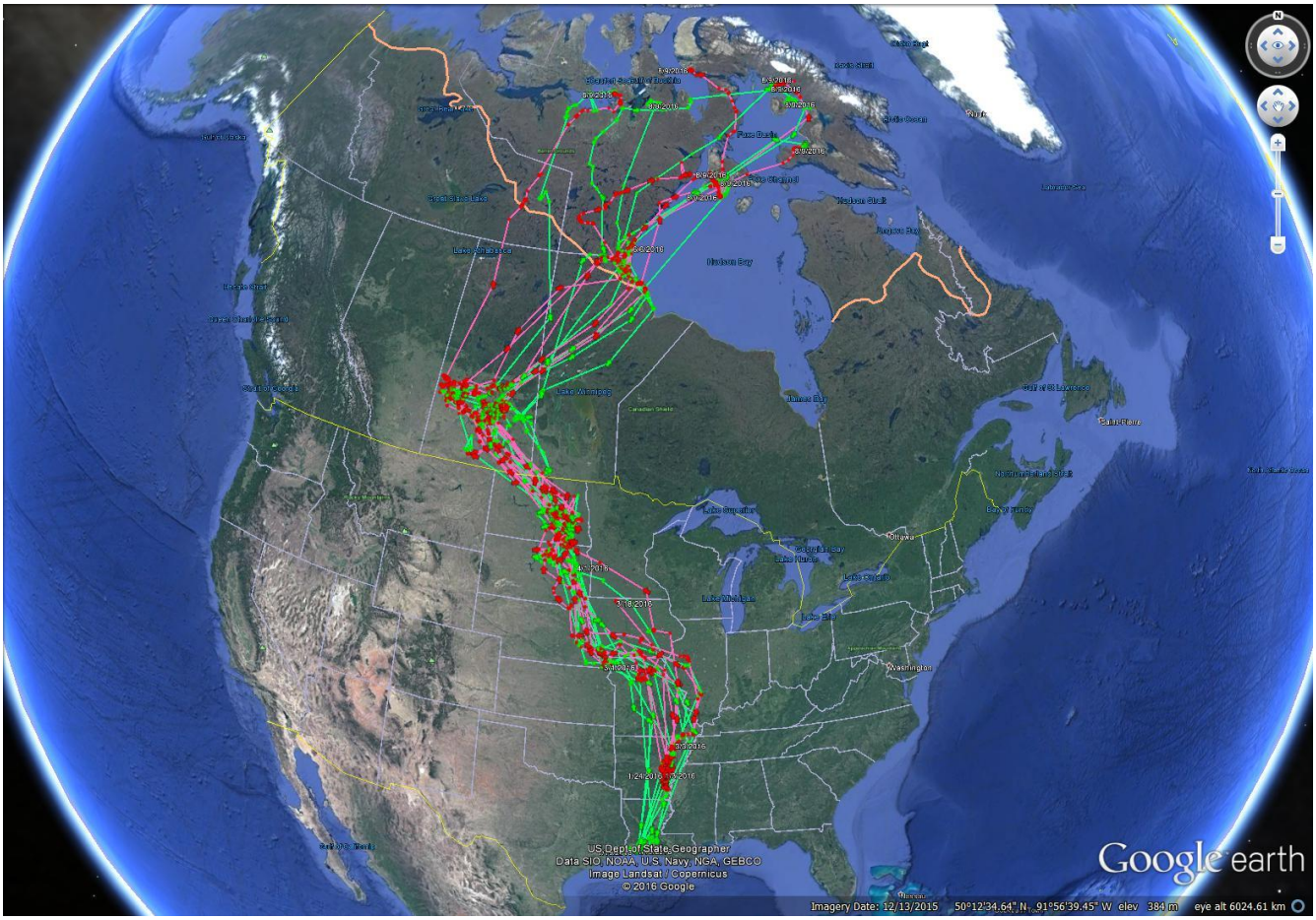

Figure 4b. Locations of snow geese generated by GPS satellite transmitters deployed in January 2016 in Louisiana (green) and Arkansas (red). The tree line is depicted in pink.

King eider hen marked with plasticine band as a duckling and later double-marked with a standard leg band when first recaptured as a nesting hen (left), Nathaniel Mimialik from Chesterfield Inlet with long-tailed duck hen (middle left), and red-throated loon nesting on an island in Karrak Lake (middle right), and Dana Kellett holding a king eider first marked in 1995 (21 years ago!, right).

<u>King eiders and long-tailed ducks: nesting ecology and capture-mark-recapture</u>

In 2016, 324 king eider and 20 long-tailed duck nests were monitored on the islands of Karrak and Adventure Lakes. Nest success for king eiders was 28.0%, slightly lower than the long-term

average of 36.7%. Nest success for long-tailed ducks was not estimated in 2016, because the field season ended before nests were scheduled to hatch. We captured adult females and ducklings at nests and marked individuals with leg bands (58 adult and 45 duckling king eiders, and 5 adult and zero duckling long-tailed ducks). Since 1995, 624 individual adult female and 3261 duckling king eiders have been captured on nests, and 78 ducklings have been recaptured as nesting females in subsequent years. Since 1998, 93 adult female and 81 duckling long-tailed ducks have been captured at nests, but no ducklings have ever been recaptured as breeding adults in subsequent years.

These nesting and capture-mark-recapture data are important in estimation of clutch size, nest survival, adult survival, age of recruitment, and fidelity to nesting areas. Each year, samples of head feathers are collected at capture, and stable isotope analyses are used to assign individuals to winter area (Atlantic or Pacific). Recent analyses combining winter area and capture-recapture data allowed estimation of apparent survival and encounter probability for each wintering population breeding at Karrak Lake. Survival of female king eiders from Pacific wintering areas was greater than that of Atlantic-wintering birds, although due to data limitations, these results are not conclusive. Consistent with differences in survival, however, lower encounter probability, which may be due to non-breeding in some years, of Atlantic king eiders suggests that poorer environmental conditions experienced by Atlantic-wintering birds or perhaps greater harvest may be responsible for both their lower survival and incidence of non-breeding.

Intact wet sedge habitat with abundant cotton grass outside the nesting colony at Karrak Lake (left), and lowland habitat altered by nesting and foraging geese showing exposed peat and colonized by marsh ragwort (right).

Habitat alteration by light geese

Within QMGMBS, the extent of habitat altered by light geese has increased within the large nesting colonies and also more widely within brood-rearing areas. A comparison of LANDSAT imagery between 1986-1992 and 2010-2011 (Fig. 5) revealed the increase of exposed peat at the Karrak Lake colony. Exposed peat results from the removal of overlying vegetation (typically graminoids), which reveals the underlying layer of *Sphagnum* spp. (moss), which can further erode and lead to desertification. However, as long as some peat remains, the existing seed bank and remaining rhizomes appears to allow for recovery as soon as grazing pressure subsides. Within the eastern portion of the QMGMBS that contains the major nesting colonies and moulting and brood-rearing areas, exposed peat increased by 411% from 1986-1992 to 2010-2011, from 269 km^2 to 1373 km^2. A large percentage (25%) of exposed peat occurred in areas previously classified as wet sedge meadow, and coincided with a decrease in wet sedge meadow habitat.

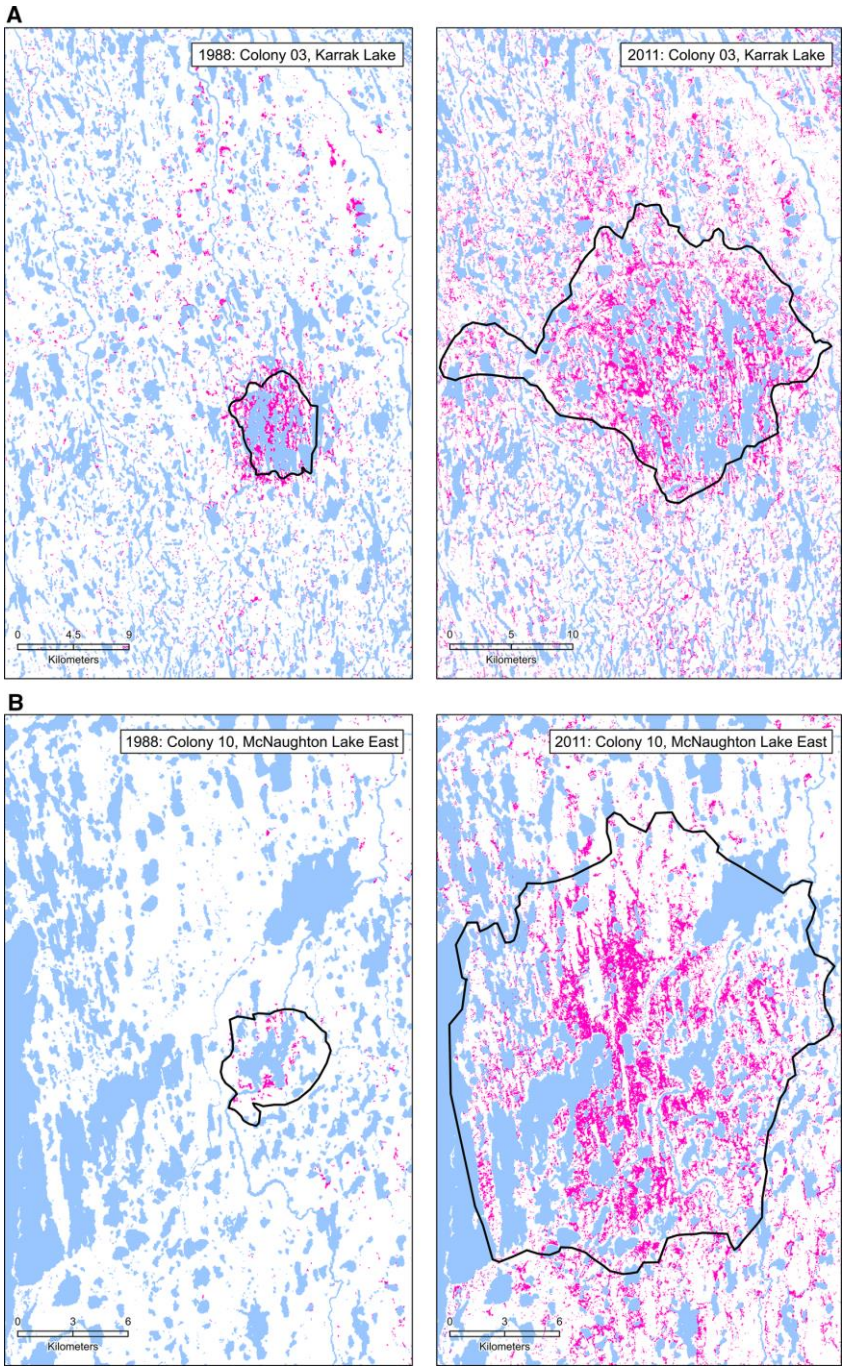

Figure 5. Expansion of exposed peat at (A) Karrak Lake and (B) Colony 10 from 1986-1992 to 2010-2011. Colony boundaries are outlined in black, exposed peat is indicated in pink, and water bodies in blue.

Vegetation enclosures have been maintained at intervals of 0, 15, 30, 45, and 60 km north of the Karrak Lake colony since the mid-1990s. In 2013, 50 enclosures were constructed in lowland habitats (preferred by geese) throughout the northerly portion of the Sanctuary, and surveys indicating extent of use by geese (indexed by number of goose droppings) and vegetation surveys

were conducted in 2013-2014. Analyses are ongoing, but preliminary investigations suggest that geese preferentially use the eastern part of the Sanctuary (Fig. 6), and vegetation height is reduced in these regions (Fig. 7).

A vegetation enclosure located 60 km north of Karrak Lake colony, showing the difference in vegetation height and species composition between grazed and ungrazed habitat (left), Teija Macdonald of Cambridge Bay among flowering arctic heather (middle), and bog rosemary (right).

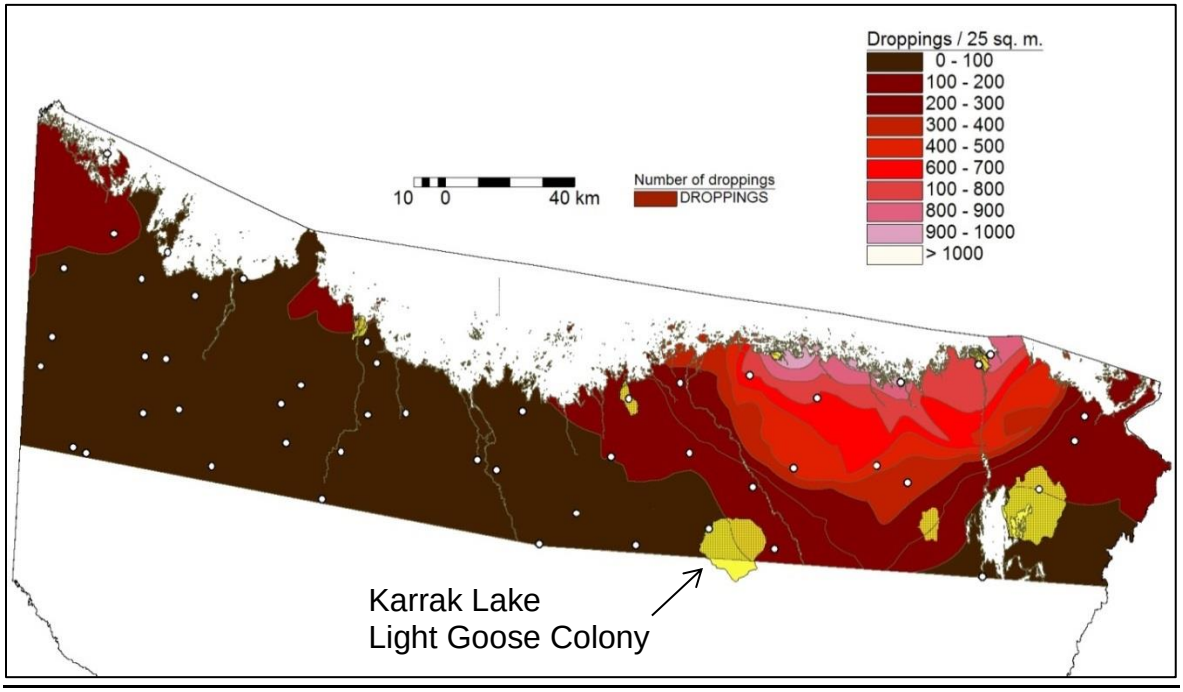

Figure 6. Variation in number of goose droppings throughout the northern portion of the QMGMBS. Major nesting colonies are denoted in yellow.

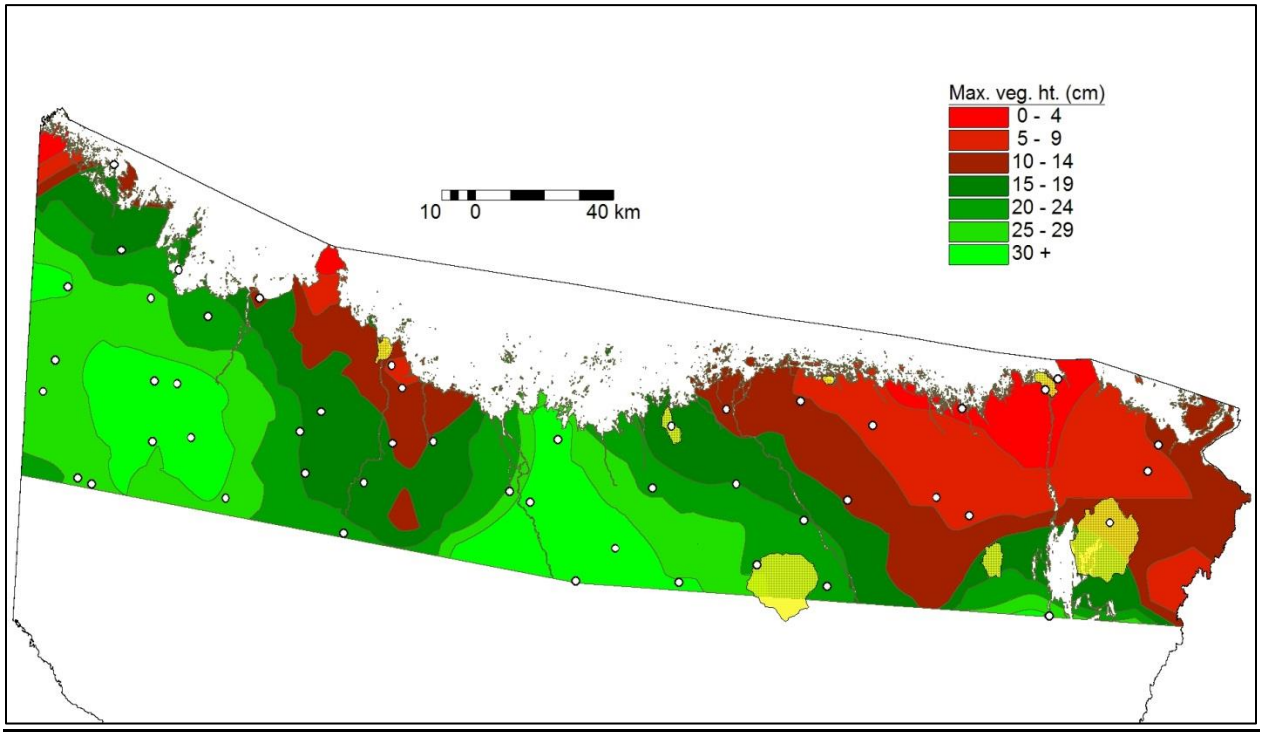

Figure 7. Variation in height of vegetation throughout the northern portion of the QMGMBS. Major nesting colonies are denoted in yellow.

A semipalmated sandpiper (left) and nest (middle), and king eiders (right).

Mercury in eggs and birds

To provide new information about mercury contamination in low arctic areas of Nunavut and to help us understand to what extent the wildlife and the people of this area might be exposed to mercury through consumption of birds or their eggs, in 2016, we continued to collect samples (eggs, muscle tissue) from birds that migrate to the QMGMBS from different parts of the world. Species sampled included king eider (10 eggs, 10 whole birds, for muscle), red-throated loon (10 eggs), glaucous gull (10 eggs), long-tailed duck (10 eggs), red-breasted merganser (4 eggs), and

semipalmated sandpiper (10 eggs). Results from chemical analyses are anticipated to be available in early 2017.

Researchers surveying for passerines and shorebirds (left), a female snow bunting with insects (middle), and a red phalarope (right).

Non-waterbird avian surveys

Surveys for non-waterfowl species were conducted on 296 and 342 nest plots in 2014 and 2015, respectively, and over 7100 observations were recorded. Most of these were of passerines (5405 in total, including 4742 lapland longspurs, 341 snow buntings, 187 horned larks, 109 savannah sparrows, plus others), but other observations included rock ptarmigan (224), shorebirds (374, primarily semipalmated sandpipers), jaegars (124), and raptors (39). These data will be used to investigate the impact of habitat alteration by nesting light geese on terrestrial bird communities by estimation of abundance and occupancy in various habitats. Results are forthcoming.

Microtine rodent abundance (lemmings and voles)

Small mammal abundance at Karrak Lake varied considerably during 1994-2016. Peaks in small mammal abundance occurred every 3-5 years (Fig. 8). We caught 242 small mammals during 15,072 trap-nights to date; red-backed voles were most common with 141 captures (58%), followed by collared lemmings with 73 captures (30%), and brown lemmings with 28 captures (12%).

Population dynamics of arctic foxes appeared to be closely linked to variation in small mammal abundance whereas nesting success of waterfowl appeared to be unrelated to small mammal abundance. We suggest that the large number of geese nesting at Karrak Lake acted as a buffer against arctic fox predation at Karrak Lake.

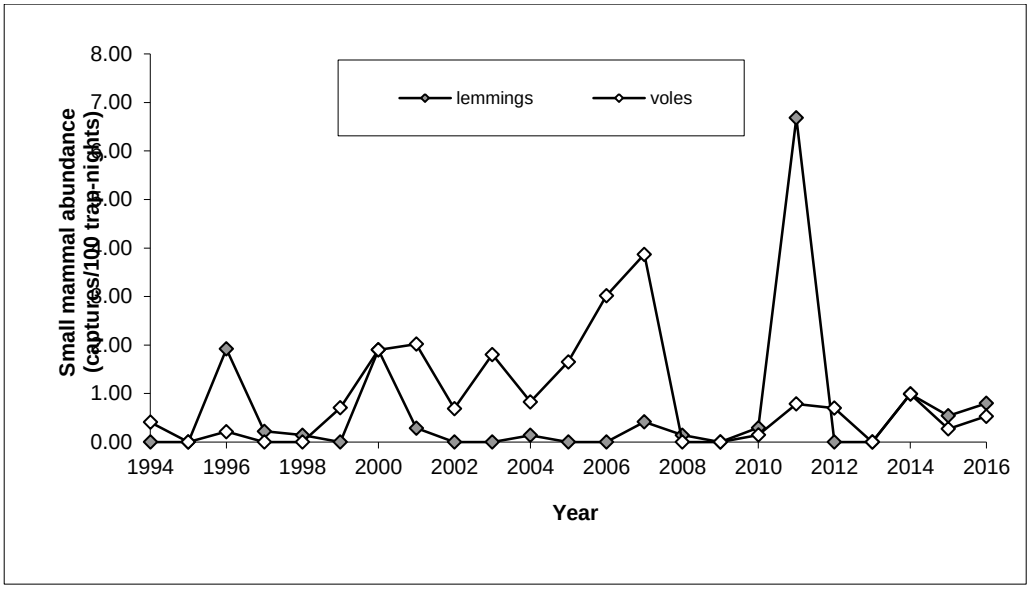

Figure 8. Abundance (number of captures per 100 trap nights) of lemmings and red-backed voles within the Karrak Lake colony, 1994-2016.

Capture-mark-recapture of lemmings on live-trapping grids in four different habitats (intact lowland tundra, inside and outside the light goose colony and altered lowland tundra inside and outside the colony) will allow the investigation of the impact of habitat alteration by nesting light geese on small mammal abundance and population dynamics. 2016 was the third season of live-capture of lemmings, and resulted in 21 captures, all of brown lemmings (2015: 73 brown and one collared lemming, 2014: 191 brown lemmings). Results are forthcoming.

Fox kits at a den within the Karrak Lake colony (left), and an adult marked with ear tags (right).

Arctic fox: capture-mark-recapture and prevalence of pathogens

During 2000-2015, 152 and 171 individual adult and juvenile foxes, respectively, have been captured and marked at Karrak Lake. Many of these individuals have been recaptured in subsequent years. In addition to foxes encountered at Karrak Lake, individuals marked at Karrak Lake have been encountered in Resolute Bay, Cambridge Bay, Kugluktuk, and Taloyoak. Analyses of capture-recapture data of arctic foxes from 2000-2015 at Karrak Lake demonstrated that survival probability of adults increased over this time period (from 0.50 to 0.70), in direct proportion to the population size of Ross's geese, but not snow geese. Survival by foxes likely due to the local superabundance of food provided by high goose densities, in particular to smaller Ross's geese possibly because of their greater vulnerability to fox predation. Adult survival was relatively stable compared to recruitment, which fluctuated considerably over the same time period. Estimates of recruitment were correlated with fluctuations in lemming abundance.

In collaboration with Dr. Emily Jenkins and her graduate and undergraduate students at the University of Saskatchewan, several parasites including *Toxoplasma gondii, Neospora caninum, Toxascaris* spp., *Cryptosporidium* spp., *Giardia* spp., *Echinococcus multilocularis*, taeniids, and unidentified tapeworms have been detected in arctic foxes at Karrak Lake. The occurrence of the protozoan parasite *Toxoplasma gondii* on arctic fox populations is known from only a few regions, but has been reported to cause mortality. Elmore et al. (2016) reported *Toxoplasma gondii* in arctic foxes at Karrak Lake, documenting a new geographical record for this parasite in arctic foxes. Further,

Elmore et al. (2014) reported that snow and Ross's geese migrating to Karrak Lake are routinely exposed to *Toxoplasma gondii* as well, and are likely intermediate hosts of this parasite.

Stormy July weather (left), an arctic tern in flight (middle), and muskoxen near a fox den across from Camp (right).

2014-2016 Publications and Presentations at Scientific Meetings

Publications:

Alisauskas, R. T., and D. K. Kellett. 2014. Age-specific in situ recruitment of female king eiders estimated with mark-recapture. Auk 131:129-140.

Bouchard, É. 2016. Transmission dynamics of *Toxoplasma gondii* in terrestrial ecosystems of the Canadian western arctic. MSc thesis, University of Saskatchewan.

Conkin, J. and R. T. Alisauskas. 2016. Conversion of tundra to exposed peat habitat by snow geese (*Chen caerulescens caerulescens*) and Ross's geese (*C. rossii*) in the central Canadian arctic. Polar Biology. DOI 10.1007/s00300-016-1979-x

Elmore, S. A. 2015. The occurrence and ecology of *Toxoplasma gondii* in a terrestrial arctic food web. PhD thesis, University of Saskatchewan.

Elmore, S. A., K. P. Huyvaert, L. L. Bailey, J. Milhous, R. T. Alisauskas, A. A. Gajadhar, and E. J. Jenkins. 2014. *Toxoplasma gondii* exposure in arctic-nesting geese: a multi-state occupancy framework and comparison of serological assays. International Journal for Parasitology: Parasites and Wildlife 3:147-153.

Elmore, S. A., G. Samelius, B. Al-Adhami, K. P. Huyvaert, L. L. Bailey, R. T. Alisauskas, A. A. Gajadhar, and E. J. Jenkins. 2016. Estimating *Toxoplasma gondii* exposure in arctic foxes while navigating the imperfect world of wildlife serology. Journal of Wildlife Diseases 52:000-000.

Elmore, S. A., G. Samelius, C. Fernando, R. T. Alisauskas, and E. J. Jenkins. 2015. Evidence for Toxoplasma gondii in migratory vs. nonmigratory herbivores in a terrestrial arctic ecosystem. Canadian Journal of Zoology 93: 671–675.

Gesy, K. M., J. M. Schurer, A. Massolo, S. Liccioli, B. T. Elkin, R. Alisauskas, and E. J. Jenkins. 2014. Unexpected diversity of the cestode *Echinococcus multilocularis* in wildlife in Canada. International Journal for Parasitology: Parasites and Wildlife 3:81-87.

Mascarelli, P. E., S. A. Elmore, E. J. Jenkins, R. T. Alisauskas, M. Walsh, E. B. Beitschwerdt, and R. G. Maggi. 2014. Vector-borne pathogens in arctic foxes, *Vulpes lagopus*, from Canada. Research in Veterinary Science. doi:10.1016/j.rvsc.2014.12.011.

Ross, M. V. 2016. Ecological factors affecting midcontinent light goose recruitment. MSc thesis, University of Saskatchewan.

Wilson, S., R. T. Alisauskas, and D. K. Kellett. 2015. Factors influencing emigration of Ross's and snow geese from an arctic breeding area. Journal of Wildlife Management 9999:1-10. doi:10.1002/jwmg.960.

Presentations:

Alisauskas, R. T., and D. K. Kellett. 2014. Diet and nutrition of king eiders and long-tailed ducks arriving to breed at Karrak Lake. Oral presentation at the 5th International Sea Duck Conference, Reykjavik, Iceland.

Alisauskas, R. T., D. K. Kellett, and J. O. Leafloor. 2015. Satellite transmitters and fall migration by snow and Ross's geese from Canada's central and eastern arctic. Oral presentation at the 13th North American Arctic Goose Conference, Winnipeg, Canada.

Alisauskas, R. T. 2015. Goose-vegetation relationships south of Queen Maud Gulf: case vs. effect with implications for carrying capacity? Oral presentation at the 13th North American Arctic Goose Conference, Winnipeg, Canada.

Alisauskas, R. T. 2015. What's up with midcontinent light geese. Invited plenary presentation at the 13th North American Arctic Goose Conference, Winnipeg, Canada.

Bouchard, É. 2016. *Toxoplasma gondii* – transmission dynamics in the Canadian arctic. Oral presentation at Host-Parasite Interactions Research Symposium, Calgary, Canada.

Bouchard, É., S. A. Elmore, R. T. Alisauskas, G. Samelius, A. A. Gajadhar, and E. J. Jenkins. 2015. *Toxoplasma gondii* – transmission dynamics in the Canadian Arctic. Poster presentation at the Annual Meeting of The Wildlife Society, Winnipeg, Canada.

Bouchard, É., S. A. Elmore, R. T. Alisauskas, G. Samelius, B. Al-Adhami, A. A. Gajadhar, and E. J. Jenkins. 2015. *Toxoplasma gondii* – Transmission Dynamics in the Canadian Arctic. Oral presentation at the 6th Student Workshop of the European Wildlife Disease Association, Veyrier-du-Lac, France.

Bouchard, É., S. A. Elmore, R. T. Alisauskas, G. Samelius, B. Al-Adhami, A. A. Gajadhar, and E. J. Jenkins. 2015. *Toxoplasma gondii* – transmission dynamics in the Canadian Arctic. Poster presentation at the Annual Meeting of the Canadian Section of The Wildlife Society, Saskatoon, Canada.

Conkin, J. A., and R. T. Alisauskas. 2015. Increases in exposed peat from 1992 to 2010 in association with increased light goose populations in the Queen Maud Gulf Migratory Bird Sanctuary. Poster presentation at the 13th North American Arctic Goose Conference, Winnipeg, Canada.

Elmore, S., K. Huyvaert, and E. Jenkins. 2014. *Toxoplasma gondii* in a terrestrial arctic food web: Who brings what to the table and uncertainty in diagnostics. Oral presentation at the 63rd International Conference of the Wildlife Disease Association, Albuquerque, USA.

Jenkins, E., J. M. Schurer, and S. A. Elmore. 2015. Toxoplasmosis in wildlife and people in the Canadian Arctic. Oral presentation at the 6th International Congress on Circumpolar Health, Oulu and Rokua, Finland.

Kellett, D. K., and R. T. Alisauskas. 2014. Population ecology of long-tailed ducks at Karrak Lake, Nunavut. Poster presentation at the 5th International Sea Duck Conference, Reykjavik, Iceland.

Kellett, D. K., and R. T. Alisauskas. 2015. Is apparent nest success a useful metric of nest survival in colonial light geese nesting at high densities? Oral presentation at the 13th North American Arctic Goose Conference, Winnipeg, Canada.

Ross, M. V., and R. T. Alisauskas. 2015. Ecological effects on midcontinent light goose recruitment. Poster presentation at the 13th North American Arctic Goose Conference, Winnipeg, Canada.

Wilson, S., R. Alisauskas, and D. Kellett. 2015. Permanent emigration by Ross's and snow geese from an arctic breeding area: the roles of prior nest success, environmental conditions and local abundance. Poster presentation at the 13th North American Arctic Goose Conference, Winnipeg, Canada.

Acknowledgements

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