



Saskatoon, Saskatchewan

October 21–25, 2025

Program and Abstracts

16th North American Arctic Goose Conference

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General Conference Information

Registration

The 16th NAAG Conference will be held at the Delta Hotels Bessborough (*601 Spadina Crescent East, Saskatoon*). The registration/information desk will be located in the convention floor foyer near the Adam Ballroom. Hours for registration will be Tuesday (Oct 21) from 7:00 AM to 6:00 PM and Wednesday (Oct 22) from 7:00 AM to 11:00 AM.

Name Tags

Your name tag is your admission to all events. Please have your name tag with you at all times during the conference. There should be three drink tickets in your name tag holder for use at the opening reception, poster session and closing banquet. For attendees with food allergies or who are vegetarian, a card will be placed in the back of your name tag for the closing banquet.

Workshops and Oral Presentations

Two workshops (morning and afternoon) will be held Tue (Oct 21) in the Adam Ballroom. Oral presentations will be held Wednesday (Oct 22) to Friday (Oct 24) in the Adam Ballroom.

Individuals giving oral presentations should make every effort to upload and check their presentations prior to the start of their assigned session. Session moderators and IT staff will assist in uploading your presentations, and this can be done during breakfast, lunch, and breaks.

Poster Presentations

The poster session will be held on Wednesday (Oct 22) at 6:00 PM in the convention floor foyer outside the Adam Ballroom. Presenters are expected to be with their posters on Wednesday night. Poster boards will be available on Wednesday at lunch and will remain up until Thursday at the afternoon break. All posters will be removed at that time.

Opening Reception, Closing Banquet, and Hospitality Room

An opening reception will be held on Tuesday (Oct 21) at 6:00 PM in the convention floor foyer near the Adam Ballroom. There will be a closing banquet on Friday (Oct 24), with cocktails 6:00 to 6:30 PM in the convention floor foyer and supper at 6:30 PM in the Adam Ballroom. The Salon Batoche room will serve as the hospitality room throughout the conference.

Breakfasts, breaks and lunches

All breakfasts, breaks and lunches will be served outside the Adam Ballroom and attendees can bring their food/drink in the Adam Ballroom.

Field Trip

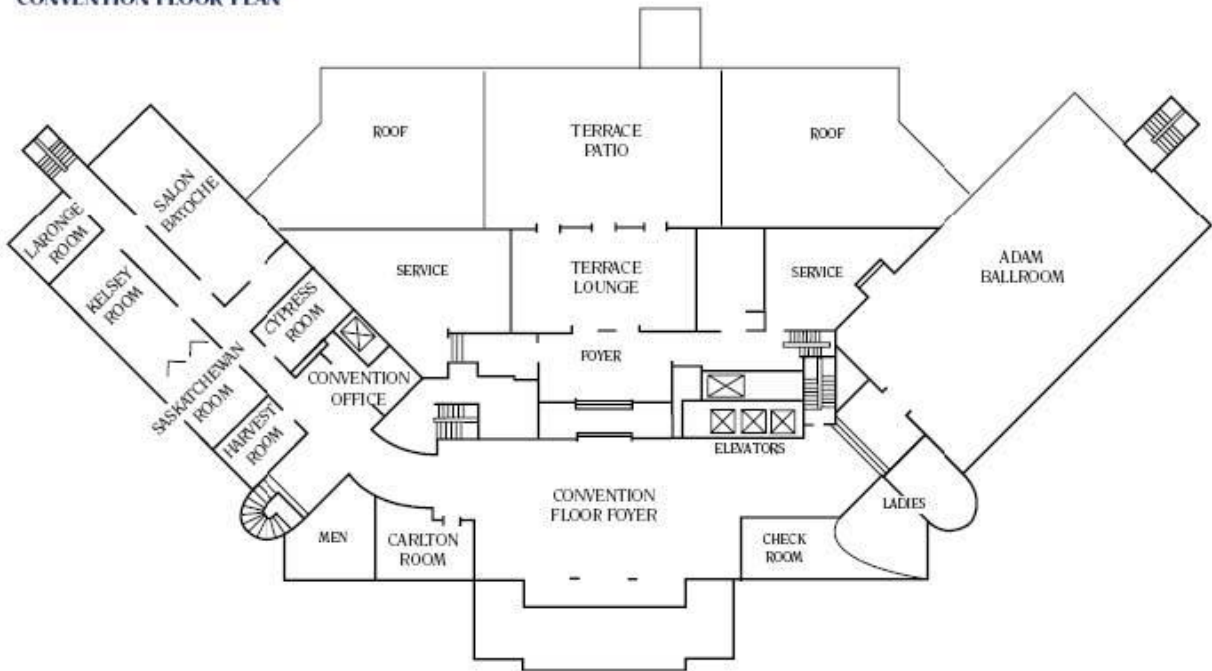
There will be a field trip on Saturday (Oct 25) to view geese and other wildlife in the surrounding area, with lunch planned at the Last Mountain Lake National Wildlife Area.

Transportation and lunch will be provided. For those going on the field trip, please meet in the hotel lobby at 8:15 AM. Buses will leave the hotel at 8:30 AM and our anticipated return will be around 5:00 PM. We advise that you bring clothing layers and binoculars. Hopefully goose migration will be in full swing!

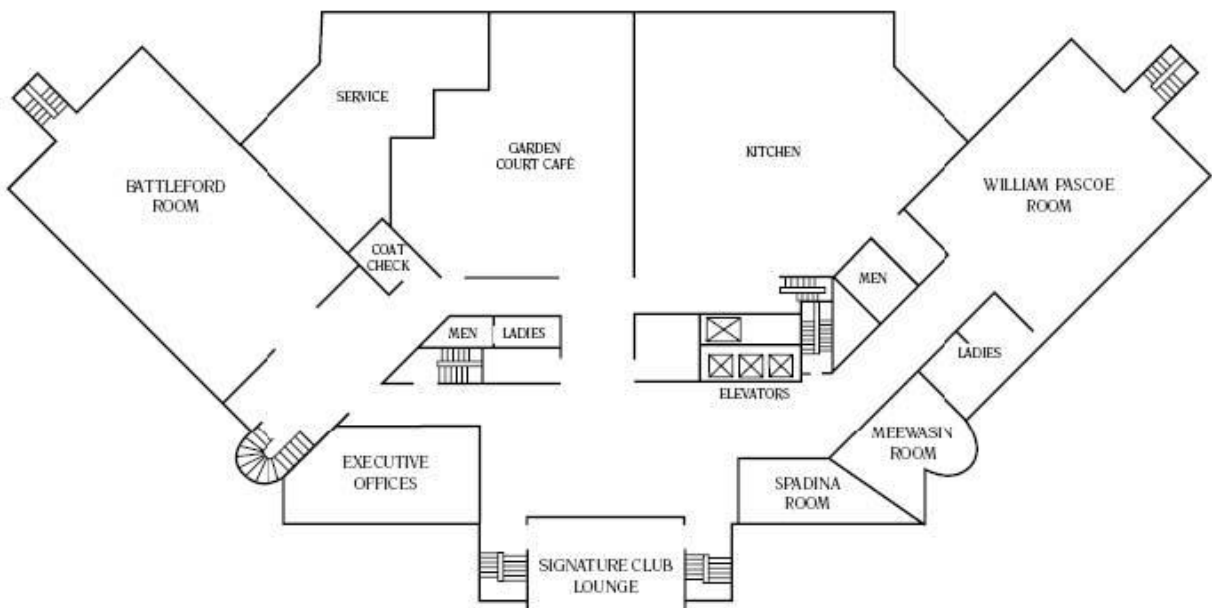
Hotel Map

Delta Hotels Bessborough

CONVENTION FLOOR PLAN



MEZZANINE FLOOR



Conference Sponsors



*Conserving
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Conference Committees

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Scientific Program Committee

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Ray Alisauskas

Frank Baldwin

Bart Ballard

Rod Brook

Jim Leafloor

Josee Lefebvre

Pierre Legagneux

Eric Reed

Vijay Patil

Student Paper, Poster, and Travel Awards Committee

Jeff Knetter – Chair

Josee Lefebvre

Ben Lewis

Paul Link

Jason Olszak

Tom Bidrowski

Conference Schedule

Tuesday, Oct 21

7:00-8:15	Breakfast
8:30-10:00	Workshop: Bayesian estimation of survival from band-recovery data (M. Schaub)
10:00-10:30	Break
10:30-12:00	Workshop: Bayesian estimation of survival from band-recovery data (M. Schaub)
12:00-1:30	Lunch
1:30-3:00	Workshop: Managing the data firehose: Tactics, tools, tips, and tricks for the effective use of large-scale and long-term telemetry projects (C. Overton)
3:00-3:30	Break
3:30-5:00	Workshop: Managing the data firehose: Tactics, tools, tips, and tricks for the effective use of large-scale and long-term telemetry projects (C. Overton)
6:00-9:00	Opening reception

Wednesday, Oct 22 – Morning Session (Moderator: Rod Brook)

7:00-8:15	Breakfast
8:15-8:30	Welcome, Opening Comments: M. Weegman
<u>Monitoring and Assessment</u>	
8:30-9:30	Plenary: <i>Michael Schaub</i> . Combining full-annual cycle and integrated population models.
9:30-9:50	<i>M. Ward, C. Wikle, M. Weegman</i> . Modelling across scales: Incorporating individual-level data into productivity models.
9:50-10:10	<i>D. Wolfson, K. Davis, J. Dooley, T. Riecke, M. Schaub, T. Arnold</i> . Efficient estimation of age-specific survival using joint encounter data.
10:10-10:30	<i>K. Davis, K. Abraham, R. Alisauskas, F. Baldwin, R. Brook, A. Calvert, D. Kellett, J. Leafloor, R. Rockwell, M. Weegman</i> . Productivity, juvenile survival, and movement drive subpopulation change in lesser snow geese.
10:30-10:50	Break
10:50-11:10	<i>F. Baldwin, M. Weegman, A. Yappert, J. Dooley, J. Leafloor, R. Alisauskas</i> . Changing light goose distribution in the central Canadian arctic; implications for research and management activities.
11:10-11:30	<i>S. Carothers, T. Carothers</i> . Unusual Colonization of Canada geese (<i>Branta canadensis</i> moffitti) along 450 kilometers of Colorado River riparian habitat in Grand Canyon, AZ.
11:30-11:50	<i>R. Wilson, S. Sonsthagen, J. Dooley, F. Baldwin, K. Scribner, S. Talbot</i> . Population Genomics of North American Geese.
11:50-12:10	<i>A. McQuillen*, S. Sonsthagen, J. Dooley, F. Baldwin, S. Rohwer, C. Wood, R. Wilson</i> . Why so blue? Hybridization in light geese and origin of the blue ross's goose.
12:10-2:00	Lunch

Wednesday, Oct 22 – Afternoon Session (Moderator: Bart Ballard)

<u>Disease and Contaminants</u>	
2:00-3:00	Plenary: <i>Andy Ramey</i> . The role of geese in the emergence, maintenance, and dispersal of highly pathogenic avian influenza viruses.
3:00-3:20	<i>C. Sharp, K. Schutten, H. Lewis, J. Giacinti, B. Stevens, C. Jardine, J. Provencher, Y. Berhane, R. Brook</i> . Highly Pathogenic Avian Influenza in Canada Geese – Insights from Surveillance and Monitoring Results.
3:20-3:40	Break
3:40-4:00	<i>L. Kercher, K. Woodard, L. Miller, P. Seiler, R. Webby</i> . Utilization of a Modern Mobile Laboratory for In-Field Detection of Avian Influenza in Waterfowl in North America.
4:00-4:20	<i>J. Segovia, K. Kraai, B. Ballard, A. Martin</i> . Avian Influenza Prevalence of Wintering Richardson's Cackling Geese.
4:20-4:40	<i>A. Arnyek*, J. Provencher, Mark L. Mallory</i> . Plastic ingestion by harvested geese in the Canadian Subarctic.
4:40-5:00	<i>E. Wong*, Aqqiumavvik Society, J. Provencher</i> . Chemical contaminants profiles of Arctic-nesting geese and eggs along the Western Hudson Bay.
6:00-9:00	Poster session

Thursday, Oct 23 – Morning Session (Moderators: Josée Lefebvre)

7:00-8:15	Breakfast
<u>Connectivity and Movement</u>	
8:30-9:30	Plenary: Thomas Lameris. Flexible waterbird migrations.
9:30-9:50	<i>B. Nolet, H. Linssen, T. Lameris, M. Boom, R. Nuijten, N. Buitendijk, A. Dokter, B. Ebbinge, G. Eichhorn, J. Geisler, T. Haitjema, A. Kölzsch, H. Kruckenberg, J. Leyrer, J. Madsen, C. Mitchell, S. Moonen, G. Müskens, K. Schreven, L. Vergin, T. Versluijs, J. Shamoun-Baranes, E. van Loon</i> . Scope for waterfowl to speed up migration to a warming Arctic.
9:30-9:50	<i>T. Mezebish Quinn, P. Paton, J. Kilburn, S. McWilliams</i> . The energy- versus time-minimization continuum: Atlantic Brant demonstrate the most energy-minimizing spring migration strategy of three sympatric-wintering waterfowl species.
9:50-10:10	<i>S. McWilliams</i> . Energy expenditure of free-living geese (and other waterfowl): things to consider when using time-energy budgets or accelerometry.
10:10-10:30	<i>J. Stiller, J. Homyack, J. Lefebvre, S. Orichefsky</i> . Factors Influencing Inferred Nest Success of Atlantic Population Canada Geese.
10:30-10:50	Break
10:50-11:10	<i>I. Zeitz*, P. Link, J. VonBank, B. Leach, T. Bidrowski, K. Kraai, M. Weegman</i> . Movement ecology and the full annual cycle of midcontinent Greater White-fronted Geese (<i>Anser albifrons frontalis</i>).
11:10-11:30	<i>Katherine A. Marthens*, Jay A. VonBank, Eric T. Reed, Amelia Cox, Cory T. Overton, Tracy Davison, Michael L. Casazza, Mitch D. Weegman</i> . Drivers of habitat transitions during different annual cycle periods in an Arctic-nesting Goose.

11:30-11:50	<i>J. Weber-Pierson*, M. Eichholz, Jason Brown.</i> Investigating Potential Distributional Effects of Interspecific Competition Among Canada, White-Fronted, and Snow Geese Across Two Illinois Wintering Areas.
11:50-12:10	<i>M. Trottier-Paquet*, F. Angelier, F. Dulude-de Broin, M. Gauthier-Bouchard, M. Hoarau, M. Martin, J. Bêty, P. Legagneux.</i> Corticosterone gives you wings: Experimentally increased spring fattening and cascading effects on migration and breeding decisions in the greater snow goose.
12:10-12:30	<i>M. Murphy*, B. Daniels, B. Sedinger, T. Lewis.</i> Patterns of Brood Dispersal and Habitat Use in Emperor Goose (<i>Anser canagicus</i>) Goslings: Behavioral and Ecological Insights.
12:30-2:00	Lunch

Thursday, Oct 23 – Afternoon Session (Moderator: Frank Baldwin)

<u>Harvest Management</u>	
2:00-3:00	Plenary: Jim Sedinger. Harvest and the dynamics of goose populations.
3:00-3:20	<i>D. Koons, J. Thompson, C. Blommel, T. Riecke, L. Aubry, J. Sedinger.</i> Effectiveness of the harvest hammer for managing Arctic goose populations.
3:20-3:40	<i>A. Schindler, A. Fox, A. Walsh, S. Kelly, M. Weegman.</i> Harvest simulations reveal illegal hunting accelerates Greenland white-fronted goose population declines.
3:40-4:00	Break
4:00-4:20	<i>J. Lefebvre, P. Legagneux.</i> Greater Snow Goose population, what do we do when we overreach the goal?
4:20-4:40	<i>R. Brook, P. Link, G. Brown, J. Feddersen, L. Naylor.</i> Does hunter selection for banded sub-Arctic breeding Canada geese cause a harvest rate bias.
4:40-5:00	<i>B. Ebbinge, R. Bom, K. Koffijberg, N. Calbrade, F. Cottaar, S. Broekhuizen.</i> Population development of Dark-bellied Brent Geese from 1956–2023: a classic case of density dependence.

Friday, Oct 24 – Morning Session (Moderator: Pierre Legagneux)

7:00-8:15	Breakfast
<u>Population Dynamics</u>	
8:30-9:30	Plenary: <i>Gilles Gauthier.</i> Population dynamics of Greater Snow Geese: a 35-year retrospective of research on Bylot Island.
9:30-9:50	<i>A. Schindler, A. Fox, A. Walsh, L. Griffin, S. Kelly, M. Weegman.</i> Environmental drivers of Greenland white-fronted goose metapopulation dynamics throughout the full annual cycle.
9:50-10:10	<i>A. Piironen, J. Knetter, K. Spragens, J. Dooley, V. Patil, E. Reed, M. Ross, D. Gibson, A. Behney, M. Petrie, T. Sanders, M. Weegman.</i> Environmental drivers of productivity explain population patterns of Pacific Flyway snow geese across a half-century.
10:10-10:30	<i>E. Elizondo, D. Cabot, M. Weegman.</i> Long-term population dynamics of barnacle geese on Inishkea, Ireland.

10:30-10:50	Break
10:50-11:10	<i>J. Thompson*</i> , <i>A. Fridberg</i> , <i>T. Riecke</i> , <i>J. Sedinger</i> , <i>D. Koons</i> . Nonlinear effects of spring timing on nesting phenology and growth of black brant goslings in western Alaska.
11:10-11:30	<i>L. Carlson*</i> , <i>J. Stiller</i> , <i>T. Nichols</i> , <i>A. Damminger</i> , <i>M. Dunn</i> , <i>E. Rabbitskin</i> , <i>J. Lefebvre</i> , <i>K. Abraham</i> , <i>F. Noisette</i> , <i>M. Leblanc</i> , <i>F. Baldwin</i> , <i>J. Leafloor</i> , <i>S. Gilliland</i> , <i>S. Slattery</i> , <i>M. Weegman</i> . Seasonal influences of behaviour and environmental conditions on Atlantic brant reproductive success.
11:30-11:50	<i>M. Misewicz*</i> , <i>C. Ely</i> , <i>T. Riecke</i> , <i>M. Tiller</i> , <i>B. Sedinger</i> . Density Dependence and Spring Phenology Affect Community-level Reproductive Success of Arctic-nesting Geese.
11:50-12:10	<i>J. Thompson*</i> , <i>T. Riecke</i> , <i>J. Sedinger</i> , <i>D. Koons</i> . The influence of developmental conditions on maintenance of individual heterogeneity in fitness of black brant.
12:10-12:30	<i>R. Thomas*</i> , <i>L. Aubry</i> , <i>T. Lewis</i> . A comparison of the demography, body condition, and diet quality of emperor geese at the geographic extremes of their wintering range.
12:30-12:50	<i>I. Greutzmann*</i> , <i>F. LeTourneux</i> , <i>F. Angelier</i> , <i>G. Yannic</i> , <i>C. Silvestri</i> , <i>G. Gauthier</i> , <i>P. Legagneux</i> . Evidence of senescence in the greater snow goose.
12:50-2:00	Lunch

Friday, Oct 24 – Afternoon Session (Moderator: Eric Reed)

<u>Co-Management</u>	
2:00-3:00	Plenary: <i>Douglas Clark</i> . Northern wildlife co-management and community-engaged research: navigating changing norms and expectations
3:00-3:30	<i>P. Schwalenberg</i> . Subsistence Harvest of Migratory Birds in Alaska: Partnerships in Conservation.
3:30-3:50	Break
3:50-4:10	<i>K. Baker</i> . Ujjiqsuiniq Young Hunters Goose Project: Community, Conservation, and Knowledge Sharing in Arviat, Nunavut.
4:10-4:30	<i>P. McCarney</i> , <i>K. Curtis</i> , <i>E. Reed</i> , <i>J. Norris</i> . Traditional Knowledge of Geese in the Inuvialuit Settlement Region.
4:30-4:50	<i>E. Reed</i> , <i>L. Carpenter</i> , <i>D. Arey</i> . Co-Management of Wildlife in the Inuvialuit Settlement Region and Implications for Arctic Goose Management.
6:00-9:00	Cocktails, closing banquet

Saturday, Oct 25

7:00-8:15	Breakfast
8:30-5:00	Field trip

**Workshop Facilitators
and
Plenary Speakers**



Michael Schaub

Michael Schaub is a population ecologist at the Swiss Ornithological Institute (SOI) in Sempach, a non-profit, privately funded research organization. He currently heads the Population Biology Unit at the SOI and lectures at the University of Bern. The subject of his PhD research was the migration ecology of passerines. Since then, he has specialized in two areas. Firstly, he has focused on the estimation of demographic parameters, with a particular emphasis on survival. Secondly, he has developed integrated population models with the aim of understanding population dynamics. While his research is primarily focused on birds, he has also worked with mammals, amphibians, and insects. He is the co-author of two books on the estimation of population parameters within the Bayesian framework and regularly teaches workshops on these topics around the world.

Workshop: Bayesian estimation of survival from band-recovery data

The workshop centers on estimating survival from band-recovery data within a Bayesian framework using the NIMBLE software package. Band-recovery models can be formulated in various ways with different parameterizations. Here, the focus will be on the Seber parameterization, but demonstrate that this model can be fitted using single-state and multistate state-space models, as well as multinomial and marginalized models. We will experience the advantages and disadvantages of each model. Particular emphasis will be placed on efficient computation, as Bayesian implementations can be slow when datasets are large. Participants will receive handouts and files containing all the code used during the workshop. Participants are encouraged to bring their own laptop, which will allow them to replicate the demonstrated model fitting and solve an exercise. To do so, they will need to install the R packages nimble, jagsUI and IPM book. All of them can be downloaded from CRAN. Participants ideally have basic knowledge of R and the basic principles of Bayesian computation.

Plenary (Monitoring and Assessment): Combining full-annual cycle and integrated population models

Typical classical population models operate on an annual timescale, requiring demographic processes such as survival to be averaged over the course of a year. However, as individuals are exposed to a temporally changing environment, these processes change continuously. This is particularly evident for migratory species. Failing to consider this results in limited inference about population dynamics. Full-annual-cycle models that specifically include different parts of the annual life cycle address this challenge. In addition to knowledge about productivity and population size, these models require information on seasonal survival and, in the case of migratory species, migratory connectivity. Data that can provide information about seasonal survival, productivity, connectivity, or population trends, are usually piecemeal and of a different nature. Integrated population models (IPMs) allow different types of data to be analyzed jointly, making them particularly well-suited to full-annual cycle models. I demonstrate through some examples how far we have come in developing full-annual-cycle IPMs. I conclude that the components necessary for developing such models are in place, but a main obstacle is the availability of the required data.



Cory Overton

Cory Overton is a wildlife biologist with the U.S. Geological Survey's Western Ecological Research Center, based at the Dixon Field Station in California. With over 25 years of experience, he specializes in the spatial ecology, movement, and population dynamics of migratory birds, particularly waterfowl and wetland-dependent species. His

research spans the Pacific Flyway and addresses how environmental stressors—such as drought, land use change, and climate variability—affect avian ecology and habitat use. He leads and contributes to several high-impact initiatives, including waterfowl and waterbird management, Avian Influenza, the Saline Lake Ecosystems Integrated Water Availability Assessment and the development of the Automated Interactive Monitoring System (AIMS) for Wildlife, which integrates telemetry and environmental data to inform conservation and resource management strategies. Cory holds a Master's degree in Wildlife Science from Oregon State University, where he studied band-tailed pigeon ecology, and earned his Ph.D. in Ecology from the University of California, Davis, focusing on the endangered Ridgway's Rail.

Workshop: Managing the data firehose: Tactics, tools, tips, and tricks for the effective use of large-scale and long-term telemetry projects

Join us for an engaging workshop focused on managing and processing wildlife telemetry data. Participants will learn how to effectively utilize tools such as Movebank for data management and MoveApps for customized analysis. We will explore the ENVData platform for environmental data integration and demonstrate custom R scripts for specific data manipulation and visualization needs related to the AIMS for Wildlife data delivery system.

In addition, we will cover best practices for data storage and management, specifically addressing strategies for handling large datasets with frequent updates. Participants will gain insights into database solutions that facilitate efficient data retrieval and storage, ensuring that telemetry data remains accessible and up-to-date. This hands-on session is designed for researchers and wildlife enthusiasts looking to enhance their skills in telemetry data analysis and improve their understanding of wildlife movements and activities.

Andy Ramey



Andy Ramey is a research scientist at the U.S. Geological Survey Alaska Science Center where he currently serves as the Director of the Molecular Ecology Laboratory. He has spent his professional career collecting and analyzing data on fish and wildlife resources in Alaska and adjacent regions for the U.S. Department of the Interior. The research program which Andy currently manages focuses on population genetics, environmental DNA, and wildlife health and disease; though, his professional background and expertise has been disproportionately biased towards the latter. A major focus of Andy's research over the past 17 years has been the ecology of influenza viruses in wild

birds, mammals, and wetland habitats. For more than two decades, Andy has lived and worked in Anchorage, Alaska, a near-perfect launch pad for his flyfishing, wingshooting, mountain trekking, and paddleboarding adventures.

Plenary (Disease and Contaminants): The role of geese in the emergence, maintenance, and dispersal of highly pathogenic avian influenza viruses

Highly pathogenic avian influenza (HPAI) was historically a poultry disease, sporadically leading to economically costly outbreaks among domestic birds and seldom detected among wild birds. This long-held paradigm slowly began to shift circa 1996 with the emergence of a new genetic lineage of HPAI virus first detected among domestic geese in Guangdong, China. Since 2002, outbreaks of HPAI caused by descendant goose/Guangdong lineage H5 subtype avian influenza viruses ('H5 HPAI viruses' henceforth) among wild birds and sympatric wildlife have become increasingly common. Relatively large-scale mortality events involving wild geese have, in several cases, signaled the establishment of H5 HPAI viruses among wildlife in new regions and/or portended epidemiological shifts in the ecology of HPAI. Specific examples include mortality among bar-headed geese (*Anser indicus*) in China during 2005, barnacle geese (*Branta leucopsis*) in the United Kingdom during 2021, and snow geese (*Chen caerulescens*) in North America during 2022. HPAI has recently become established as an ecologically important wildlife disease nearly globally, having now affected considerable numbers of wild birds and mammals on all continents except Oceania. Throughout the evolution of H5 HPAI viruses, research and surveillance efforts directed towards geese have informed our collective understanding of the emergence, maintenance, and dispersal of these viruses, both in these birds and more broadly. More specifically, characterization of mortality events and experimental challenge studies have provided important insights into the ability of geese to harbor productive HPAI infections and the manifestation of disease among birds. Sampling of hunter-harvested and live-captured geese has afforded us a better understanding of natural infections and host population immunity among birds following exposure, both having important implications for viral maintenance and dissemination. As conservation organizations, domestic animal producers, public health systems, and government agencies grapple with an uncertain future per the continued evolution and potential shifting ecology of H5 HPAI viruses, a review and synthesis of decades of research and surveillance efforts directed towards geese provides important context for assessing change and may also offer clues as to what lies ahead.



Thomas Lameris

Thomas Lameris is a migration ecologist, employed at the University of Groningen (The Netherlands) as assistant professor. He studies Arctic migratory waterfowl and shorebirds, following these birds from wintering grounds around the Wadden Sea to breeding sites in the Eurasian Arctic. His main interest is the behavioural flexibility of birds to adjust to a warming and changing environment. He combines old-school observational studies, tracking technologies and experiments to test the limits of behavioural flexibility in migratory birds. He is also the chair of the IUCN Goose Specialist Group, connecting goose researchers

with a focus on Eurasia.

Plenary (Connectivity and Movement): Flexible waterbird migrations

With rapid climate warming affecting our planet, many biologists are studying the impact of the resulting environmental changes on animals and its potential role in ongoing biodiversity loss. For many migratory bird species, a key hypothesis is that due to inflexibility in the timing of migration and reproduction, the moment of chick growth is becoming mismatched with earlier seasonal food peaks under climate warming, with as a result reductions in chick survival and population growth. Whether such mismatches are and will become important as factors driving population change depends on (i) other climate-related environmental changes impacting reproductive success and (ii) the flexibility of waterbirds to adjust timing of reproduction and migration. In this presentation we will follow barnacle geese and red knots during their annual cycle taking a backward approach – starting with the potential impacts of mistiming and mismatches on the Arctic breeding grounds, followed by changes in phenology along their migration routes, all the way back to the start of migration.



Jim Sedinger

Jim Sedinger started his professional life as an electrical engineer but with a hidden desire to study birds. Through a series of serendipitous events he became a student of Dennis Raveling in 1977. He, Craig Ely, and Dr. Raveling were dropped off by ski plane at Old Chevak on the Yukon Kuskokwim Delta (YKD) around midnight during the first week of May 1977, which began a long association with this part of the world. During his graduate career the La

Perouse snow goose project was producing amazing work on life-histories and population biology of Lesser Snow Geese and when he was later hired by the U.S. Fish and Wildlife Service to study geese on the YKD he asked to work on a brant colony to take advantage of the opportunity to work with colonial geese. Thus, began the Tutakoke Black Brant project, now in its 42nd year, under the excellent guidance of Dave Koons at Colorado State University. Many graduate students have worked at the site as have > 150 technicians, who were nearly all undergraduates or recent graduates. Twenty-four of these technicians went on to earn an M.S. degree, and sixteen earned Ph.Ds. Adding up the months and weeks, Jim has spent nearly three of his 75 years on the YKD. He has wonderful memories of his avian friends, his friends in Chevak Alaska, the occasional spectacular scenes one can only experience in the Arctic, and of course, the sharing of mutual hardships enjoyed by students working in the Arctic. He is privileged to be a member of the waterfowl community, a special group of people, a community that is under threat if the members of the community don't act to preserve and build on their heritage.

Plenary (Harvest Management): Harvest and the dynamics of goose populations

Geese are long-lived and population dynamics are most sensitive to adult survival. For this reason, managing harvest rates has long been thought to be an important tool for managing geese. There is no doubt that very high harvest levels in North America associated with hunting for the commercial market drove some populations to near extinction around the turn of the 20th century. As recently as the 1980s excessive harvest is believed to have substantially reduced numbers in three populations of geese on the Yukon-Kuskokwim Delta, Alaska. In more recent decades, in contrast, there are numerous examples where managing harvest has not been an effective tool or has not had a demonstrable effect on population dynamics. There are numerous reasons for this ineffectiveness. For several populations of white geese, we substantially underestimated abundance until populations were too large for harvest to be an effective tool. Poor performance of some traditional aerial surveys extends to other populations, a problem that needs attention if management is to be effective. There is evidence from at least two populations of heterogeneity in innate survival probability; to the extent that harvest is concentrated on subgroups with lower inherent survival probabilities, harvest will be partially compensated, rendering harvest less effective at influencing population dynamics. Colonially-nesting geese substantially modify the ecosystems where they breed, producing both lagged positive density dependence as grazing increases the availability of high-quality food, and negative density dependence in recruitment as populations and competition for food increase. Effects of such habitat modification may extend to other sympatric breeding species, which is deserving of attention. Declining recruitment, sometimes combined with density dependent declines in adult survival, is implicated in recent declines of several goose populations; for populations of conservation concern improving recruitment will be essential for population recovery. Going forward it is: (1) important to acknowledge the complexity of mechanisms of population regulation, and (2) improve monitoring of both abundance and recruitment.



Gilles Gauthier

Gilles Gauthier has been a professor of animal ecology at the biology department and the Centre d'études nordiques of Université Laval from 1987 to 2022 when he retired and became a professor emeritus. He was also scientific director of the Centre d'études nordiques from 2016 to 2022. He completed his MSc at Université Laval in 1981 on greater snow goose energetics and his PhD at the University of British Columbia in 1985 on the reproductive ecology of buffleheads. His research focuses on the population biology of birds, primarily waterfowl and birds of prey, and mammals, mainly in the Arctic. He is interested in demographic processes responsible for

change in population abundance and their ecological determinants. Several of his projects address problems of interest for the management of exploited wildlife populations and the conservation of species and ecosystems. He founded the Bylot Island research station and managed its research activities for >30 years. During his career, he trained 23 PhD and 48 MSc students and authored or coauthored more than 250 peer-reviewed publications and over 310 conference presentations.

Plenary (Population Dynamics): Population dynamics of Greater Snow Geese: a 35-year retrospective of research on Bylot Island

In this presentation, I will present an overview of 35 years of research on greater snow geese at the Bylot Island breeding colony in the High Arctic. Our main research activities include habitat studies, monitoring of goose reproduction and banding. Like many other populations, the greater snow goose population was growing exponentially near the end of the 20th century due to multiple factors. Our initial studies showed that grazing impact on Arctic freshwater wetlands, the primary brood-rearing habitat of greater snow geese, was high and decreased plant production. To prevent damage to its breeding habitat, the population was declared overabundant in 1999 and special management actions were implemented, including a spring conservation harvest in Canada in 1999 and a Conservation Order in the USA in 2009. We showed that these actions resulted in a significant increase in harvest and a reduction in adult survival. Despite changes in seasonal survival, annual survival did not decrease further after implementation of the Conservation Order, possibly due to compensatory effects between management actions during the winter in the Atlantic Flyway and spring in Quebec. Management actions had little effect on juvenile survival, which appears to be strongly affected by the timing of gosling hatch and conditions encountered during early growth on the breeding ground. Surprisingly, nest predation was found to be an important driver of annual productivity of geese. We uncovered a complex relation between goose nesting success and lemming abundance due to shared predators, primarily the Arctic fox. The functional and numerical responses of foxes to cyclic variations in lemmings, their main prey, strongly affect goose nesting success. We recently showed that these indirect interactions extend to other bird species like shorebirds. High goose abundance reduces nesting success and breeding density of shorebirds primarily due to increased predator activity in the goose colony, which may be a concern for some declining species. Globally, management actions to stop the growth of greater snow geese have been successful over the past 25 years and studies conducted on Bylot Island provided vital information to determine which demographic parameters were mostly affected by these actions.



Douglas Clark

Douglas Clark is a professor in and former Acting Executive Director of the School of Environment and Sustainability at the University of Saskatchewan. His research and professional experience in northern Canada spans 33 years, 8 of which he spent living year-round in Nunavut, northern Manitoba, and the Yukon. Since coming to SENS in 2009 as the Centennial Chair in Human Dimensions of Environment and

Sustainability, he has built a research program on human-wildlife interactions rooted in the relationships he formed during his previous career with Parks Canada. During that time he served in six different parks, including as the first Chief Warden of Wapusk National Park, which contains the long-term snow goose study sites at La Perouse Bay. During his service in Kluane National Park, Yukon, he was twice awarded the Agency's Award of Excellence, for mountain rescue and training program design. His research focuses on northern conservation, wildlife management, and policy development, often integrating traditional knowledge with scientific approaches to identify and secure common interests.

Plenary (Co-Management): Northern wildlife co-management and community-engaged research: navigating changing norms and expectations

The global movement towards Indigenous peoples' self-determination has profoundly changed how wildlife is managed and studied in the circumpolar north. Indigenous land claim settlement has driven these changes in Canada, but parallel changes in different governance systems are evident in other countries too. For scientists and managers these changes have upended traditional scientific management regimes and necessitated sometimes-difficult transformations, but also ushered in a new era of adaptive governance with northerners instead of simply making decisions for them. This transformation upholds a fundamental principle in liberal democracy: the people most affected by a decision should have the greatest say in it. Practically though, navigating these situations is hard work for professionals trained in scientific management, so how can these tasks be made easier? Drawing from successful examples in management and research I identify lessons, strategies, and tactics for wildlife researchers and co-managers who want to work in ways that both benefit wildlife and advance human dignity.

Oral Presentation Abstracts

(alphabetical order, by last name of lead/presenting author)

**Student as primary author*

Plastic ingestion by harvested geese in the Canadian Subarctic.

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Concerns about interactions between plastic pollution and wildlife have been increasing since the 1970s. While substantial research effort has been devoted to investigating plastic ingestion by seabirds, little is known about plastic loads in waterfowl. We examined the incidence of plastic ingestion by wild geese harvested in Arviat, Nunavut. Given that geese regularly forage in agricultural and coastal areas known to accrue plastic debris, we anticipated that they would ingest some of this material. Furthermore, a few studies have observed ingested plastic in North American geese. We dissected the gizzards of lesser snow geese (*Anser caerulescens caerulescens*), Ross's geese (*Anser rossii*), cackling geese (*Branta hutchinsii*), and greater white-fronted geese (*Anser albifrons*) to quantify the level of ingested anthropogenic particles >1 mm in diameter. No evidence of ingested plastic was found in any of the goose species. Metal shot was found in 3.6% (1/28) of lesser snow geese and 7.3% (3/41) of cackling geese. Our results suggest that the effect of anthropogenic debris >1 mm on geese in the Canadian Subarctic is minimal. Given that geese are harvested in northern communities, this contaminant assessment informs our understanding of the health of goose populations and of humans consuming wild geese.

Ujjiqsuiniq Young Hunters Goose Project: Community, Conservation, and Knowledge Sharing in Arviat, Nunavut

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The Ujjiqsuiniq Young Hunters Goose Project brings together Inuit community-driven research and western science. The Aqqiumavvik Society has partnered in this research project with McMaster University, Carlton university, McGill University, Canadian Wildlife Service and the Canadian Food Inspection Agency; with many different aspects to the overall project. Through the project the Ujjiqsuiniq Young Hunters and community members are conducting research through learning how to conduct interviews, collecting animal samples, egg samples, learning about and practicing nesting ecology research, goose banding research, goose health metrics, goose terminology and goose recipe development. Through this process we hope to revitalize the hunting and consumption of goose and the use of goose products in our community, look at the population and health of the migrating geese in our area and to see if the population could sustain a commercial harvest in the future, as well as looking at the contaminants affecting these geese.

Migrating goose populations were central to the cultural and nutritional lives of Inuit. However, the imposed goose ban in the 1950's and 1960's in the Arviat area have diminished the hunting and use of both geese and goose eggs, resulting in the loss of skill and knowledge in cultural harvesting practices and the consumption of geese. The project addresses these challenges by fostering stewardship that bridges scientific research and Inuit Qaujimajatuqangit. Key objectives include monitoring goose health and migration using both modern tools and local observation, documenting and teaching cultural skills, engaging youth and elders in fieldwork, workshops, interviews and informing policy with both ecological data and Inuit perspectives.

Fieldwork involves banding and tracking goose nesting, conducting community interviews, and holding both on-the-land and in community workshops where both Elders and Research Partners mentor Youth. Knowledge sharing is central, using the Aajiqatigiingniq Research Mythology, a continual evaluation process of the project is done to make changes as necessary in the research methods, areas being researched or any other changes necessary to move forward in a good way that is beneficial to both the community and research partners involved in the project.

Community-driven research ensures that training in wildlife monitoring and environmental stewardship builds local capacity while supporting broader conservation networks.

The project's success is measured by both ecological and social outcomes, such as stable goose populations, greater youth involvement, and stronger community cohesion. Challenges remain, including adapting to rapid environmental change and balancing scientific and cultural approaches. Looking ahead, the Ujjiqsuiniq Goose Project continues to expand its reach, demonstrating how Indigenous knowledge and science can work together for ecological conservation and cultural resilience.

Changing light goose distribution in the central Canadian arctic; implications for research and management activities

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Major changes in light goose distribution are occurring throughout the Canadian arctic and are believed to be driven by climate, weather, and habitat change across breeding, migration and wintering areas, which interact to explain regional variation in reproductive success and breeding site fidelity. In the central Canadian arctic, two areas only ~250 km apart have undergone opposite trends in light goose breeding abundance over the last 15 years. The light goose nesting colony at southeast Victoria Island, which has traditionally been small, has undergone particularly rapid growth despite the overall decline in the mid-continent population. Helicopter surveys in 2023 revealed a single colony near Cambridge Bay consisted of approx. 300,000 breeding geese, more than double the size of the total estimated number of light geese in the entire south-east portion of the island in 2011. Around the same time, light goose colonies in the Queen Maud Gulf, which have been studied since the early 1990s, were in a state of population collapse after decades of growth. The rapid decline in nest density and shifts in the location of the colony have compromised ground-based studies about the breeding biology of light geese and associated ecosystem impacts, which were based at Karrak Lake Research Station. In addition, banding operations, which had been carried out in the Perry River area, ~100 km north of Karrak Lake, were increasingly inefficient due to low densities and abundance of light geese within working range of a helicopter, and frequent busts in light goose production.

As colonies change in density, location, and abundance, there are downstream impacts to the feasibility, relevance, and cost-effectiveness of fieldwork associated with them. Decisions to shift study areas have many implications, from interruption of long-term databases to logistical and administrative challenges associated with establishing operations in a new area. However, such changes also offer new opportunities, including potential for novel collaborations, as well as operational efficiencies to ensure long-term studies are sustainable. We wish to share our experience shifting research about light goose breeding biology and banding operations from the Queen Maud Gulf region to southeast Victoria Island from 2023 to present. We will share

preliminary results from field programs and discuss short and long-term objectives for this new study area, which is becoming an increasingly relevant breeding area for mid-continent light geese and other Arctic-nesting goose species.

Does hunter selection for banded sub-Arctic breeding Canada geese cause a harvest rate bias

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Many waterfowl harvest management plans use harvest rate as a metric for monitoring harvest sustainability. For Arctic and sub-Arctic breeding geese, this metric is derived from leg banding operations where samples of flightless geese are captured during the annual wing molt just before goslings are fledged. When hunters encounter leg bands on harvested birds, they can report them, and those data are used to estimate harvest rates for each population. Thresholds for maximum sustainable harvest rates can be estimated by modeling dynamic rates. Together, these guide harvest regulations to ensure harvest sustainability.

Leg bands and other research markers applied to waterfowl (e.g., neck collars, tarsus markers, transmitters) are considered a trophy by most hunters. There is anecdotal evidence that some hunters specialize in targeting marked birds. Some hunting outfitters offer hunts to clients specifically for providing opportunity for hunters to harvest marked birds. The targeting or preference for harvesting birds with markers has the potential for biasing harvest rates and possibly biasing modeled threshold estimates as well.

To assess the potential for a harvest rate bias, we simultaneously applied standard aluminum and cerakote coated leg bands to samples of sub-Arctic breeding Canada geese (*Branta canadensis interior*) from 2021 to 2025. Bands were applied, alternating by type, to adult geese in the same flock at capture with cerakote bands being extremely difficult to detect while hunting. Analyses indicate a small but inconsistent direction of difference in harvest rates between band types when assessed by year. Overall, the difference in direct recovery rates (harvest rates) between standard aluminum banded geese (0.094, 95% CL = 0.086 to 0.102) and cerakote banded geese (0.084, 95% CL = 0.076 to 0.092) was trivial but was in the direction of the predicted bias. We suggest that hunter selection for banded sub-Arctic breeding Canada geese is not currently pervasive enough to cause a concerning harvest rate bias.

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Seasonal influences of behaviour and environmental conditions on Atlantic brant reproductive success

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Some long-lived species are thought to defer reproduction in favor of increased survival when conditions are undesirable, or preparation is insufficient. For populations limited by fecundity,

understanding the impact of intrinsic (e.g., individual heterogeneity in preparation and behavioural decision-making) and extrinsic factors (e.g., regional differences in environmental conditions) across the annual cycle on subsequent reproductive outcomes can help direct targeted conservation strategies. We used GPS location and acceleration data from 121 Atlantic brant (*Branta bernicla hrota*) to evaluate effects of behaviour and environmental conditions experienced during three temporally and geographically distinct seasons -- the mid-Atlantic coast prior to spring migration, spring staging on James Bay, and the period after arrival on the breeding grounds in the Foxe Basin. Brant with higher energy expenditure (across all seasons, but particularly on staging areas) were less likely to breed successfully. There was some evidence that spending more time in aquatic environments (time spent swimming) was beneficial and more time spent feeding in terrestrial areas was detrimental to breeding success. Individual heterogeneity in behavioural responses to weather and habitat conditions across all three seasons suggests plasticity in responses to conditions, or an ability to avoid significantly detrimental extremes.

Unusual Colonization of Canada geese (*Branta canadensis moffitti*) along 450 kilometers of Colorado River riparian habitat in Grand Canyon, AZ

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Canada geese (*Branta canadensis moffitti*), previously considered winter visitors and transients along the Colorado River in Grand Canyon, have recently begun colonizing portions of that 450-kilometer reach. Our recent field observations (2018–2025) document that nesting Canada geese are now regularly and successfully raising broods in two geographically and morphologically distinct areas within the river corridor. A single nesting pair was recorded in the 1950s, followed decades later by single-pair nesting in 2001, 2012, 2013 and 2016. No nesting was recorded in 2017. In 2018, we began annual monitoring and encountered one family group in that year. From there the total number of nesting goose pairs increased sharply from two pair in 2019 to 22 pair in 2022, then leveled off in 2023 and 2024 and dropped substantially in 2025. Three factors likely contribute to the recent colonization of geese in Grand Canyon. First, the North American population of non-migratory, resident geese has increased as a whole, and their breeding range has expanded southward; second, likely source populations have been established nearby due to translocated nuisance geese, and third, nesting habitat now exists along the Colorado River that did not exist historically. We propose that prior to extensive modification of the river corridor by two large dams, breeding habitat for nesting geese would have been virtually nonexistent. Glen Canyon Dam, upstream of our study area, and Hoover Dam, downstream, have dramatically altered the natural hydrograph of the Colorado River. While we understand why colonization took place in the first place, we do not understand why since 2022 the population of nesting geese has declined when we would have expected it to continue increasing.

Leveraging existing projects to document highly pathogenic avian influenza among Arctic nesting geese and sympatric species on the Yukon Delta National Wildlife Refuge, Alaska during 2022

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Historically (i.e., prior to 2002), highly pathogenic avian influenza (HPAI) infections were associated almost exclusively with domestic birds. Since 2002, HPAI has become more common in wild birds and in 2014 HPAI was recorded for the first time in Canada and the United States. During 2022, HPAI caused unprecedented disease and mortality among wild birds in North America, including Arctic nesting geese and sympatric taxa on the Yukon Delta National Wildlife Refuge (YDNWR), Alaska, and in the surrounding area. During June, July and August 2022 on YDNWR, researchers leveraged existing field projects to document observations of sick and dead birds, estimated abundance of carcasses, collected swab and sera samples to detect viruses, and monitored bird nesting on the Yukon-Kuskokwim Delta region of Alaska to document potential effects of disease. Thirty-six reports of sick and dead birds were registered across the region. Nineteen carcasses were opportunistically collected for diagnostic testing, of which 12 were confirmed to be infected with clade 2.3.4.4b HPAI viruses. Carcass abundance estimates from line-distance sampling provided evidence that the most common species of dead birds from the western Yukon-Kuskokwim Delta region were Cackling Goose (*Branta hutchinsii minima*), Glaucous Gull (*Larus hyperboreus*), and Black Brant (*Branta bernicla nigricans*). Of 195 sera samples from waterfowl screened for antibodies reactive to influenza A viruses, antibodies were found in 41–98% of samples collected from Emperor Goose, Cackling Goose, Black Brant, and Spectacled Eider (*Somateria fischeri*). Additionally, 15–98% of the same sera samples were reactive to a clade 2.3.4.4b H5 antigen. Fewer Black Brant and Emperor Goose nests were found on long-term study plots during 2022 as compared to previous years. Collectively, we found that HPAI viruses affected at least eight species of wild birds inhabiting the region during 2022. The full scope of impacts of HPAI at this location during 2022 are unknown, but our data indicate that acute effects to avian population health on the Yukon-Kuskokwim Delta region were likely modest. This project exemplifies how leveraging of existing field projects may be useful towards elucidating the impacts of HPAI on wild bird outcomes.

Analysis of Survival and reproductive changes using three marking methods on adult female Emperor Geese

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Beginning in the early 1980's, Indigenous Alaskan observational reports and aerial surveys documented a population decline of emperor geese (*Anser canagicus*) that closed sport and subsistence harvest in 1985. These declines prompted studies of demographic rates, including annual and seasonal adult female survival, as well as local and seasonal movement information. To begin with, emperor geese were marked with neck collars both with and without VHS transmitters, but these were found to significantly decrease survival. Accordingly, studies shifted to color marked tarsal bands for Capture-Mark-Recapture studies of demography. Since then, there has been a need for more fine scale movement data without decreasing survival. New techniques of marking arctic nesting geese have become increasingly widespread, including internal transmitters and backpack style transmitters. From 2017-2025, Yukon Delta National Wildlife Refuge (YDNWR) has deployed color marked tarsal bands on adult female emperor geese for CMR analyses. Over this same period, YDNWR deployed 20 backpack harness style GPS transmitters, and Alaska Department of Fish and Game deployed 193 internal transmitters on nesting female emperor geese. We conducted three sets of analyses relevant to effects of these markers on emperor geese. In the first, we applied Cormack-Jolly-Seber models to our capture-resight data to estimate the survival probabilities of geese marked with tarsal bands or backpacks, and known-fate models to estimate survival of geese with internal transmitters. In our second set of analyses, we examined clutch size and egg size in the subset of marked birds we observed on nests in a subsequent years. Our preliminary analyses of transmitter effects on survival indicated that: survival of emperor geese marked only with tarsal bands varied between 0.73 - 0.95 (95% CI; 0.61- 0.99); survival of geese with backpack style transmitters was zero; and survival of emperor geese marked with internal transmitters varied between 0.83 - 0.92 (95% CI; 0.66- 0.96). Clutch sizes of tarsal banded geese were similar to what they produced before being banded. In contrast, clutch sizes for internal transmitter geese were roughly 2 eggs fewer than what they produced when unmarked. Egg width for internal transmitter birds did not differ from untagged birds, but their egg lengths were nominally longer. Lastly, we had zero resights of backpack-tagged birds in subsequent years and conclude that backpack style transmitters should be discontinued on emperor geese.

Productivity, juvenile survival, and movement drive subpopulation change in lesser snow geese

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Reliable estimates of wildlife abundance and demographic rates are imperative for assessing trends across time and space. While complete estimation of all demographic rates is important when evaluating contributions to population change, movement rates are often challenging to estimate, particularly for wide-ranging or migratory species. The midcontinent population of lesser snow geese (*Anser caerulescens caerulescens*, hereafter snow geese) has experienced dramatic shifts in population trends in recent decades resulting in the loss of millions of individuals in recent years. The mechanisms driving snow goose population decline are believed to be due to poor reproductive success and declining recruitment instead of decreased adult survival, but patterns in these demographic rates within and among subpopulations have not been evaluated in a comprehensive modeling framework. In this study, we developed an integrated metapopulation model using mark-recapture-recovery data for five subpopulations of snow geese in the Canadian Arctic and subarctic to determine the demographic mechanisms for meta- and subpopulation-level changes, including movement, as well as the environmental drivers of snow goose demography. Results from this study showed differing trends in juvenile survival among subpopulations, yet adult survival was similar among subpopulations. Productivity was highly

variable among years and subpopulations, but the subarctic subpopulations had consistently higher productivity than the Arctic. Site fidelity was high in this system, yet when individuals dispersed, movement primarily occurred to one of the Arctic subpopulations or to an unobservable state from which individuals rarely returned. This work provides a framework for integrating movement ecology into population models, allowing for full demographic estimation of mechanisms influencing population change and thus, offering a new understanding of population dynamics of a long-lived species in space and time.

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Integrating data and statistical models improves inference about demography of harvested populations

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Uncertainty and bias about population trajectory limits ecological inference and challenges management of exploited populations. Abundance of harvested populations can be estimated by dividing harvest rates (i.e., counts of harvested individuals) by harvest probabilities (“Lincoln’s method”). Harvest probabilities for use with Lincoln’s method are conventionally estimated from recoveries of recently tagged individuals; these “direct” recoveries are assumed to best meet a key model assumption of demographic closure. Direct recoveries usually comprise 25–50% of total recoveries, with the remaining recoveries being those occurring at least 1 year after an individual is tagged (“indirect recoveries”). Within a single Bayesian estimation framework, we used hazard-rate parameterizations of tag-recovery models to estimate harvest probabilities from both direct and indirect recoveries and univariate state-space models to estimate harvest rates. We then derived abundance estimates from fitted values of harvest rates and harvest probabilities (“Brownie-Lincoln approach”). With both simulated and empirical data, we show the Brownie-Lincoln approach increased certainty of abundance estimates when compared to more conventional formulations of Lincoln’s method. We also demonstrate how inference about abundance may be unreliable when recently tagged individuals are more vulnerable to harvest. In a case study using data from the midcontinent population of greater white-fronted geese (*Anser albifrons frontalis*) collected during 1990–2019, the Brownie-Lincoln approach substantially reduced inter-annual variability of abundance estimates in a manner consistent with observed life histories of this population when compared to Lincoln’s method. Integrating tag-recovery models with Lincoln’s method, two models whose combined publication age is approaching 150 years, provided inference about population dynamics that was less influenced by sampling variability and less suggestive of density dependence. By reducing epistemic uncertainty about population dynamics, the Brownie-Lincoln approach increases the value of information obtained from long-term ecological and harvest datasets without increasing monitoring effort or cost. This talk focuses on practical lessons learned from this work, future directions, and how results from our methodology are advantageous to decision making.

Atlantic Population Canada Goose Integrated Population Model: development, use, and future direction

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Atlantic Population Canada geese (*Branta canadensis interior*), which primarily breed on the Ungava Peninsula, Quebec and winter in mid-Atlantic coastal states, are an important component of the Atlantic Flyway waterfowl harvest and have exhibited dramatic changes in population status and trends over the last half century. Atlantic Population Canada geese were once considered the largest Canada goose population in North America, with winter indices approaching 1 million geese in the mid-1980s. Beginning in the late-1980s, abundance of the population, based on both winter and breeding ground surveys, declined sharply, by more than 75% in less than a decade, which prompted harvest closures beginning in 1995 that remained until 1999. With harvest closures and improved productivity on the breeding grounds, the population recovered. Indices of total geese based on a June survey on the Ungava Peninsula were near or above 1 million geese for most of the 2000s. However, in the mid-2010s, abundance began to decline for unknown reasons. Additionally, in 2013, the U.S. Fish and Wildlife Service changed its process for setting waterfowl hunting regulations, which required managers to select hunting season frameworks one year in advance. The increased uncertainty

about population status and the new regulatory changes prompted the Atlantic Flyway to develop an integrated population model (IPM) to better assess population dynamics and help guide management, which was formally adopted for use in a revised harvest strategy in fall 2020. We describe analyses that were conducted to guide construction of the IPM and important relationships between productivity and environmental covariates as well as hunting regulations and harvest/survival probabilities. We provide an overview of how the IPM was used to revise the harvest strategy, including deriving optimal regulatory packages to achieve desired harvest probabilities, and how managers consider the IPM out-year prediction of breeding pairs with other information within a prescribed harvest strategy to select optimal hunting regulations, particularly during years of missing monitoring data due to COVID. We discuss the pros and cons of using IPMs to inform harvest regulations, uncertainties of current population status, role of monitoring data, and some potential modifications and improvements to the IPM that are being considered.

Population development of Dark-bellied Brent Geese from 1956–2023: a classic case of density dependence

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The development of the Dark-bellied Brent Goose *Branta bernicla bernicla* population breeding in Siberia has been monitored through mid-winter counts along the coasts of western Europe in France, UK, Netherlands, Germany and Denmark from 1956–2023. The narrow coastal zone of western Europe, and a high density of observers make complete coverage of this population possible. In addition to the total number of birds, data on breeding success (age ratio estimates of the wintering flocks) and brood sizes (the number of accompanying young in families) were recorded. The number of successful breeding pairs was estimated using the total number of juveniles divided by mean brood size. Estimates of the number of still immature (second-year birds) in the population were made based on the proportion of juveniles in the previous year. This allowed us to recalculate the proportion of juveniles while excluding the second-year (non-breeding) birds. Huge numbers of well over 200,000 Dark-bellied Brent Geese reported in the early 20th century had decreased alarmingly to only 15,500 birds by 1955. Hunting bans in the Netherlands (1950), UK (1954) and France (1966) yielded some increase to about 30,000 birds in the mid-20th century, but following a ban on hunting in Denmark in 1972 the population started to recover unexpectedly to a level of 250,000 birds during the period 1991–2024. Historic anecdotal information on hunting pressure since 1860 shows that many birds were harvested using guns and punt-guns in winter, while catches of flightless Dark-bellied Brent Geese during wing moult in northern Russia also occurred. The unprecedented population growth since 1972 indicates a major impact of hunting in Europe on its numbers.

The rate of reproduction has declined from 22.9% first-winter birds before 1990 to 12.1% thereafter. Studies from the Taimyr Peninsula in the Russian arctic (the main breeding grounds for Dark-bellied Brent Geese) illustrate that safe nesting sites are scarce and depend on cycles in

abundance of lemmings: Siberian Lemmings *Lemmus sibiricus* and Collared Lemmings *Dicrostonyx torquatus*. The average annual survival rate of 78% between 1955–1972 rose to 88% for the period 1973–2016. The number of successful breeding pairs, plotted against the number of potential breeding pairs has declined significantly, showing a density-dependent decline in of reproductive success. The high level of exploitation before 1972 kept the population well below the carrying capacity of the breeding grounds, but at present its limits seem to be reached.

Long-term population dynamics of barnacle geese on Inishkea, Ireland

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Arctic ecosystems have experienced marked changes over the past decades, many of which have been driven by human activities, such as anthropogenically accelerated climate change. These systems are characterized by incredibly productive summers and harsh winters, leading many birds to evolve migratory strategies that allow them to take advantage of these seasonal resources. The complex life histories associated with these strategies complicate the management of these species, many of which are largely only monitored during their non-breeding period. One such example is the Barnacle Goose (*Branta leucopsis*), which breeds primarily in the Arctic but is more heavily monitored during the fall and winter when they migrate south. The Greenland sub-population winters largely in Ireland and Scotland, where the geese spend much of their time on coastal islands. Inishkea, an island off the west coast of Ireland, has long been considered an important wintering area for barnacle geese and has been monitored annually since the 1960s. Historically, a large proportion of the barnacle geese overwintering in Ireland were found on the island of Inishkea. Ireland-wide aerial censuses conducted in the 1960s and 70s estimated that roughly half of the birds wintering in Ireland were located on Inishkea. More recent surveys, however, indicate that the Inishkea sub-population makes up a dwindling proportion of the overall count, down to ~15% of the overall Irish counts. Using data from 1971 to 2023, we built an Integrated Population Model to estimate the survival, productivity, and size of the Inishkea sub-population over the full time series. We included banding and color-band resighting data, survey counts, and proportions of juveniles observed within the population from each year. The preliminary analysis reveals that the population is fairly stable with high adult survival, moderate juvenile survival, and low numbers of offspring produced each year. Although the overwintering population in Ireland is increasing overall, Inishkea appears to be at carrying capacity. The consistent trends in fecundity suggest that the growth elsewhere in Ireland may be driven by increased juvenile survival, as opposed to improved breeding conditions contributing to increases in fecundity across the population.

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Evidence of senescence in the greater snow goose

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In long-lived species, adult survival is the demographic parameter with the highest relative contribution. Though it is stable in time when averaged at the population scale, it shows individual heterogeneity when observed at a finer scale. Furthermore, when individuals age, their performance can also decrease in a process called senescence. Presence of senescence in wild populations has been thoroughly proven in the last two decades, and researchers are now trying to decipher the underlying factors. Interestingly, by looking at some key traits and their variations with age, it is possible to associate individual heterogeneity and senescence in understanding the individual variations in survival. This heterogeneity is sometimes accounted for using latent unmeasurable latent variables, but to understand the individual variations more precisely, one has to look at definite individual traits. We selected telomere length to reflect individual physiological state, body condition for endogenous reserves, and body condition, as an indicator of early-life conditions. Using these traits, we investigated the respective roles of senescence, hunting pressure, stress and individual quality in the variations of survival in the greater snow goose (*Anser caerulescens atlanticus*). We used morphometric, physiological and demographic data from two complementary datasets: 30 years of CMR data and colony monitoring at Bylot Island (Nunavut), as well as data from an experiment that took place in 2009 at Île-aux-Oies, followed by 13 years of monitoring. We were able to establish the actuarial senescence pattern of this species for the first time, unaffected by hunting pressure. Senescence sets at ca. 11 years, with a progressive decrease in survival, accompanied by a decrease in post-reproduction body condition with age. Survival is marginally explained by body size, while telomere length modulates vulnerability to hunting in interaction with breeding propensity. Hunting mortality seems to be compensatory and affect lower quality individuals. We also found that telomere length mainly varies with age, body

size, and nest density during growth showing an influence of early-life conditions and senescence in the observed individual heterogeneity. Three major determinants of survival heterogeneity and individual quality in the Greater Snow Goose emerge from this work: developmental conditions, the effects of telomere length and body condition on hunting vulnerability, and age. Our study shows the importance of considering the interaction between intrinsic and extrinsic sources of mortality when considering survival dynamics and opens interesting future research avenues allying physiology and demography.

Utilization of a Modern Mobile Laboratory for In-Field Detection of Avian Influenza in Waterfowl in North America.

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With sustained circulation of highly pathogenic avian influenza (H5N1) 2.3.4.4b viruses in North America the need for faster, broader, and higher-scale surveillance of avian viral reservoirs is at an all-time high. We have initiated an alternative to traditional surveillance operations with **B**ioinformatic **I**nfluenza **R**isk **D**etection & **W**aterfowl **A**ssessment for **T**racking, **C**ontrol, & **H**ealth (**BIRDWATCH**), a mobile scientific laboratory that is operated for field testing and analysis of waterfowl samples. In 2024 during preseason banding, we piloted the mobile laboratory in Alberta, Canada, and at national wildlife refuges in both North and South Dakota. We used a magnetic induction thermocycler for real-time PCR screening of cloacal samples hours after collection, a total of 782 cloacal samples were screened, and we detected 11.1% M+ gene positive demonstrating successful screening of fresh waterfowl samples over 10-day periods at each site. Therefore, BIRDWATCH represents a fundamental shift in the way we can monitor influenza threats from a retrospective- to a prospective-designed operation that can generate an overall picture of the prevalence of influenza on site *before* returning to the laboratory. In addition to rapid screening in the field, BIRDWATCH is also primed for mobilization to areas of animal-to-human interface, as well as outbreak areas where rapid determination of influenza genotyping is necessary.

Effectiveness of the harvest hammer for managing Arctic goose populations

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In Arctic geese and other long-lived species, elasticity analyses clearly indicate that *in a world where all else is equal*, proportional changes in adult survival have the greatest impact on population growth rates. When combined with the fact that harvest has an additive effect on adult mortality of Arctic geese, prudence is necessary when setting harvest regulations to sustain populations. The same logic also implies that harvest could be an effective management tool for controlling abundance, and these premises of demography were central to planning the Conservation Orders (or Seasons) for mid-continent light geese and greater snow geese. Our survey of Arctic goose management plans revealed a heavy emphasis on the harvest hammer for tinkering with populations, but derived harvest strategies (e.g., mid-continent mallards) are utilized in < 10% of the management plans. Prescriptive harvest management strategies are the norm (described in 74% of the plans), and a shift toward greatly simplified hunting regulations compared to the past may indicate a recognition that other factors play a greater role in governing some Arctic goose populations. Using a detailed long-term study of black brant and retrospective perturbation analyses, we measure the influence of demographic mechanisms on population outcomes in a world where all else is *not equal* and demonstrate how to quantitatively weight harvest management efforts relative to other needs associated with goose demography. Our analytical approach is by no means restricted to the brant dataset, and could be applied to a variety of other Arctic goose populations and management issues.

Greater Snow Goose population, what do we do when we overreach the goal?

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The exponential increase of the Snow Goose population represents one of the most notable cases of overabundance species in North America. A combination of factors—including the creation of bird sanctuaries, decreased hunting pressure, climate change and new agricultural practices – contributed to this rapid growth. Within less than three decades, the population expanded at an average annual rate of 9%. At that time, managers feared that breeding, migration and wintering grounds were being severely damaged, prompting the implementation of special conservation measures. These measures, consisting of liberalized spring hunting were introduced in 1999 in Canada and in 2009 in the United States. The objective was to limit population size in order to sustain harvest opportunities while reducing risks to the ecological integrity of northern habitats and the species that interact with snow geese. Controlling the population also aimed to mitigate crop damage while maintaining socio-economic benefits such as ecotourism and outfitting. A population target range of 500,000 and 750,000 individuals was therefore established. Following the introduction of these measures, the population stabilized and eventually reached the target in 2019, although a gradual decline of the population had already begun around 2012. In spring 2025, the Greater Snow Goose population dropped below the target population bracket.

We will review the potential mechanisms underlying this decrease, including direct effects on mortality and indirect effects on reproduction and survival. Through the framework of adaptive population management, now applied in both Canada and the United States, we will discuss possible strategies to reduce anthropogenic pressures so that the population can recover to target levels. However, because the factors that initially drove overabundance have not disappeared, relaxation of special conservation measures must be approached cautiously to avoid a rapid rebound in population growth.

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Drivers of habitat transitions during different annual cycle periods in an Arctic-nesting Goose

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Understanding habitat use can provide important perspective about drivers of survival and reproductive success, particularly in Arctic-nesting migratory bird species, because resource availability on breeding areas is relatively brief. We studied habitat use of lesser snow geese (*Anser c. caerulescens*, hereafter snow geese) breeding in the western Canadian Arctic during 2023 and 2024. The western Arctic snow goose population has increased substantially over the last 10 years, and indigenous communities in northern Canada are concerned that snow geese are outcompeting caribou and muskox, whose populations are declining. Advances in tracking technology now provide high resolution information to study habitat use in space and time as never before in these remote areas. Between 2018 and 2024, ~100 GPS collars were deployed on snow geese on breeding and wintering areas. The collars collect GPS and acceleration data every 15 min. North America and NOAA National Snow and Ice Data Center daily snow and ice cover data were used to classify GPS points into 8 landcover types, and ERA5 hourly temperature and precipitation data were compiled associated with each GPS position. A machine-learning model was used to classify behaviours into four categories: walking, foraging, flight, and resting. Using a Markov model in a Bayesian framework, we assessed how behavioural decisions (i.e., proportion of time spent on different behaviours) influenced movement among landcover types during summering periods as well as during northern staging periods in spring and fall. We also assessed the effects of weather on habitat transition probabilities. Our results suggested that birds had a strong affinity grassland and shrubland-lichen-moss habitat; however, the primary habitats used changed among seasons. During spring staging, birds used snow and ice more frequently

compared to other frequently used habitat types. Birds similarly changed to greater use of barren-lichen-moss habitat during fall staging, suggesting that there may be some resource there that current maps are not effectively quantifying. As temperature decreased, we found that birds were more likely to transition to grassland, shrubland, and barren-lichen-moss habitats where more forage material is likely to be available. These results expand our understanding of how snow geese use western Arctic landscapes and will inform future analyses linking to caribou and muskox distributions, quantifying multi-species relationships and informing future conservation planning in Arctic ecosystems.

Traditional Knowledge of Geese in the Inuvialuit Settlement Region

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The Inuvialuit Settlement Region (ISR) of Canada's western Arctic is home to diverse goose populations that play critical roles in Inuvialuit culture, food security, and community well-being. Geese are central to seasonal harvests, intergenerational knowledge sharing, and ecological relationships, and can serve as indicators of broader environmental change. Inuvialuit harvesters and Elders have expressed concerns about shifts in goose migration timing, abundance, health, and habitat quality, particularly as these factors affect access to harvesting areas and timing. Inuit observations about changes in goose populations emphasize the need to use both Indigenous and Western knowledge to inform wildlife management and conservation planning. This project employs a community-based participatory research framework as a partnership among the Inuvialuit Game Council, the Wildlife Management Advisory Council (NWT), the Inuvialuit Joint Secretariat, the six Inuvialuit Hunters and Trappers Committees (HTCs), and Yukon University. One of the project's goals is to actively involve community members in the research to enhance research capacity in the ISR. Methods include semi-structured participatory mapping interviews and facilitated community workshops to refine findings. Together, these approaches are documenting ecological changes observed by the communities being directly impacted. Early conversations indicate noticeable shifts in goose abundance, migration phenology, nesting patterns, changes in habitats, and increased unpredictability of weather affecting hunters' ability to access harvesting grounds safely. Community members emphasize the importance of involving youth in conversations about conservation, as well as ensuring local and cultural knowledge transmission. By centring Inuvialuit knowledge, this research contributes to Arctic wildlife co-management, food security, and climate adaptation. It demonstrates the importance of Indigenous-led research in increasing the opportunities for conservation strategies to address ecological concerns and uphold community well-being and knowledge.

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Why so blue? Hybridization in light geese and origin of the blue ross's goose

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The increase in agricultural production in the 1970s and a warming Arctic has extended breeding season, such that many geese species especially snow geese (*Anser caerulescens*) and ross's geese (*A. rossii*) have grown exponentially. Although trends in population sizes have recently begun to decline, the prior substantial population increase has likely altered intra-species population dynamics as well as inter-species interactions within the light goose species complex. One such consequence of altered species interactions is hybridization and the incorporation of genetic material (introgression) between species. These events can lead to modified phenotypes and pose concerns about species' genetic integrity. Prior to the 1920's, both species were presumed to be highly structured with little to no inter-species interaction. However, as populations sizes increased, breeding and wintering ranges expanded, potentially resulting in an increase in hybridization rates. The blue ross's goose (first reported in 1979) and the decline in body size in the snow geese are both examples of altered phenotypic variants over the last few decades that may be attributed to introgression within light geese. Thus, we estimated species level divergence and the prevalence and directionality of hybridization between snow and ross's geese using reduced representation genomic (i.e., ddRAD) sequencing. We hypothesized that asymmetrical backcrossing would occur, if present, into the ross's goose due to smaller body size, low frequency of forced copulation, and smaller population size. We found a high rate (~20%) of individuals that had morphological characteristics consistent with a ross's goose that were hybrids (F1 and subsequent backcross generations) compared to only ~5% of snow geese having hybrid signatures, demonstrating a clear asymmetrical directionality in backcrossing. Asymmetrical introgression could be due to assortative mating based on larger body size observed in snow geese and the large disparity in species abundance which may limit availability

of mates for hybrids and ross's geese in general. The two blue ross's geese were identified as late generation hybrids indicating that this rare color variant is not maintained via recurrent hybridization events, rather is present in the ross's goose gene pool albeit at a low frequency. Interestingly, the same genetic variant in the color gene found in blue snow geese is present in the blue ross's goose suggesting that the blue color is likely the result of the same genetic variant and therefore, the hybridization event transferred the variant controlling for blue color between species.

Energy expenditure of free-living geese (and other waterfowl): things to consider when using time-energy budgets or accelerometry

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Energy budgets are commonly estimated for free-living waterfowl because they tell us useful things like how much food our favorite geese need, the cost of reproduction or other life history events, whether a given habitat might satisfy the energy requirements of a certain goose population, or how disturbance from predators including humans might increase energy needs. Such energy budgets can be derived from more direct measurements (e.g., doubly-labelled water) but indirect approaches such as time-energy budgets or telemetry-accelerometry are much more commonly used these days. All such approaches require us to make key assumptions and one, in particular, is central to almost all: extent of movement is directly related to the amount of energy expended. Empirical studies of exercising, flying birds show that the energy cost of a certain athletic feat (e.g., flying for 6 hrs at the same pace) substantially varies and depends on fuel composition (for birds, the fatty acid composition of their fat stores). We can use these studies and others to determine how wrong our estimates of energy expenditure could be when using time-energy budgets or telemetry-accelerometry.

The energy- versus time-minimization continuum: Atlantic Brant demonstrate the most energy-minimizing spring migration strategy of three sympatric-wintering waterfowl species

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Migratory birds face considerable temporal and energetic constraints during spring migration. To balance these demands and maximize breeding success, migratory birds may optimize spring migration by adopting a migration strategy that primarily favors minimizing time or energy spent on migration. We used GPS telemetry to quantify interspecific, interindividual, and annual variation in spring migration strategies of 3 species of waterfowl, including the Arctic-breeding Atlantic Brant (*Branta bernicla hrota*), that share a common wintering area in southern New England, USA, but differ in distance traveled between wintering and breeding areas, breeding latitude, breeding strategy, and breeding range size. We characterized spring migration strategies by quantifying ordinal spring migration initiation date, ordinal spring migration completion date, migration duration, number of stopovers, average stopover duration, proportion of migration time spent in stopover, and a stopover to travel ratio. Atlantic Brant (n = 20) demonstrated the most energy-minimizing spring migration strategy compared to Greater Scaup (*Aythya marila*; n = 9) and American Black Ducks (*Anas rubripes*; n = 20). Atlantic Brant and Greater Scaup also had less intraspecific variation in metrics of spring migration strategy than American Black Ducks, particularly those associated with stopover behavior, highlighting the importance of key stopover sites for long-distance migrating species. We also found limited evidence of carryover effects of winter movement and space use patterns on spring migration behavior across all 3 species. Our findings demonstrate that sympatric-wintering waterfowl adopt distinct spring migration strategies along the continuum from energy- to time-minimization and also differ in the extent of intraspecific variation in migration strategy which, together, has important conservation implications. Specifically, our findings highlight the importance of conservation efforts at James Bay, a key stopover site for Atlantic Brant.

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Density Dependence and Spring Phenology Affect Community-level Reproductive Success of Arctic-nesting Geese

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Among waterfowl populations, productivity is closely tied to conditions encountered on the breeding grounds. For example, spring phenology, weather, and predation dynamics can affect reproductive success. Arctic-breeding geese in particular face strong selective pressures during reproduction, as the short breeding season requires synchrony between hatching and resource availability while competition with conspecifics may constrain reproductive success. Although the effects of phenology and density dependence are well established in colonial nesters like Black Brant (*Branta bernicla nigricans*), their roles in dispersed-nesting geese remain poorly understood. This gap is critical, given that many Arctic goose populations exhibit shifting population trends while climate change continues to advance the onset of spring. We investigated how spring phenology and local density influence nest survival and gosling growth in dispersed-nesting Arctic geese (Cackling Goose (*Branta hutchinsii minima*), Greater White-fronted Goose (*Anser albifrons*) and Emperor Goose (*Anser canagicus*)). We analyzed data collected at Old Chevak, Yukon-Kuskokwim Delta, Alaska, from 1985-2005 to examine daily nest survival as a function of spring onset, nesting density, and their interaction, while also quantifying gosling body mass growth rates relative to hatch timing and brood density. Our results indicate strong density-dependent effects on nest survival: nests in areas of higher local density exhibited lower daily survival probabilities. Earlier springs were associated with higher nest survival, but the benefits diminished when density was high, suggesting interactive effects of phenology and competition. For gosling growth, phenology effects were less consistent, with earlier-hatched broods showing higher growth rates in some years but not others, while density dependence again played a role, with goslings in denser areas showing reduced growth. Together, these findings demonstrate that both environmental timing and conspecific density shape reproductive success in dispersed-nesting Arctic geese. As climate warming continues to shift Arctic phenology, our results suggest that density-dependent constraints may offset some benefits of earlier springs, with important implications for predicting population trajectories under ongoing environmental change.

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Patterns of Brood Dispersal and Habitat Use in Emperor Goose (*Anser canagicus*) Goslings: Behavioral and Ecological Insights

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Animals make decisions about habitat use that have lifelong implications for survival and fitness. For waterfowl, decisions made between hatching and fledging are especially important, as precocial young must not only grow and complete their molt but also prepare for their first fall migration. Emperor geese (*Anser canagicus*) are endemic to the Bering Sea region and of growing conservation concern given their dependence on high latitude coastal ecosystems and declining population. To better understand how emperor goose broods use varying habitats during the brood rearing period, we deployed GPS transmitters on females with broods to track gosling movements on the Yukon-Kuskokwim Delta, Alaska. From this GPS data, we determined distance traveled by broods from the nesting site, brood home range size, types of habitats used, and resource selection. We found that emperor goose broods stayed within 5km of their nesting site and maintained an average home range of $\sim 10\text{km}^2$. Both grazing lawn and mudflat habitats were present within their home range but broods preferentially selected grazing lawns. Broods were observed to forage for algae on mudflat and *Carex* sedges on grazing lawns. Our results reveal that grazing lawn remains the most important habitat for brood-rearing emperor geese on the Yukon-Kuskokwim Delta, consistent with past studies; however, broods also appear to regularly forage on green algae present on mudflats when these areas are available during low tide. This is the first-known study that has documented emperor goslings extensively using non-vegetated mudflat habitats, which provide forage while allowing adults to better observe incoming predators and competing species. We also found that females and their broods do not travel as far as anticipated to reach brood rearing sites and that home range size varied based on individual, not habitat used. Overall, the dependence on grazing lawn habitat combined with long-term declines in these habitats across the Yukon-Kuskokwim Delta may have lasting implications on fitness of emperor goose broods.

Scope for waterfowl to speed up migration to a warming Arctic

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Climate change is causing an earlier onset of spring, requiring migratory birds to accelerate their spring migration to avoid arriving late at the breeding grounds. This acceleration hinges on the capacity to shorten the time spent building energy reserves (fuelling) for migratory flight, which is currently thought to be very limited. Combining multiyear global-positioning-system tracking and body mass data from five large-bodied Arctic-breeding waterfowl species, we demonstrate that there is considerable scope for the studied species to migrate faster by shortening the fuelling time, either before departure or at stopovers. With the exception of one species (brent goose), populations were able to largely or fully offset their spring departure date with subsequent fuelling time en route. Still, under the current rates of Arctic warming, this may allow them to mediate only a few more decades of spring advance by migrating faster.

Shortening migration by 4500 km does not affect nesting phenology or increase nest success for black brant

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Since the 1980s, Pacific Black Brant (*Branta bernicla nigricans*, hereafter brant) have shifted their winter distribution northward from Mexico to Alaska (approximately 4500 km) with changes in climate. Simultaneously, the primary breeding population of brant in subarctic Alaska has declined while a smaller Arctic breeding population has remained stable, but the reasons for this discrepancy are not fully understood. We used light-level geolocators to estimate the extent of spatial and temporal overlap in migration movements between Arctic (Colville River Delta) and subarctic (Tutakoke River) breeding populations in Alaska, and to test the hypothesis that variation in nest survival rates between the two breeding populations could be explained by differences in migration movements and winter site selection. The two breeding populations were well mixed during the winter, as indicated by a migratory connectivity score close to 0 (-0.06) at the primary wintering sites of Izembek Lagoon, Alaska ($n = 11$ brant) and Baja California, Mexico ($n = 48$). However, Arctic birds were more likely to migrate the shorter distance to Izembek Lagoon in southwestern Alaska compared to subarctic birds. The probability of nest survival was relatively high for both breeding populations (0.88–0.92), but did not differ between brant that overwintered in Alaska compared to Mexico despite a 4500 km difference in migration distances. Our results also suggested that the growing Arctic breeding population is unlikely to compensate for declines in the larger breeding population of brant in the subarctic. However, data collection for this study took place in 2011–2014 and wintering at Izembek Lagoon may have greater implications for reproductive success under future climate conditions.

Environmental drivers of productivity explain population patterns of Pacific Flyway snow geese across a half-century

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Much effort has been devoted to understanding population dynamics of abundant midcontinent light goose populations. Simultaneously, smaller populations in the Pacific Flyway have reached less attention. We developed an integrated population model combining all available data on demography and population size from different sources to understand the population ecology of the lesser snow goose (*Anser caerulescens caerulescens*) in the Pacific Flyway from 1970 to 2022. We divided the flyway population into Wrangel Island and Western Arctic subpopulations and assessed demographic mechanisms for population change and environmental and anthropogenic drivers that influenced demography. During 1970–2022, the estimated spring population of snow geese in the Pacific Flyway increased from ~300,000 to ~2,300,000. Short-

term changes in population growth rate were primarily driven by changes in productivity in the Western Arctic and productivity and immigration in Wrangel Island. Changes in hunting and natural mortality had less influence on short-term but likely contributed to the pronounced long-term population growth. Early snowmelt positively influenced per capita productivity in both regions, and warm, rainy weather during the non-breeding season was associated with high per capita productivity in the Western Arctic. In the Western Arctic, per capita productivity was negatively associated with population size, and adult natural mortality was positively associated with population size, indicating density-dependent regulation in this subpopulation. In Wrangel Island, warm weather in early fall decreased juvenile natural mortality. Our results demonstrate that per capita productivity and immigration, rather than adult survival, were the primary mechanisms of short-term population change. Our results also indicate that environmental conditions and density-dependent effects have impacted population dynamics more than harvest. We demonstrate that a warming climate can have multiple effects on demography, emphasizing the importance of assessing a variety of spatial and temporal factors when predicting how populations might respond to large-scale environmental changes.

Co-Management of Wildlife in the Inuvialuit Settlement Region and Implications for Arctic Goose Management

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The Inuvialuit Final Agreement (IFA), which covers the western portion of Canada's Arctic, was signed between Canada and the Inuvialuit in 1984. It was the first comprehensive land claim agreement signed north of the 60th parallel and only the second in Canada at that time. It enshrines the rights of the Inuvialuit in relation to lands and wildlife management, among other things, in the Inuvialuit Settlement Region (ISR). A co-management system is in place which brings together the Inuvialuit, the Government of the Northwest Territories and the Government of Canada. Together, they address issues related to and make recommendations on harvest management, monitoring, research, and the . Arctic-nesting geese are an important component of the Inuvialuit landscape and are culturally very important to the Inuvialuit. We will discuss the co-management process in the ISR as it relates to Arctic-nesting goose management as well as reflect on approaches that could be used to enhance the integration of Inuvialuit views and concerns into the north American goose management framework.

Environmental drivers of Greenland white-fronted goose metapopulation dynamics throughout the full annual cycle

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Assessing the impacts of ongoing environmental changes on species of conservation concern requires a thorough understanding of population dynamics. By estimating demographic rates of animal populations, researchers can directly test hypothesised mechanisms of how weather and habitat conditions throughout the year affect annual survival, reproduction, dispersal, and ultimately, changes in population size. However, our understanding of population dynamics is complicated when animals aggregate in spatially discrete subpopulations, resulting in demographic heterogeneity among a collection of subpopulations (i.e., a “metapopulation”). We developed an integrated metapopulation model that incorporated annual capture-resighting, productivity, and population size information from 1983 to 2022 to study environmental drivers of metapopulation dynamics of the declining Greenland white-fronted goose (*Anser albifrons flavirostris*). We found that low fecundity due to earlier spring vegetation phenology on staging areas and increased snow on breeding areas explained declines across the entire metapopulation, though strength of these effects varied by subpopulation. Survival in both adults and juvenile geese was high and stable among subpopulations and years, and adult survival was higher following hunting protection on spring staging areas. Differential immigration and emigration rates affected local wintering abundance trends, highlighting the importance of quantifying subpopulation-metapopulation dynamics for understanding fragmented animal populations. We provide a framework for extending commonly used integrated population models to a metapopulation framework for testing novel ecological hypotheses about how changing environmental conditions within and among subpopulations can cause declines in animal abundance.

Harvest simulations reveal illegal hunting accelerates Greenland white-fronted goose population declines

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Effective management plans for harvested species require detailed knowledge about the role of harvest in regulating changes in population size. However, accurate harvest information (e.g., total number and age of harvested animals, harvest mortality rates, etc.) are notoriously difficult to obtain and typically require participation from hunters in reporting harvested animals. Estimating illegal or unregulated harvest of animals is even more difficult, as hunters are unlikely to accurately report harvest rates. The Greenland white-fronted goose (*Anser albifrons flavirostris*) population has declined by more than 50% from 35,000 individuals in 1999 to 15,000 in 2024. Despite range-wide hunting protections, illegal Greenland white-fronted goose harvest still occurs, especially during autumn migration on staging areas in Iceland. We used an integrated population model paired with matrix population modelling simulations to assess the effects of illegal harvest on Greenland white-fronted goose population declines. Our objectives were to 1) estimate annual population size, fecundity, and survival at the population level from winter 1983/84 to winter 2021/2022), 2) estimate the range of possible harvest annually from 2006 to 2021 (i.e., following the hunting ban), and 3) quantify the effects of harvest on population growth rates from 2006 to 2021. We found that harvest was potentially as high as 1.69 times reported numbers, with an average total harvest between 332 and 561 geese per year from 2006 to 2021. If no Greenland white-fronted geese had been illegally harvested, the mean population growth rate from 2006 to 2021 would have been between 0.986 and 0.997, which is significantly higher than the observed growth rate (0.975). Thus, although not enough to completely reduce population declines, eliminating illegal Greenland white-fronted goose hunting would likely improve population growth rates and bring population trends closer to stability. Our study provides a reproducible framework for conservation practitioners to explore how harvest affects population trends of species of concern, even in the absence of reliable harvest data.

Subsistence Harvest of Migratory Birds in Alaska: Partnerships in Conservation

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Collaborative harvest management of migratory birds in Alaska links Indigenous users with others across the state and internationally. The history of bird harvest management has greatly influenced relations between Alaska Native peoples and resource management agencies, often setting barriers for Indigenous peoples to engage in harvest management and conservation. The Alaska Migratory Bird Co-Management Council (AMBCC) was created in 2000, and brings together Indigenous, federal, and state partners to manage the subsistence harvest of migratory birds in Alaska.

The 1918 Migratory Bird Treaty Act set a hunting closure in spring and summer to protect nesting birds and restore bird populations depleted by commercial hunting. However, for millennia, spring bird harvests had been key to supporting food security for northern Indigenous peoples. The spring-summer hunting closure brought hardships for Alaska Native peoples.

Acknowledging this history is crucial to understanding the perspectives of Alaska Native peoples regarding bird harvest management and working together to achieve common conservation goals. In sharing the AMBCC history and context with a broader audience, we hope to demonstrate how partnerships and collaboration among Indigenous and non-Indigenous individuals and organizations can work to ensure sustainable harvest opportunities, healthy wildlife populations, and community well-being. By working effectively together, we will be able to overcome societal and environmental challenges we now face to ensure healthy bird populations that can sustain harvest by diverse user groups throughout North American flyways.

Annually, Alaska is host to approximately 400 species of migratory birds. Our 101 million acres of prime habitat provide excellent breeding and nesting grounds. Subsistence is a term used to describe the Alaska Native way of life as it relates to the harvest and processing of wild resources for food, raw materials or other traditional uses.

This presentation will provide an overview of subsistence in Alaska, Alaska Native tribes, a broad overview of the Alaska Migratory Bird Co-Management Council and its regulatory process, and lessons learned by working within a co-management system.

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Avian Influenza Prevalence of Wintering Richardson's Cackling Geese.

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Wild waterfowl, such as ducks, geese, and swans, are natural hosts for the zoonotic, avian influenza virus. The virus occurs in low pathogenic (LPAI) strains that cause little to no signs of disease in wild birds, but can also occur in highly pathogenic (HPAI) strains that can cause respiratory issues, violent head shaking, and eventually death. The current outbreak in North America is descended from the 2021 detection of H5N1 (clade 2.3.4.4.) in Newfoundland and Labrador on the east Canadian coast. According to the Centers for Disease Control and Prevention, HPAI has infected 70 humans and resulted in one mortality. No evidence has been found of human-to-human transmission, and generally, the threat of this disease is considered low. This outbreak event is ongoing, and surveillance systems are in place to monitor prevalence in wild waterfowl through hunter harvest and live sampling. However, there are species that have not been well sampled. Richardson's cackling geese (*Branta hutchinsii hutchinsii*) migrate through the mid-continent from their arctic breeding areas to as far south as the Texas panhandle. These birds can be observed roosting in urban water bodies, coming into close contact with domesticated waterfowl that are susceptible to infection. We investigated the prevalence of avian influenza antibodies in 50 cackling geese captured throughout their wintering range in the Southern Great Plains (14 in Fort Morgan, Colorado, 8 in Las Vegas, New Mexico, 21 in Amarillo, Texas and 7 in Post, Texas). Serum was delivered to the Texas A&M Veterinary Medical Diagnostic Laboratory (TVMDL) for enzyme-linked immunosorbent assays (ELISA) and confirmatory agar gel immunodiffusion (AGID) testing. H5/H7 lineage testing performed by the National Veterinary Services Laboratory (NVSL) identified antibodies of the H5 lineage in two cackling geese, one from Amarillo and the other from Post. The samples of H5 positive cackling geese currently reported by the USDA-APHIS only come from mortality events or hunter harvests. Incorporating live-sampling method, as used in this study, can provide detailed information on other waterfowl species' surveillance potential.

Highly Pathogenic Avian Influenza in Canada Geese – Insights from Surveillance and Monitoring Results

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The Highly Pathogenic Avian Influenza (HPAI) outbreak has resulted in unprecedented infections across taxa. While the severity of disease is variable among wild bird species, Canada geese have proven vulnerable to infection, often associated with high profile mortality event. Understanding the role of Canada geese in the ecology of avian influenza and as well as the impacts on this important One Health species is not only important for wildlife health, but will also help inform disease prevention and control strategies for protecting human health and the health of domestic animals. In Ontario, we have applied a comprehensive approach to surveillance, combining results from sick and dead birds as well as samples from hunter harvested, apparently healthy birds and egg sampling. Our results from 2022 to 2024 indicate while some CAGO experience acute morbidity resulting from H5N1, shedding is extremely rare in apparently healthy birds, and serology and egg antibody data suggest that a high proportion of

these individuals were exposed to HPAI and recovered from infection. Infection appears to be very seasonal among Canada geese, helping to contextualize their risk of transmitting HPAI throughout their annual cycle. Our data also suggests that current surveillance efforts may be missing periods of widespread infection in CAGO. Finally, we highlight opportunities to improve surveillance to better understand the implications of HPAI in this emblematic One Health species.

Factors Influencing Inferred Nest Success of Atlantic Population Canada Geese

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Atlantic Population (AP) Canada Geese nest throughout much of northern Quebec and winter primarily on the Delmarva Peninsula (Delaware and the eastern shores of Maryland and Virginia). The AP is the most abundant migratory Canada Goose population in the Atlantic Flyway and has experienced significant fluctuations in size since structured population surveys began in 1993. Similar to other Arctic and sub-Arctic nesting geese in eastern North America, recent declines in breeding population and productivity estimates have raised concerns about range shifts, survey coverage, and regional differences in productivity. Banding and survey crews have observed reduced recruitment in portions of the range and evidence that the breeding distribution is shifting northward.

To investigate these trends, the Atlantic Flyway has marked over 500 AP Canada Geese with 44g GPS/GSM neck collars on both breeding and wintering grounds since 2022. Our objectives are to improve understanding of nest success, settlement patterns of winter-marked birds, and nesting chronology. Using accelerometer and location data, we inferred nesting attempts and locations, and applied Bayesian generalized linear models to evaluate drivers of nest success.

Preliminary analyses indicate that breeding region and nest initiation date were the most influential factors. Earlier nest initiation consistently increased success across all breeding areas, while regional differences were also evident, with the Northern Peninsula showing notably greater nest success compared to other regions.

Telemetry data further supported field observations of potential range shifts, particularly in the most productive nesting areas on the Ungava Peninsula. Additionally, 40.7% of winter-marked geese (both deferred and nest-attempting birds) settled outside of the current survey area. These early results underscore the need to periodically reassess survey coverage in Arctic habitats and reinforce the importance of ongoing collaboration with Canadian partners to ensure accurate representation of AP breeding habitats.

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A comparison of the demography, body condition, and diet quality of emperor geese at the geographic extremes of their wintering range

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Emperor Geese (*Anser canagicus*) are unique among the seven species of North American geese in that they remain at high latitudes year-round, nesting in western Alaska and wintering in remote coastal areas of the Bering Sea and Gulf of Alaska. They are an important game species, especially in rural Alaska where they are a culturally and traditionally important resource for Native Alaskans and subsistence hunters. The population of Emperor Geese in Alaska has undergone several substantial fluctuations in abundance, marked by a steep decline during the latter decades of the 1900's, a brief recovery in the early 2000's, and a more recent decline once again. While their breeding biology is relatively well-studied, much less is known about Emperor Geese at their winter grounds, where they spend much of the year. Indeed, winter conditions and resources may play an important role in the recruitment, survival and overall population dynamics of emperor geese. We hypothesize that diet, body condition and recruitment at the western end of their wintering range (Shemya Island) should be less than at the eastern edge (Kodiak Island), where winter conditions are less extreme and resources more diverse. We collected morphometric measurements to assess body mass and condition (2023-2025), collected tissue samples from captured birds to test for dietary differences between each site using stable isotope analysis of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$, and conducted age ratio surveys at each location during 2024 and 2025 winters. Stable isotope signatures from winter of 2024 suggest that emperor geese on Kodiak foraged at a higher trophic level and relied on more marine based food sources than birds on Shemya. In 2024, body mass and body condition of emperor geese on Kodiak was higher on average than on Shemya but contrary to our predictions, body mass of emperor geese was similar between Kodiak and Shemya in 2025. In 2024 Kodiak's juvenile to adult ratio was approximately ten times higher than Shemya and in 2025 it was approximately five times higher. We are now investigating how these differences scale up to potentially explain differences in overwinter survival between the two sites.

**Student as primary author*

Nonlinear effects of spring timing on nesting phenology and growth of black brant goslings in western Alaska

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Environmental conditions often have significant impacts on growth and survival of young birds. Growth rates of precocial goslings in Arctic and subarctic ecosystems are primarily driven by environmental and ecological processes that affect biomass and quality of preferred forage plants, including timing of spring onset. The timing of spring onset at Arctic and subarctic breeding areas is expected to advance and become more variable with climate change. Understanding how variation in timing of spring onset affects developmental rates of young can help understand species-specific responses to changing environmental conditions. We used long-term (1989–2024) field data from a black brant (*Branta bernicla nigricans*) colony on the Yukon-Kuskokwim Delta in western Alaska and remotely sensed data to explore how the onset of spring (indexed by the date of 10% snow cover on the study area) has changed through time, and how variation in the timing of spring onset influences timing of nesting and gosling growth rates. Our results suggest that the mean date of 10% snow cover on the study area has advanced approximately 14 days during our study. We found that mean nest initiation dates were positively related to the date of 10% snow cover except in years when snow melted extremely early (i.e., before May 8), suggesting a constraint on timing of nesting in years with early spring onset. Lastly, we found support for a concave relationship between the date of 10% snow cover and gosling growth rate, indicating that both early and late springs can lead to poor developmental conditions for brant. Our results highlight the potentially complex relationships between environmental conditions and reproduction in geese that could have significant effects on population dynamics.

**Student as primary author*

The influence of developmental conditions on maintenance of individual heterogeneity in fitness of black brant

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Positive covariation between fitness components (e.g., survival and reproduction) is commonly observed in wild populations and is often attributed to variation in the ability of individuals to acquire resources. While quantifying this “individual heterogeneity” in vital rates has received considerable attention, few studies have investigated the factors that maintain this heterogeneity in wild populations. Conditions during development have profound impacts on phenotypes of wild birds and may contribute to maintaining individual heterogeneity in fitness components over life. For geese specifically, variation in environmental and ecological conditions (e.g., density of geese) causes significant spatial and temporal variation in gosling growth rates by affecting biomass of preferred forage plants and access to grazing lawns. We used long-term capture recapture data and hierarchical models to quantify joint individual heterogeneity in vital rates (i.e., survival, breeding probability, and clutch size) of black brant (*Branta bernicla nigricans*). Our preliminary results suggest positive covariation between survival, breeding probability, and clutch size consistent with individual quality. We use this model to examine the role of early growth conditions (indexed by mean gosling growth rate during the birth year) in maintaining variation in individual quality and provide findings that lay the foundation for further investigations of life-history variation in brant and other long-lived species, such as variation in rates of reproductive and actuarial senescence. Our results reveal how changing environmental conditions on breeding areas can affect important demographic processes in brant populations.

**Student as primary author*

Corticosterone gives you wings: Experimentally increased spring fattening and cascading effects on migration and breeding decisions in the greater snow goose

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Seasonal migration allows species to find favorable conditions for survival and reproduction. In the context of global change, an individual's resilience depends on its ability to adjust its migration and reproduction decisions in response to disturbances. However, the physiological and behavioral mechanisms that enable or constrain these adjustments remain poorly understood. In this project, we focused on corticosterone, a hormone that regulates feeding behavior and energy mobilization to meet daily or seasonal needs at low or moderate doses. We conducted a field experiment in which we slightly increased baseline corticosterone levels in wild greater snow geese at spring staging areas prior to Arctic departure.

From 2021 to 2023, 140 females in comparable condition were paired (25; 21 and 24 pairs in 2021, 2022 and 2023 respectively), implanted with either a CORT pellet (90 mg) or a placebo. Their foraging and migration behaviors were tracked using Ornitela N-44 collars, which recorded GPS locations every 15 minutes and behavioral data via accelerometry. We predicted that a slight elevation in corticosterone would stimulate feeding before departure, thereby benefiting migration phenology and reproductive decisions under favorable conditions. In 2021, the treated birds increased their food intake and advanced their departure by two to six days.

However, in 2022 and 2023, although implants similarly increased food intake, they did not affect departure timing, likely due to less favorable conditions. GPS and accelerometry data suggest that enhanced fattening in spring may affect breeding parameters, such as the pre-laying period (the interval between arrival on the breeding ground and laying), but only under favorable environmental conditions. Body condition and associated levels of endogenous reserves at departure appear to be key determinants of migration and reproductive decisions. Nevertheless, the benefits of elevated spring foraging rates were insufficient to offset migration costs under less favorable conditions. This unique field experiment is one of the few to demonstrate a potential advantage conferred to a migratory species, while also revealing the key role of hormonal mechanisms in spring fattening and the overriding influence of environmental variability on migratory and reproductive outcomes.

Modelling across scales: Incorporating individual-level data into productivity models

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For decades, banding operations within Arctic-nesting goose populations have produced valuable data for demographic studies. Integrated population models (IPMs) offer a Bayesian framework to link these different population counts, capture-resight studies, and productivity surveys into one jointly estimated model to gain insights into how productivity and annual survival contribute to population growth rates. In more recent years, technological advancement has enabled widespread deployment of Global Positioning System (GPS) and accelerometry (ACC) transmitter tags. As a result, for many waterfowl species there is now a large collection of data at a high temporal resolution that can be used to test hypotheses about the effects of environmental factors on individuals' behaviours and subsequent breeding success. However, there has not previously been statistical methodology available to link these individual-level hypotheses to demographic processes. We propose an extension to IPMs that can flexibly account for multiple individual, spatial, and temporal aggregation scales to connect GPS/ACC data with productivity survey data. Specifically, our framework allows for information-sharing between individual- and population-level processes by using proxies of propensity and nest success gained from GPS/ACC data to help explain variation in the overall productivity of the population. We illustrate the framework through a simulation study where data are simulated to represent the life history of greater white-fronted geese (*Anser albifrons*). We also examine the impacts of differing sample sizes of tagged geese and assess the modelling framework for potential sources of bias. Ultimately, this newly developed framework will allow ecologists to gain insights about the impacts of different components of reproductive success on productivity, without requiring direct observation on the breeding grounds.

**Student as primary author*

Investigating Potential Distributional Effects of Interspecific Competition Among Canada, White-Fronted, and Snow Geese Across Two Illinois Wintering Areas

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Migratory birds select overwintering areas based on climate, habitat availability, food resources, predation risk, and fidelity to traditional routes, but climate and land-use change are potentially altering these drivers and contributing to northward shifts in wintering ranges for many species. Canada Goose (*Branta canadensis*), Greater White-fronted Goose (*Anser albifrons*), and Snow Goose (*Anser caerulescens*) exemplify these shifts. Historically, White-fronted and Snow Geese wintered in Mexico, Texas, and coastal Louisiana, while Canada Geese established stable wintering populations in southern Illinois by the mid-20th century, resulting in limited wintering overlap. Overlap has since expanded, with White-fronted and Snow Geese moving into southern Illinois first and later into west-central Illinois, raising the possibility that Canada Geese, the larger-bodied and behaviorally dominant species, may influence the ability of the other two species to access and persist in wintering areas. We evaluated whether competitive interactions differed between regions with long-term versus recent overlap, predicting that interactions would be more frequent in west-central Illinois, that interspecific interactions would exceed intraspecific interactions, and that Canada Geese would be disproportionately involved in interspecific interactions. Focal observations were conducted during winters 2021–2024 across southern (Jackson, Perry, Williamson) and west-central (Fulton, Knox) Illinois, recording all competitive interactions involving randomly selected focal individuals. A Bayesian categorical model was fit with study area as a fixed effect and focal individual, year, time difference, and habitat use as random effects. Model estimates indicated no strong differences among interaction types within regions. Between regions, three interaction types showed credible differences: Canada $\times$ White-fronted interactions were more frequent in west-central Illinois ($\Delta p = +0.047$, 95% CrI [0.00001, 0.957]); White-fronted $\times$ White-fronted interactions were also more frequent in west-central Illinois ($\Delta p = +0.067$, 95% CrI [0.00001, 0.934]); and White-fronted (no interaction) events were less frequent in west-central Illinois ($\Delta p = -0.606$, 95% CrI [-0.999, -0.0005]). All other categories showed no credible regional differences. An asymmetry index further showed no evidence that Canada Geese disproportionately engaged in interspecific interactions; values were near zero with wide credible intervals spanning zero in both regions. Overall, our results do not support the hypothesis that Canada Geese are displacing White-fronted or Snow Geese. While some interaction types differed between regions, patterns were not consistent with strong competitive asymmetry. These findings suggest that factors beyond direct competition are more likely drivers of recent shifts, underscoring the importance of explicitly

testing interspecific interactions when incorporating biotic factors into species distribution models.

Population Genomics of North American Geese

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An understanding of the genetic structure of populations is essential for long-term conservation and stewardship in the face of environmental change. This is especially true of widely distributed species that are often composed of populations connected by varying degrees of ecological or evolutionary dispersal. Although dispersal and flyway connectivity is routinely measured directly via observations, telemetry, and band recoveries in geese, genetic data can provide an indirect, yet complementary, measure of dispersal that is robust to short-term habitat dynamics. Geese occupying northern high latitudes exhibit life-history traits that may facilitate population structure and restrict inter-flyway genetic exchange, including philopatry in both sexes, long-term pair bonds and familial associations, and delayed reproduction. Conversely, other goose species possess traits that may promote admixture across flyways such as pair-bond formation on wintering grounds co-occupied by multiple populations. Most geese species exhibit some genetic structure that can be explained by flyway and/or wintering ground location. However, the degree of differentiation varies considerably across species. The greater white-fronted goose shows significant flyway structure in addition to sub-structuring within flyways that corresponds to timing of pairing and staging site usage. On the opposite extreme, very little to no genetic structure was evident across flyways in wintering lesser snow geese, except in geese using the Atlantic flyway. A similar pattern is observed between lesser and greater snow geese within the Atlantic flyway. Brant have a strong east-west migratory divide, across marker systems, with individuals coming into contact in the Western High Arctic. Flyway structure explains a significant proportion of genetic variation based on mtDNA within both the Canada and cackling goose, but genetic variation among flyways is nearly absent at bi-parentally inherited markers. The varied patterns of genetic diversity across the landscape highlights the role of behavior in shaping interactions of individuals and populations throughout the annual cycle and the importance of species-level assessments. Species that exhibit limited dispersal, and therefore corresponding genetic structure, may be less resilient to rapid environmental change as populations may exhibit delayed responses. Conversely and assuming suitable habitat is

available along alternate routes/locations, species comprised of individuals with lax dispersal and/or migratory tendencies may be able to respond rapidly by shifting movement patterns.

Efficient estimation of age-specific survival using joint encounter data

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Arctic-nesting geese exhibit deferred reproduction, typically nesting for the first time at ages 2 or greater, suggesting that models for estimating survival with 3 or more age classes should be considered (e.g. hatch year (HY), second year [SY], and after second year [ASY]; or juvenile, subadult, adult). But because most fully-grown geese are banded as undifferentiated after hatch year (AHY) individuals, analysts using dead encounter data typically employ models using only 2 age classes: juveniles and adults. Past studies demonstrated that estimates of juvenile survival can be severely biased from 2-age-class (juvenile and adult) dead-recovery models if additional age-class structure and unaccounted for demographic heterogeneity exists within the "adult" age class. Additional simulations have demonstrated that reliable estimation of juvenile and subadult survival requires the inclusion of live-encounter data. To facilitate the efficient use of joint-encounter data for estimation of age-specific survival and encounter probabilities, we demonstrate use of multi-state models that can be analyzed using multinomial likelihood with data in m-array format, greatly speeding up computational times while allowing for full Bayesian inference. Supported models can make use of dead recoveries, live recaptures and resightings during the banding period (e.g., Burnham models), and supplemental live resightings from throughout the year (e.g., Barker models). In addition, finite mixtures (Pledger approach) can be used to sort undifferentiated AHY bandings into SY and ASY components. In this talk, we evaluate the Burnham approach using simulated data and show that it provides unbiased estimates of survival, recapture, recovery, and fidelity probabilities for all three age classes. We conclude by discussing real-world applications that might include a mixture of HY, AHY, SY, and ASY bandings.

**Student as primary author*

Chemical contaminants profiles of Arctic-nesting geese and eggs along the Western Hudson Bay

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Arctic-nesting geese are an abundant food source for Inuit living along the western shore of the Hudson Bay. The eggs and meat of cackling geese (*Branta hutchinsii*), snow geese (*Anser caerulescens*), and Ross's geese (*Anser rossii*) are excellent sources of protein, iron, omega-3 fat, and A and B vitamins.

Concerns about goose overabundance on the Arctic landscape, combined with the fact that 63% of households in Nunavut report food insecurity, have prompted some Nunavummiut to consider increased goose harvesting as a strategy to address both ecological and nutritional challenges.

Aqqiumavvik Society, a community-based research organization in Arviat, Nunavut, has brought together a team of researchers from universities and government departments across Canada to study Arctic-nesting goose health and the feasibility of increasing harvest. Projects include: monitoring geese for avian influenza, documenting Inuit metrics of goose health, assessing population ecology, and promoting community consumption of geese. Specifically, researchers at Carleton University are testing geese meat and eggs for chemical contaminants that could pose a risk to people consuming geese. We are monitoring a co-developed list of contaminants that reflect community concerns and includes pollutants from both local sources and long-range transport.

In the spring of 2024, Inuit youth and hunters in Aqqiumavvik's Ujjiqsuiniq Young Hunters program collaborated with researchers to collect samples of goose muscle, gizzard, liver, and eggs near Arviat. Nest locations were recorded to explore spatial patterns of contamination. Trace element concentrations were quantified in both raw and cooked goose meat. Eggs were analyzed for a broad suite of legacy and emerging contaminants of concern, including per- and polyfluoroalkyl substances (PFAS), organophosphate esters (OPEs), polycyclic aromatic compounds (PACs), UV stabilizers, polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), and legacy organic pesticides such as dichlorodiphenyltrichloroethane (DDT).

Goose meat was generally low in toxic metals, but sometimes contained lead, likely from lead shot. Sampled eggs were low in most organic contaminants compared to other country foods (e.g., seal, beluga, caribou). Notably, PFAS concentrations were higher in cackling goose eggs collected closer to Arviat, while PACs were higher in eggs from nests farther away.

This research updates contaminant profiles of geese in Nunavut, which have not been monitored since 1995. In this presentation, we will share results, discuss implications for harvesting, and reflect on lessons learned in our efforts to weave Western science and Inuit knowledge to create insights meaningful at both local and national levels.

**Student as primary author*

Movement ecology and the full annual cycle of midcontinent Greater White-fronted Geese (*Anser albifrons frontalis*)

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Previous studies suggest that the behavioural decisions made by an animal in one season influence the outcome of subsequent behavior and decisions made in future seasons. These “carry-over effects” can be modeled using a hierarchical model in a Bayesian framework known as a Full Annual Cycle Model. This model can allow for the quantification of the relative importance of environmental drivers on movements and behaviour, and collectively, those on reproductive success and survival. We plan to apply this modeling framework to the midcontinent population of Greater White-fronted Geese (*Anser albifrons frontalis*). This subpopulation’s non-breeding range extends from the Canadian prairies through the American prairies down to the gulf coast. Currently, little is known about how this population utilizes these areas on a broad and regional scale. We hope to leverage dynamic Brownian bridge movement models to better understand habitat use and identify sites of high usage for improved management throughout the non-breeding range. These two models will be employing the use of seven years of GPS and accelerometer data collected using OrniTrack-N38 GPS neck collars, attached to adult female geese. With this analysis we hope to deepen our understanding of the drivers of habitat use and the connections between environmental factors, white-front behaviour and reproductive success and survival.

Poster Presentation Abstracts

(alphabetical order, by last name of lead/presenting author)

Engaging Hunters in an Examination of Goose Hybridization through duckDNA

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duckDNA is a community science initiative launched in 2023 by Ducks Unlimited and the University of Texas at El Paso that engages hunters in collecting tissue samples for genetic analysis from harvested waterfowl across the Lower 48 states. The primary objectives are to assess the prevalence of game-farm mallard genes in mallards (*Anas platyrhynchos*), American black ducks (*A. rubripes*), Mexican ducks (*A. diazi*), and mottled ducks (*A. fulvigula*), identify ancestry of hybrid waterfowl, and build a dataset of waterfowl genomes to enhance understanding of how genetics affect waterfowl populations. Building on the success of our first few seasons, we are expanding our sample collection in 2025–26 to include hybrid geese and a subset of goose populations across North America (e.g., Midcontinent lesser snow geese, Ross's geese, greater white-fronted geese, etc.). Each submission provides hunters with a certificate of verified genetic identification, allowing for a unique educational opportunity in conservation genetics and waterfowl population management. Beyond providing individual results for hunter participants, the genetic data generated will contribute to a genetic reference library of North American goose species and their hybrids. This resource will support future research into goose population demographics, hybridization, migratory behavior, and potential impacts on habitat conservation and population management. During the first two years of this project, we have analyzed samples from 21 geese, 15 of which were identified as hybrids. By combining community science with modern genetic tools, duckDNA fosters hunter engagement, advances waterfowl research, and strengthens the foundation for science-based management of North America's goose populations.

They're good geese, Brant. Co-developing a survey design to evaluate changes in distribution and abundance of Arctic Breeding Geese in the Inuvialuit Settlement Region

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Here we summarize the first steps in the co-development of breeding waterfowl survey for parts of the Yukon North Slope, Mackenzie River Delta and Tuktoyaktuk Peninsula. Arctic breeding geese are a high research priority in community land use plans in the Inuvialuit Settlement Region (ISR), in the western Canadian arctic. Land use plans highlight the desire to know more about the biology and ecology of geese, improving census methods, and identifying important habitat. The Canadian Wildlife Service (CWS) conducts periodic surveys to estimate waterfowl distribution and abundance. It has been at least 15 years since the last comprehensive surveys in this region: in 2010 the US Fish and Wildlife Service (USFWS) flew fixed-wing transects; between 2002 and 2006 CWS conducted a systematic helicopter transect surveys. Areas on the western side of the Mackenzie Delta and the Yukon North Slope, including areas inside Ivvavik National Park, were last surveyed in 2005-2006. Since there are limited resources for periodic western scientific surveys community knowledge is key to help prioritize site selection. Community members are often the first people to notice changes in the distribution and abundance of breeding geese and bring their knowledge to co-management working groups. We have developed an initial sampling plan using a 5km diameter hexagon survey grid and stratified random sampling design that incorporates spatial balance, habitat type and cost of access. Data from previous transect and plot surveys in the area will be included in the site selection model but community knowledge will be key to help prioritize site selection. Community members are often the first people to notice changes in the distribution and abundance of breeding geese and bring their knowledge to co-management working groups. To help define areas where sampling should be prioritized, we will add Indigenous Traditional Knowledge (ITK) summarized in the Goose Companion Report to the WMAC-NS Wildlife Conservation and Management Plan and hopefully work by with researchers at Yukon University conducting an ITK study about Snow/Ross' Geese, Cackling/Canada Geese, Yellowlegs (White-fronted Geese) and Brant. The initial sampling plan will be brought to co-management partners to help define areas to prioritize, areas to avoid, appropriate timing of surveys, species of interest beyond geese (e.g. "black ducks", long-tailed ducks, geese).

**Student as primary author*

Habitat status after goose-induced damage on the Cape Churchill Peninsula.

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Destructive foraging by the Mid-continent Population of Lesser Snow Geese (*Anser caerulescens caerulescens*) initiated processes that have led to severe degradation of coastal and inland areas in Wapusk National Park. A primary goal of the Canada/U.S.A. management plan addressing this degradation is to reduce the population of Lesser Snow geese until “...***there is no further damage to the habitat and there are indications of recovery.***”

Annual monitoring of 42 plots within the damaged habitat continues with the addition of abundance and biodiversity of insects and soil tests. Habitat recovery is predicated on soil quality, presence of a seed bed, deposition of seeds or propagules by air, water or animals. Little is known about the recovery dynamics of the severely damaged habitat in use by Lesser Snow Geese. One recovery area starts with a halophyte (*Salicornia borealis*) which is not used by local herbivores. The first edible species in this area is *Puccinellia phryganoides*. This is a sterile triploid grass not known to set seed. This raises the question of how a salt marsh grass arrived and colonized a freshwater habitat 15km inland? We look at dispersal mechanisms including herbivore feces.

While revegetation is proceeding rapidly at some sites, at other sites there is no sign of recovery, either inside or outside of the exclosures. That recovery is happening inside the exclosure is indicative that the potential for recovery at that site exists. The impact on other species within that habitat is an important element of recovery. We have added trail cameras and insect traps to the exclosure sites. We estimate the abundance and diversity of organisms at sites with and without recovery.

**Student as primary author*

Assessing the impact of liberalized hunting regulations on population dynamics in Greater Snow Geese: A 35-year analysis

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The Greater Snow Goose (*Anser caerulescens atlanticus*) was declared overabundant in 1998. To manage its population growth, a special spring hunting season, known as the conservation harvest, was implemented in eastern Canada in 1999. In 2009, the United States adopted a special hunting season in the Atlantic Flyway (AF), the Conservation Order. Conservation measures aimed to reduce the population to a target range of 500,000 to 750,000 individuals. The population was relatively stable between 1999 and 2022, fluctuating between 700,000 and 1,000,000 birds. However, over the past 3 years, the population has declined by 43% to reach its lowest value in more than 30 years, below the minimum population target. Special hunting seasons in both Canada and the US likely played a significant role in limiting the growth of the population over the past 25 years although other factors such as the rise in avian influenza and increased Bald Eagle (*Haliaeetus leucocephalus*) abundance may have contributed to the recent decline. Previous studies suggested that Greater Snow Geese can change their behaviour or migratory route to avoid high hunting pressure areas. Hunting disturbance also has non-lethal effects by reducing access to foraging sites or inducing repeated stress-response that affect their ability to store endogenous reserves, which can negatively affect their reproductive success.

Our goal is to examine potential relationships between harvest and population trends of the Greater Snow Goose over the past 35 years. First, we aim to determine to what extent harvest rate can explain observed changes in population size. Second, we will assess if changes in the distribution of geese during migration and in winter may have affected harvest rate. Finally, we will examine if a recent increase in the overlap of the wintering range of Greater and Lesser Snow Geese could affect harvest estimates of the former population in the Atlantic Flyway. We will use harvest survey data in combination with the spring population survey to determine season-specific harvest rates. We will also analyze changes in the geographic distribution of geese using band recovery and harvest survey data from the entire flyway. Additionally, telemetry data from approximately 200 GPS-tracked geese (since 2006) will provide further insights into these changes. A deeper understanding of the effects of conservation harvests on the

Greater Snow Goose population in the Atlantic Flyway will help fine-tune hunting regulations and management policies to maintain the population within the desired range.

**Student as primary author*

Differential Migration Strategies and Potential Carry-Over Effects on Black Brant Breeding Probability.

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The black brant (*Branta bernicula nigricans*, hereafter brant) undertakes long-distance migrations annually from Holarctic breeding sites to wintering areas along the Pacific coast, ranging as far south as Baja California Sur, Mexico. In recent times, however, northward shifts in wintering distributions of brant have been observed. Accompanying this recent shift is apparent portions of the Pacific population overwintering in historical fall and spring staging habitat around Izembek Lagoon, Alaska, a phenomenon known as ‘migratory short-stopping’. Climate and land-use change is likely to disrupt some winter habitats by reducing quality and quantity of vital resources available to brant, limiting access to those resources, or both; thereby altering energy stores used for breeding. Individuals may be responding to these changes by shifting migration strategies, but the demographic consequences of differential migration and associated carry-over effects remain relatively understudied in Arctic geese. This dearth of knowledge is compounded by technological and logistical constraints that have made it difficult to collect unbiased locational and movement data for brant. As a continuation of the long-term demographic study of the Tutakoke River black brant colony, we have deployed passive-light recording geolocators on individual brant to address this knowledge gap. The use of these small, inexpensive, and reliable light recorders on bands allows for robust sample sizes with minimal effect on the carrier. Location data received through multiple years of geocator deployment will be combined with other types of citizen and scientific reencounters to obtain more precise estimates of brant winter habitat use and migration induced carry-over effects on brant breeding probability. These estimates can better inform and improve cross-seasonal management strategies for a species inhabiting habitat that is highly sensitive to a rapidly changing environment.

The Recent Growth of the Cackling Goose (*Branta hutchinsii*) Population on Bylot Island at Its Northern Range Limit

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Bylot Island (Nunavut) is an important nesting ground for many migratory bird species, harboring the largest known colony of greater snow goose (*Anser caerulescens atlanticus*). Cackling geese (*Branta hutchinsii*), historically rare on the island, were first recorded nesting there in 1996. Since then, their numbers have grown exponentially. Unlike snow geese, which use both mesic and wetland habitats, most of cackling geese are nesting in wetlands, particularly on pond islets, a limited habitat feature in the landscape. Cackling goose nesting success is higher on islets than on shore, a pattern also observed for artificial nests and indicating reduced predation risk on islets. Cackling geese can nest sympatrically with snow geese, and cackling geese nesting success is positively associated with annual snow goose density, suggesting a positive indirect effect mediated by shared predators. Long-term monitoring of this population since the onset of their colonization on Bylot Island provides a unique opportunity to document colonization dynamics at the northern range limit of a species and to better understand the ecological processes driving local goose population growth.

Genomic analyses of emperor geese nesting in Alaska reveal a paradox: high gene flow across breeding populations despite female philopatry

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The emperor goose (*Anser canagicus*) is endemic to coastal regions of western Alaska and the Chukotka Peninsula in Russia. While it is a subsistence food resource for Alaska Natives, it has also been subject to sport harvest in the past. Emperor geese are a species of conservation concern due to population declines that have resulted in harvest closures. Despite sustained efforts to maintain emperor goose abundance in Alaska at or beyond management goals, recent surveys on the Yukon-Kuskokwim Delta breeding grounds have documented annual population declines over several years. Most (~80-90%) of the population in Alaska breeds on the Yukon-Kuskokwim Delta with smaller numbers breeding on the Seward Peninsula yet emperor geese are currently managed as a single population in Alaska. Limited information exists on subadult movement and recruitment into breeding populations, and the species' genetic population structure remains unknown. In this study, we used restriction site-associated DNA sequencing (RAD-seq) data collected from 216 adult female emperor geese nesting in Alaska to: (i) assess whether geographically distinct breeding aggregations in Alaska are genetically differentiated, and (ii) evaluate the spatial scale of dispersal among related individuals. Using 44,602 autosomal single nucleotide polymorphisms, we found minimal genetic differentiation between breeding aggregations on the Yukon-Kuskokwim Delta and the Seward Peninsula. However, estimates of genetic relatedness revealed that first-, second-, and third-degree relatives nested within 10 km of one another, indicating that multiple generations of female relatives occurred within the same breeding aggregation. We hypothesize that these patterns reflect a behavioral system in which females exhibit natal philopatry, while males facilitate gene flow between breeding aggregations.

**Student as primary author*

**Migratory Connectivity and Network Structure of Cackling Geese (*Branta hutchinsii*)
Wintering on the Southern Great Plains**

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Migratory species make impressive movements between breeding and nonbreeding areas annually, but the capability to track species throughout the annual cycle at fine spatiotemporal scales is the result of recent technological innovations. Advances in animal tracking allow for more accurate tracking of migratory species, more frequent datapoint collection, and over longer periods of time. This can reveal aspects of the annual cycle in greater detail than previously possible. Cackling Geese (*Branta hutchinsii*) migrate thousands of miles annually between breeding, molting, and wintering sites. In their seasonal movements between wintering and breeding localities, numerous stopover sites are used to rest and refuel. The importance of stopover sites to migratory birds like Cackling Geese cannot be overstated, yet there is a significant lack of knowledge to inform management on where the key stopover areas are for most species, making conservation efforts less impactful. In the winters of 2022-2025, we deployed 301 GPS-GSM transmitters on female Cackling Geese wintering in the southern Great Plains. We aim to quantify fine-scale movement patterns and identify areas of conservation importance throughout the annual cycle. We plan to apply network analysis and graph theory to create a network model for midcontinent Cackling Geese. We expect that results from this project will provide important information to help guide managers on where to invest in conservation efforts.

**Student as primary author*

Using programmable infusion pumps in geese: a validation methodology

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Wildlife face anthropogenic and natural stressors that affect their physiology and behaviour. The activity of the hypothalamic-pituitary-adrenal axis and glucocorticoid (GC) production is intrinsically linked with energy regulation and environmental stressors. Understanding the physiological mechanisms behind animals' decisions requires experiments that manipulate GC levels and measure behavioural or life-history outcomes. Current phenotypic engineering experiments lack the ability to deliver hormones in a pulsatile or circadian manner, limiting our ability to mimic chronic stress or isolate the effects of capture and handling from GC manipulation. We developed a method to externally attach commercial programmable infusion pumps (iPrecio SMP-200) to birds to deliver hormones subcutaneously at pre-programmed rates. We tested this method on five semi-captive Canada geese (*Branta canadensis*) and five greater snow geese (*Anser caerulescens atlanticus*), monitoring changes in body mass, wound healing, and the operational state of the pumps. In snow geese, we conducted a hormonal experiment by delivering adrenocorticotrophic hormone (ACTH) via the pumps to stimulate GC production. We then measured body mass at three time points, recorded activity using dynamic body acceleration, and collected fecal samples daily to assess corticosterone levels (the main GC in birds). Pumps were deployed for 11 to 14 days, with 7 out of 10 remaining functional throughout. One bird showed minor inflammation, but no apparent adverse effects on body mass or activity were observed. ACTH delivery led to significant increases in fecal corticosterone levels and dynamic body acceleration. This study represents the first successful external use of iPrecio pumps in birds and provides a promising tool for investigating circadian hormone dynamics, chronic stress, and ecotoxicology in wild species under more natural conditions.

From Boom to Balance? Revisiting Snow Geese at La Pérouse Bay in Wapusk National Park

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La Pérouse Bay on the western Hudson Bay coast in northern Manitoba has long been central to our understanding of Lesser Snow Goose (*Anser caerulescens caerulescens*) ecology. Pioneering studies on nesting biology, distribution, behaviour, genetics, and survival helped document the rapid population growth and severe habitat impacts that made the site emblematic of the “boom” years of Arctic geese. Yet today, uncertainty remains: are colonies declining, stabilizing, or redistributing across the landscape? To address this, Parks Canada and partners renewed monitoring at La Pérouse Bay and Thompson Point in 2024 with the first comprehensive aerial photo survey in over a decade. This effort complements Wapusk National Park’s long history of ecological integrity monitoring (1996–present), nearly a decade of aquatic research linking goose activity to water quality, and collaborative initiatives with Indigenous partners through community hunts and knowledge sharing. Together, these efforts provide the foundation for re-examining how snow geese are monitored within Wapusk’s ecological integrity framework. Parks Canada aims to add to the timeline of snow goose nesting colony estimates and examine on-going impact studies to guide long-term conservation decisions in Wapusk National Park and a changing Arctic.

**Student as primary author*

Assessing the influence of environmental drivers and light goose population dynamics on components of king eider recruitment in the central Canadian Arctic

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Lesser snow geese (*Anser caerulescens caerulescens*) and Ross's geese (*Anser rossii*; hereafter light geese) are among the most abundant waterfowl in North America, and their overabundance has raised concern due to widespread ecological impacts across the Arctic. Karrak Lake, Nunavut supported one of the largest light goose breeding colonies in Canada, providing a unique opportunity to examine long-term population dynamics and their potential ecological consequences. Using monitoring data collected between 1993 and 2019, we evaluated changes in colony size, density, and reproductive success to assess how population growth and decline have reshaped the ecosystem. Our analyses revealed rapid increases in colony size during the early 2000's, reaching a peak in the population, estimated at 1.2 million individuals, in 2011. This was followed by a plateau and reduced population beginning in 2012 until the colony collapsed to an estimated 230,000 individuals in 2019. Variation in demographic processes can strongly influence habitat structure and predator distributions near the light goose colony, potentially generating indirect consequences for sympatric species. To explore these effects, we will examine whether shifts in light goose colony dynamics correspond with changes in the reproductive effort (i.e., clutch size and nest success) of king eiders (*Somateria spectabilis*), a sea duck that nests in close proximity to the Karrak Lake colony. King eiders are a part of one of the least studied waterfowl groups, yet their populations may be particularly sensitive to habitat alteration and predator swamping caused by overabundant geese across their breeding range. Preliminary results suggest that variation in goose colony size and productivity partially explains fluctuations in king eider reproductive success. By linking long-term goose monitoring with sea duck reproductive ecology, our study highlights the importance of integrating multi-species perspectives into conservation planning and contributes to ongoing discussions on managing overabundant goose populations.

**Student as primary author*

Movement Differences Between Molting and Brood-Rearing Female Canada Geese, 2023-2024.

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The annual cycle of sub-Arctic nesting Canada geese (*Branta canadensis interior*) consists of migration between breeding and wintering areas but may also include migration to molting areas away from the breeding range. Females encumbered with goslings will molt their flight feathers within the brood rearing area whereas females without goslings (too young to breed, failed nesting or lost their brood) may migrate to a different location to molt. To investigate how movement patterns vary between brood rearing and other molt locations, we used location information from 140 sub-Arctic nesting Canada geese that were captured and collared with GSM-GPS transmitters along James and Hudson Bay in Ontario Canada during July, 2022 - 2024. We used the GPS data to characterize the spatial behavior of adult female geese during the flightless period. We compared movement metrics and core area size of females between two states during the flightless period: non-reproducing females in molting areas and females rearing broods on the breeding range. We predicted that females unencumbered with goslings would make larger movements in their search for high quality and abundant food on molting areas at higher latitudes where vegetation growth is slower. We found variation among brood rearing female core area and among those females molting away from the breeding area with some overlap between the two conditions. Variation in movement during the flightless period is likely due to specific habitat quality conditions, abundance and composition of the predator community, annual weather conditions and individual female variability. These differences in movement illustrate how specific phases of the annual cycle, along with their associated physical constraints, influence space use and mobility in female Canada geese.