15TH NORTH AMERICAN ARCTIC GOOSE CONFERENCE & WORKSHOP 2022

Corpus Christi, TX

6-10 December, 2022

Program and Abstracts

15th North American Arctic Goose Conference

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General Information

Registration
The registration/information desk will be located to the right of the Nueces A Ballroom on the 3rd floor foyer. Hours for registration will be: Tuesday: 7 am – 6 pm and Wednesday: 7:00 am – 4:00 pm.

Name Tags
Your name tag is your admission ticket to all events. Please have your name tag with you at all times during the conference. For attendees with food allergies, a card will be placed in the back of your name tag to be used at the banquet dinner. All other meals are buffet style.

Oral Presentations
Individuals giving oral presentations need to 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. Please see the registration desk if you need further assistance.

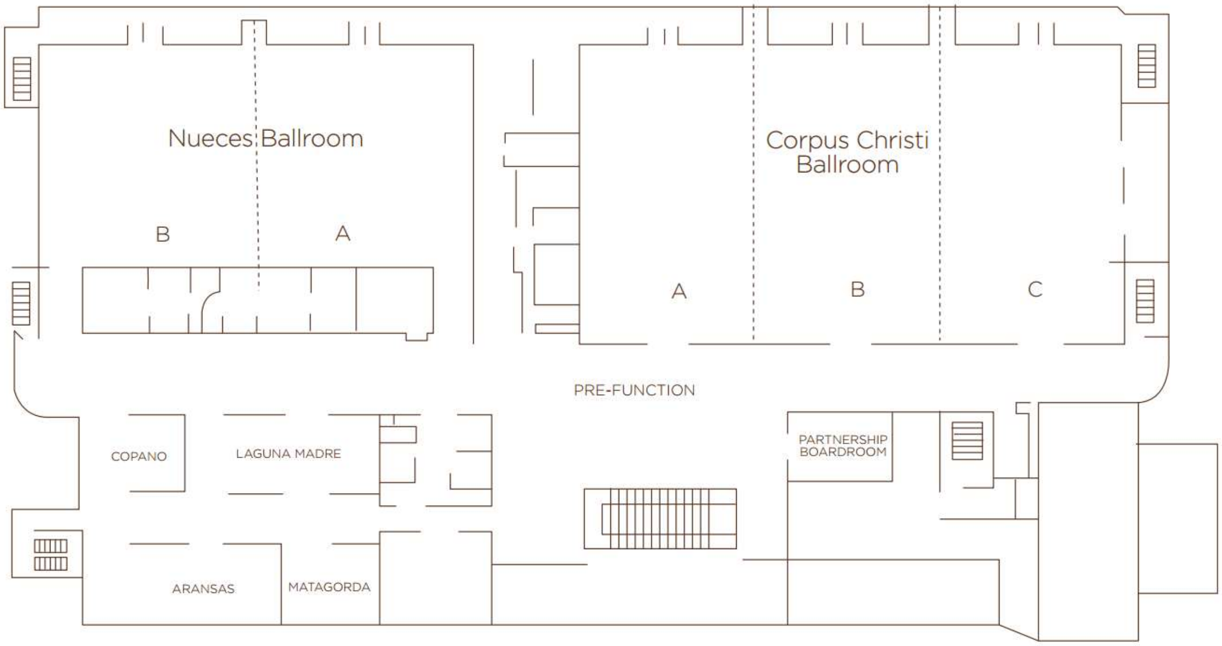
Poster Session, Papers and Workshop
The poster session will be held in Nueces B Ballroom. Presenters are expected to be with their posters on Wednesday night. Poster boards will be available on Wednesday morning and will remain up until Friday at noon. All posters will be removed at that time.

Reception and Banquet
The Tuesday night welcome social will be held in the Bayview room on the first floor. The Friday night banquet will be held in the Nueces A Ballroom where the main conference will be held.

Field Trip
A field trip touring the coastal waters near Aransas National Wildlife Refuge to observe the endangered whooping crane will occur on Saturday, December 10. For those going on the field trip, meet in the lobby at 6:50 am. Transportation will leave the Omni hotel at 7:00 am on Saturday and our anticipated return will be around 1:00 pm. Bring any desired drinks/snacks. We advise that you wear layers and bring a rain jacket just in case. The boat has an interior cabin in case of inclement weather.

Omni Hotel Map

Corpus Christi Bayfront Third Floor



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Field Trip Committee:
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Tuesday, 6 December 2022

8:30 AM – 5:00 PM	Integrated Population Modeling Workshop
6:00 PM – 8:00 PM	Welcome Social

Wednesday, 7 December 2022 – Morning Session

(Session Moderator – Bart Ballard)

8:20–8:30 Welcome, Opening Comments – B. Ballard

Full Annual Cycle Ecology

8:30-9:30	Plenary – *Ryan Norris*
9:30-9:50	*P. Link, W. Beatty, E. Webb, B. Leach*. Interpreting Greater White-fronted Goose habitat use and selection across a changing agricultural landscape.
9:50-10:10	*F. DiDonato, T. Nichols, J. Stiller, K. Abraham, E. Sinnott, M. Weegman*. Environmental drivers of Atlantic brant productivity.
10:10-10:30	Break
10:30-10:50	*L. Carlson, T. Nichols, J. Stiller, M. Dunn, E. Rabbitskin, J. Lefebvre, K. Abraham, F. Noisette, M. Leblanc, F. Baldwin, J. Leafloor, S. Gilliland, S. Slattery, M. Weegman*. Ascribing the importance of Atlantic brant staging areas for holistic conservation planning.
10:50-11:10	*T. Nichols, J. Stiller, J. Leafloor, L. Neufeld, L. Clark, L. Carlson, M. Weegman, F. Baldwin*. Migration chronology, breeding sites, and wintering locations of Atlantic brant using telemetry and geolocators.
11:10-11:30	*A. Schindler, A. Fox, C. Wikle, B. Ballard, A. Walsh, S. Kelly, M. Weegman*. A full annual cycle approach to quantifying environmental drivers of Greenland white-fronted goose abundance using single-season count data.
11:30-11:50	*J. VonBank, K. Kraai, D. Collins, P. Link, M. Weegman, L. Cao, B. Ballard*. Evidence of Longitudinal Differences in Spring Migration Strategies of an Arctic-nesting Goose.
11:50-1:30	Lunch

Wednesday, 7 December 2022 – Afternoon Session

(Session Moderator – Frank Baldwin)

Full Annual Cycle Ecology (Continued)

1:30-1:50	*C. Walters, M. Weegman*. Evaluating ecological memory of energy expenditure and foraging behaviour on breeding success by midcontinent white-fronted geese.
1:50-2:10	*S. Ulman, C. Latty, D. Safine, J. Schamber, B. Reishus, K. Spragens, M. Robards, J. Sands, D. Collins*. Delineating flyway affiliation of cackling geese (*Branta hutchinsii*) breeding on the Arctic Coastal Plain of Alaska.

Integrated Science and Communication

2:10-3:10	Plenary – *Morgan Heim*
3:10-3:40	Break
3:40-4:00	*J. Dooley, D. Gordon, D. Dixen, J. Leafloor, M. Robertson*. Arctic Goose Joint Venture: Overview and Update.
4:00-4:20	*S. Oldenburger, M. Brasher, J. Brice, E. Carrera, J. Eadie, D. Eggeman, J. Foth, M. Gloutney, A. Janke, R. Kaminski, K. Ringelman, C. Roy, W. Webb*. The North American Waterfowl Professional Educational Plan Objectives, accomplishments, and opportunities in training the next generation of waterfowl conservationists.
4:20-4:40	*J. Thompson, B. Uher-Koch, B. Daniels, J. Schmutz, B. Sedinger*. Factors influencing nest survival of emperor geese on the Yukon-Kuskokwim Delta, Alaska.
4:40-5:00	*M. Vrtiska, M. Gruntorad, C. Chizinski*. Goose hunting ≠ duck hunting: What satisfies the Central Flyway goose hunter?
6:00	Poster session

Thursday, 8 December 2022 – Morning Session

(Session Moderator – Mitch Weegman)

	Climate Change
8:30-9:30	Plenary – Paul Smith
9:30-9:50	*F. Baldwin, R. Alisauskas, J. Leafloor*. Dynamics of pre-breeding nutrient reserves in sub-arctic staging Lesser Snow and Ross's geese: implications for reproduction.
9:50-10:10	*A. Cantu de Leija, J. Donnelly, S. King*. Surface water dynamics of Chihuahuan Desert wetlands: implications for migratory bird habitat conservation.
10:10-10:30	Break
10:30-10:50	*T. Grandmont, F. Dulude-de Broin, F. LeTourneux, G. Gauthier, J. Bêty, P. Legagneux*. Phenological adjustments of migration and reproduction under climate change: can Greater snow geese "wind the clock"?
10:50-11:10	*C. Overton, M. Casazza, A. Mott, F. McDuie, A. Lorenz, E. Matchett, E. Reed, J. Wettlaufer*. Assessing multi-year nesting ecology among 4 taxa of geese.
11:10-11:30	*V. Patil, D. Ruthrauff, J. Hupp, D. Ward*. Nest survival of black brant at a rapidly expanding lesser snow goose colony in Arctic Alaska.
11:30-11:50	*M. Szymanski*. Midcontinent light geese: Heterogeneity in spring migration.
11:50-12:10	*J. Sedinger*. Large-scale decline of Black Brant in the Arctic and subarctic over the last 70 years?
12:10-1:30	Lunch

Thursday, 8 December 2022 – Afternoon Session

(Session Moderator – Josh Dooley)

	Midcontinent light geese/harvest
1:30-2:30	Plenary – *Ray Alisauskas*
2:30-2:50	*M. Weegman, R. Alisauskas, D. Kellett, Q. Zhao, S. Wilson, T. Telensky*. Local population collapse of Ross's and lesser snow geese driven by failing recruitment and diminished philopatry.
2:50-3:10	*F. LeTourneax, T. Grandmont, F. Dulude-de Broin, M. Martin, J. Lefebvre, A. Kato. J. Bêty, G. Gauthier, P. Legagneux*. Impacts of spring hunting on body condition and production of young in greater snow geese: insights from the COVID lockdown.
3:10-3:40	Break
3:40-4:00	*N. Huck, J. Stiller, B. Harvey, C. Williams*. Estimating hunting exposure days of Atlantic Population Canada geese during September.
4:00-4:20	*B. Daniels, B. Uhler-Koch, J. Schmutz*. Survival Probabilities of Adult Female Emperor Geese during Harvest Closure and After Harvest Opening.
4:20-4:40	*E. Osnas*. Using an integrated population model to guide emperor goose management under extreme uncertainty.
4:40-5:00	*T. Roberts, J. Dooley, B. Ross, T. Nichols, J. Leafloor, K. Dufour*. An Integrated Population Model to Inform Harvest Management of Atlantic Brant
6:00	*R. Alisauskas, J. Leafloor, M. Virtiska, J. Dooley*. Light goose roundtable

Friday, 9 September 2022 – Morning Session

(Session Moderator – Ted Nichols)

	Expanding human populations and goose interactions
8:30-9:30	Plenary – *Janet Bucknall*
9:30-9:50	*B. Daniels, D. Koons, M. Murphy, J. Thompson, M. Boldenow, M. Brubaker, R. Gerlach, D. Stallknecht, R. Poulson, A. Ramey*. Unprecedented observations of highly pathogenic avian influenza among Arctic nesting geese and sympatric species on the Yukon Delta NWR, Alaska during 2022.
9:50-10:10	*M. Hardy, C. Williams, J. Buler, P. Legagneux, J. Lefebvre*. Examining Wintering Goose Ecology, Response to Anthropogenic Disturbance, and Avian Influenza Virus Threats to Food Security
10:10-10:30	Break
10:30-10:50	*A. Mott, M. Casazza, C. Overton, F. McDuie, A. Lorenz, E. Matchett*. Habitat use and Distribution Implications of Four Goose Species Wintering in California's Sacramento Valley.
10:50-11:10	*C. Sharp, H. Lewis, C. Jardine, B. Stevens, R. Brook, K. Schutten, J. Provencher*. Highly Pathogenic Avian Influenza in Canada Geese – Insights from Surveillance and Monitoring.
11:10-11:30	*J. Weber-Pierson, M. Eichhholz, J. Brown*. Habitat use, competition, distribution, and their management implications for the three species of geese found in Illinois.
11:30-11:50	*J. Leafloor, F. Baldwin, B. Bartzen, N. Pople, K. Warner*. Prevalence of Highly Pathogenic Avian Influenza in Midcontinent Lesser Snow Geese.
11:50-1:30	Lunch

Friday, 9 December 2022 – Afternoon Session

(Session Moderator – Ray Alisauskas)

	Technological and Analytical Advancements
1:30-2:30	*T. Riecke, D. Koons, L. Aubry, M. Schaub, M. Lohman, J. Sedinger*. Using structural equation models to understand life-history trade-offs in Arctic-breeding geese.
2:30-2:50	*E. Weiser, P. Flint, D. Marks, B. Shults, H. Wilson, S. Thompson, J. Fischer*. Optimizing surveys of fall-staging geese using aerial imagery and automated counting.
2:50-3:10	*F. LeTourneux, G. Gauthier, J. Lefebvre, R. Pradel, P. Legagneux*. Combined effects of collar-marking and hunting result in a synergistic interaction and reduce greater snow goose survival.
3:10-3:30	Break
3:30-3:50	*J. Dooley, P. Doherty, D. Otis, G. White, T. Piaggio, D. Taylor, S. Chandler, R. Raftovich, S. Catino, K. Flemming*. Evaluation and improvement of U.S. goose harvest estimates.
3:50-4:10	*B. Tasker, C. Overton, M. Casazza, M. Mariano*. Modeling Fall Light Goose Migration in Relation to a Large, Toxic Lake.
4:10-4:30	*M. Murphy, B. Sedinger, T. Lewis, B. Daniels*. Monitoring post hatch movements of Emperor Geese (*Anser canagicus*) using internal transmitters and GPS backpacks.
4:30-4:50	*C. Blommel, J. Sedinger, T. Riecke, L. Aubry, D. Koons*. Estimating cause-specific mortality rates of Black Brant.
6:00	Closing banquet

Workshop Facilitator and Plenary Speakers

Todd Arnold

Todd is a Morse Distinguished Teaching Professor in the Department of Fisheries, Wildlife and Conservation Biology at the University of Minnesota, a position he began in 2002. Prior to that he worked as Senior Scientist for Ducks Unlimited Canada, Scientific Director for Delta Waterfowl Foundation, and as Assistant Professor of Wildlife Management at Humboldt State University in California. Dr. Arnold received his Ph.D. in Zoology from the University of Western Ontario in 1990, where he conducted his dissertation research on American coots. His master's degree was from the University of Missouri – Columbia, where he studied mink predation on breeding waterfowl. His current research interests focus on developing better methods of estimating population size of wetland and grassland wildlife, estimation of population vital rates such as nest success and brood survival, and development of integrated population models to help guide management activities. He teaches courses in Populations Ecology and Wildlife Management to undergraduate students, and seminars in quantitative methods for graduate students. He has authored or coauthored over 100 peer-reviewed papers and more than 150 conference presentations.

Using integrated population models to gain broader insights about Arctic goose demography

Todd W. Arnold, University of Minnesota

In this one-day, hands-on workshop, we will explore Bayesian methods for integrated analysis of demographic data. The workshop will be a combination of short lectures followed by hands-on analysis of real world data using program JAGS (as accessed through R Studio or R Studio Cloud). Examples will include count data from aerial surveys, Lincoln estimates of abundance and recruitment based on harvest data and direct band recoveries, analysis of survival and harvest rates from band-recovery data, and estimates of survival and movement probabilities from live-encounter data. The final objective will be to combine multiple data streams to jointly estimate population trajectories, age-specific survival, annual recruitment, and potential environmental factors that contribute to variation in these parameters. We will assume familiarity with Program R and the data types listed above, but data and code will be provided in "plug-and-play" format for those lacking prior experience.

Ryan Norris

Ryan Norris is an Associate Professor in the Department of Integrative Biology at the University of Guelph, Ontario, Canada. His research focuses on the behaviour, population ecology, and conservation of terrestrial animal populations, many of which are endangered or threatened. Combining a variety of tracking techniques with muddy-boots ecology, much of his work over the past two decades has sought to understand the year-round ecology and population dynamics of songbirds and butterflies. In addition to his extensive research on monarch butterflies over the past 15 years, he leads two long-term avian demographic studies that predate his existence as an ecologist: a 35-yr study of migratory Savannah sparrows breeding on Kent Island, NB and a 55-yr study of resident Canada Jays in Algonquin Park, ON. To answer questions about year-round population dynamics, he has even moved into mathematical modelling and model lab systems (fruit flies)…but he's really a field ecologist.

Plenary: Full Annual Cycle Ecology

Ryan Norris, Department of Integrative Biology, University of Guelph, Guelph, Ontario.

Migratory animals present a suite of unique challenges for understanding how individuals and populations respond to changes in the environment. The most obvious, of course, is that individuals can move long distances between different periods of the annual cycle, making it difficult to track individual success and survival over more than one period. Large distances between stationary periods of the year also present logistical challenges for quantifying population-level vital rates in both the breeding and non-breeding period. However, aside from challenges associated with migration distance, individuals are typically members of different populations throughout the year, meaning that predicting vital rates also requires detailed knowledge of spatial connections between stages of the annual cycle (i.e. range-wide migratory connectivity). Layered over these challenges is the possibility that events in one period may carry over to influence the success of individuals in a following period (i.e. carry-over effects), which can then scale-up to influence population dynamics. I will argue that one approach for addressing these challenges is the development of spatially explicit network models designed to help identify spatial and temporal gaps in our knowledge of the annual cycle and, once developed, the major drivers of population change and the relative importance sites within the network. However, I also acknowledge that the development of such models will not always be feasible, either in terms of time or cost. Thus, we must continue to also look for alternative approaches to help guide conservation efforts. Some of this innovation may come from collaborations across different migration systems and even different disciplines.

Morgan Heim

Morgan (Mo) Heim is a conservation photographer, filmmaker and adventurer focusing on the ways human-influenced environmental changes impact wildlife. With a background in ecology and journalism, her goal is to find the beauty, humor and perseverance in stories about wildlife, and how those stories teach us about who we are and what we might become. She's lived among seabird colonies with scientists studying climate impacts, trekked across the tundra to find the world's fattest reindeer and descended beneath the Astoria-Megler Bridge to observe cormorants, which has driven home the fact that wild stories are everywhere. Morgan is a Senior Fellow of the International League of Conservation Photographers, a mentor for Girls Who Click and founder of Neon Raven Story Labs — a storytelling and strategy platform for conservation. In 2020, she co-launched Her Wild Vision Initiative to raise the voices of diverse women in conservation visual storytelling. Her work appears in outlets such as *Audubon*, *Smithsonian*, *National Geographic*, *Newsweek* and *The New York Times*. She lives in Astoria, Oregon, where the waves are big, the mountains close, and the weather not nearly as bad as everyone thinks it is.

Plenary: Integrated Science and Communication

On an average summer morning, biologist Greta Wengert peeks into her daughter's room. She leaves the light off, so as not to wake her and heads out the door of her California home. Within hours, she will hike into the forest guarded by several gun-toting, camo-wearing officers. What happens next? In this plenary, I will describe how researchers and managers can craft deeper and more meaningful science stories. I will tackle questions such as what makes a story sticky, and once you have a vision for that story, how do you make it happen? Teaching through examples, I will present strategies for developing and executing more powerful storytelling in service of science. Research has shown that information alone won't leave a lasting imprint. You have to connect with viewers and/or readers to make them feel, find common ground, and give them an experience. I will describe how we can advance beyond communicating information, and tap into the heart of your research so that you give that information a chance to stick. By the end of this talk, you will know how to rethink the story potential of your projects and come away with tips and tricks on the fundraising and logistics of working with creatives.

Paul Smith

Paul Smith is a research scientist with Environment and Climate Change Canada, and an adjunct professor in the biology departments of Carleton and Trent Universities. He has studied coastal tundra ecosystems in the Canadian Arctic for 25 years and operates a long-term research program at the Qaqsauqtuuq (East Bay) Migratory Bird Sanctuary in Nunavut. Much of his research is focused on the study of shorebirds, and how changing conditions in the Arctic could be contributing to population decline in these species. His interest in geese arose 10 years ago when he began to wonder whether the poor breeding conditions for shorebirds and other tundra bird species on Southampton Island might be a consequence of hyperabundant geese. With support from AGJV, he initiated a series of studies to clarify the effects of abundant geese on tundra ecosystems and sympatric species. These studies began with a focus on habitat effects and predator prey dynamics, and were later expanded to include effects on aquatic ecosystems, gas flux, indigenous food security, and other topics. Paul lives with his wife and 2 children in Lanark County, west of Ottawa.

Plenary: Climate Change

Paul Smith, Wildlife Research Division, Environment Climate Change Canada

In some regions of the North American Arctic, hyperabundant geese are a rapid and significant source of environmental change. The effects of these elevated goose populations on their habitat, through overgrazing and grubbing, are well documented. However, until recently, the impacts of this goose-induced habitat change on other sympatric species was poorly documented. Through field studies at sites representing a gradient of goose impacts, we have clarified the scope and magnitude of the effects of geese on sympatric shorebirds, the most diverse and abundant group of birds in the coastal tundra. We demonstrated that overabundant geese reduce the quality of nesting habitat available for shorebirds, with impacts on individuals' nest site selection, breeding behaviour and reproductive success. At the site scale, goose colonies lead to locally elevated predator abundance, with adverse effects on the nest survival of artificial and real shorebird nests. At larger spatial scales, the abundance and diversity of other birds are reduced in the vicinity of goose colonies. We then explored the impacts of geese on other trophic levels, demonstrating that goose faeces can lead to enhanced productivity or even eutrophication of Arctic ponds, with shifts in the diversity and abundance of aquatic invertebrates. We've also shown that goose faecal deposition in terrestrial habitats can change the diversity and abundance of shorebirds' invertebrate prey, with a positive influence on prey abundance in some cases. This ecosystem-level research makes a clear case for multifaceted effects of geese on tundra ecosystems, with primarily negative consequences for sympatric shorebirds. In a final step of this project, we shared these findings with Inuit communities, and co-developed management recommendations to address the issue of goose overabundance, drawing from both scientific and Inuit perspectives.

Ray Alisauskas

Ray completed his MSc (1982) and PhD (1988) working with Dave Ankney at the University of Western Ontario. After a brief postdoctoral fellowship working at Delta Waterfowl (1988-1989), he was hired as a Research Scientist by the Canadian Wildlife Service in 1989 in Saskatoon, Saskatchewan. In 1991, he joined the Department of Biology as an Adjunct Professor at the University of Saskatchewan. In that capacity, he supervised a number of MSc and PhD students studying waterfowl and other wildlife in Canada's central arctic and in Prairie Canada. He also assisted other graduate students as a member of their advisory committees. He initiated a long-term field research site at Karrak Lake in Nunavut in 1991 working closely with wildlife technicians, Garry Gentle and Dana Kellett. The focus was on understanding population dynamics of Ross's and Midcontinent Snow Geese, and their effects on the local arctic ecosystem and vice versa. Other facets of research with light geese nesting at Karrak Lake included vegetation studies, population dynamics of other sympatric wildlife (Passerines, small mammals, arctic fox, King Eiders and Long-tailed Ducks) and emerging disease issues. His Prairie research included population dynamics of White-winged scoters. In addition to field research, Ray has an interest in technical aspects of abundance estimation.

Plenary: Midcontinent light geese/harvest

Ray T. Alisauskas, Wildlife Research Division, Environment and Climate Change Canada, Prairie and Northern Wildlife Research Centre, Saskatoon, SK, Canada S7N 0X4. Email: Ray.Alisauskas@ec.gc.ca

In his seminal 1996 paper, "An embarrassment of riches: too many geese", C. Davison Ankney reviewed the evidence for detrimental effects of growing goose populations in North America. He questioned the practise of restrained harvest management in North America if a solution to apparent ecological problems stemming from increasingly high goose populations required active population reduction. This was a paradigm shift in thinking about waterfowl conservation, as practised since the early 20th century. Following broad consensus, specific goals were proposed in 1997 for (1) a 50% reduction in numbers by 2005, (2) annual rate of decline in the population of 5%, and (3) a tripling of annual harvest. Special conservation measures started in February 1999, permitting greatly liberalized harvest opportunities for midcontinent light geese with the goal of reducing population size. By 2006, none of these three management goals had been achieved. The over-optimism about achieving goals was probably a result of a drastic underestimation of population size, in part due to reliance on midwinter counts as the main index of abundance. As well, greater consideration of banding data (showing low harvest rates that never exceeded 0.05 after 1987), instead of a focus on total annual harvest, probably would have provided more realistic predictions about how effective attempted population reduction could be. Subsequent studies showed that survival for most arctic breeding subpopulations of midcontinent snow geese, actually increased during special conservation measures, and largely remained ≥0.90 at least until 2015. Meanwhile, natural mortality exceeded hunting mortality. A reintroduced approach to abundance estimation was the straightforward method proposed by Frederick Lincoln that relies on banding data, including the citizen science provided by hunters. Proponents of Lincoln's methods inferred that midcontinent snow geese had increased from 1-2 million adults in the 1970s to 16-18 million by 2007, with much of the increase DURING conservation order efforts. However, as of August 2021, adult population size had declined to about 6 million birds. The decline was unrelated to harvest or reduced survival; instead, declining fecundity, gosling survival and recruitment, at least in the NW portion of their breeding range in the Central Arctic, appeared to be responsible. Since 6 million is about 50% of the 12 million estimated to be alive in 1997 using Lincoln's method, and the decline in the population shows no sign of stopping, the waterfowl community might now face an approaching decision about when to end special conservation measures for midcontinent light geese.

Janet Bucknall

Janet Bucknall serves as the Deputy Administrator of the Wildlife Services Program within the USDA Animal and Plant Health Inspection Service (APHIS), a position she has held since 2018. Previously, she served as the Director of the WS Program's Eastern Region and as the Associate Deputy Administrator of APHIS Biotechnology Regulatory Services where she handled the international portfolio in support of trade. Prior, Janet worked as a field biologist and manager within Wildlife Services in Wisconsin, New York, New Jersey and Pennsylvania. Janet received her BS in forest and wildlife management from the State University of New York College of Environmental Science and Forestry, and an MS degree in wildlife management from the University of Minnesota.

Plenary: Expanding human populations and goose-human interactions

Janet L. Bucknall, United States Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services, 1400 Independence Avenue, Washington, DC 20250, Email: janet.l.bucknall@usda.gov

According to the United Nations, the world population is projected to reach 8.5 billion people in 2030, and to increase further to 9.7 billion in 2050 and 11.2 billion by 2100. The wildlife conservation community around the world eyes these predictions with interest. We wonder if the Earth's natural resources can sustain a world heavy with people. Every day, wildlife biologists, public managers, and citizens experience interactions with wildlife. The Wildlife Services Program, within USDA's Animal and Plant Health Inspection Service (APHIS), has a public service mission to provide federal leadership to manage wildlife damage so that people and wildlife can coexist. The Program uses an integrated wildlife damage management approach to protect resources and to safeguard human health and safety. Program biologists and leaders collaborate with other agencies, organizations and resource owners to address problems according to wildlife conservation values and principles. Goose-related damage issues reported to Wildlife Services include crop depredations, bird-aircraft strike hazards, disease concerns, and property damage. During 2005 - 2021, the Wildlife Services Program provided technical assistance and management advice regarding the seven artic nesting goose species via more than 14,000 events (personal interactions, presentations, etc.). Arctic goose species are present in the FAA national strike database; the majority involve Canada geese (nearly 2000 strikes during 1990-2021), and snow geese (207 strikes), white-fronted geese (82), cackling geese (32), emperor geese (2) and Ross' geese (1) are also involved. Migratory Canada geese were involved in 2009's "Miracle on the Hudson" collision with a passenger airline on departure from New York's LaGuardia Airport, and in the 1995 collision with a military aircraft near Alaska's Elmendorf Air Force Base which resulted in the loss of 24 lives. During the 2022 outbreak of highly pathogenic avian influenza, the Wildlife Services program conducted wild bird surveillance for avian influenza viruses in the four flyways and assisted with bird morbidity and mortality events around the country. HPAI was detected in Canada, snow, Ross', white-fronted, and cackling geese as well as in brant. These are a few examples of arctic goose-human interactions related to Wildlife Services work. Arctic geese are a valued component of our environment, and citizens expect and deserve responsive public agencies to lead goose conservation, which includes management of negative interactions, to ensure healthy goose populations for future generations. Collaborative partnership is the key to successful wildlife management involving arctic nesting geese and all wildlife species.

List of Abstracts for Oral Presentations

Dynamics of pre-breeding nutrient reserves in sub-arctic staging Lesser Snow and Ross's geese: implications for reproduction.

Frank Baldwin, Environment Canada, Canadian Wildlife Service, Suite 150, 123 Main Street, Winnipeg, Manitoba, Canada R3C 4W2. Email: Frank.Baldwin@ec.gc.ca

Ray T. Alisauskas, Department of Biology, University of Saskatchewan, Saskatoon, SK, Canada S7N 5E2, Environ-ment Canada, Prairie and Northern Wildlife Research Centre, Saskatoon, SK, Canada S7N 0X4. Email: Ray.Alisauskas@ec.gc.ca

James O. Leafloor, Environment Canada, Canadian Wildlife Service, Suite 150, 123 Main Street, Winnipeg, Manitoba, Canada R3C 4W2. Email: Jim.Leafloor@ec.gc.ca

Phenological mismatch occurs when the timing of reproductive events and seasonal availability of resources become decoupled, and is increasing in migratory birds in response to climate change. Arctic nesting geese acquire important nutrient reserves at spring staging areas, but advancing springs, combined with large population increases and long-term goose-mediated habitat alteration, could induce a mismatch between optimal timing of nesting and accumulation of required reserves. From 2012-2019, we randomly sampled Lesser Snow and Ross's geese throughout their spring migration near Churchill, Manitoba. Our objectives were to evaluate patterns of protein and lipid accumulation, and draw comparisons to historical estimates obtained before widespread habitat changes. We found significantly reduced pre-breeding protein reserves in snow geese relative to their historical values, but average protein reserve size increased somewhat with declining population size during the years of our study. Snow geese catabolized lipid reserves, and no longer increased protein reserves during spring staging. Protein reserves were on average 17-23% smaller in 2012-2019 than in the 1970s, the deficit being equivalent to the amount of protein found in 2-3 eggs. In contrast, Ross's geese maintained lipid reserves, and accumulated protein during the staging period, irrespective of annual snow goose abundance. Based on patterns in gizzard hypertrophy, they appeared to be using a more digestible food source than were snow geese. Declines in protein reserves may hinder the ability for snow geese to keep nutritional pace with increasingly early springs, and could be an important underlying mechanism driving mismatches between vegetation phenology and emergence of goslings. Differences in recruitment between snow and Ross's geese could be related to differences in nutrient reserve dynamics during the final stages of spring migration, which can carry-over to influence annual breeding probability, clutch size, nest success, and likelihood of mismatch at a population level.

Estimating cause-specific mortality rates of Black Brant

Caroline M. Blommel*, Department of Fish, Wildlife, and Conservation Biology, Colorado State University, Fort Collins, CO 80523, USA: caroline.blommel@colostate.edu

James S. Sedinger, Natural Resources and Environmental Science, University of Nevada Reno, Reno, NV 89557, USA: jsedinger@cabnr.unr.edu

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Recoveries of banded waterfowl reported by hunters provide an important source of information on the status of waterfowl populations, and when combined with other data streams have the potential to inform cause-specific mortality and other vital rates. As a coastal long-distance migrant, black brant (*Branta bernicla nigricans*) are vulnerable to climate and land-use change while also facing hunting pressure along the Pacific Coast where they are a culturally important game species. Though various surveys contradict one another, some indicate the continental black brant population may have declined since the 1990's and band recovery rates have increased dramatically since the early 2000's. To examine changes in vital rates that may be related to declining abundance, we combined band-recovery data with live recapture and resighting data from 1990 – 2021 for the Tutakoke River breeding colony of brant on the Yukon-Kuskokwim Delta in western Alaska. We fit a custom Bayesian multistate model to these data to estimate temporal changes in cause- and age-specific mortality probabilities over the last 30 years. Updated insight into possible changes in mortality probabilities will help elucidate how the brant population is responding to harvest pressure and anthropogenic changes to the environment over time. We are particularly interested in using the results from this time-variant model to inspire hypotheses for particular seasons, and particular environmental variables within seasons, that may be responsible for observed change in the estimated mortality probabilities and in other vital rates such as breeding propensity. Understanding how harvest and environmental variation over time are impacting brant seasonally will provide valuable information on how to manage brant most effectively across their migratory range.

Surface water dynamics of Chihuahuan Desert wetlands: implications for migratory bird habitat conservation

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Wetlands in the Chihuahuan Desert provide important stopover and wintering habitats for migratory birds, including the most important wintering grounds for Snow Geese (*Anser caerulescens*) and White-fronted Geese (*Anser albifrons*) in Mexico. The timing and spatial distribution of surface water availability across this landscape is fundamental to migratory success. Without this resource, the increase in energetic cost of migration can severely affect survivorship and impact their populations. Anthropogenic activities and climate change are impacting wetland habitats across arid systems globally through increasing consumptive water use and changes in climate-driven hydrologic patterns, including regions within North America's central and pacific flyways, and resulting in spatiotemporal changes in surface water availability for migratory birds. However, these effects have not been assessed in the Chihuahuan Desert. To better understand patterns of habitat availability in this ecoregion, we evaluated surface water dynamics of 29 historically important wetlands to migratory waterbirds by reconstructing a 36-year (1984-2019) time series of seasonal (October-March) surface water extent via remote sensing. At the ecoregional level, annual surface water extent increased slightly over the observed period (tau = 0.14, $p < 0.05$). However, at the site level, we observed mixed trends; 5 sites experienced declines in surface water (tau < -0.10), particularly in the northern part of the Chihuahuan Desert, 12 experienced increased surface water (tau > 0.10), particularly in the central and southern part, and 13 sites demonstrated no change (tau < 0.10 and > -0.10). Evapotranspiration best explained annual surface water extent variability in the region. The periodicity of wet and dry cycles differed by site, ranging from 2 to 12-year recurrence intervals, with several sites matching El Niño Southern Oscillation patterns, while no periodicity was observed for seven sites. Our results provide quantitative insight into patterns and trends in surface water availability and inform where restoration and protection efforts may be most beneficial. Moreover, as other regions within the same flyways are experiencing water declines, wetlands in the Chihuahuan Desert could take an increased role in supporting migratory bird populations.

Ascribing the importance of Atlantic brant staging areas for holistic conservation planning

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Despite the species' high conservation priority, population dynamics of Atlantic brant (*Branta bernicla hrota*) remain poorly understood. The population fluctuates dramatically, from 111,000 individuals in 2015 to 170,000 individuals in 2018, with even greater historical variations. Because adult survival has been relatively constant since 1980, fluctuations in population size are most likely due to "booms" and "busts" in annual productivity. Annual fall age-ratios suggest as many as 40% juveniles in some years, and as few as 2% in other years. Variation in waterfowl

productivity is often attributed to food availability and environmental conditions on the breeding grounds. Increasingly though, studies have shown that events and conditions such as climate and habitat quality experienced by an individual in one season can carry-over to affect fitness in subsequent periods. The likely drivers of Atlantic brant productivity as in-season or carry-over effects have not been robustly evaluated, although there is building evidence that conditions experienced by birds during spring staging along James Bay could be most influential. Nearly the entire population of Atlantic brant stages in James Bay during both spring and fall migration. There is evidence of eelgrass decline, a preferred forage for brant, over the past 50 years, and climate extremes and disturbance events are known to cause significant annual variation in eelgrass distribution and quality. Meanwhile, processes such as shrub encroachment and changes in patterns of Canada (*Branta canadensis*) and snow goose (*Anser caerulescens*) use in James Bay may have decreased wetland habitat distribution and quality. We began data collection in 2022 and don't have results to share, but here we present a prospective overview of the ecological questions of interest and the framework for evaluation. Our first objective is to evaluate the relationship between the proportion of time feeding and dynamic body acceleration (based on data from GPS transmitters) and forage quality to better understand habitat selection, and to quantify the importance of different habitat types (e.g., eelgrass beds, saltmarsh) for staging brant. Ultimately, we aim to link the effects of winter and spring preparation choices and conditions experienced to individual breeding propensity and full-term incubation. We will examine these processes in a full annual cycle modeling framework, which will allow us to evaluate trade-offs between breeding and deferring reproduction in a given year and conduct hypothesis tests of environmental drivers on productivity.

Survival Probabilities of Adult Female Emperor Geese during Harvest Closure and After Harvest Opening

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Beginning in the early 1980's, agency aerial surveys and Indigenous Alaskan observational reports documented a population decline of emperor geese (*Anser canagicus)* that led to harvest restrictions and closures implemented in 1985. These declines prompted studies to determine demographic rates of emperor geese, including adult female survival, because adult survival rate is a critical parameter influencing population dynamics. We conducted Capture-Mark-Resight efforts from 1994-2016 at the Manokinak River on the Yukon-Kuskokwim Delta (YKD) during the period when harvest was closed. Preliminary results of apparent annual survival of adult female emperor geese ranged from 0.75 to 0.80, with a population increase of 2% over the time period. In 2016, surveys indicated the population reached an index-threshold allowing the reopening of emperor goose harvest. With the opening of harvest for the first time in over 30 years, managers and biologists had concerns about the potential level of harvest the population could sustain. To quantify survival rates of emperor geese following the opening of harvest, the Yukon Delta National Wildlife Refuge began Capture-Mark-Resight efforts on Kigigak Island (2017-2019, 2021-2022). Preliminary results of apparent survival of adult female emperor geese nesting on Kigigak Island was 0.74 over the 5 years of this study, ranging from 0.62 to 0.96. These preliminary results suggest that survival of emperor geese may be decreasing since the initiation of the open harvest. With limited prior information on emperor goose survival on the YKD during open harvest, the results of this study will provide needed information for population management decisions regarding emperor geese.

Unprecedented observations of 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 in wild birds inhabiting Canada and the United States for the first time. 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 and July 2022, observations of sick and dead birds on YDNWR were made by wildlife managers, researchers, and the general public that were later confirmed to be the result of HPAI. Confirmed detections included affected individuals of the following species: black brant (*Branta bernicla nigricans*), arctic tern (*Sterna paradisaea*), glaucous gull (*Larus hyperboreus*), short-billed gull (*Larus brachyrhynchus*), Sabine's gull (*Xema sabini*), parasitic jaeger (*Stercorarius parasiticus*), common raven (*Corvus corax*), dunlin (*Calidris alpina*), and sandhill crane (*Antigone canadensis*). Given these first confirmed cases of HPAI on the YDNWR and in the surrounding area, as well as additional observations of other non-sampled birds displaying

clinical signs suggestive of HPAI, including Arctic nesting geese, we collected paired serum and oropharyngeal/cloacal swabs from emperor geese (*Anser canagicus)*, cackling geese (*Branta hutchinsii minima),* and black brant during brood drives to test for active subclinical HPAI infections and prior exposure to avian influenza viruses, including those causing HPAI. Results generated from testing these latter samples will help to elucidate the impacts of HPAI during the ongoing outbreak in North America by informing managers on potential wild bird outcomes thereby facilitating planning and response efforts for future outbreak events.

Environmental drivers of Atlantic brant productivity

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Migratory animals experience a suite of challenges and threats across their annual cycle which may manifest as within-season or cross-seasonal effects on productivity (i.e., reproductive success). Further, there is building evidence that environmental conditions at varying scales can drive population dynamics in migratory animals. We quantified the influence of breeding season and cross-seasonal environmental effects on the proportion of juveniles in wintering flocks of a migratory Arctic-nesting goose, the Atlantic brant (*Branta bernicla hrota*), from 1977 to 2021. We investigated the extent to which weather (temperature and precipitation), regional snow and ice cover, and climatic variables across the annual cycle explained variation in the proportion of juvenile Atlantic brant, using linear regression in a Bayesian framework. During spring migration, climate index values associated with warmer, wetter conditions, warmer local weather temperatures, and reduced snow and ice cover on staging areas had strong positive effects on subsequent productivity. In addition, during the breeding season, local weather but not broader climatic conditions or regional snow and ice cover, explained variation such that productivity increased with warmer temperatures. Notably, for winter, we observed inverse effects of temperature and snow and ice cover on Atlantic brant productivity, such that less snow and ice cover and lower temperatures were positively related to productivity. These results suggest that environmental conditions at different scales throughout the annual cycle have driven productivity of Atlantic brant during the last 44 years. We anticipate that practitioners could use these results to focus future work in space and time to better customize conservation plans that target increased Atlantic brant productivity. This might include quantifying reproductive metrics and identifying core breeding areas in the Arctic, understanding nutrient dynamics of staging areas in James Bay, and determining habitat and space use of wintering areas on the heavily urbanized Atlantic coast.

Evaluation and improvement of U.S. goose harvest estimates

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Harvest is an important metric for monitoring status and trends, efficacy of harvest regulations, and, in conjunction with band-recovery data, abundance of many North American goose populations. Each year in the United States, fall-winter (sport) harvests of goose species are estimated from Federal surveys, including the Migratory Bird Harvest Survey to estimate total goose harvest and the Parts Collection Survey (PCS) to estimate age and species proportions. For the PCS, a randomly selected group of hunters collect tail and wing feathers of each goose shot during the hunting season, and then biologists determine the age and species of each sample at events called "Wingbees". For morphologically similar goose species, such as Ross's (*Anser rossii*) versus snow (*A. caerulescens*) geese and cackling (*Branta hutchinsii*) versus Canada (*B. canadensis*) geese (and various management populations), different protocols evolved among Wingbees to differentiate samples into groupings of management interest, leading to difficulties in estimating species-level harvests among Flyways or nationally. Also, in 2020, the U.S. Fish and Wildlife Service updated its List of Migratory Birds (50 CFR 10.13) and separately listed Canada goose and cackling goose, further prompting the need for updated methods to accurately estimate the harvests of these two species. Thus, we undertook a large, coordinated study among the four Flyway Wingbees to develop standardized protocols and analytical methods to separately estimate harvests of Canada versus cackling geese and Ross's versus snow geese.

During three years of the PCS (2018-19, 2019-20, and 2020-21 hunting seasons), Wingbee participants similarly classified and measured about 38,000 Canada/cackling goose and 5,400 Ross's/snow samples and collected 3,400 samples to be available for genetic testing. For a sub-sample of collected parts, we evaluated phylogenetic and population-level relationships based on mitochondrial DNA (mtDNA) and nuclear DNA (nuDNA) and performed a variety of analyses to discriminate species based on central tail feather lengths. We found that mtDNA sequences differentiated cackling and Canada geese well, with strong support for two divergent clades that had associated patterns in central tail feather lengths. Based on study results and in coordination with partners, new U.S. Wingbee protocols were implemented beginning in 2022 to separately estimate the harvests of cackling and Canada geese. In contrast, discriminate analyses and genetic testing to date revealed more ambiguous results for Ross's and snow geese. We discuss reasons for the contrasting results among species' groupings and future genetic analyses that may help to better elucidate genetic relationships among light geese.

Arctic Goose Joint Venture: Overview and Update

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North America supports millions of migratory geese, which play an important role in our natural world and provide a variety of benefits to the public. To properly manage this valuable resource, a strong foundation of science is needed as well as institutions to spearhead and coordinate efforts to obtain this information. The Arctic Goose Joint Venture (AGJV) is one of the original joint ventures, initiated by the North American Waterfowl Management Plan Committee at their inaugural meeting in 1986. The AGJV is a partnership-based program co-chaired by the Canadian Wildlife Service and the U.S. Fish and Wildlife Service with representation from Federal, state/provincial, and non-governmental organizations within all 4 Flyways. The goal of the AGJV is to improve scientific information to support and promote effective monitoring, management, and conservation of arctic- and subarctic-nesting geese. The AGJV helps to fund, plan, facilitate, communicate, and coordinate activities to achieve this goal and has been instrumental in advancing our collective knowledge about North American geese and their habitats. To date, more than 100 projects have been endorsed or funded by the AGJV, and over 400 publications have resulted from AGJV supported projects. We briefly discuss the history, objectives, and governance of the AGJV and detail the coordinated process among partners to develop and update the AGJV Strategic Plan, identify highest priority research and information needs, and solicit and select projects for endorsement and funding. We highlight some important developments in monitoring and management of arctic- and subarctic nesting geese over the past decades, including the issue of overabundant populations, improvements to the delineations of populations for management purposes, and changes in methods and indices to assess population abundance and status. Lastly, we describe recent research focus areas and some of the information gaps that we hope to address in the future as well as tips to improve the competitiveness of proposals for those seeking AGJV funding or endorsement on future projects.

Phenological adjustments of migration and reproduction under climate change: can Greater snow geese "wind the clock"?

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Climate change is highly heterogenous across the globe and reduces the reliability of environmental cues used by migratory birds to time their migration and maximize their reproduction. Links between migration and reproduction decisions are well-known for arctic-nesting geese but climate change, which are more pronounced in the Arctic than anywhere else, could modify or alter such relationships leading to a potential mismatch on the breeding grounds. Understanding the mechanisms underlying geese's response to climate change requires individual-level information. In the greater snow goose, (*Anser caerulescens atlantica*), we compared departure dates from the staging grounds, migration duration, arrival date on the breeding grounds, prelaying period duration, and laying dates over the last 24 years (1997-2021). Furthermore, we quantified the role of local spring temperatures, wind encountered during migration and date of snowmelt on the breeding grounds on these phenological parameters. Over three periods (1997-1999 (n=75), 2007-2008 (n=27), 2019-2021 (n=31)), females with radio-collars were tracked from their departure from the staging grounds in Québec to their nesting site in the high Arctic. Temperature on the breeding site is the only parameter that presented a warming trend over the period considered. All other environmental parameters (temperature during migration, wind condition, snowmelt) remained relatively stable and we observed no changes in geese's phenological parameters over the study period. Relationships between migration and reproduction phenology remained unchanged with a prominent role of arrival date and snowmelt on laying date. However, we found a very strong effect of wind conditions experienced during migration on arrival date directly affecting laying dates. Most of the breeding phenology was explained by *en route* wind conditions. This often-overlooked environmental parameter was found to directly drive the timing of spring goose migration of the Atlantic flyway with the possibility to have mitigating impacts on potential mismatch caused by global warming.

Examining Wintering Goose Ecology, Behavioral Response to Anthropogenic Disturbance, and Avian Influenza Virus Threats to Food Security in the Mid-Atlantic

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Rapid advancements in animal tracking technologies and ability to record biological information (biologging) has allowed for many new questions to be addressed, ranging from natural history to disease dynamics. Our research focuses on both resident and non-resident Canada Geese (*Branta canadensis*) and Greater Snow Geese (*Chen caerulescens atlantica*) in the Mid-Atlantic for three winters (November 1st – March 15th 2019-2022), specifically in the Delmarva Peninsula (Delaware, Maryland, and Virginia) which is an area dense in both poultry facilities and wintering waterfowl. The risk of avian influenza virus (AI) to commercial poultry operations increases through interactions with wild waterfowl. Substantial economic losses caused by the 2021-2022 outbreak continues to emphasize the need for improved biosecurity of this important industry. We used biologging data, with data collected every 5 minutes from 72 individuals (57 Greater Snow Geese, 15 Canada Geese) to calculate proximity of all goose ground points (calculated by step length) to poultry facilities throughout the winter as a measure of AI risk. Further, we examined goose wintering home range size at the weekly and monthly level using autocorrelated kernel density estimates. Additionally, we modeled wintering goose distributions as a function of environmental drivers, resources, and anthropogenic disturbance (e.g., hunting seasons). Lastly, goose response to anthropogenic disturbance was examined, using proportion of time spent in flight, and flight distance as measures of disturbance. We will also evaluate behavioral shifts in response to anthropogenic pressure by comparing day and night home range size and overall flight activity. This study embraces the One Health concept and AI related products will be used to guide poultry farm biosecurity practices and risk mapping, while

Estimating hunting exposure days of Atlantic Population Canada geese during September

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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 population size since structured population surveys began in 1993. The changes have led to carefully constructed zones and season structures to protect migratory geese while maximizing opportunity for Resident Canada geese. Traditionally, the AP Canada goose zones and seasons dates were determined primarily using band recoveries and neck collar observations. However, typical band recovery data (i.e., date and recovery location) is limited to periods when hunting seasons are open and may not adequately capture migration routes and timing. September Canada goose seasons were established to target resident populations and band recoveries from the past 20 years (since RP seasons were established) suggest the special seasons are effectively limiting the impact on migratory populations. In August 2022, we captured 106 after hatch-year female AP Canada geese on the Ungava Peninsula and fitted them with 44g Ornitela Global Positioning System-Global System for Mobile communication transmitters. The transmitters were programmed to collect locations every 10 minutes. To determine exposure to harvest we plotted locations of each bird and determined the daily proportion of points from each bird within each hunting zone in Ontario, Quebec, and the Atlantic Flyway U.S. states. We will discuss the arrival timing and exposure during the first year of a three-year study. We plan to further evaluate harvest exposure over the remainder of the study to evaluate the potential impacts of September goose seasons on AP Canada geese.

Prevalence of Highly Pathogenic Avian Influenza in Midcontinent Lesser Snow Geese

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In the spring of 2022, highly pathogenic avian influenza virus (HPAIV) spread quickly across much of North America, representing an emerging disease threat to wild birds in Canada and the United States. The rapid spread of the virus was accompanied by a number of mortality events in wild birds during northward migration, some of the most conspicuous of which involved the death of up to a few thousand midcontinent lesser snow geese, and generated substantial public interest. Previous research indicated that other low pathogenic strains of AIVs in arctic-nesting geese tended to peak in late winter or spring, and that by late summer, the prevalence of viruses declined to very low levels before increasing again after their arrival on wintering areas. We sampled 1039 hunter-shot snow geese in late April and May in prairie Canada and northern Manitoba, and 999 during banding operations on summer breeding areas to document prevalence during both time periods. Our objectives were to 1) provide insight on the proportion of the population infected during their spring staging period, when they are heavily concentrated, and to 2) document whether the new strain of HPAIV persisted in the midcontinent population of lesser snow geese over the summer. Information on prevalence, coupled with estimates of annual survival rates, may provide managers with a sense of the overall impact of the new virus on midcontinent lesser snow geese, if any.

Combined effects of collar-marking and hunting result in a synergistic interaction and reduce greater snow goose survival.

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Non-additive interactions between multiple stressors can affect wildlife populations in unexpected ways and failing to consider them may result in unsound scientific conclusions. One example is the potential interaction between changing environmental conditions and markers used to identify and track wildlife. In greater snow geese, neck-collars used to identify and resight individuals from a distance were shown to have a mild negative effect on body condition and reproduction parameters but not on survival. Over the past 30 years, the traditional fall and early-winter snow goose hunting seasons were extended to spring in 1999 and to all winter in 2009, which increased hunting disturbance and physiological stress associated with hunting. We evaluated if survival could be affected by an interaction between the presence of a collar and a putative increase in stress experienced by birds though these temporal changes in hunting regulations. We estimated survival and partitioned mortality into hunting and non-hunting sources using 30 years of capture-mark-recapture data of adult females in a joint live encounter and dead recovery model. We found a strong synergistic interaction between the effects of collar-marking and hunting on greater snow goose survival. Collars negatively affected survival, but only after hunting regulations were liberalized (spring hunt implementation) in 1999. This effect intensified after 2009 when the winter hunting season was also extended in the USA, although annual survival of non-collared birds remained unaffected by the latter regulation change. Both hunting and natural mortality of collared birds increased following changes in hunting regulations. A reduction of body condition of collared birds due the cumulative effect of wearing a collar and hunting disturbance is the most likely mechanism leading to increased mortality although other factors may also contribute, such as targeting of collared birds by hunters. Our results thus highlight the importance of frequently re-evaluating the effects of wildlife markers, particularly in the context of changing environmental conditions.

Impacts of spring hunting on body condition and production of young in greater snow geese: insights from the COVID lockdown.

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Many species adjust their behavior in response to constraints imposed by human activities. In greater snow geese (*Anser caerulescens atlanticus*), the special spring hunting season established in 1999 in Québec to control their population growth is an important source of disturbance that affects their behavior and nutrient acquisition dynamics during staging. In 2020, the lockdown imposed by the COVID19 pandemic reduced spring hunting pressure by at least 31% in the Québec province. This provided a unique opportunity to assess the effects of a sudden reduction in hunting disturbance on geese. We used long-term data on spring body mass and proportion of young in fall in combination with data on habitat use from GPS-tracked birds from 2019 to 2021 to assess how the lockdown affected the behavior, spring body condition and subsequent production of young in greater snow geese. Snow goose body condition in 2019 and 2020 were at the highest level since the implementation of the spring hunt in 1999. However, geese reached a high body condition earlier during staging in 2020 than in any other year with comparable data, including 2019. Compared to 2019 and 2021, geese reduced by half the time spent in agricultural fields, a profitable but highly risky habitat due to hunting, near the end of staging. This suggests that the high body condition reached early in 2020 has influenced the trade-off usually made by geese to forage in these profitable habitats despite the high hunting risk they represent. Despite a negative effect of hunting pressure on body condition and production of young over the past 30 years, production of young in 2020 was lower than expected based on hunting pressure in the preceding

spring. This was not surprising and highlights that other parameters not measured in this study also significantly contribute to yearly variation in production of young in this species.

Interpreting Greater White-fronted Goose habitat use and selection across a changing agricultural landscape

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Louisiana has historically provided winter habitat for most Greater White-fronted Geese (GWFG) in the Mississippi Flyway. However, recent increases in GWFG counts in mid-latitude states and concomitant decreases in Louisiana indicate a shift in winter distribution of GWFG in the Mississippi Flyway. The cause(s) of the midcontinent-wide shift in GWFG winter distributions are ultimately unknown, but land use change in Louisiana may have reduced available foraging habitats, which may have partially contributed to GWFG declines in the state. The objective of this study was to quantify GWFG habitat use and selection in Louisiana to evaluate the impacts of changing land use and agricultural practices on this species. We captured GWFG with rocket nets in southwest Louisiana in autumn and winter from 2016–2019. We fitted 83 adults with neck collar solar powered GPS transmitters that were programmed to collect a location every 30 min. A total of 132,315 locations spanning 2016-10-21 to 2019-03-06 were collected in Louisiana. To quantify habitat use, technicians visited all GWFG locations in Louisiana within two weeks of documented use to ground-truth habitat and record fine-scale habitat features. GWFG used herbaceous wetlands (35% of locations), rice (22% of locations), and fallow cropland (21% of locations) with all other habitats comprising <8% of locations. Ground-truthed habitat data were cross-checked with remotely sensed data from the USDA National Agricultural Statistics Service Cropland Data Layer (i.e. Cropscape). CropScape correctly classified 66% of herbaceous wetland locations, 88% of rice locations, and 23% of fallow cropland locations. To evaluate habitat selection, we are developing models that account for CropScape misclassification error through a bootstrap procedure. We generated 100 different instances of Louisiana land cover data using the misclassification matrix to quantify available habitats and compare used to available habitats using conditional logistic regression. We will report preliminary results of the resource selection analysis and discuss implications of relying exclusively on remotely sensed geospatial data to understand habitat selection patterns.

Habitat use and Distribution Implications of Four Goose Species Wintering in California's Sacramento Valley

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One of the most important biotic interactions that influences communities and species distributions is competition and Pacific Flyway waterfowl species compete for space and food across California's Central Valley during winter. The increasing goose population is well above population targets which may spell trouble for smaller species of goose and duck that use the same food resources. We used GPS-GSM telemetry to track 211 individuals of 4 species: the Lesser Snow Goose (*Anser caerulescens caerulescens*), Ross's Goose (*Anser rossii*), Pacific White-fronted Goose (*Anser albifrons sponsa*), and Tule White-fronted Goose (*Anser albifrons elgasi*) across the Sacramento Valley of California. Using step selection analyses, we modeled how agricultural crop, photo period (day or night), habitat condition (wet or dry) and age of those habitat conditions impact goose habitat selection. All species showed a strong preference for wet rice habitat at night, but daytime preferences varied. Lesser snow and Pacific white-fronted geese were the most similar, selecting wet fallow and dry rice habitats over wet rice and dry fallow during the day. Conversely, the California species of concern, Tule geese, strongly preferred wetlands while Ross geese preferred dry rice, followed by wet and dry fallow habitats. Habitat age was also important with preference for wet rice and wetlands decreasing over time while selection of dry rice and wet fallow generally increased with age. Due to agricultural flooding cycles, wet rice habitats likely offer substantial quantities of nutrient dense food resources to arriving migratory birds but over time heavy consumption and decomposition caused by water cover reduces the attractiveness of this habitat, coinciding with the period which birds often switch to green browsing in other habitats.

Monitoring post hatch movements of Emperor Geese (*Anser canagicus*) using internal transmitters and GPS backpacks

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In waterfowl, the time period between hatch and independence from adults is difficult to study, generally due to constraints in the ability to tag or observe the young while they travel and learn from their parents. When examining population declines, understanding this time period becomes relevant as the success of broods directly contributes to population numbers. The emperor goose (*Anser canagicus*) is a medium-sized goose that is endemic to the Bering Sea region, and breeds primarily on the subarctic Yukon-Kuskokwim Delta in western Alaska. Following a severe population decline, the number of emperor geese increased from the mid 1980's through 2017; however, an apparent population decline from 2018-2021 prompted a need to study post-hatch survival and movements of emperor geese. The movements of emperor geese have historically been recorded using coarse collection technologies such as geolocators or internal satellite transmitters, primarily due to low survival probabilities of emperor geese with external attachment techniques (e.g., neck collars) and the challenges presented by working in rural Alaska. Moreover, because the species overwinters in non-populated and remote regions of Alaska, using more advanced data-collection technologies such as cellular or GSM transmitters are largely unrealistic. Here we present preliminary results from a study initiated during summer 2022 where we deployed 6 Argos equipped backpack transmitters on adult female emperor geese to examine fine-scale movements during the post-hatch. We compare these results to 86 internal transmitters deployed from 2019-2022. We present brood rearing home range size, movements, and dates of fall migration for emperor geese outfitted with backpack versus internal transmitters. The analysis of this data will aid in producing effective management strategies that promote brood survival.

Migration chronology, breeding sites, and wintering locations of Atlantic brant using telemetry and geolocators.

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Atlantic brant (*Branta bernicla hrota*) are among the least abundant hunted waterfowl species in North America with a mean estimated wintering population of 144,000 birds from 2000-22. Atlantic brant (brant) breed in the eastern Canadian arctic, primarily in Foxe Basin, and winter exclusively in coastal areas of the Atlantic Flyway with ~85% wintering in New Jersey and New York. During the winters of 2020-22 we instrumented 182 brant (both male and female) with Ornitela GPS-GSM-ACC backpack telemetry units in New Jersey and New York; we plan to mark 50 additional birds with these units during winter 2023. Also, from 2018-21 we marked 822 females with geolocators mounted on uniquely-coded tarsal bands in Nunavut, Canada (*n*=384) breeding grounds (Southampton and Baffin Islands) and during winter in NJ/NY (*n*=438). Using this mixed approach of tracking devices, we hope to determine: 1) Wintering ground departure dates; 2) Spring and fall migration routes; 3) Duration of stay for spring and fall staging on James Bay; 4) Breeding and molting areas; 5) Faithfulness of brant to breeding areas between years; 6) Faithfulness of brant to wintering areas among and between years. This talk will focus on preliminary results to date including: 1) Marking techniques and methods; 2) Arrival/departure dates and duration of stay on James Bay staging areas during spring and fall migration; 3) Arrival/departure dates on breeding and wintering grounds; 4) Comparisons between transmitter and geolocator locations during winter and breeding seasons. Telemetered brant marked during this study will also be used to guide spring and fall staging ecology research in James Bay and energetics research on the wintering grounds.

The North American Waterfowl Professional Educational Plan Objectives, accomplishments, and opportunities in training the next generation of waterfowl conservationists

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The North American Waterfowl Management (NAWMP) was enacted in 1986 to conserve wetlands and associated habitats across the continent and promote the recovery of North American waterfowl populations that plummeted during the 1980s from widespread drought and landscape transformations. The NAWMP is a premier example of a continuing continental ecosystem management and conservation plan. It has influenced the conservation of hundreds of millions of acres of waterfowl and other wildlife habitat since its inception, thereby facilitating the recovery and sustainment of waterfowl and wetland bird populations across North America. However, management and conservation neither progress effectively nor efficiently without trained professionals to study and steward natural resources. In the early 2000s, published research revealed that the number of university-based waterfowl and wetlands programs were declining in North America. By 2013, >40% of these programs were ended after faculty retired or passed, and their positions were not filled with experts in waterfowl and wetlands because of funding limitations or transition to other curricular priorities. Accordingly, the waterfowl community recently questioned who would educate and produce skilled waterfowl and wetlands scientists and stewards for future conservation. The 2018 Update of the NAWMP identified the critical need to maintain and expand educational capacity to ensure availability of an appropriately skilled workforce to meet NAWMP conservation goals. In February 2020, the NAWMP Committee endorsed a new initiative termed the North American Waterfowl Professional Education Plan (NAWPEP). The goal of NAWPEP is to engage and assist universities, colleges, and all NAWMP partners with establishing, sustaining, and enhancing academic programs and experiential learning in waterfowl and wetlands science and management. As a result, the goal is to ensure enough inclusively diverse professionals with this expertise from across North America are available to sustain professional capacity and excellence of future waterfowl science and management. We will present background and justification for development of NAWPEP, accomplishments since inception, future plans to sustain and grow this initiative, and update on endowed professorships and education programs of waterfowl-centric academic positions in North America.

Using an integrated population model to guide emperor goose management under extreme uncertainty

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In 2016, revised management plans for emperor goose (*Anser canagicus*) were developed by the Pacific Flyway Council and the Alaska Migratory Bird Co-Management Council as a prerequisite for opening a recreational and subsistence hunt in Alaska. To guide this process, I used a simple population model that integrated data from the Alaska Yukon-Kuskokwim Delta Coastal Zone Breeding Pair Survey with prior information on goose demographic rates and past harvest data to predict future total population size, given uncertainty in goose demography and future realized harvests. This model and the associated uncertainty were then combined with elicited objectives and risk tolerance of stakeholders to derive decision thresholds for management action (e.g., season closure). The model parameters have been updated after observation of population and harvest data since the opening of the season (2017 – 2022). Average harvest during an open season was much lower than originally hypothesized in 2016, but little information has been gained about demographic parameters from these data. This new data has changed population projections compared to those in 2016, including the expected population size, harvest rate, and frequency of season closures under the current harvest policy. The updated model enables exploring how optimal decision thresholds may have changed compared to those used in 2016 and how actions that reduce harvest during an open season may affect the probably of season closure. These updated results are being used to guide revisions to the 2016 management plans that are currently in progress.

Assessing multi-year nesting ecology among 4 taxa of geese.

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Understanding reproductive output is a fundamental practice in population ecology, enabling calculation of vital rates, predicting expected population change, determining beneficial habitats or environmental conditions, and can be used to assess impacts during previous life history states (i.e. carryover effects). Contrasting reproductive ecology among populations may also provide insight to niche differentiation or other differential impacts among populations such as density dependence. We developed an indirect determination of nesting activity across 4 species (n = 109 individuals; n= 157 bird-years) using GPS location data (~15-minute interval) using a combination of optimized algorithms and visual assessments of the individual animal location data to identify nests and evaluate likely nest fates. Greater white fronted geese (*Anser albifrons* ; GWFG) were represented by both Pacific (*A. a. sponsa*; n= 18 individuals; n = 33 bird-years) and Tule (*A. a. elgasi*; n= 10 individuals; n = 14 bird-years) subspecies captured in Oregon or California. Ross's geese (*Anser rossii*; ROGO; n= 12 individuals; n = 14 bird-years) were captured in California. Lesser snow geese (*Anser caerulescens caerulescens*; SNGO; n= 68 individuals; n = 94 bird-years) included individual caught in California as well as captures of molting birds on Wrangel Island, and near the Ikpikpuk, and Colville colonies in Alaska, and on Banks Island in the Canadian arctic. Nesting propensity ranged between 23% (ROGO) to 44% (SNGO) and non-significantly increased with time since marking (GWFG and SNGO) and did not differ between sexes (SNGO). Nest site fidelity was particularly high for GWFG, but we observed colony switching among both SNGO and ROGO which included SNGO emigration from Western Arctic populations to both Central and Eastern Arctic populations. Although uncommon, male SNGO were observed abandoning females at nest sites for extended periods during incubation before returning at hatch to initiate brood care. Successful SNGO nests were generally easy to confirm using a visual assessment of the movement data due to comparatively

slow and linear movement tracks as parents led brood away from nest sites. However, brood tracks were less evident for GFWG. Modern approaches have used animal movement measured using accelerometry or incorporated both accelerometry and GPS location data to determine nesting activity. Simple, universal approaches to nest site identification across species are likely to be complicated by species behavior, biology, and location of breeding populations. Using higher frequency GPS locations alone we identified nesting attempts as short as 2 days and maintained data intervals across multiple years. The propensity and extent of SNGO colony switching we observed was higher than expected and suggested a greater interconnection between arctic goose population management units than previously considered.

Nest survival of black brant at a rapidly expanding lesser snow goose colony in Arctic Alaska

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The population of lesser snow geese (*Anser caerulescens caerulescens)* in northern Alaska is rapidly increasing, creating concern that locally overabundant nesting populations could negatively impact other bird species. We examined the effects of snow goose nesting density on the daily nest survival of black brant (*Branta bernicla nigricans*) on the Colville River Delta, which historically contained the largest nesting population of black brant in Arctic Alaska. Snow geese began nesting there in 2005 and the local population has since expanded at an average rate of 30% per year. Dense aggregations of snow goose nests could benefit nesting brant due to predator saturation, but brant nests typically hatch after snow geese and could be exposed to increased predation risk at the end of the incubation period. An overabundant snow goose population could also negatively affect brant through increased nest-site competition as well as degraded nesting and brood-rearing habitat. We monitored brant nest success at randomly located plots over five years (2015-2018 and 2022) and modeled the effects of brant and snow goose nesting density on the daily survival rate of individual brant nests after accounting for effects of nest age, phenology, and spring weather conditions. We also established vegetation plots to monitor the grazing and grubbing effects of snow geese. During the study period, the adult brant population grew from approximately 1300 to 2800 individuals, but the snow geese increased from <5,000 individuals in 2015 to > 36,000 in 2022. Despite this trend, snow goose nest density on random plots did not increase from year to year. The effects of nest density and species composition on daily nest survival had less support than effects of initiation date and nest age. The probability that a brant nest would survive until hatch was positively correlated with the local density of snow goose nests, whereas the density of nesting brant had little effect. Brant have not been excluded from their original nesting areas and may have benefited from proximity to abundant snow goose nests. However, the extent of early-season grubbing by snow geese has expanded substantially, and grazing pressure has increased in nearby saltmarsh brood-rearing habitat. If the snow goose population continues to expand at its current rate, the positive effects on brant nest success may still be outweighed by the consequences of habitat degradation and reduced forage availability for nesting brant and their goslings.

Using structural equation models to understand life-history trade-offs in Arctic-breeding geese

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Populations of wild organisms consist of individuals with diverse genotypes, phenotypes, and behaviors. Previous research has consistently demonstrated that this variation leads to heterogeneity in demographic outcomes. However, this variation is often difficult to quantify, particularly when it is not directly associated with measurable traits (e.g., body size). Recent research has also demonstrated that commonly used existing approaches for estimating this variation (e.g., multivariate normal distributions) fail to recover simulated parameter values, suggesting that much previous research may have under-reported the strength of the relationships among demographic parameters. In response, we demonstrate the use of a quantitative technique, structural equation models embedded in capture-recapture models, to assess latent variation in individual fitness and link this latent variation to specific demographic components. We apply this technique to simulated data and a long-term (1988-2014) capture-recapture dataset collected on Pacific black brant (Branta bernicla nigricans) in western Alaska. Results from simulations demonstrate that this technique is a viable and preferable alternative to multivariate normal distributions, and results from our case study demonstrate relationships among individual clutch size, laying date, and breeding propensity, with little change in adult survival for black brant. This suggests that individuals adjust reproductive allocation to maximize survival in this population of long-lived geese. This tool may be useful to assess individual heterogeneity in demographic performance in other wildlife populations, and to estimate baseline fitness prior to experimental fitness manipulations in this and other study populations.

An Integrated Population Model to Inform Harvest Management of Atlantic Brant

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Atlantic brant are important game birds in the Atlantic Flyway and several long-term monitoring data sets could inform harvest management, including a count-based survey and demographic data. Considering their relative strengths and weaknesses, integrated analysis to these data would likely best inform harvest management, but tools for integration have not yet been developed. Managers currently use an aerial count survey on the wintering grounds, the Mid-Winter Survey, to set harvest regulations. We developed an integrated population model (IPM) for Atlantic brant that uses multiple data sources to inform harvest management by simultaneously estimating population abundance, survival, and productivity 1975-2018. The IPM abundance estimates were less variable than annual Mid-Winter Survey counts or Lincoln estimates, presumably reflecting better accounting for observer error and incorporation of demographic estimates by the IPM. Posterior estimates of adult survival were high (0.77-0.87), and harvest rates of adults and juveniles were positively correlated with more liberal hunting regulations (i.e., total hunting days and the daily bag limit). Productivity was highly variable, with the percent of juveniles in the winter population ranging from 1% to over 40%. We found no evidence for environmental relationships with productivity. Using IPM-predicted population abundances rather than Mid-Winter Survey counts alone would have meant fewer annual changes to hunting regulations since 2004. We think that use of the IPM improves harvest management for Atlantic brant by providing the ability to predict abundance before annual hunting regulations are set, and providing more stable hunting regulations, with fewer annual changes.

A full annual cycle approach to quantifying environmental drivers of Greenland white-fronted goose abundance using single-season count data

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Environmental conditions experienced year-round, including during breeding, migration, and wintering phases, play critical roles in driving abundance in migratory bird populations. Our understanding of these mechanisms of population change are further complicated when birds aggregate into multiple distinct subpopulations. We evaluated drivers of subpopulation dynamics in a long-distance migratory bird of conservation concern, the Greenland white-fronted goose (*Anser albifrons flavirostris*). We used *k*-means clustering to identify common trends in abundance among ~66 Greenland white-fronted goose flocks (i.e., subpopulations) and developed a generalized linear mixed model in a Bayesian framework to quantify the effects of extreme climatic events and land cover changes experienced throughout the year on wintering abundance of each common population trend. We found three common flock trends following a spatial gradient across the wintering range from southern Ireland to northern Scotland: southern wintering flocks steeply declined, often towards extinction; central wintering flocks declined less rapidly; northern wintering flocks were stable. Grass cover (negatively) and cereal cover (positively) affected abundance of central and northern wintering flocks. Bog cover negatively affected abundance of central wintering flocks and positively affected abundance of northern wintering flocks. Grass growth in early March negatively affected abundance of southern and central wintering flocks. Our findings suggest a range contraction, as birds increasingly wintered in the northern part of the wintering range. Future efforts to increase acreage of cereal stubble and nutritional quality of managed grassland could improve local habitat conditions and maintain the current Greenland white-fronted goose wintering range. Our modeling framework helps to disentangle environmental drivers of subpopulation-metapopulation dynamics using single-season count data, which is often the only available data source for land managers. This approach is widely applicable to investigating similarly complex processes to improve conservation management for other Arctic-nesting geese.

Large-scale decline of Black Brant in the Arctic and subarctic over the last 70 years?

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A substantial percentage (> 50%) of the Black Brant (*Branta bernicla nigricans*) has historically not bred. Breeding brant were concentrated historically on the Yukon-Kuskokwim Delta (YKD) in western Alaska, whereas large numbers of nonbreeders in addition to failed breeding brant were distributed throughout the Arctic. These large numbers of nonbreeding or failed breeding brant were generated primarily by breeding brant on the YKD. Nests on the YKD have declined substantially over the past 40 years (and possibly longer) with potential impacts on numbers of brant in the Arctic. I compiled as many peer-reviewed publications and agency reports as I could access to assess abundance of brant throughout their summer distribution in light of declines in breeding brant on the YKD. S. Rozenfeld also provided unpublished data from surveys of brant in the Russian Arctic during 2019-2021. In addition to the well-documented declines on the YKD, long-term and widespread declines appear to have occurred in both Russia and Canada, although variation in methodology makes it difficult to quantify the magnitude of the declines. One exception to the general pattern is the Arctic Coastal Plain of Alaska, where both nonbreeding and failed breeding brant, and breeding brant have increased over the past three decades. Widespread declines in both the subarctic and Arctic are consistent with declining survival and recruitment rates and declines recently estimated using a Lincoln estimator. The Lincoln estimator, however, also suggests Black Brant were historically far more abundant than previously believed, similar to the application of Lincoln estimators to other waterfowl populations.

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

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The ongoing 2021-2022 wave of Highly Pathogenic Avian Influenza (HPAI) is unprecedented in its rapid spread and high frequency of outbreaks in domestic and wild birds. While the severity of disease is variable among wild bird species, Canada geese have proven susceptible to mortality from infection. Understanding the role Canada geese play in the ecology of avian influenza and their ability to survive infection is not only important for wildlife health, but will also help inform disease prevention and control strategies that are vital for protecting human and domestic animal health. We summarize results from sick/dead bird surveillance, fecal sampling as well as swabs and serology samples taken during annual banding operations in Ontario. We discuss the implications of these results, apparent seasonality of infection in Canada geese and identify next steps for improving our understanding of HPAI dynamics in Canada geese.

Midcontinent light geese: Heterogeneity in spring migration.

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A Conservation Order was implemented in spring 1999 with the objective of reducing the size of the midcontinent light goose population (collectively and lesser snow geese [*Anser caerulescens caerulescens*] and Ross's geese [*A. rossii*]) through additional hunter harvest. The midcontinent light goose population had grown beyond what was believed to be a size that could ensure sustained quality in Arctic habitats, and not have adverse interactions with other species through competition for food or transmission of disease. While harvest rates have remained low, further interest has emerged regarding ancillary consequences of hunter-harvest pressure, such as reduced body condition, or quality of birds being harvested. Additionally, new hypotheses are emerging regarding different components of the population and their contribution to annual production. I measured mass and body size of light geese harvested over decoys during springs, 2018, 2020, and 2022 in North Dakota and southwest Manitoba from 20 March – 10 May. I found that morphometrics were consistently larger for males than females, but did not differ by age. Thus, I used a principle components analysis to adjust body mass by species and sex, and set a harvest date relative to 19 March for each year. I found a strong relationship between date and size-adjusted body mass where birds were 36% heavier at the end of spring migration than those at onset of arrival of migrants. Moreover, size-adjusted body mass was also related to the percent of geese that were adult birds in the area at time of hunts. The representation of adults in migration was also related to date, with earliest migrations being comprised mostly of adults, which were also in substantially worse condition than birds arriving later in spring. The heterogeneity of individuals and how they time migration has consequences for sampling paradigms by researchers, exposure to risks for geese due to inclement weather and disease, and likelihood of contributing to annual production.

Modeling Fall Light Goose Migration in Relation to a Large, Toxic Lake

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The Berkeley Pit (hereafter the Pit) in Butte, Montana is a relic of decades of open-pit copper mining. Backfilled with water after mining ended, the Pit is now a toxic lake designated as an EPA Superfund site. This lake is in the Rocky Mountains of Southwestern Montana along a major migration corridor in the Pacific Flyway. Each year, thousands of waterfowl in a variety of species attempt to use the lake as a rest stop during their fall and spring migrations. Efforts to mitigate risk to birds including dissuasion efforts such as hazing and creating visual disturbances have been successful for most species. However, limiting light geese (lesser snow geese [*Anser carerulescens carerulescens*] and Ross's geese [*Anser rossii*]) occurrence at the Pit remains difficult because these species rapidly migrate in large flocks, which presents difficulties in managing response to bird arrival at the Pit. Protection efforts are now focused understanding the drivers behind light goose migration to be better prepared for their arrival. Migration forecasts have been developed for many species including migratory dabbling ducks (Anatidae), cranes (Gruidae), and sparrows (Passeridae). In these forecast models, weather plays a critical role in the birds' decision to migrate. Similarly, by understanding which environmental factors trigger light goose migration, we can further enhance the preparedness of waterfowl managers and the protection of these birds at the Berkeley Pit and beyond. Using an extensive database of GPS marked light geese, we created a predictive model to forecast light goose migration events through Western Montana. We modeled migration occurrence and timing by individual geese using environmental covariates obtained for bird locations and the staging region more broadly. During fall migration, most individuals migrated over the southern portion of the Montana Rockies and nearly uniformly throughout the day. However, birds passing closest to the Pit did so almost entirely during daylight hours. Further analysis will evaluate migration timing and environmental covariates for light geese in Western Montana. Ultimately, we aim to integrate these findings into the waterfowl mitigation plan at the Pit.

Factors influencing nest survival of emperor geese on the Yukon-Kuskokwim Delta, Alaska

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Waterfowl productivity is often influenced by environmental conditions on the breeding areas. For example, factors such as spring phenology, weather conditions during nesting, and local abundance of predators and alternative prey can affect productivity in Arctic-nesting goose populations. While nest survival is an important component of productivity in geese, the effects of breeding area conditions on nest survival are not well understood for some species, including the emperor goose (*Anser canagicus*), a species of conservation concern that is endemic to the Bering Sea region. We estimated nest survival and examined how indices of environmental conditions, individual nest variation (e.g., nest initiation date, maximum number of eggs in the nest), and researcher disturbance influence daily survival probabilities of emperor goose nests using hierarchical models and 24 years of nest monitoring data (1994–2017) from the Yukon-Kuskokwim Delta in western Alaska. Our results indicate that overall nest survival was generally high ($\mu\mu$ = 0.742, 95% CRI: 0.617–0.836) and ranged from 0.283 (95% CRI: 0.137–0.443) in 2013 to 0.894 (95% CRI: 0.819–0.948) in 1995. We found that daily survival probabilities of nests were influenced by individual nest variation, tidal flooding events, and researcher disturbance, but were not strongly influenced by indices of spring phenology, temperature, precipitation, or fox and vole abundance on the Yukon-Kuskokwim Delta. Furthermore, including covariates in our model reduced annual variance in daily survival probability of nests by ~2%, suggesting that important factors may not have been considered. Our results suggest that environmental variation measured on large spatial or temporal scales had minimal influence on nest survival of emperor geese. We suspect that within-year variation in weather conditions and local abundance of predators and alternative prey may be important and should be considered in future studies.

Delineating flyway affiliation of cackling geese (Branta hutchinsii) breeding on the Arctic Coastal Plain of Alaska

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Midcontinent cackling geese (*Branta hutchinsii)* are jointly managed by the Central and Mississippi Flyways using two management plans. These plans define the population as cackling geese nesting north of tree line in Canada. Cackling geese nesting on the Arctic Coastal Plain of Alaska (ACP) are not included, but instead are included as part of the Taverner's cackling geese (*Branta hutchinsii taverneri)* population managed by the Pacific Flyway. Taverner's cackling geese breed in tundra areas of western, northwestern, and northern Alaska. The current population index is a combination of counts from three aerial surveys in these regions. The inclusion of the ACP population in the Taverner's index is significant because populations on the ACP have increased in the last 2-3 decades, while Taverner's populations in other areas have been stable to decreasing. Limited band return data for molting cackling geese on the ACP suggested some birds may winter in the Central Flyway. Therefore, a more refined understanding of winter affiliation of cackling geese breeding on the ACP is necessary to improve population delineation and further inform monitoring and harvest strategies for both midcontinent and Taverner's cackling geese. During the summers of 2021 and 2022, crews deployed transmitters on nesting cackling geese at three study sites across the ACP. We captured 68 females on nests and fitted them with ~22–28 gram GPS-GSM neck collar transmitters; 13 at Colville River Delta, 33 at Prudhoe Bay, and 22 at Canning River Delta. We will deploy additional collars in

2023. During winter of 2021-2022, we obtained locations from 13 birds that nested near Prudhoe Bay and Canning River Delta. All 13 geese wintered in the western portion of the Central Flyway. Specifically, nine wintered primarily in Colorado, and four in New Mexico. The majority of these birds used urban environments (e.g., Denver and Albuquerque) during winter. One bird also moved through Oklahoma, Kansas, and Nebraska during winter. We expect to strengthen our understanding of flyway affiliation this winter (2022–2023) with data from the 41 birds marked in summer 2022, including birds from nesting locations west of the Canning River Delta.

Goose hunting ≠ duck hunting: What satisfies the Central Flyway goose hunter?

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Research within the field of human dimensions of wildlife has historically studied topics of duck hunting and goose hunting as a combined activity, with the assumption that trends in hunter motivations, specialization, constraints, and satisfaction are similar among all waterfowl hunting activities. Recent work as uncovered those attributes specifically important to duck hunter satisfaction (harvest and hunting access), but comparatively little has been published on the satisfaction of goose hunters within the field of human dimensions of wildlife. Using a penalty-reward contrast analysis, we compared attributes important to satisfaction for duck hunting and goose hunting by waterfowl hunters in the Central Flyway over a five-year period. Of the attributes we explored, all but harvesting the daily bag limit of birds were found to be important performance factors to duck hunters ($R^2 = 0.58$, $P < 0.01$). For goose hunting, we found all attributes to be important to satisfaction ($R^2 = 0.58$, $P < 0.01$). Specifically, harvesting the daily bag limit was qualified as an excitement factor (raises satisfaction if achieved, but will not induce dissatisfaction if expectations fall short). Our study underscores the need to evaluate duck hunting and goose hunting as separate activities, and our results provide the groundwork to further study differences among waterfowl hunting activities.

Evidence of Longitudinal Differences in Spring Migration Strategies of an Arctic-nesting Goose

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During spring migration, waterfowl are required to optimally balance energetic costs of migration with physiological factors across heterogeneous landscapes and weather conditions in order to survive and subsequently reproduce successfully. Therefore, an individual's migratory performance may influence reproductive outcomes. Given large-scale changes in land use (e.g., agricultural expansion), variable effects of climate on migration cues and habitat conditions throughout migration and breeding areas, and potential carry-over effects from previous seasons, understanding how individuals conduct migration in relation to breeding performance is critical to predicting how future scenarios may affect populations. To examine migration characteristics and determine breeding performance, we used GPS tracking devices fitted to 56 Greater White-fronted Geese (*Anser albifrons frontalis*) during spring migration over 4 years. We examined whether migration characteristics, including winter origin, migration duration, migration distance, number of stopovers, reverse migration movements, arrival date, pre-nesting duration, and incubation initiation date, influenced the probability of attempting to breed, and if a breeding attempt was successful or failed. We found a strong longitudinal difference in arrival to the breeding areas, pre-nesting duration, and incubation initiation dates between eastern Arctic and western Arctic breeding regions with contrasting effects on breeding performance between regions, but no migration characteristics influenced breeding performance. Additionally, we found that breeding region influenced whether an individual likely pursued a capital or income breeding strategy where individuals fell along the capital-income breeding continuum was influenced by longitude, revealing geographic effects of life-history strategy among conspecifics. Greater White-fronted Geese extensively used agricultural crops during stopovers in North Dakota, South Dakota, and Saskatchewan, likely mitigating the effects of energetically expensive migratory movements prior to arriving to breeding areas. Therefore, factors that govern breeding

performance likely occur primarily upon arrival to breeding areas or are related to individual quality and previous breeding performance.

Evaluating ecological memory of energy expenditure and foraging behaviour on breeding success by midcontinent white-fronted geese

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The use of full annual cycle models could provide a framework to evaluate both in-season and carryover effects and allow for a greater strength of inference in evaluating factors that regulate population dynamics of migratory species. Full annual cycle models are defined as population models that include the effects of events in both the breeding and nonbreeding seasons on the population dynamics of migratory animals. We evaluated the effects of energy expenditure and foraging behaviour during the late staging period on the subsequent breeding success of midcontinent white-fronted geese using a stochastic antecedent modelling framework. Stochastic antecedent models allow for the evaluation of the relationships between time-varying predictor variables and static response variables, such as breeding success. Stochastic antecedent models also allow for the estimation of the relative importance of the contributions of each predictor variable during individual days to determine important time frames for management of the species. We used GPS and acceleration data from eighteen female midcontinent white-fronted geese outfitted with Ornitela GPS/ACC collars across three years ($N_{bird\text{-}years} = 23$) to evaluate the effects of energy expenditure and daily proportion of time spent feeding during the sixty days prior to arrival on breeding areas on subsequent breeding success. Overall dynamic body acceleration was calculated for each catalogued ACC burst and averaged within each day to provide an index for mean daily energy expenditure. Proportion of time feeding was determined by using a random forest machine learning algorithm to classify each ACC burst into one of three behaviors (feeding, stationary, or flying) and then calculating the ratio between the number of bursts classified as feeding and the total number of bursts each day. Breeding success was determined using another random forest machine learning algorithm based on various movement and energy expenditure metrics during known breeding periods. Results from the stochastic antecedent model indicate a lack of ecological memory regarding energy expenditure or proportion of time feeding as indicated by wide credible intervals around and similarity to the arithmetic mean of the daily weights. Results also indicate a positive relationship between the antecedent effects of proportion of time feeding ($\beta = 2.87$) and a negative relationship between the antecedent effects of energy expenditure ($\beta = -1.09$) and subsequent breeding success. Our results indicate that while the relative importance of each day during the late staging period are similar, conditions within this period have strong effect on subsequent breeding success.

Habitat use, competition, distribution, and their management implications for the three species of geese found in Illinois

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The wintering distributions of three economically important geese species have changed throughout the last century. Canada geese (*Branta canadensis*) experienced a shift northward into southern Illinois starting around 1930 and another shift in the 1990s into central Illinois with wintering populations estimates in southern Illinois dwindling dramatically. Corresponding with the decline, wintering greater white-fronted (*Anser albifrons*) and lesser snow geese (*Chen caerulescens caerulescens*) were observed at a greater frequency in southern Illinois, relating to a more general recent north-eastern shift in their distributions. The first shift in Canada geese distributions occurred simultaneously with a boom in agricultural development, producing an overabundance of waste grain, and the creation of wildlife refuges that provided protection from hunting. Several proposed causes for the second shift include milder winter temperatures and weather, more open water environments, development in agricultural practices, and increases in the populations of temperate breeding geese. Including the proposed causes above, white-fronted and snow geese distribution change causes also include larger hunting pressures in their traditional ranges, increased overall population abundances, and less competition with the larger Canada geese. The purpose of the project is to determine the drivers of the changing distributions throughout time and space and provide property management recommendations. Fieldwork was conducted in west-central and southern Illinois over two counties within each region starting over the winter of 2021-2022 and will also be conducted yearly for the next two years. The location, use, behavior, and movement between each feeding and roosting location were recorded for all three species. The landscape and environmental characteristics of each location were also recorded. The ultimate result of the project will be species distribution models for all three species. We will address how current distributions are impacted by the proposed causes of their change in distributions and predict future distributions.

Local population collapse of Ross's and lesser snow geese driven by failing recruitment and diminished philopatry

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Dynamics of free-ranging animal populations can result from complex interplays of survival, recruitment and movement. Yet incomplete understanding of demography impedes conservation strategies intended to modify population dynamics of focal species. We estimated survival and per capita production of young, as well as emigration and immigration, from 1997 to 2017 in Ross's goose *Anser rossii* and lesser snow goose *Anser caerulescens caerulescens*, which are sympatric species of migratory birds that nest in the central Canadian Arctic at one of the largest breeding colonies in North America. We formed age-structured integrated population models (IPMs) for each species that jointly analyzed live and dead encounter data as well as breeding adult population size and fecundity data to understand drivers of population dynamics. We compared the demography between species because both species increased during the 1990s and early 2000s yet thereafter snow geese declined, while Ross's geese continued to increase, then stabilized and similarly declined. Declines in Ross's and snow goose populations were caused by reduced per capita production of young, and juvenile survival, as well as increased adult and juvenile emigration. Stronger declines in juvenile survival in snow geese explain their earlier population decline compared to Ross's geese. Despite the divergence in population trends in Ross's and snow geese, we found strong synchrony in demographic rates which suggested substantial emigration from this colony and similar responses to environmental conditions. Direct estimation of demographic patterns in the IPM framework permitted hypothesis testing and inference about the role of immigration, even though immigrant sources were unsampled. We provide a novel m-array implementation specific to a multi-state Burnham model which greatly improved computational efficiency and convergence of posterior estimates. Our findings are an important reminder of the role that permanent movements can play in animal demography and metapopulation structure.

Optimizing surveys of fall-staging geese using aerial imagery and automated counting

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Ocular aerial surveys allow efficient coverage of large areas and can be used to track abundance and distribution of wild populations. However, resulting population estimates can uncertain due to difficulty in visually detecting, identifying, and counting animals from an aircraft. Photographic aerial surveys can mitigate these challenges, and can also allow higher flight altitudes to minimize disturbance and improve safety. We evaluated an aerial photographic survey that incorporated a systematic sampling design with automated photo capture and processing for fall-staging geese at Izembek Lagoon, Alaska, in 2017–2019. Ocular surveys have been completed at the lagoon for >40 years. For the new photo survey, we used a commercial system to automatically trigger cameras at preset points. We then applied a machine-learning algorithm to identify and count geese in our photos and manually corrected those counts. We extrapolated density of birds in photos across the lagoon to estimate total population size for brant (*Branta bernicla*) and white-cheeked geese (*B. hutchinsii* and *B. canadensis*). The algorithm undercounted geese, but successfully identified the small subset of photos containing geese. Manual correction was therefore needed only for photos automatically identified as containing geese, substantially reducing the workload. Manually corrected photo-based estimates of brant and white-cheeked goose population sizes were considerably larger than the ocular estimates in all three years. To reduce costs with little penalty for variance around population estimates, the photographic survey design could be optimized by reducing the number of transects to ~67%; and further advances in automated counting technology may reduce the proportion of photos to be manually corrected. Further years of both ocular and photo surveys would be needed to calibrate the photo estimates against the >40-year timeseries of the ocular survey, after which the photo series could successfully guide management of Pacific brant. As technologies continue to advance, we expect photographic surveys with automated counting to be easily implemented and advantageous to many monitoring programs.

List of Abstracts for
Poster Presentations

Revegetation

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Destructive foraging by the Mid-continent Population of Lesser Snow Geese (*Answer 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/US 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***".
More than 40 exclosures, installed in 2005-2007 by The Hudson Bay Project have been monitored annually, with covid exceptions for 2020 & 2021. Revegetation is predicated on the quality of the soil and the potential presence of a remnant seed bed or deposition of air, water or animal borne seeds of various plants or viable tissues from graminoids. Little is known about the recovery dynamics of the severely damaged freshwater habitat in use by Lesser Snow Geese. Revegetation is proceeding at a more rapid rate than originally thought. Succession looks different in different exclosures and habitats. Succession of species in one recovery area starts with *Salicornia borealis,* a halophyte this is not used by local herbivores. In this area the first edible species to recover is *Puccinellia phryganoides. Puccinellia* is a sterile triploid grass that has never been observed to set seed, however it can grow from fragments of meristematic tissue. How did these fragments arrive 5 km inland? Possible transportation mechanisms include spring floods, fall storm surges, wind, snow melt and herbivore faeces. Other study sites continue to show no signs of revegetation. We present the results through 2022. It is significant to note that in 2022 we had an extended cold, wet spring. This resulted in a paucity of nesting Lesser Snow Geese in the traditional areas of the Cape Churchill peninsula. Next year's data may look very different due to this dramatic decrease in nesting.

Heterogeneity between direct and indirect harvest probabilities affects abundance estimates: results from a Bayesian Brownie-Lincoln estimator

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Estimating abundance using Lincoln's method has relied on direct recoveries to meet the assumption of demographic closure. For adult waterfowl, direct recovery probability may differ from indirect recovery probability if recently captured individuals differ in their body condition, innate quality, reproductive status, or migration chronology relative to most individuals in a population. We parameterized a Bayesian Brownie-Lincoln abundance estimator that combines the basic concepts of Lincoln's method with harvest probabilities estimated by Brownie band-recovery models. We parameterized our models to estimate annual harvest probability in place of annual recovery probability by including reporting probabilities in the model likelihood. This method of estimating harvest probability (instead of deriving harvest probability) offers an advantage in that estimates are more precise. Our Brownie-Lincoln abundance models allowed us to compare abundance estimates from Brownie models parameterized to estimate direct and indirect harvest probability (2 estimates per year) to abundance estimates from Brownie models parameterized to estimate a combined harvest probability from both direct and indirect recoveries (1 estimate per year). Using data from the midcontinent population of greater white-fronted geese (Anser albifrons) collected from 1990–2019, we found abundance estimates were of similar magnitude and variability when obtained from indirect or combined harvest probabilities. When abundance was estimated from direct harvest probabilities, abundance was of reduced magnitude and greater variability when compared to our indirect and combined results, but these differences were not consistent over time. Given that these results are from the same band-recovery and flyway harvest data (U.S. and Canada), we conclude there is important heterogeneity in harvest susceptibility among greater white-fronted geese that cannot be accounted for when using a standard approach to Lincoln abundance estimation. Our results indicate sampling variation in band-recovery data should be assessed with modeling approaches that assess multiple competing hypotheses about variation in harvest susceptibility between just-banded waterfowl and individuals harvested at least one year after being banded. We predict this conclusion is applicable to other duck and goose populations.

Assessing the feasibility of a capture-resighting framework to improve precision in survival estimates for Atlantic brant

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Survival estimates from hunter-shot band recoveries inform North American waterfowl conservation and management, but recovery data may be sparse for some populations with small banding samples or low recovery rates. Joint-encounter (JE) models combine live resightings of marked animals with dead-recovery data to estimate survival probability. Such models could improve precision in survival estimates compared to those using dead-recovery (DR) data only. However, improvements may depend on the annual number of marked birds and resighting probability. In 2018, a capture-resighting program for Atlantic brant (*Branta bernicla hrota*) was initiated where birds were captured and marked on Arctic breeding areas during summer and Atlantic coast wintering areas, then resighted by trained observers during winter. We developed a two-season, Bayesian multistate JE model to estimate seasonal and annual survival, resighting, and reported mortality probabilities for Atlantic brant, 2000-2021. Using these results, we created two simulation sets modeling survival for a 10-year period, varying annual releases of marked birds (100-850) and resighting probabilities (0.04-0.35). The first simulation set evaluated a two-season, two age-class model and the second set evaluated a single-season, single age-class model. We compared JE and DR model estimated survival probabilities among scenarios to understand the extent of precision improvements. Over the period 2000-2021, adult survival during the hunting and non-hunting season was 0.91 (95% Credible Interval [CRI] 0.87-0.94) and 0.96 (95% CRI 0.90-0.99), respectively, and juvenile survival during the hunting and non-hunting season was 0.89 (95% CRI 0.83-0.94) and 0.70 (95% CRI 0.43-0.92), respectively. Reported mortality probability of metal banded brant was 0.43 (95% CRI 0.31-0.63) and 0.55 (95% CRI 0.37-0.87) for double color-marked brant, respectively. Both two-season and single-season simulated JE models did not improve precision in survival estimates compared to DR

models. We ascribed this primarily to JE model complexity and limited brant sample sizes. Simulations were a useful tool in scenario playing, but replicating ecological processes was challenging. Our results suggest supplemental winter marking does not improve brant survival estimation capacity. Additional simulations determining annual releases and resighting probabilities that might improve precision of survival estimates in single-season JE models should be explored. Modifying the two-season JE model structure by leveraging overall means or using variance-covariance matrices could better address small sample sizes. This work was an important first step in evaluating the feasibility of a long-term capture-resighting program for Atlantic brant. Continued data collection will allow further analyses and more realistic scenarios in simulations.

The use of band-recovery data and total harvest data to estimate temperate breeding Canada geese fall flight populations in the state of Tennessee, 2000-2017.

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Since the 1970's anthropogenic changes to the landscape (e.g., shifts in agricultural practices, increase in waterfront lawns, golf courses, and stormwater ponds) combined with favorable environmental conditions, have resulted in the creation of ideal habitat for the Canada Goose (*Branta canadensis*) in the state of Tennessee, USA. The status of temperate-breeding Canada Goose populations in this region are at or well above management population objectives. In some areas, these populations have grown rapidly to the point where they are causing conflicts with humans. Regulatory amendments liberalizing the harvest of temperate-breeding populations were adopted in recent years to reduce their population sizes and potential conflicts with humans. Although, population estimates for temperate breeding Canada Geese are not well documented in Tennessee. To better understand population dynamics for this species, we developed a Lincoln estimator where we used annual estimates of total harvest from the USFWS Parts collection Survey and brownie dead-recovery models in a Bayesian framework to derive estimates of hunting mortality probabilities, for use in Lincoln abundance estimates for this species. Canada goose populations in Tennessee from 1961-2017 averaged 314,371 individuals (95% Bayesian Credible Intervals 220,096 – 464,950).

Distance sampling estimates of goose nest abundance in 2022 on the Yukon-Kuskokwim Delta, Alaska

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The Yukon-Kuskokwim Delta, Alaska, is a major breeding area for emperor goose (*Anser canagicus*), cackling goose (*Branta hutchinsii minima*), Pacific greater white-fronted goose (*Anser albifrons frontalis*), Pacific black brant (*Branta bernicla nigricans*), and other large ground nesting birds (gulls [*Laridae*], eiders [*Somateria spp.*], sandhill crane [*Antigone canadensis*], and tundra swan [*Cygnus columbianus*]). We used conventional distance sampling to estimate the abundance of nests for these birds in 2022 and to compare estimates to past estimate based on plots. Sampling consisted of 83 clusters of ten 1 km transects placed systematically across the study area. Field crews searched each transect using a distance sampling protocol and used a GPS to locate the transect and to record nest positions. All clusters except five were searched for a total transect length of 780 km. The R package *Distance* will be used for fitting detection functions and abundance estimation. Data is currently being proofed and results will be presented at the conference. Species' density estimates and the effect of observer and species on the shape and scale of the detection function will be examined so that these can be used to assess the importance of location accuracy and to optimize of future survey design. Estimates will be compared to historical estimates that used a plot-based search method and a double-observer mark-recapture model with covariates to estimate nest detection.

Recent changes to white goose harvest regulations for the Wrangel Island population of lesser snow geese in Washington state

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Since 2016, several changes to goose harvest regulations have occurred in Washington state with the primary, or sole, justification directly linked to influencing total harvest of 'white geese', specifically towards the population of lesser snow goose (*Anser caerulescens*) associated with a traditional, but expanding, breeding colony on Wrangel Island, Russia. This series of rapid regulatory changes was not desirable as it creates regulatory complexity and confusion often resulting in increased enforcement interactions and lags in the opportunity being fully taken advantage of by active goose hunters. However, these changes have all been adaptive, strategic, and appropriate to address the management concerns of this goose population while assessing available information through annual surveys, hunter harvest estimates and band recoveries. The most significant change in patterns of harvest have come from the separation of goose-type bag limits in eastern Washington, with eastern Washington accounting for approximately 75% of white goose harvest statewide since 2018-2019 season. Harvest recoveries in Washington have provided important insights as the population and season structures have changed rapidly, benefiting from significant banding efforts on Wrangel Island, Russia with a noticeable increase of harvest recoveries started to come from Whatcom County, which influenced the county's inclusion in the modification of Goose Management Area 1 boundary. Finally, the current population abundance and distribution of Wrangel Island lesser snow geese is not in isolation of other major concentrations of wintering waterfowl in the Fraser-Skagit region. Significant winter presence of trumpeter and tundra swans and the largest winter concentration of dabbling ducks in western Washington means that supplemental food sources found on the agricultural landscape are in higher competition with these other high priority winter waterfowl populations. The concurrence of changing agricultural practices, tidal estuarine restorations driven by endangered salmonids, in addition to concerns over sea level rise, storm surges, and growth management (planned development) should raise the priority and need for understanding the current carrying capacity and potential limitations or conflicts within this important waterfowl and wetland system.

Pacific Brant of Washington State: determining breeding origin using stable isotopes from hunter harvest bag checks

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Brant harvested in certain regions of the state are comprised of two populations, Western High Arctic and Black Brant. Western High Arctic, also referred to as “grey-bellied”, are a unique group of brant that have several morphological (color) and behavioral (migration pathways, timing of migration, breeding and wintering range) characteristics that have prompted special management considerations in Washington state when setting brant season dates and length. While we know this to be true in Skagit County in northern Puget Sound region of Washington state, the recent reopening of brant harvest in Clallam and Whatcom counties have required additional information from harvest to assure proper harvest strategy assignment. Black Brant wintering in the Pacific Flyway are supported by two “segments” of the population. One segment breeds in the coastal subarctic region of the Yukon-Kuskokwim Delta in western Alaska, and the other segment breeds in multiple arctic regions of Alaska, Canada, and Russia. These two segments are indistinguishable by plumage color or body measurements alone. However, recent studies conducted by collaborators in Alaska breeding areas have shown techniques using stable isotope analysis with feather samples that allow us to differentiate between these regions, particularly using feathers from juvenile brant. During 2017-2019 brant seasons, primary feathers from bag-checked hunter harvested brant in Skagit and Clallam bays to properly assign to black or Western High Arctic. We present results from 135 brant assessed during this effort and considerations for harvest strategies implemented in Washington state.

Effects of previous reproductive success and environmental variation on nest-site fidelity of emperor geese

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Nest-site fidelity is a common strategy in birds and is believed to be adaptive due to familiarity with local resources. Returning to previously successful nest sites (i.e., win-stay/lose-shift strategy; WS-LS) may be beneficial when habitat quality is spatially variable and predictable; however, variation in environmental conditions, such as spring phenology, may constrain dispersal decisions in Arctic-nesting species despite previous reproductive success. We used 18 years (2000–2017) of capture-mark-reencounter data and multistate models to examine fine-scale nest-site fidelity of emperor geese (*Anser canagicus*) on the Yukon-Kuskokwim Delta in western Alaska. Our objectives were to estimate nest-site dispersal probabilities for emperor geese, determine whether dispersal is affected by previous nest fate, spring phenology, and major flooding events on the study area, and determine if nest-site fidelity is adaptive in that it leads to higher nest survival. Our sample consisted of 1,256 encounters of 536 marked emperor geese from 2000–2017, and we defined dispersal as moving ≥200m from an individual's nest site in the previous year. Dispersal probability was 0.337 (95% CRI: 0.283–0.393) for individuals with successful nests and 0.477 (95% CRI: 0.313–0.644) for individuals with failed nests in the previous year when there was not a major flooding event. Dispersal probability was not affected by variation in spring phenology regardless of previous nest fate. Dispersal probability was higher for birds following a year with a successful nesting attempt and a major flooding event than years without a major flooding event, and lower for birds following a year with a failed nest and major flooding event than years without a major flooding event. Furthermore, dispersal probability for birds with failed nests in years with a major flooding event was lower than those with successful nests in years with a major flooding event. Lastly, fidelity to a nest site increased nest survival by 0.06. Our results suggest that nest-site fidelity for emperor geese follows the WS-LS strategy under certain conditions, but this varies with extreme weather events. We recommend future studies on nest-site fidelity of geese consider the role of individual heterogeneity and habitat quality on dispersal decisions.

Expectations of duck and goose hunters across the Central Flyway

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Fulfilling expectations is a widely accepted necessity for users to justify continued use of a product or service. As expectations have been found important in duck hunting, we conducted a revised importance-performance analysis to measure expectations of duck and goose hunters in the Central Flyway. Our objective was to discern which shared attributes of duck and goose hunting activities wildlife agencies should most invest their resources. Over a five-year study period, we discovered that the attributes of seeing and harvesting ducks were consistently qualified as areas where agencies should concentrate their resources ($R^2 = 0.56$, $P < 0.01$). Goose hunting similarly held seeing birds and harvesting birds as the most deserving attributes for agency focus, but compared to duck hunting, harvesting geese was more important than simply seeing geese ($R^2 = 0.56$, $P < 0.01$). Measuring the importance and performance of duck and goose hunting attributes may be useful for understanding how agencies should manage these comparable, yet separate waterfowl hunting activities.

Predicting the response of a long-distance migrant to changing environmental conditions in winter

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Mexico has traditionally been the primary wintering area for the eastern Pacific population of brant (*Brant bernicla nigricans*), but numbers have been decreasing (>30%) since the late 1990s. The decline of brant appears linked to a northward shift in out of Mexico driven by a decrease in the abundance of their primary winter food, eelgrass (*Zostera marina*). To test this hypothesis, we used an individual-based model and data collected at Bahia San Quintin (BSQ), Mexico between 1997-2013 to predict how changes in the biomass and availability of eelgrass influences energy reserves needed for winter survival (November-April) and spring migration to nesting grounds. We found that brant were not constrained by eelgrass in fall (November-December) despite a negative trend in eelgrass abundance over the study period. However, during winter (January-February) and spring (March-April) brant could not meet energy demands without foraging on an alternative food source, such as *Ulva* spp. or *Triglochin maritima*, which were more difficult to access. Food constraints were greatest for brant during El Niño events, because of additional declines in abundance (shorter shoots and lower density) and availability due to a rise sea levels. Changes in eelgrass biomass had a greater affect on energy demands than changes in sea level. Nevertheless, sea level has risen nearly 16 cm since the late 1990s and is likely exacerbating the long-term declines in eelgrass abundance at BSQ and likely at other brant wintering areas in Mexico. Results from this modeling exercise support the belief that negative trends in eelgrass abundance and availability in Mexico are a key driver in the northward shift in winter distribution and reduction of nest on the Yukon-Kuskokwim Delta, Alaska, and are contributing factor in the long-term decline in annual survival of brant.

Atlantic Brant Upland Habitat Use and Bioenergetics on Wintering Grounds

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Atlantic brant (*Branta bernicla hrota*) populations are one of the least abundant game waterfowl species in North America. After a steep decline in eelgrass (*Zostera marina*) abundance during the 1930s on Atlantic Flyway wintering grounds, brant have partially switched to feeding on upland grasses (e.g. parks and golf courses) in many areas. Relatively little is known about habitat use in these upland habitats and how these upland habitats contribute to energetic needs of wintering brant. To better understand the wintering habitat needs as well as bioenergetic carrying capacity across the full use of available habitats, 230 individuals are being marked with Ornitela GPS-GSM-ACC backpack telemetry units in New Jersey and New York. We will estimate wintering brant home range, daily movements, and habitat use using GPS data, with a particular focus on upland field use. We will also estimate daily energy expenditure using time-activity budgets derived from accelerometry data, with a particular emphasis on refining flight and nocturnal energy expenditure estimates. To assess upland field use and selection, we will sample upland turfgrass fields used by marked brant and paired unused fields within individual bird's monthly home range. Turfgrass samples will be analyzed to determine caloric or nutritional differences between used and unused fields that may be influencing field selection. We will strive to inform a wintering habitat carrying capacity model for Atlantic brant and determine the importance of upland turfgrass fields for wintering brant.