14th North American Arctic Goose Conference and Workshop

Lincoln, Nebraska
March 13-17, 2018

Program and Abstracts

14th North American Arctic Goose Conference and Workshop

Program and Abstracts

Table of Contents

Welcome 1
General Information 2
Conference Center Map 3
Conference Sponsors 4
Conference Committees 5
Plenary Speakers 6
Meeting Schedule 9
Abstracts–Plenaries 15
Abstracts–Oral Presentations 17
Abstracts–Poster Presentations 43

14th North American Arctic Goose Conference and Workshop
Lincoln, Nebraska
March 13-17, 2018

We are pleased to welcome you to Lincoln and the 14th North American Arctic Goose Conference and Workshop! Lincoln is the state capital of Nebraska and home to the University of Nebraska. March is a special time in Nebraska. Millions of ducks and geese and a half-million sandhill cranes have or will come through the state stopping and “fueling” up before they migrate on to their breeding areas. Indeed, Arctic-nesting geese use all of parts of Nebraska either in fall, winter, or spring, and the logo for the 14th NAAGC represents that. To the left is Chimney Rock, near Bayard, Nebraska, in western Nebraska, with the Sandhills in the background, and the Capital Building in Lincoln on the right. Running through all is the Platte River. Conserving and managing spring habitat for these migrating birds is a source of pride among wildlife professionals and conservation agencies across the state.

Although NAAGC8 was held in Albuquerque, New Mexico, the 14th NAAGC represents the first time this important meeting has been held in the Central Flyway proper. Changes are, have, and will continue to occur in the Central Flyway as well as the rest of North America in terms of climate, habitat, and management challenges. NAAGC serves to provide current information on a variety of aspects of arctic geese that describe or identify those challenges as well as provide a network for goose biologists and managers. We believe the program for NAAGC14 will continue that tradition as past conferences have.

We hope you enjoy your stay, the conference, and your time with students, professionals, colleagues, and friends.

- Mark Vrtiska
- Dana Varner

General Information

Registration

The registration/information desk will be located to the right of the main lobby and across from Regents ballroom, labelled "Pre-convene" on map. Hours for registration will be:

Tuesday: 2 – 8pm
Wednesday and Thursday: 7:30am – 5:30pm
Friday: 7:30am – 12:30pm

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. Additional tickets located with your name tag are associated with the banquet.

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 hotel staff will assist in uploading your presentations and this can be done during breakfast and lunch breaks. Please see the registration desk, if you need further assistance.

Poster Session, Papers and Workshop

The poster session will be held in a portion of the Regents Ballroom. Presenters are expected to be with their posters on Wednesday night. Poster boards will be available on Tuesday at noon and will remain up until Friday at noon. All posters will be removed at that time.

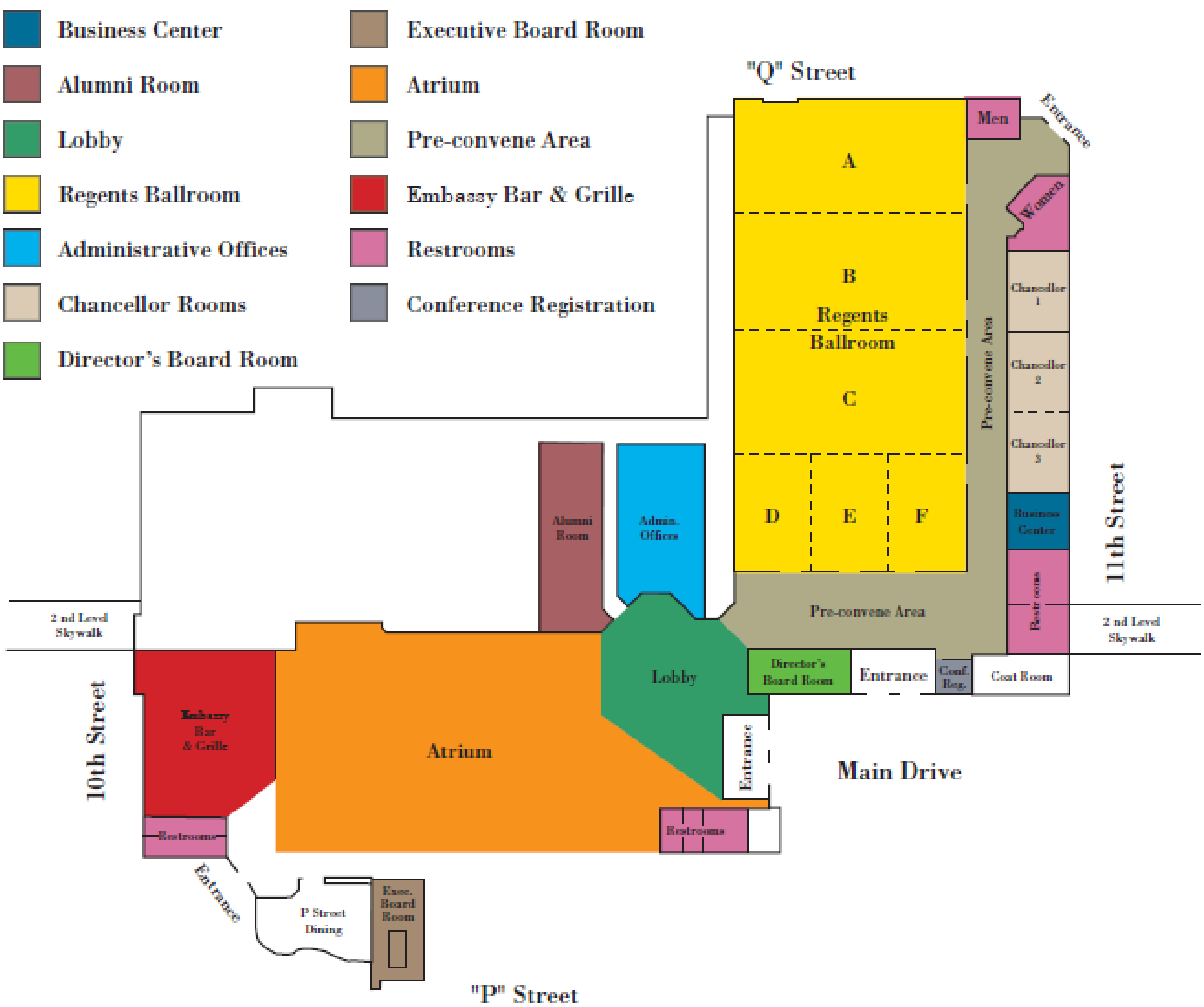
Reception and Banquet

Both the Tuesday night welcome social and the Friday night banquet will be held in the Regents Ballroom where the main conference will be held. Your ticket with your name tag designates your choice for entrée.

Field Trip

A field trip touring the Rainwater Basin area and the Platte River will occur on Saturday, March 17. For those registered for the field trip, meet in the lobby at 7:45am. Transportation will leave the Embassy Suites hotel at 8:00am on Saturday and our anticipated return will be around 5:00pm.

Conference Center Map



Conference Sponsors

Atlantic Flyway Council

California Waterfowl Association

Canadian Wildlife Service · Service Canadien de la Faune

Central Flyway Council
Northwest Territories
Alberta Saskatchewan
Montana North Dakota
Wyoming South Dakota
Colorado Nebraska
New Mexico Kansas
Oklahoma
Texas
1948

Delta Waterfowl

Ducks Unlimited Canada
Conserving Canada's Wetlands

Ducks Unlimited
www.ducks.org

Mississippi Flyway Council
1952

Nebraska
Game Parks

Pacific Flyway Council

Rainwater Basin
Joint Venture
Established 1992

Texas
Parks &
Wildlife

USGS
science for a changing world

Sillosocks
Windsock Decoys
www.sillosocks.com

University of Nebraska
UNK
Kearney

School of Natural Resources

Conference Committees

Organizing Committee

Mark Vrtiska – Co-chair
Dana Varner – Co-chair
Andy Bishop
John Denton
Joseph Fontaine
Larkin Powell
Letty M. Reichart

Scientific Program Committee

Robert Rockwell – chair
Rod Brook
Anthony David Fox
Gilles Gauthier
David Koons
Kevin Kraai
Scott Mcwilliams

Student Travel, Poster, and Presentation Awards Committee

Ken Abraham
Susan Felege
Chris Nicolai

Field Trip

John Denton
Jeff Drahota
Randy Stutheit
Matt Haugen

Plenary Speakers

Stuart Bearhop
Carryover and Cross-seasonal Effects

Stu Bearhop is a Professor of animal ecology at the University of Exeter. He has a range of interests mainly related to migration and foraging ecology of birds and the application of stable isotope techniques to animal ecology. Stu has been a bander for over 20 years and has been fortunate enough to work with birds all over the world, from mist netting neotropical migrants in the Bahamas to noosing albatrosses and penguins in the sub-Antarctic. Much of his work focuses on the ecology of migratory wildfowl, including whooper swans, Bewick's swans, Greenland white-fronted geese and barnacle geese. However, his greatest obsession is the East Canadian High Arctic Brant and working closely with the Irish Brent Goose Research Group, he has helped establish a long term study on this species comprising around 5000 marked individuals and almost 200,000 observations.

Joël Bêty
Effects of Geese on Other Species in the Arctic

Joël Bêty is a Biology Professor at University of Quebec in Rimouski, co-leader of the Canada Research Chair on Northern Biodiversity and Adjunct Director of the Center for Northern Studies (CEN). He grew up in a small town near Quebec City and started hunting waterfowl in farmlands at a very young age. He quickly became fascinated by geese and strongly wanted to follow them up to their arctic breeding grounds. He first studied the migrating and breeding ecology of snow geese with Gilles Gauthier and obtained his Ph.D. at Laval University in 2001. Joël has done intensive fieldwork in the Canadian Arctic since 1995 and has worked on a diverse set of charismatic tundra wildlife, including ducks, raptors, shorebirds and foxes. His current research integrates various levels of biological organisation (from individual to ecosystem), and is centered on arctic migratory birds and species interactions in the tundra. He leads and co-leads long-term studies in the Arctic, including the ecological monitoring on Bylot Island (home of the largest greater snow goose colony). His research contributes to the ecological integrity monitoring program of Parks Canada as well as species management and conservation. Joël gave his first international oral presentation during the 9th NAAG meeting in 1998!

Andy Raedeke
Human Dimensions

Andy was raised in the prairie pothole region in southwest Minnesota where he developed a passion for waterfowl. His academic training focused on the connections between social and ecological systems and included a Ph.D. in Rural Sociology and M.S. in Fisheries and Wildlife from the University of Missouri, a M.A. in Pastoral Theology and Ministry with a focus on environmental ethics from Luther Northwestern Theological Seminary, St. Paul, MN, and a B.A. in Psychology from Concordia College, Moorhead, MN. Prior to his current role as a Waterfowl/Wetland Ecologist with the Missouri Department of Conservation, Andy served as a Research Assistant Professor in Rural Sociology at the University of Missouri. He participated on the North American Waterfowl Management Plan writing teams for the 2012 NAWMP Revision and the 2018 NAWMP Update. He now serves as the coordinator the North American Waterfowl Management Plan/National Flyway Council Human Dimensions Working Group.

Joel Schmutz
Herbivory: the Trophic Dynamics of Geese and Their Food Supply

Joel is a Research Wildlife Biologist for the USGS Alaska Science Center in Anchorage, Alaska. He has studied geese and other waterbirds for 29 years, mostly in northern tundra habitats. His longest running project focuses on the ecology and population dynamics of emperor geese. Other goose-related work includes survival of greater white-fronted geese, trophic dynamics of brant geese, demography of cackling geese, and goose response to population variation in timing of greenup. He obtained his B.S. from the University of Vermont, his M.S. from Colorado State University, and his Ph.D. from the University of Alaska Fairbanks.

Mark Vrtiska
Wintering and Staging Ecology

Mark is currently the waterfowl program manager for the Nebraska Game and Parks Commission, in Lincoln, Nebraska. He is the agency's representative on the Central Flyway Waterfowl Technical Committee and has been involved with the Harvest Management and Human Dimensions Working Groups. He also has served on the Rainwater Basin Joint Venture Technical Committee and chaired the Conservation Planning Working Group. He has taught a waterfowl ecology and management course at the University of Nebraska-Lincoln. Prior to his current position in Nebraska, he was a regional biologist with Ducks Unlimited, Inc., in Jackson, Mississippi. He had the pleasure of working on various waterfowl research projects in Montana, North Dakota, California, Oregon, Louisiana, Kentucky, Mississippi, and Akimiski Island and Baffin Island, Nunavut, Canada. He received his B.S. at the University of Nebraska-Lincoln, M.S. from Eastern Kentucky University, and Ph.D. from Mississippi State University.

Mitch Weegman
Movement and Spatial Ecology

Mitch is an Assistant Professor of Avian Ecology in the School of Natural Resources at the University of Missouri. Prior to joining MU in 2016, he was a postdoctoral research associate at the University of Minnesota working with Todd Arnold and, prior to that, a postdoctoral fellow at the University of Saskatchewan working with Bob Clark. Mitch earned his Ph.D. from the University of Exeter where he studied the demography of Greenland white-fronted geese under Stuart Bearhop, Tony Fox and Geoff Hilton. Mitch earned his B.S. from Mississippi State University under the guidance of Rick Kaminski. Mitch's research is primarily focused on understanding how individual and population processes drive variation in the abundance of animals, whereby individual-level data form the basis for understanding animal behavior and decision-making as well as population dynamics, through acceleration, GPS, capture history and population survey information. Current projects include 1) quantifying the causes and consequences of variation in life histories of long-distance migrant birds in Europe and North America, 2) studying environmental drivers of population change in migratory and resident birds in North America, and 3) metapopulation modeling of overabundant birds in the Canadian Arctic.

Tuesday, March 13, 2018

7:00–11:00	**Welcome Social – Sponsored by Sillosocks**

Wednesday, March 14, 2018 – Morning Session

8:00–8:15	**Welcome, Opening Comments – M. Vrtiska**
	Wintering and Staging Ecology
	Moderator: K. Kraai
8:15-8:25	Introductory Comments – R. Rockwell
8:25-9:10	**Plenary – M. Vrtiska**.
9:10-9:30	**E. Massey*** and **D. Osborne.** Arctic geese in Arkansas: diet composition and temporal trends in body condition in a new wintering area.
9:30-9:50	**C. Nicolai, M. Petrie, J. Ackerman, C. Brady, M. Casazza, J. Eadie, C. Feldheim, M. Herzog, E. Matchett, C. Overton, D. Skalos, M. Weaver,** and **G. Yarris.** Increasing goose populations in the Central Valley of California and potential impacts to duck habitat conservation.
9:50-10:10	**J. VonBank*, B. Ballard, K. Kraai, M.Weegman, D. Collins,** and **H.Perotto-Baldivieso**. Winter movements and habitat use by midcontinent greater white-fronted geese.
10:10-10:30	**Break**
10:30-10:50	**D. Varner, A. Pearse, A. Bishop, J. Davis, J. Denton, R. Grosse, H. Johnson, E. Munter, K. Schroeder, R. Spangler, M. Vrtiska,** and **A. Wright**. Habitat use of Sandhill Cranes and waterfowl on the North and South Platte Rivers in Nebraska.
10:50-11:10	**S. Boyd**. Wrangel Island snow geese wintering in the Fraser and Skagit River delta: population dynamics, foraging impacts, and management via flexible harvest strategy.
11:10-11:30	**D. Ward**, **C. Amundson**, **R. Stehn**, and **Christian P. Dau**. Trends in Pacific black brant productivity in fall at Izembek Lagoon.
11:30-11:50	**M. Eichholz**, **K. Slown**, **B. Dorak**, **H. Hagy**, and **M. Ward**. Strategies and adaptations of wintering geese to an urban environment.
11:50-1:00	**Lunch (provided)**

* denotes student presenters

Wednesday, March 14, 2018 – Afternoon Session

1:00–1:05	Announcements – M. Vrtiska
	Effects of Geese on Other Species in the Arctic
	Moderator: G. Gauthier
1:05-1:15	Introductory Comments – G. Gauthier
1:15-2:00	**Plenary – Joël Bêty**
2:00-2:20	**V. Baranyuk.** Wolves and lesser snow geese on Wrangel Island, Russia.
2:20-2:40	**D. Kellett** and **R. Alisauskas.** Impacts of habitat alterations by lesser snow geese and Ross's geese on avian communities.
2:40-3:00	**K. Schnaars-Uvino, R. Jeffries,** and **R. Rockwell.** Tundra re-vegetation: location, location, location.
3:00-3:20	**Break**
3:20-3:40	**C. Nissley*, C. Williams,** and **K. Abraham.** Assessing pre-emptive and apparent competition on breeding Atlantic brant.
3:40-4:00	**D. Fowler*, J. Dooley, M. Weegman, R. Rockwell, M.Vrtiska,** and **E. Webb.** Evaluating heterogeneous adult survival among subpopulations in midcontinent lesser snow geese.
4:00-4:20	**D. Koons, L. Aubry,** and **R. Rockwell.** Updated insights into hunting and other sources of mortality for a southern breeding population of midcontinent lesser snow geese.
4:20-4:40	**E. Reed, C. Wood,** and **M. Robertson.** Population growth, harvest and survival of overabundant western arctic lesser snow geese, 1998-2017.
7:00-9:00	**Poster Session – Sponsored by Delta Waterfowl**

* denotes student presenters

Thursday, March 15, 2018 – Morning Session

8:00–8:15	**Announcements – M. Vrtiska**
	Carryover and Cross-seasonal Effects
	Moderator: A. Fox
8:15-8:25	**Introductory Comments – A. Fox**
8:25-9:10	**Plenary –** S. Bearhop
9:10-9:30	**F. Baldwin**, **V. Harriman**, and **J. Leafloor.** Pre-breeding protein reserves of lesser snow geese staging in the sub-Arctic.
9:30-9:50	**S. McWilliams, S. Richman, J. Leafloor,** and **W. Karasov.** How small herbivores (like goslings) try to get what they need: a comparative view.
9:50-10:10	**J. Schmutz**, **B. Uher-Koch**, **S. McCloskey**, **D. Rizzolo**, **R. Buchheit**, **P. Lemons**, **L. Naves**, and **J. Fischer**. Carry over effects and seasonal sympatry with ecologically similar species drives survival of an uncommon goose.
10:10-10:30	**Break**
10:30-10:50	**A. Fox, T. Balsby, A. Walsh, I. Francis, D. Norriss, D. Stroud,** and **H. J. Wilson.** Confirming annual reproductive success as the demographic determinant of contrasting population growth rates in Greenland white-fronted geese over more than 35 years.
10:50-11:10	**G. Gauthier** and **J. Lefebvre**. Projecting the population dynamic of greater snow geese into an uncertain future: the interplay between management actions and climate change.
11:10-11:30	**T. Riecke***, **A. Leach**, and **J. Sedinger.** Climatic oscillations drive selection in a long-lived specialist herbivore.
11:30-11:50	**R. Buchheit*** and **J. Schmutz.** Blood parasite prevalence in sympatrically nesting emperor and cackling geese on the YKD with confirmation of transmission occurring on the breeding grounds.
11:50-1:00	**Lunch (provided)**

*** denotes student presenters**

Thursday, March 15, 2018 – Afternoon Session

1:00–1:05	**Announcements – M. Vrtiska**
	Movement and Spatial Ecology
	Moderator: D. Koons
1:05-1:15	Introductory Comments – D. Koons
1:15-2:00	**Plenary –** M. Weegman
2:00-2:20	**R. Alisauskas, A. Calvert, J. Leafloor, R. Rockwell, K. Abraham, R. Brook, K. Drake,** and **D. Kellett**. Survival and movement among breeding areas of the midcontinent snow goose metapopulation in Canada’s central and eastern arctic.
2:20-2:40	**V. Patil, J. Hupp, D. Ward,** and **T. Obritschkewitsch.** The influence of local recruitment and immigration on increasing population trends of two Arctic-breeding goose species.
2:40-3:00	**C. Moore*** and **D. Osborne**. Evaluating spatiotemporal changes in wintering harvest distribution of midcontinent white-fronted geese.
3:00-3:20	**Break**
3:20-3:40	**D. Osborne** and **R. Askren.** Migration chronology, stopover duration, and winter distribution of midcontinent white-fronted geese.
3:40-4:00	**J. Drahota**. Shifts in light goose distribution and peak abundance within the Rainwater Basin during spring migration.
4:00-4:20	**X. Wang, L. Cao**, and **A. Fox**. The Far East taiga forest: unrecognized inhospitable terrain for migrating Arctic-nesting waterbirds?
4:20-4:40	**J. Lefebvre, M. Cruz, M. English, S.Gilliland,** and **F. St-Pierre**. Using CountEm to efficiently estimate flock size from aerial photographs.
4:40-5:00	**R. Askren***. City parks to polar bears: Long distance molt migrations of Canada geese (*Branta canadensis*) transmittered in Chicago.

* denotes student presenters

Friday, March 16, 2018 – Morning Session

8:00–8:10	Announcements – D. Varner
	Human Dimensions and Goose Management
	Moderator: R. Brook
8:10-8:20	Introductory Comments – R. Brook
8:20-9:05	**Plenary** – A. Raedeke
9:05-9:25	**J. Denton, D. Varner,** and **A. Bishop**. Planning and Implementation of Waterfowl Conservation in the Rainwater Basin region of Nebraska.
9:25-9:45	**M. Szymanski, J. Dooley, S. Chandler, R. Raftovich,** and **K. Kraai**. Monitoring goose harvest as a product of ultra-liberal bag limits.
9:45-10:05	**J. Dooley, S. Chandler, M. Otto, R. Raftovich,** and **N. Zimpfer**. Evaluation of Federal Goose Harvest Surveys: some current issues and their implications on harvest and Lincoln estimates.
10:05-10:25	**Break**
10:25-10:45	**C. Deane*** and **G. Frye**. Unobservable harvest mortality: treating harvest data as a process subject to imperfect detection.
10:45-11:05	**F. LeTourneux*, G. Gauthier, R. Pradel,** and **J. Lefebvre**. Impact of recent changes in hunting regulation on seasonal survival of male and female greater snow geese.
11:05-11:25	**C. Deane*, G. Frye,** and **M. Lindberg**. Current shortcomings and possible solutions to understanding process correlation estimates from Bayesian models for harvest inference.
11:25-11:45	**T. Riecke*, B. Sedinger,** and **J. Sedinger**. Estimating process correlations with capture-mark-recovery and capture-mark-recapture data: understanding life-history trade-offs in Pacific black brant.
11:45-1:00	**Lunch (on your own)**

* denotes student presenters

Friday, March 16, 2018 – Afternoon Session

1:00–1:05	Announcements – D. Varner
	Herbivory: The Trophic Dynamics of Geese and Their Food Supply
	Moderator: S. McWilliams
1:05-1:15	Introductory Comments – S. McWilliams
1:15-2:00	**Plenary – Joel Schmutz**
2:00-2:20	**D. Fowler*, M. Vrtiska,** and **E. Webb.** Selective harvest: evaluating differences in body condition of lesser snow and Ross's Geese during spring migration by harvest technique during the Light Goose Conservation Order.
2:20-2:40	**J. T. Kemper, E. Beck, J. Ingram,** and **K. Abraham**. Status of breeding and brood-rearing habitats of lesser snow geese at Southampton Island and Western Baffin Island, Nunavut.
2:40-3:00	**A. Barnas*, C. Felege, G. Vandeberg, R. Rockwell,** and **S. Ellis-Felege**. Rapid evaluation of lesser snow goose habitat degradation using an unmanned aircraft vehicle.
3:00-3:20	**Break**
3:20-3:40	**J. Hupp, D. Ward, D. Soto, V. Patil,** and **K. Hobson**. Spring temperature, migration chronology, and nutrient allocation to eggs in three sympatric species of geese: Implications for Arctic warming.
3:40-4:00	**L. Carlson*** and **C. Deane**. Linking black brant gosling growth and spatial nutrient dynamics of brood-rearing area grazing lawns in the Yukon-Kuskokwim River Delta.
4:00-4:20	**S. Cunningham*, M. Weegman,** and **B. Ballard**. Relationship between spring migration and vegetation phenology in Greenland white-fronted geese.
6:30-10:00	**Social and Banquet**

Saturday, March 17, 2018

8:00–5:00 Field Trip, Rainwater Basin and Platte River

* denotes student presenters

Fat, frost and fitness: How carry over effects and climate underpin demography in High Arctic Goose

Stuart Bearhop, Centre for Ecology and Conservation, University of Exeter, Cornwall Campus, Penryn, Cornwall, TR10 9EZ, UK. E-mail: S.Bearhop@exeter.ac.uk

In recent years, it has become clear that carry-over effects can explain a significant amount of variation among individual animal life histories and in turn drive population processes. Carry-over effects occur when individuals make the transition between seasons/time points in different states that subsequently affect individual performance. However, the field is very much still in its infancy, there is some confusion as to what a carry-over effect is and substantial knowledge gaps remain.

I will discuss what a carry-over effect is (and what it is not) and explore some of the traits (focusing on the migratory lifestyle) that likely increase their impact using wildfowl study systems as examples. Drawing on our long-term study of East Canadian high Arctic Brant, I will show how carry over effects interact with other important regulators to great a demography that fluctuates between winter and summer limitation. I will conclude with some tentative predictions for the future of this population with respect to warming of the Arctic and in turn what this might tell us about other high latitude breeding wildfowl.

Predator-mediated effects of overabundant Snow Geese on tundra wildlife

Joël Bêty, Département de Biologie and Centre d'Etudes Nordiques, Université du Québec à Rimouski, Rimouski, QC G5L 3A1, Canada. E-mail: Joel_Bety@uqar.ca

Overabundant species can strongly affect ecosystem functioning through trophic cascades. The strong increase in several arctic geese populations can have severe direct impacts on tundra ecosystems through vegetation degradation. However, predator-mediated negative effects of goose overabundance on other tundra species can also be significant but are poorly understood. Large goose colonies represent a predictable pulse resource that can induce indirect trophic interactions by affecting the behavior and abundance of predators. Shared predation is a widespread phenomenon that can affect prey species abundance and species coexistence in natural communities. I will tackle this issue by providing an overview of data acquired in the Canadian Arctic on both predators and prey breeding on Bylot Island, which is characterised by the presence of a large greater snow goose colony.

Human dimensions of arctic goose management

Andy Raedeke, Missouri Department of Conservation, 3500 East Gans Road, Columbia, MO 65201, USA. E-mail: Andrew.Raedeke@mdc.mo.gov

Many of the major challenges in goose management today are as much about people as they are about geese. In the case of snow geese, what is more acceptable in the court of opinion? Will the public be more accepting of taking more aggressive measures, including direct control, to reduce snow goose numbers or would they be more accepting of allowing more damage to arctic habitats and potentially lower sized populations of other species that depend on these habitats? In the case of Canada geese, how do we address the concerns of landowners, urban residents, and hunters? In the case of both Canada geese and snow geese, what are the implications of declining hunter numbers? All of these questions require a better understanding of the interactions between people and wildlife and the connections between social systems and ecological systems. Although many of the most pressing issues of arctic goose management are social and not ecological in nature, the management community continues to mainly rely on assumptions based on personal experience rather than scientific information. This presentation will focus on some of our current assumptions regarding the human dimensions of arctic goose management, the social science tools available to look at the connections between social and ecological systems, and potential opportunities for future research.

Top down, bottom up, and temporal dynamics of sedge communities, with consequences on greenhouse gas emissions

Joel Schmutz, USGS Alaska Science Center, 4210 University Drive, Anchorage, AK 99508, USA. E-mail: jschmutz@usgs.gov

Geese consume many herbaceous plants, but during the breeding season, most geese focus on a few plant species that have relatively high nitrogen contents. Carex species, particularly Carex subspathacea and Carex ramenkii are the most ecologically germane plants to geese in tundra areas of Alaska. Carex meadows are subject to both top down (e.g., herbivory by geese) and bottom up (e.g., sedimentation and temperature change) forces. Using a 20-year data set from 5 colonies of brant in western Alaska, we are assessing the magnitudes of these two forces. In northern Alaska, somewhat similar dynamics occur, but due to a much greater magnitude of permafrost, stronger state changes appear to be more lasting. Goose herbivory and habitat distinctions affect the magnitude of greenhouse gas emissions in these tundra ecosystems.

Wintering and Staging Ecology of Arctic Geese – Changes and New Challenges

Mark P. Vrtiska, Nebraska Game and Parks Commission, 2200 N. 33rd St, Lincoln, NE 68503, USA.
E-mail: mark.vrtiska@nebraska.gov

While arctic geese still occupy and use traditional wintering and staging areas, there have been dramatic changes in distribution of wintering and staging geese in the past 40 years. In the mid-continent portion of North America, changes have primarily occurred with geese moving from coastal regions into more interior areas. Causes behind these distribution shifts may include climate change, hunting pressure, changes in agricultural practices, urban development and other causes. These distributional changes may necessitate new joint venture habitat planning, examining harvest management considerations, and assessing human dimensions aspects. Additionally, more current information on wintering and staging is needed and provides to opportunity to examine comparisons between new wintering and staging areas. Current information of arctic geese wintering and staging ecology are necessary to better understand goose biology and ecology and inform conservation and management decisions.

Tackling challenges in movement ecology with Arctic-nesting geese: linking population and individual processes

Mitch Weegman, University of Missouri, Columbia, MO, 65211, USA. E-mail: weegmanm@missouri.edu

The field of movement ecology has expanded dramatically in recent years, due to substantial advancements in tracking technologies, processing power and statistical tools, which have enabled researchers to answer detailed questions related to animal decision-making in space and time. Such advancements are particularly useful for study of Arctic-nesting geese because the birds are difficult to observe throughout the year as they fly thousands of kilometers between breeding and wintering areas. Yet researchers often study movement ecology at the population or individual level, and not both. I will discuss advancements in movement ecology by describing how population and individual processes can inform each other, using multiple populations of greater white-fronted geese as case studies. These birds are of conservation interest for different reasons: the Greenland white-fronted goose population has declined by greater than 50% since 1999, while the North American mid-continent greater white-fronted goose population is stable or increasing. I will discuss our development of population models that incorporate movement and identify demographic mechanisms for population change in greater white-fronted geese, and inform research using tracking technologies that collect Global Positioning System and sensory (e.g., acceleration) data to quantify the contributions of individual decisions to demographic mechanisms. I also will discuss the potential to utilize this framework in other goose systems to encourage future conservation planning be based on a more complementary understanding of population and individual processes.

Abstracts – Oral Presentations

Wintering and Staging Ecology– Wednesday Morning

Arctic Geese in Arkansas: Diet Composition and Temporal Trends of Body Condition in a New Wintering Area

Ethan R. Massey,* University of Arkansas, Division of Agriculture, Arkansas Agricultural Experiment Station, Monticello, AR 71656, USA. E-mail: masseyer@uamont.edu
Douglas C. Osborne, University of Arkansas, Division of Agriculture, Arkansas Agricultural Experiment Station, Monticello, AR 71656, USA. E-mail: osborne@uamont.edu

Arctic geese, particularly greater white-fronted geese *(Anser albifrons frontalis),* lesser snow geese (*Anser caerulescens caerulescens*), and Ross's geese (*Anser rossii*) have experienced increases in abundance and geographic shifts in winter distribution over the past several decades. Due to the increases and shifts of these populations, large numbers of arctic geese now winter in new areas such as the Mississippi Alluvial Valley (MAV). The MAV, which is also an important wintering area for many other species of waterfowl, now has an increased demand on the resources available on the landscape. Increased competition among waterfowl species for food resources that are important for the maintenance of body condition and the building of endogenous nutrient stores has the potential for negative impacts such as decreases in survival and breeding propensity. The purpose of this research project was to investigate the diet and body condition of three species of arctic geese while wintering in the MAV of Arkansas. To do this, arctic geese were collected while foraging in agriculture fields, October – February, 2015-16 and 2016-17 across six counties in eastern Arkansas. Using the esophageal contents from these geese, an analysis of diet composition was done. In most cases, diet was consistent with the dominant crop type in the field geese were collected in, and shifted from predominately rice grain in early winter to more grasses later in the winter. Proximate analysis was also done to determine the size of lipid and protein stores as an index of body condition. Temporal trends in body condition demonstrate that lipid storage is important during early winter when high-energy food resources are abundant. Lipid stores showed an early increase then a slow decline as the winter progressed. On the other hand, protein stores were stable with a slight increase through the winter. The decline in stored lipids as winter progressed may be driven by numerous factors such as rice depletion, a shift in diet, physiological factors, hunting pressure, and increased energetic demands. The maintenance of body condition is a dynamic system for arctic geese, and is affected by diet to some degree. A better understanding of both diet and body condition may aid in the management of arctic geese in a relatively new wintering area and the mitigation of potential impacts on resources shared by many other species of waterfowl.

Increasing Goose Populations in the Central Valley of California and Potential Impacts to Duck Habitat Conservation

Chris A. Nicolai, U.S. Fish and Wildlife Service, Region 8 Migratory Bird Program, Reno, NV 89502, USA. E-mail: chris_nicolai@fws.gov
Mark Petrie, Ducks Unlimited, Vancouver, WA 98660, USA. E-mail: mpetrie@ducks.org
Josh Ackerman, US Geological Survey, Western Ecological Research Station, Dixon Field Station, Dixon, CA 95620, USA. E-mail: jackerman@usgs.gov
Caroline Brady California Waterfowl Association, Roseville, CA 95678, USA. E-mail: cbrady@calwaterfowl.org
Mike Casazza US Geological Survey, Western Ecological Research Station, Dixon Field Station, Dixon, CA 95620, USA. E-mail: mcasazza@usgs.gov
John Eadie University of California Davis, Department of Wildlife, Fish, and Conservation Biology, Davis, CA 95616, USA. E-mail: jmeadie@ucdavis.edu
Cliff Feldheim, California Department of Water Resources, Suisun Marsh Program, West Sacramento, CA 95691, USA. E-mail: Cliff.Feldheim@water.ca.gov
Mark P. Herzog US Geological Survey, Western Ecological Research Station, Dixon Field Station, Dixon, CA 95620, USA. E-mail: mherzog@usgs.gov
Elliott Matchett US Geological Survey, Western Ecological Research Station, Dixon Field Station, Dixon, CA 95620, USA. E-mail: ematchett@usgs.gov
Cory Overton US Geological Survey, Western Ecological Research Station, Dixon Field Station, Dixon, CA 95620, USA. E-mail: coverton@usgs.gov
Dan Skalos, California Department of Fish and Wildlife, Sacramento, CA 95814, USA. E-mail: Dan.Skalos@wildlife.ca.gov
Melanie Weaver, California Department of Fish and Wildlife, Sacramento, CA 95814, USA. E-mail: Melanie.weaver@wildlife.ca.gov
Greg Yarris U.S. Fish and Wildlife Service, Central Valley Joint Venture, Sacramento, CA 95825, USA. E-mail: greg_yarris@fws.gov

The Central Valley of California supports one of the largest concentrations of wintering waterfowl in the world despite the loss of > 90% of its historic wetlands. Approximately 5 million ducks winter in the Central Valley, including a third or more of North America's pintails. Geese in the Central Valley include lesser snow (both Wrangel Island and western arctic populations), Ross', greater white-fronted (both Pacific and tule populations), and cackling geese (including Aleutian, cackling, and Taverner's populations). Over the past decade, the goose index has increased from 1 million to 2.3 million geese in the Central Valley. Nearly all the food available to ducks in the Central Valley is provided by managed wetlands and rice fields that are flooded after harvest (winter-flooded), and recent modelling suggests that duck food resources are just adequate to meet population requirements. As a result, waterfowl managers are concerned about the impact of growing goose populations on duck food supplies, especially within winter-flooded rice. One option to offset the effect of geese on duck food supplies, is to increase the quantity and quality of managed wetlands because geese do not appear to consume food resources as much in these habitats. However, the cost of restoring wetlands in the Central Valley averages $12,000 per acre. In the future, wetland enhancement/restoration to support duck populations in the Central Valley will be partly dependent on the population sizes of geese wintering in the Central Valley. It seems unlikely that food resources in the Central Valley itself will limit goose numbers in the immediate future. Unlike ducks, geese are able to shift their diet to green forage as the food resources in rice fields become depleted. We are initiating a research program to 1) determine the likelihood that goose populations in the Central Valley will continue to increase, 2) model the impacts of geese on duck food resources, and 3) evaluate the need for additional wetland restoration. We will be marking geese with GSM-GPS devices on wintering and breeding areas to further understand distribution of specific breeding white-goose populations during the winter, their migration ecology, and use of wintering habitats. We will then use wintering habitat information to inform wintering area energetic models (TRUMET and SWAMP). We are beginning a pilot year in late winter 2018 to test 3 models of GSM devices and will expand efforts by late 2018.

Winter Movements and Habitat Use by Midcontinent Greater White-fronted Geese

Jay A. VonBank,* Caesar Kleberg Wildlife Research Institute, Texas A&M University–Kingsville, Kingsville, TX, 78363, USA. E-mail: jay.vonbank@students.tamuk.edu
Bart M. Ballard, Caesar Kleberg Wildlife Research Institute, Texas A&M University–Kingsville, Kingsville, TX, 78363, USA. E-mail: bart.ballard@tamuk.edu
Kevin J. Kraai, Texas Parks and Wildlife Department, Canyon, TX, 79015, USA. E-mail: kevin.kraai@tpwd.texas.gov
Mitch D. Weegman, University of Missouri, Columbia, MO, 65211, USA. E-mail: weegmanm@missouri.edu
Daniel P. Collins, U.S. Fish and Wildlife Service Region 2, Albuquerque, NM, 87102, USA. E-mail: dan_collins@fws.gov
Humberto L. Perotto-Baldivieso, Caesar Kleberg Wildlife Research Institute, Texas A&M University–Kingsville, Kingsville, TX, 78363, USA. E-mail: humberto.perotto@tamuk.edu

Historically, a large portion of the midcontinent population of greater white-fronted geese (*Anser albifrons frontalis*; hereafter: white-fronts) wintered in Texas. However, recent winter population surveys have suggested that white-front abundance and distribution during winter has shifted northeastward. Changes in land use, climate, and resource availability are likely drivers of the distribution shift, yet the degree to which these drivers effect the change in distribution is unknown. We captured adult white-fronts during winters 2015–2017 and attached Global Positioning System (GPS) neck collar tracking devices fitted with Global System for Mobile communication technology. We used GPS information from white-fronts (n = 37) to determine movement patterns and decipher specific habitat use and selection made by white-fronts throughout winter. Tracking devices collected 60,615 GPS locations during the winter period (25 October – 28 Feb) on white-fronts that wintered in Arkansas, Mississippi, Louisiana, Texas, and Nuevo Leon, Tamaulipas, Durango, and Jalisco, Mexico. Mean daily movement distance decreased as winter progressed ($P < 0.001$) and was not influenced by average daily minimum ($P = 0.929$) or maximum ($P = 0.719$) temperatures. During winter 2016-2017, 30.6% of tagged white-fronts (n = 37) moved among wintering regions, and 16.7% moved between the Central and Mississippi flyways. White-fronts marked before 1 December 2016 moved among regions (50.0%) and between flyways (83.3%) more frequently. Habitat use of geese changed monthly, and agricultural crops including sorghum, rice, peanuts, and winter wheat, and wetland types including palustrine emergent and scrub-shrub wetlands, were used most frequently. Understanding the drivers of movements in relation to habitat selection will aid in determining factors influencing the winter distribution shift by white-fronts, and inform future harvest management strategies between flyways and among states.

Habitat use of Sandhill Cranes and waterfowl on the North and South Platte Rivers in Nebraska

Dana M. Varner, Rainwater Basin Joint Venture, 9325 S Alda Rd, Wood River, NE 68883. E-mail: dana_varner@fws.gov
Aaron T. Pearse, U.S. Geological Survey, Northern Prairie Wildlife Research Center, 8711 37th Street Southeast, Jamestown, ND 58401. E-mail: apearse@usgs.gov
Andrew A. Bishop, Rainwater Basin Joint Venture, 2550 N. Diers Ave, Grand Island, NE 68803. E-mail: andy_bishop@fws.gov
Jonas I. Davis, Ducks Unlimited, 2525 River Rd, Bismarck, ND 58503. E-mail: jdavis@ducks.org
John C. Denton, Ducks Unlimited, 2121 N. Webb Rd, Suite 309, Grand Island, NE 68803. E-mail: jdenton@ducks.org
Roger C. Grosse, Rainwater Basin Joint Venture, 9325 S Alda Rd, Wood River, NE 68883. E-mail: roger_grosse@fws.gov
Heather M. Johnson, University of Nebraska Kearney, Department of Biology, Bruner Hall of Science 066, Kearney, NE 68849. E-mail: johnsonhm2@lopers.unk.edu
Emily J. Munter, U.S. Fish and Wildlife Service, 43655 Kalifornsky Beach Rd, Soldotna, AK 99669. E-mail: emily_munter@fws.gov
Kirk D. Schroeder, U.S. Fish and Wildlife Service, 9325 S Alda Rd, Wood River, NE 68883. E-mail: kirk_d_schroeder@fws.gov
Robert E. Spangler, Branch of Migratory Bird Surveys, U.S. Fish and Wildlife Service, 755 Parfet St, Suite 496B, Lakewood, CO 80215. E-mail: rob_spangler@fws.gov
Mark P. Vrtiska, Nebraska Game and Parks Commission, 2200 N. 33rd St, Lincoln, NE 68503. E-mail: mark.vrtiska@nebraska.gov
Angelina E. Wright, Ducks Unlimited, 2121 N. Webb Rd, Suite 309, Grand Island, NE 68803. E-mail: awright@ducks.org

Numerous studies have examined migration ecology and habitat use of spring migrating birds using the Central Platte River, yet less is known about use of the North and South Platte Rivers (NSPR) in western Nebraska. Conservation organizations generally deliver habitat programs in the region with limited information and without landscape prioritization tools. We used aerial surveys to determine population distribution and migration phenology of ducks, Canada Geese (*Branta canadensis*), and Sandhill Cranes (*Antigone canadensis*) using the NSPR during spring migration. We used these data and geospatial information to identify important river reaches for these species and habitat covariates that discriminate between those used at lower and higher densities. We found that Sandhill Cranes and waterfowl generally used different segments of the NSPR and, subsequently, different factors were associated with intensity of use. Larger concentrations of Sandhill Cranes favored wider river reaches with less unvegetated sandbar area and more wet meadow within 1 km. Use by Canada Geese and ducks was most intense in segments associated with wetland and sand pit habitats when compared with segments associated with wet meadow areas. Human disturbance variables in this rural region had little effect on identification of areas used intensively by all groups. Habitat conservation efforts that specifically target Sandhill Cranes based on our results will not have similar positive effects on Canada Goose and duck use and distribution in the NSPR. Our identification of priority core segments should allow managers to better target resources to areas that will have the greatest impact on either waterfowl or Sandhill Cranes.

Wrangel Island Snow Geese Wintering on the Fraser (BC) and Skagit River (WA) deltas: population dynamics, foraging impacts, and management via a flexible harvest strategy

W. Sean Boyd, Environment Canada, Science and Technology Branch, RR#1, 5421 Robertson Rd, Delta, BC V4K 3N2, Canada.
E-mail: sean.boyd@canada.ca

The Wrangel Island population of Snow Geese wintering on the Fraser and Skagit river deltas has grown from ca. 40K in the early 1990s to more than 100K in recent years. Relatively high recruitment is expected to continue as the Arctic warms so the potential for this sub-population to increase to an 'unmanageable' level is high, as has occurred with other N.A. white geese. The interaction between the geese and bulrush rhizomes on the Fraser delta was at a 'low-level, steady-state' throughout the 1990s, meaning that the geese were consuming rhizomes at about the same rate as they were being produced. However, once the population increased above ca. 60K, rhizome density declined to the lowest level recorded since the late 1980s. Other factors are acting in concert with goose grubbing to cause large parts of the Fraser tidal marshes to move toward a state of 'functional extinction'. This has serious implications for the estuarine food web as well as for the Snow Geese themselves. Bulrush is an important part of their diet, especially during extreme weather events when farms are frozen or snowed under for an extended period. To ensure the long-term sustainability of bulrush marshes on the Fraser delta, the number of geese over-wintering there will have to be reduced substantially. Fraser geese move to the Skagit delta for 1-2 months in mid-winter and that delta supports more hunters than the Fraser so altering hunting regulations in WA State has the highest potential to affect goose abundance and bulrush density back on the Fraser delta.

Trends in Pacific Black Brant Productivity in fall at Izembek Lagoon

David H. Ward, U.S. Geological Survey, Alaska Science Center, 4210 University Drive, Anchorage, AK 99508, USA.
E-mail:dward@usgs.gov
Courtney L. Amundson, U.S. Geological Survey, Alaska Science Center, 4210 University Drive, Anchorage, AK 99508, USA.
E-mail: camundson@usgs.gov
Robert A. Stehn, Migratory Bird Management-Region 7, U. S. Fish and Wildlife Service, Anchorage, AK 99503, USA, Retired.
E-mail: bob.stehn@gmail.com
Christian P. Dau, Migratory Bird Management-Region 7, U. S. Fish and Wildlife Service, Anchorage, AK 99503, USA, Retired.
E-mail: christianpdau@gmail.com

Accurate estimates of the age composition of populations can inform past reproductive success and future population trajectories. We examined fall age ratios of black brant (*Branta bernicla nigricans*) staging in fall at Izembek National Wildlife Refuge near the tip of the Alaska Peninsula, southwest Alaska, USA, 1963-2015. We also investigated the source of the fall brant productivity by examining stable isotope signatures of flight feathers taken from juveniles harvested at Izembek and adult and juveniles at different breeding areas. Understanding trends in age ratios and sources of the fall productivity of brant is of particular interest because of long-term declines in first-year (>-50%) and adult (-6%) survival since the mid-1980s and number of nests on the Yukon-Kuskokwim Delta (YKD), where the majority (~75%) of the brant population has traditionally bred. Nevertheless, the overall population index of brant may have increased over the same time period, suggesting there may have been an offsetting increase in productivity from non-YKD breeding areas. We found that age ratios declined 0.6% per year or a reduction of 36% since 1963. Most (80%) of the annual age ratios since 1990, the period when losses on the YKD were most severe, were below the long-term average. We also found that most of the fall brant production has originated from non-YKD rather than YKD sources since 2014. This result suggests that there appears to have been a shift in the source of the fall productivity in brant in recent years to non-YKD breeding areas, but the magnitude of the change does not appear to be large enough to offset overall declines in productivity. We discuss possible reasons for the divergence in the demographic trajectories and population indices.

Strategies and Adaptations of Wintering Geese to an Urban Environment

Michael W. Eichholz, Cooperative Wildlife Research Laboratory, Center for Ecology, Department of Zoology, Southern Illinois University, Carbondale, IL 62901, USA. E-mail: eichholz@siu.edu
Kendra Slown, Cooperative Wildlife Research Laboratory, Center for Ecology, Department of Zoology, Southern Illinois University, Carbondale, IL 62901, USA E-mail: kendra.slown@siu.edu
Brett E. Dorak, Montana Fish, Wildlife, and Parks, Malta, MT E-mail: Bret.Dorak@mt.gov
Heath M. Hagy, Waterfowl Ecologist, USFWS Region 4 Hatchie National Wildlife Refuge 6772 Highway 76 South Stanton, TN 38069. E-mail: heath_hagy@fws.gov
Michael P. Ward, Department of Natural Resources and Environment Sciences, University of Illinois at Urbana–Champaign, Urbana, Illinois, USA. E-mail: mpward@illinois.edu

The wintering distribution of Canada geese (*Branta canadensis*) has been shifting northward for several decades. At the same time, Canada goose populations in many cities in the United States and Canada have experienced dramatic increases, suggesting that geese are selecting for urbanized environments. The heavily urbanized Greater Chicago Metropolitan Area (GCMA) is terminal wintering latitude for many migratory and resident Canada geese in mild winters. Canada geese wintering in the GCMA did not make foraging flights to nearby agricultural fields as expected, foraging instead on dormant urban herbaceous vegetation. Geese in the GCMA do not experience hunting pressure and were found to use roosting areas such as deep-water habitat and rooftops, which allow for very low disturbance. This suggests geese wintering in the GCMA have developed a unique wintering strategy of acquiring large endogenous reserves prior to winter, then minimizing their activity and energy expenditure, utilizing endogenous reserves throughout winter. We tested this hypothesis by comparing body condition dynamics and behavior of Canada geese wintering in the GCMA in the winters of 2014-2016 to geese which wintered in southern Illinois (SIL) in the winters of 1984-1989 and geese wintering areas west of the GCMA in in the Fox River Valley (FRV) in 2014-2015. We predicted geese wintering in the GCMA would enter winter with greater reserves, spend more time feeding due to lower perceived predation risk, and use nutrient reserves at a faster rate due to lower forage quality relative to geese wintering in SIL or the FRV. We observed geese wintering in the GCMA enter the wintering period at greater masses relative to geese in the SIL; however, both groups declined in mass at similar rates. Although both FRV and GCMA geese spent similar time foraging, FRV geese increased in mass more rapidly in late winter and early spring than GCMA geese. This difference was likely due to differences in nutritional quality of forage between FRV and GCMA geese. GCMA geese spent a greater proportion of time foraging and lower proportion of time resting than geese in SIL, while FRV geese exhibited higher proportions of alert behavior in late winter than did geese wintering in the GCMA. These findings suggest geese in the GCMA are selecting poor quality foraging areas based on low perceived predation risk and increasing foraging behavior in order to attain their daily food requirements.

Effects of Geese on Other Species in the Arctic – Wednesday Afternoon

Wolves and lesser snow geese on Wrangel Island, Russia

Vasiliy V. Baranyuk, the Nonprofit Partnership Working Group on Waterfowl of Northern Eurasia (RGG), Moscow, Russia; the Washington Brant Foundation, 15929 Fir Island Rd, Mount Vernon, WA, 98273. E-mail: vasiliy.baranyuk@gmail.com

Historically, before Wrangel Island was settled by humans, this ecosystem was without ungulates and large predators. The main herbivores were two species of lemmings and lesser snow geese (*Anser caerulescens caerulescens)*. Since the mid-19th century, people brought reindeer and muskoxen to the island. The wolf (*Canis lupus)* was considered an undesirable element, and people shot wolves. The situation changed at the beginning of the new millennium and in the last 15 years, the wolf has become an important factor in the ecosystem of Wrangel Island. Snow geese breed in a large colony within an intermountain valley on the island. The colony area has no natural barriers and is accessible to terrestrial predators. Previously, it was believed that successful nesting of geese was possible only in simple ecosystems without large predators, and in large colonies adapted to predation by Arctic fox (*Alopex lagopus*). There is competition among arctic foxes for territories in the colony area, and most of the resident foxes are experienced goose hunters. An Arctic fox and a snow goose are comparable in weight: the average experienced gander can successfully protect the nest from the average fox. But a pair of geese usually can't protect the first egg laid during the initiation phase of the nesting if the pair encounters an Arctic fox that is an active, experienced goose hunter. Group nesting in a large colony in a limited area gives the geese a certain advantage. Without the presence of wolves, the Arctic fox has been an important factor in the formation of colony structure. Incursion of the wolf onto Wrangel Island not only dramatically reduced the number of Arctic foxes, but also destroyed their local population of active hunters. This significantly reduced the role of Arctic foxes as a selective factor for geese. The number of geese on Wrangel Island in the last 6 years increased from 150,000 to 350,000 individuals and the colony reached 118,000 nests. Large predators, such as wolves and wolverines (*Gulo gulo)*, are not deterrents to this large colony of snow geese. On the contrary, the presence of large predators dramatically reduces the role of foxes in this ecosystem, which favorably affects snow geese.

Impacts of habitat alteration by lesser snow and Ross's geese on avian communities

Dana K. Kellett,* Department of Biology, University of Saskatchewan, Saskatoon, SK, Canada S7N 5E2, Environment and Climate Change Canada, Prairie and Northern Wildlife Research Centre, Saskatoon, SK, Canada S7N 0X4.
E-mail: Dana.Kellett@Canada.ca
Ray T. Alisauskas, Department of Biology, University of Saskatchewan, Saskatoon, SK, Canada S7N 5E2, Environment and Climate Change Canada, Prairie and Northern Wildlife Research Centre, Saskatoon, SK, Canada S7N 0X4.
E-mail: Ray.Alisauskas@ec.gc.ca

Lesser snow geese (*Anser caerulescens caerulescens*) have been described as a keystone species, as these herbivores can modify species composition and biomass of plant communities over extensive scales in arctic ecosystems. Together with Ross's geese (*A. rossii*), populations of light geese have increased to unprecedented levels in recent decades, raising questions about potential impacts of known habitat alteration on arctic ecosystem components and function. Populations of specific birds, and perhaps entire avian communities, breeding in habitats altered by light geese may be impacted through a variety of mechanisms; these include changes to nesting habitats, availability of food, or altered predator-prey dynamics. We investigated occupancy of sympatrically-breeding passerines and shorebirds at Karrak Lake, a large light goose colony in the central Canadian arctic, in relation to habitat type, extent of habitat alteration, and density of nesting geese. Habitat alteration (increased prevalence of exposed peat, mineral soil, and colonizing species such as *Senecio congestus*) was evident in both upland and lowland habitats within the goose colony. In addition, after many years of use by nesting geese, lowland habitats dominated by graminoid species appeared to have converted to one dominated by birch (*Betula glandulosa*). Occupancy for all species examined was not strongly influenced by either extent of alteration (sum of exposed peat and mineral substrate, and *Senecio*) or density of nesting geese. However, some species such as snow buntings (*Plectrophenax nivalis*), horned larks (*Eremophila alpestris*), and semipalmated sandpipers (*Calidris pusilla*), in addition to showing high occupancy in predicted preferred habitats, also showed high occupancy in birch-dominated habitat; conversion of lowland habitats from graminoid-dominated to birch-dominated may be beneficial for these species. On the other hand, occupancy was highest for species such as dunlin (*Calidris alpina*), pectoral sandpiper (*Calidris melanotos*), white-rumped sandpiper (*Calidris fuscicollis*), and red and red-necked phalaropes (*Phalaropus fulicarius and P. lobatus*) in graminoid-dominated lowland habitats; such species may be more negatively impacted by wide-spread removal of graminoid vegetation by geese in both light goose nesting colonies and heavily-used brood-rearing areas.

Tundra Re-Vegetation: Location, location, location

Kathleen Schnaars-Uvino, University of Jamestown, Jamestown, ND 58405, U.S.A. E-mail: Kathleen.uvino@uj.edu
Robert Jeffries[1], University of Toronto
Robert Rockwell, AMNH, 79th Street & CPW, NY , NY 10024, U.S.A. E-mail: rfr@amnh.org

Processes initiated by destructive foraging of the Mid-continent Population of Lesser Snow Geese (*Anser caerulescens caerulescens*) have led to severe degradation of portions of both coastal and inland landscapes 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"*.

It is unknown what population size will result in a cessation of damage or the onset of recovery. It is possible, however, to begin assessing the potential for recovery in the region. Recovery of vegetation is predicated on the quality of the soil and the potential presence of a remnant seedbank 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 habitat in use by Lesser Snow Geese. We began revegetation exclosure work in 2005. Some study sites show no signs of revegetation. Revegetation in some areas is proceeding at a more rapid rate than anticipated. 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, snowmelt and herbivore faeces.

[1] Deceased

Assessing pre-emptive and apparent competition on breeding Atlantic brant

Clark Nissley,* Waterfowl and Upland Gamebird Research Program, Department of Entomology and Wildlife Ecology, 249 Townsend Hall, University of Delaware, Newark, DE 19713, USA. E-mail: can@udel.edu
Christopher K. Williams, Waterfowl and Upland Gamebird Research Program, Department of Entomology and Wildlife Ecology, 249 Townsend Hall, University of Delaware, Newark, DE 19713, USA. E-mail: *ckwillia@udel.edu*
Kenneth F. Abraham, Emeritus Research Scientist, Ontario Ministry of Natural Resources & Adjunct Professor, Trent University, Wildlife Research and Monitoring Section, 2140 East Bank Drive, DNA Building Peterborough, ON, Canada K9J 7B8. E-mail: ken.abraham@ontario.ca

Atlantic brant populations are known to fluctuate; however, productivity surveys on the wintering grounds indicate the number of young in flocks has declined in recent decades. This may be indicative of a limitation on the breeding grounds and possible competition with expanding lesser snow geese (*Chen caerulescens caerulescens*) and cackling geese (*Branta hutchinsii*). We studied the interactions occurring between brant, snow geese, and cackling geese on the coast of East Bay, Southampton Island in the summers of 2014 and 2015. We compared historical brant nesting sites to those found in 2014 and 2015 to assess potential pre-emptive competition occurring between brant and cackling geese. Increased presence of cackling geese nesting in areas previously occupied by brant has limited brant to nesting in small and less than optimal pockets. Exclusion from optimal nesting islands can lead to increased depredation by predators. In addition to this exclusion, increased populations of nesting snow geese and cackling geese at East Bay may be drawing higher densities of predators than a nesting area occupied predominantly by brant. To test these hypotheses we monitored brant nest sites in the summers of 2014 and 2015 to document availability and density of competing geese. We calculated nest fate probabilities in both 2014 and 2015 using the same set of covariates to determine under what circumstances brant nest success increases. Daily nest survival in 2014 equaled 0.828 (SE + 0.029) and in 2015 equaled 0.924 (SE + 0.012). Deeper water surrounding brant nests in both years was strongly associated with success. As water depth increased, fox depredation decreased, and daily nest success rose. Probability of fox predation appeared to decrease significantly around 20–30 cm, suggesting that this may be the limiting water depth for arctic fox access to nest islands. To measure the effects of increased predator density on breeding brant, we conducted an artificial nest experiment with three artificial nest densities: high, low, and control. The control and low-density treatments did not differ in cumulative nest survival; however, high-density treatment showed significantly lower cumulative nest survival.

Evaluating heterogeneous adult survival among subpopulations in midcontinent lesser snow geese

Drew N. Fowler,* Missouri Cooperative Fish and Wildlife Unit, School of Natural Resources, University of Missouri, Columbia, MO 65211, USA. E-mail:dnftgb@mail.missouri.edu
Josh L. Dooley, U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Vancouver, WA 98683, USA. E-mail: joshua_dooley@fws.gov
Mitch D. Weegman, School of Natural Resources, University of Missouri, Columbia, MO 65211, USA. E-mail: weegman@missouri.edu
Robert F. Rockwell, Vertebrate Zoology, American Museum of Natural History, New York, NY 10024, USA. E-mail: rfr@amnh.org
Mark P. Vrtiska, Nebraska Game and Parks Commission, Lincoln, NE 68503, USA. E-mail: mark.vrtiska@nebraska.gov
Elisabeth B. Webb, U.S. Geological Survey, Missouri Cooperative Fish and Wildlife Unit, School of Natural Resources, University of Missouri, Columbia, MO 65211, USA. E-mail: webbli@missouri.edu

Despite efforts to reduce population size of midcontinent lesser snow geese (*Chen c. caerulescens*) and Ross's geese (*Chen rossii*) through the Light Goose Conservation Order (LGCO), low adult harvest rates (< 3%) have been achieved, and adult survival rates have not declined and in some subpopulations continue to increase. Prior analyses to estimate survival rates have typically assumed homogeneity within banded cohorts of hatch and after-hatch year individuals. However, concurrent research indicated that harvested individuals exhibited poorer body condition relative to the overall population. Understanding the amount of heterogeneity among subpopulations, and accounting for this effect in survival analyses, can help to further assess the true effect of harvest and the LGCO on adult survival rates (and overall population size). Thus, we evaluated Pledger-mixture (heterogeneous) dead-recovery models (Seber parameterization) in program MARK of arctic and subarctic subpopulations of adult lesser snow geese during 1999 - 2016 to determine the extent of heterogeneous survival rates within each subpopulation. Band recovery data for subarctic adults were better supported by models accounting for heterogeneous survival compared to homogeneous survival models. In contrast, homogeneous survival models better explained patterns of survival for the larger arctic subpopulation. In general, these results suggest that it may not be appropriate to assume that all after hatch year individuals experience the same annual survival rate. Reasons for such patterns in heterogeneity among subpopulations could result from multiple factors (e.g., differences in age structure composition, body condition, environmental conditions, sampling bias, or canalization). Further, previous research has shown that harvest among the subarctic subpopulation has had more of an additive effect compared to the arctic subpopulation. However, the LGCO harvest may remove subarctic individuals of lower fitness, perhaps disproportionately so, which may reduce the overall population-level effect from this source of mortality. Future research focused on partitioning survival estimates within the after-hatch year class could better account for age or intrinsic quality and may more robustly evaluate the contributions of these individuals to harvest and potential population reduction.

Updated insights into hunting and other sources of mortality for a southern breeding population of midcontinent lesser snow geese

David N. Koons, Department of Fish, Wildlife, and Conservation Biology, Colorado State University, Fort Collins, Colorado 80523. E-mail: david.koons@colostate.edu
Lise M. Aubry, Department of Fish, Wildlife, and Conservation Biology, Colorado State University, Fort Collins, Colorado 80523. E-mail: lise.aubry@colostate.edu
Robert F. Rockwell, Division of Vertebrate Zoology, American Museum of Natural History, New York, NY 10024. E-mail: rfr@amnh.org

The abundance of midcontinent lesser snow geese (*Anser caerulescens caerulescens*) continues to grow to unprecedented levels. In areas heavily used for both breeding and spring migration, the evidence is strong that their over-abundance and destructive impact of foraging has caused a trophic cascade. Out of concern that these problems could spread and degrade biodiversity across large spatial scales, managers seek to reduce the abundance of midcontinent snow geese. The current management approaches for achieving these goals are liberalized harvest regulations during regular hunting seasons and the Spring Conservation Order (SCO). Comparisons across breeding populations indicate that snow geese from southern breeding locales have experienced higher harvest rates than those from northern breeding grounds, where annual adult survival now exceeds 90%. Northern breeding populations seem to migrate later in the fall relative to southern populations, which may offer northern birds some protection from hunting. If so, the impacts of harvest management should be most evident in southern populations.

In 2014, we published a paper on the southern population that breeds along the Cape Churchill Peninsula (inclusive of LaPérouse Bay), which focused on long-term temporal variation in cause-specific mortality (retrieved hunting mortality vs. other sources) between 1969 and 2010. Despite additive impacts of harvest on overall mortality in AHY birds and HY birds since 1989, retrieved hunting mortality increased for only a few years following implementation of the SCO but then declined below the long-term average. We concluded that snow geese had become so numerous that they swamped out the ability of goose hunters to have any meaningful impact on harvest rates, and thus population growth rates.

The presiding management practices have since continued, and a key element of adaptive harvest management is monitoring. Here, we present preliminary results from an update to our 2014 paper using refined statistical methods and data through 2017. Our goal is to learn whether or not our reported low rates of retrieved hunting mortality after implementation of the SCO were a stochastic artifact and have since increased to desired levels, or whether evidence has strengthened for the inability of current harvest management to achieve objectives.

Population Growth, Harvest and Survival of Overabundant Western Arctic Lesser Snow Geese, 1998-2017

Eric T. Reed, Canadian Wildlife Service, Environment and Climate Change Canada, Yellowknife, NT, Canada. E-mail: eric.reed@canada.ca
Cindy Wood, Canadian Wildlife Service, Environment and Climate Change Canada, Yellowknife, NT, Canada. E-mail: cindy.wood@canada.ca
Myra W. Robertson, Canadian Wildlife Service, Environment and Climate Change Canada, Yellowknife, NT, Canada. E-mail: myra.robertson@canada.ca

The Western Arctic population of lesser snow geese (*Anser caerulescens caerulescens*) has been increasing since the mid 1970's. However, there is some uncertainty as to the current trajectory of the population as photo-surveys of the main nesting colonies in Canada suggest a stable or declining trend since 2002 whereas Lincoln population estimates derived from banding recovery data suggest an increase over the same time period. Nevertheless concerns over the impact of this population on migratory birds and their habitats led to its designation as overabundant in Canada in 2015. The population has not been designated as overabundant in the U.S. at this time. The overabundant designation led to implementation of Special Conservation Measures in Canada, including a spring conservation harvest, in Alberta and the Northwest Territories in spring 2015 (i.e. 2014-15 hunting season) and in the Yukon in spring 2016. Concurrently a banding program aimed towards adult lesser snow geese was re-established on Banks Island in 2015, complementing a mark-recapture and recovery study conducted between 1998 and 2007. Survival and recovery rates were estimated using band recovery models and we compared population growth before and after the implementation of Special Conservation Measures using reverse-time mark-recapture (Pradel) models. Recovery rates were generally low (average: 0.021, 95%CI [0.020 – 0.023]) but were higher in 2 out of the three years where they could be measured during Special Conservation Measures (0.038 [0.029 – 0.050] in 2014-15 and 0.0460 [0.037 – 0.056] in 2015-16). Survival was high for both females (0.85, 95%CI [0.84 – 0.87]) and males (0.87 [0.85 – 0.88]). There was uncertainty as to whether survival differed in years where Special Conservation Measures were in place (sum AICc weight for models including an effect of Special Measures on survival: 0.50). Reverse-time mark-recapture models indicated that the growth rate of the population (λ) between 1998 and 2017 was approximately 1.05 and there was no indication that growth rate had changed since 2014. These results will be discussed in relation to the population's overabundance status and recent efforts to reduce population growth.

Carryover and Cross-Seasonal Effects– Thursday Morning

Pre-breeding protein reserves of lesser snow geese staging in the sub-Arctic

Frank B. Baldwin, Manitoba Wildlife and Fisheries Branch, Box 24, 200 Saulteaux Crescent, Winnipeg, MB, Canada R3J 3W3. E-mail: Frank.Baldwin@gov.mb.ca
Vanessa Harriman, Manitoba Wildlife and Fisheries Branch, Box 24, 200 Saulteaux Crescent, Winnipeg, MB, Canada R3J 3W3. E-mail: Vanessa.Harriman@gov.mb.ca
James O. Leafloor, Canadian Wildlife Service, 150 - 123 Main Street, Winnipeg, Manitoba, Canada R3C 4W2. E-mail: Jim.Leafloor@canada.ca

The size and rapid growth of the mid-continent lesser snow goose (*Anser caerulescens*) population has caused changes in arctic ecosystems, including loss of preferred forage species in coastal salt-marshes of Hudson Bay. Historically, lesser snow geese relied on coastal marshes to replenish reserves expended during spring migration, and to acquire reserves necessary for gonadal recrudescence and metabolic demands during incubation. We hypothesized that lesser snow geese staging along Hudson Bay would have smaller protein reserves, and reduced ability to acquire reserves while staging, when compared to the 1970s, before major population increases and concomitant habitat alteration occurred. We sampled adult lesser snow geese throughout their two week spring staging period in the Hudson Bay Lowlands near Churchill, Manitoba from 2012-2017 and estimated protein reserves of individuals. We investigated the influence of scaled collection date (reflecting the relative position within staging period each year), sex, and gonad weight on size-adjusted protein reserves. Consistent with our predictions, protein reserves of lesser snow geese did not increase during the two week staging period, and were 14-20% smaller than those observed in the 1970s at west Hudson Bay and James Bay. The deficiency in protein reserves in females represents the equivalent of the protein found in almost three eggs. There is increasing evidence that insufficient protein reserves can influence gosling production in this population, and reduced per capita food availability in sub-Arctic staging areas could be a factor capable of driving density dependence at a large scale.

How small herbivores (like goslings) try to get what they need: a comparative view

Scott R. McWilliams, Wildlife Ecology & Physiology Group, Department of Natural Resources Science, University of Rhode Island, Kingston, RI 02881, USA. E-mail: srmcwilliams@uri.edu
Samantha Richman, Wildlife Ecology & Physiology Group, Department of Natural Resources Science, University of Rhode Island, Kingston, RI 02881, USA. E-mail: cruciger7@gmail.com
James O. Leafloor, Environment Canada, Canadian Wildlife Service, 123 Main Street, Suite 150, Winnipeg, MB R3C 4W2, Canada. E-mail: Jim.Leafloor@ec.gc.ca
William H. Karasov, Department of Forest and Wildlife Ecology, 226 Russell Laboratories, University of Wisconsin, Madison, WI 53706, USA. E-mail: wkarasov@wisc.edu

Goslings that grow up in high-latitudes have it tough. They must grow relatively quickly while eating primarily leaves that, even when carefully selected, contain relatively low protein and high fiber compared to what most other growing birds consume. We conducted a common-garden experiment in which we raised Canada and Lesser Snow Goose goslings from Akimiski Island, Canada, on grass-based diets that differed in protein (10, 14, or 18%) and fiber (30 or 45%). Canada goose goslings fed low protein (10%) diets were on average 44% lighter in body mass, had slower growth rates, and were delayed >20 days in reaching 90% of asymptotic size compared to Canada goose goslings fed 18% protein. In contrast, snow goose goslings were unable to survive on the low protein diets, and those fed high or medium protein diets grew at a similar rate and achieved similar asymptotic size. Free-ranging Canada goslings on Akimiski Island were similar in mass and structural size to captive-reared goslings fed low protein diets. In contrast, snow goslings were similar in mass and structural size to the captive-reared goslings fed the high and medium protein diets. These differences in growth and survival between species in response to forage quality are the result of differences between species in protein requirements and phenotypic flexibility, and digestive constraints associated with being small herbivores. The ecological implications of these physiological constraints include degraded habitats with mostly low protein forage may be able to support Canada goslings better than snow goslings which require higher quality forage to survive.

Carry over effects and seasonal sympatry with ecologically similar species drives survival of an uncommon goose

Joel A. Schmutz, USGS Alaska Science Center, 4210 University Drive, Anchorage, AK 99508. E-mail: jschmutz@usgs.gov
Brian D. Uher-Koch, USGS Alaska Science Center, 4210 University Drive, Anchorage, AK 99508. E-mail: bhure-koch@usgs.gov
Sarah E. McCloskey, Adkins Consulting Inc., Durango, CO 81301. E-mail: mcclostkeys@gmail.com
Daniel J. Rizzolo, U.S. Fish and Wildlife Service, Fairbanks, AK, 99701. E-mail: Daniel_rizzolo@fws.gov
Raymond M. Buchheit, Department of Ecology, Montana State University, P.O. Box 173460, Bozeman, MT 59717. E-mail: rmbuchheit@gmail.com
Patrick R. Lemons, U.S. Fish and Wildlife Service, 1011 East Tudor Road, Anchorage, AK 99503. E-mail: Patrick_lemons@fws.gov
Liliana C. Naves, Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, AK 99518. E-mail: Liliana.naves@alaska.gov
Julian B. Fischer, U.S. Fish and Wildlife Service, 1011 East Tudor Road, Anchorage, AK 99503. E-mail: Julian_fischer@fws.gov

Many migratory animals co-occur with one complex of species during breeding seasons, but are allopatric from many of those species during other seasons of the year. Carry over effects occur when ecological circumstances in one season affect the species' ecology in a subsequent season. The combination of seasonal sympatry and carry over effects, particularly when perturbed by anthropogenic inputs, can alter species interactions and population dynamics.

The Yukon-Kuskokwim Delta (YKD) in remote western Alaska, a relatively unperturbed ecosystem, annually hosts large populations of breeding geese of four species nesting in close proximity. The least abundant species, the emperor goose (*Chen canagica*), spends its entire life cycle in natural habitats in remote regions of Alaska, migrating to the Aleutian Islands during winter. The most abundant species, the greater white-fronted goose (*Anser albifrons*), migrates principally to wetlands in California that are dominated by rice agriculture.

The expansion of rice agriculture starting in about 1990 facilitated rapid population growth of greater white-fronted geese. Whereas the ratio of nesting greater white-fronted geese to emperor geese on the YKD in 1990 was 1.22, it was 7.19 in 2016. Using a 22-year mark-resight data set on emperor geese, we found the best fitting model of annual survival of emperor geese exhibited a gradually increasing rate of survival and included the covariate of annual abundance of greater white-fronted geese. This result suggests that hunting effort and harvest at the YKD may be shifting towards the most abundant goose, and thereby facilitating an increase in survival of the comparatively rare emperor goose.

These patterns connote that dynamics of one species can be impacted by ecosystem processes completely foreign to it via carry over effects of an ecologically similar species that is sympatric only seasonally. For migratory animals, these types of seasonal dynamics are likely quite common, particularly due to human modification of landscapes.

Confirming annual reproductive success as the demographic determinant of contrasting population growth rates in Greenland White-fronted Geese over more than 35 years

Anthony D. Fox, Thorsten J.S. Balsby, Department of Bioscience, Aarhus University, Kalø, Grenåvej 14, DK-8410 Rønde, Denmark. E-mail: tfo@bios.au.dk; thba@bios.au.dk
Alyn Walsh, National Parks and Wildlife Service, Department of the Arts, Heritage and the Gaeltacht, Wexford Wildfowl Reserve, North Slob, Wexford, Ireland. E-mail: alynwalsh@eircom.net
Ian S. Francis, Royal Society for the Protection of Birds, 10 Albyn Terrace, Aberdeen AB10 1YP, UK. E-mail: ian@farmland.plus.com
David Norriss, 1, Springmount Cottage, Glenard Avenue, Bray, County Wicklow, Ireland. E-mail: dwnorriss@gmail.com
David A. Stroud, Greenland White-fronted Goose Study, Spring Meadows, Taylors Green, Warminster, Peterborough, PE8 6TG, UK. E-mail: David.Stroud@jncc.gov.uk
H. John Wilson, Seapoint House, Seapoint Road, Bray, Co. Wicklow, Ireland. E-mail: h.john.wilson@gmail.com

Most northern hemisphere goose populations have increased dramatically in the last 20-30 years, linked to shifts from traditional wetland wintering habitats to agricultural landscapes. A notable exception to this pattern has been the Greenland White-fronted Goose *Anser albifrons flavirostris*, breeding in west Greenland and wintering in Ireland and Britain. After increasing at *c*.6% per annum from a global population of 16,500 to 35,600 between 1983 and 1999, numbers declined at *c*.3% per annum to 18,800 in spring 2016, despite increasingly exploiting farmland to feed and forsaking traditional oceanic patterned mires in winter. We exploited the high levels of within- and between-year winter site fidelity in this population to assess changes in wintering site annual abundance and distribution, based on winter age ratios and counts at all 66 known regularly used winter resorts during 1983-2017. Capture-mark-recapture studies carried out at the single most important wintering site (Wexford in SE Ireland) during 1982/3 to 2009/10 showed no significant change in long-term first winter and adult survival to explain this pattern, but we lack such data from elsewhere. We test the hypothesis that observed declines in annual reproductive success during the late 1990s/early 2000s (which correlated with heavy spring snowfall on the breeding grounds) were responsible for the ultimate reduction in increase in the late 1990s and the subsequent decline to current population levels. We used a generalised linear modelling approach to show that differences in abundance between year t and t+1 could be explained by local reproductive success in the intervening summer at the global, regional and site levels. We also use annual reproductive success to estimate the degree of annual site-specific loss between consecutive winters, *i.e.* the composite of emigration/immigration flux and mortality allowing for observed reproductive success at each site in each year. Using the same modelling approach, we show that the average impact of reproductive success was 26.7 times greater than this loss parameter in explaining annual changes in abundance between year t and t+1. Finally, we demonstrate a lack of statistically significant differences in annual loss between the period of population growth and that of subsequent decline amongst the top ten numerically most important wintering resorts for the population (supporting *c*.80% of this population). Based on these results, we conclude that the reductions in reproductive success since the mid-1995 have made the major contribution to the decline of the Greenland White-fronted Goose over the last 20 years.

Projecting the population dynamic of greater snow geese into an uncertain future: the interplay between management actions and climate change

Gilles Gauthier, Département de Biologie & Centre d'études Nordiques, Université Laval, 1045 Avenue de la Médecine, Québec, QC G1V 0A6, Canada. E-mail: gilles.gauthier@bio.ulaval.ca
Josée Lefebvre, Canadian Wildlife Service – Quebec region, Environment and Climate Change Canada, 801-1550 Avenue d'Estimauville, Québec, QC G1J 0C3, Canada. E-mail: josee.lefebvre@canada.ca

The greater snow goose (*Anser caerulescens atlantica*) population increased exponentially during the last 2 decades of the 20th century and reached almost 1 million birds in 1999. Like other white goose population in North America, it was declared overabundant and special conservation actions were implemented to stop its growth. These actions included a spring conservation harvest in southern Quebec since 1999 and a Conservation Order in the Atlantic Flyway states since 2009. The greater snow goose population breeds in the Canadian High Arctic, a region that has been warming rapidly in recent decades. In this presentation, I will show 1) changes in population size and seasonal harvest rate since implementation of the special management actions, 2) the effect of temperature on various demographic components throughout the annual cycle and 3) future population increase based on a population model combining climate–demographic trait relationships, climate warming scenarios and management actions. Since implementation of the special management actions, the greater snow goose population has been relatively stable between 800,000 and 1,000,000 individuals. Increase in harvest rate and a reduction in fecundity due to the spring harvest in Quebec and, more recently, an increase in harvest during the Conservation Order in the US have been responsible for this stability. However, the relative contribution of these management actions in limiting population growth changed over time. Data from the long-term banding program of this population on Bylot Island, NU, allowed us to quantify how temperature during the breeding season, migration and winter affected first-year survival, recruitment probability, breeding propensity and clutch size. Our stochastic population model, which incorporated these relationships, predicted a modest population increase (1%/yr) for the next 40 yrs under various climate warming scenarios and with the current management actions. However, uncertainty around this prediction was very large once all sources of errors were taken into consideration (i.e. structural uncertainty in climate scenarios and in the demographic model, climatic stochasticity, environmental stochasticity unexplained by climate-demographic trait relationships, and sampling variance in demographic parameter estimates). Nonetheless, these results suggest that maintaining the greater snow goose population below 800,000 in the future will remain a challenge for managers in a climate warming context.

Climatic oscillations drive selection in a long-lived specialist herbivore

Thomas V. Riecke,* Program in Ecology, Evolution, and Conservation Biology, Department of Natural Resources and Environmental Science, University of Nevada, Reno, NV, USA 89557. E-mail: triecke@cabnr.unr.edu
Alan G. Leach, Program in Ecology, Evolution, and Conservation Biology, Department of Natural Resources and Environmental Science, University of Nevada, Reno, NV, USA 89557. E-mail: aglcfr@gmail.com
James S. Sedinger, Department of Natural Resources and Environmental Science, University of Nevada, Reno, NV, USA 89557. E-mail: jsedinger@cabnr.unr.edu

Body size in black brant is heritable, where larger females are more fecund, their offspring survive and reproduce at greater rates, and previous research has failed to find demographic costs of increased size. Conversely, body size of adult female brant breeding at Tutakoke has declined since the project's inception. We attribute this to two primary mechanisms. First, reduced forage availability has affected gosling development, which can have long-term impacts on first-year survival, adult body size, and adult fecundity. Second, brant are specialist herbivores on *Zostera marina* (eelgrass) during the non-breeding season (September-April), where eelgrass beds in American Pacific estuaries have putatively been negatively affected by anthropogenic habitat alteration, climate change, and increased frequency and intensity of ENSO events, leading to long-term declines in brant survival rates. We hypothesize that the loss and degradation of non-breeding habitat may have altered selection pressures on adult female brant, potentially affecting trajectories of brant populations. Long-term demographic research at the Tutakoke River Brant Colony on the Yukon-Kuskokwim River Delta, Alaska began in 1984. Since that time, over 48,000 brant have been uniquely marked with stainless steel USGS rings and plastic tarsal rings. Apparent survival probability (φ) has declined substantially since the project's inception (β_{Time} = -0.1, f = 0.99). Prior to 1990, apparent survival rates were greater for larger adults regardless of ENSO events (β_{Size} = 0.08, f = 0.98). Since 2010, survival rates have been greater for smaller adults ($\beta_{Size:Time}$ = -0.02, f = 0.9), and these effects are more pronounced during climatic anomalies (Figure 6). In addition, the effects of climatic anomalies on breeding probability (γ) are now much more pronounced ($\beta_{ENSO:Time}$ = -0.35, f = 1; $\beta_{ENSO^2:Time}$ = -0.44, f = 1; Figure 6), where major El Niño events dramatically reduce breeding probability. Additionally, available data indicate that smaller individuals are now more likely to breed than larger individuals (β_{Size} = -0.05, f = 0.9; $\beta_{Size:Time}$ = -0.03, f = 0.85; Figure 6) during typical years and La Niña events.

Blood parasite prevalence in sympatrically nesting emperor and cackling geese on the YKD with confirmation of transmission occurring on the breeding grounds

Raymond M. Buchheit*, Department of Ecology, Montana State University, P.O. Box 173460, Bozeman, MT 59717.
E-mail: rmbuchheit@gmail.com
Joel A. Schmutz, USGS Alaska Science Center, 4210 University Drive, Anchorage, AK 99508.
E-mail: jschmutz@usgs.gov

Exposure to haemosporidian parasites can have significant population consequences for avian populations. Changes in climate conditions may cause range shifts for the vectors responsible for transmission of these parasites. Previous research suggested that emperor geese (*Anser canigicus*) may have experienced an increase in infection rates from *Leucocytozoon* blood parasites between the 1990's (<1%) and 2010's (>20%). However, different detection methods were used between these time periods – microscopy in the 1990's, and genetic PCR analysis more recently. We applied consistent genetic methods across study periods to stored blood samples collected in 1998 and 2014 to assess whether this apparent increase in prevalence was a result of methodology, or perhaps a true change in the rate emperor geese are infected with *Leucocytozoon* parasites. Results were similar between the two periods, suggesting relatively long-term exposure to blood parasites.

In 2014, we collected blood samples from adult and gosling emperor and cackling geese (*Branta canadensis minima*) to contrast infection rates relative to species and age. Only three cackling geese (1 gosling, 2 adults) tested positive for *Leucocytozoon* out of 110 individuals sampled (~2.7%), as opposed to 15 emperor geese (6 goslings, 9 adults) of 97 samples (~15.5%), suggesting a higher infection rate for emperor geese. Interestingly, in 2011 a flock of 111 non-breeding cackling geese were sampled near our study site and none were infected. One hypothesis for the lack of any blood parasite infections in that flock is that geese unencumbered by the rigors of breeding may have better ability to ward off infections.

The presence of blood parasites in goslings of both species confirms that transmission is taking place on the breeding grounds, which was previously not established. In addition, we documented the first *Plasmodium* infection in emperor geese, which is notable because *Plasmodium* parasites typically incur more virulent infections in birds than the more common *Leucocytozoon* parasites. As temperatures in the Arctic increase, we expect to observe an increase in rates of blood parasite infections, which may affect the demography of goose populations.

Movement and Spatial Ecology – Thursday Afternoon

Survival and movement among breeding areas of the midcontinent snow goose metapopulation in Canada's central and eastern arctic

Ray T. Alisauskas, Department of Biology, University of Saskatchewan, Saskatoon, SK, Canada S7N 5E2, Wildlife Research Division, Environment *and* Climate Change Canada, Prairie and Northern Wildlife Research Centre, 115 Perimeter Rd., Saskatoon, SK, Canada S7N 0X4. E-mail: Ray.Alisauskas@canada.ca

Anna M. Calvert, 4560 ave Mayfair, Montreal QC, H4B 2E5. E-mail: Anna.Calvert@Dal.ca

James O. Leafloor, Canadian Wildlife Service, Environment and Climate Change Canada, Suite 150, 123 Main Street, Winnipeg, Manitoba, Canada R3C 4W2. E-mail: Jim.Leafloor@canada.ca

Robert F. Rockwell, Vertebrate Zoology, American Museum of Natural History, Central Park West at 79th St., New York, NY 10024 USA. E-mail: rfr@amnh.org

Ken Abraham, Ontario Ministry of Natural Resources, DNA Building 2140 East Bank Drive, Peterborough, ON, K9J 7B8, Canada. E-mail: ken.abraham@ontario.ca

Rod Brook, Wildlife Research & Development Section, Ministry of Natural Resources, DNA Building, 2140 East Bank Drive, Peterborough, ON, K9J 7B8, Canada. E-mail: rod.brook@ontario.ca

Kiel L. Drake, Bird Studies Canada, 115 Perimeter Rd., Saskatoon, SK, Canada S7N 0X4. E-mail: kdrake@bsc-eoc.org

Dana K. Kellett, Department of Biology, University of Saskatchewan, Saskatoon, SK, Canada S7N 5E2, Environment *and* Climate Change Canada, Prairie and Northern Wildlife Research Centre, 115 Perimeter Rd., Saskatoon, SK, Canada S7N 0X4. E-mail: Dana.Kellett@canada.ca.

We used a joint multi-state dead recovery mark recapture model (Barker et al. 2005) to estimate, for each k state, annual probabilities of (i) survival, (ii) capture, (iii) movement between pairs of 5 breeding areas, and (iv) reported mortality or Seber's r. We used a global model without annual variation in any latent parameters, focusing on region, age and sex differences only. Our data included 144,754 snow geese that were marked only with metal legbands from 2006 to 2015 and were captured/recaptured from 5 regions in central and eastern arctic and subarctic Canada including Queen Maud Gulf (QMG, n=33,177), Baffin Island (BAF, n=20,343), Southampton Island (SOU, n=21,565), La Pérouse Bay (LPB n=50,137), and Cape Henrietta Maria or Akimiski Island (JAM, n=19,497). The total number of males and females banded was nearly equal for both adults (AM: 50,199; AF: 50,891) and juveniles (JM: 21,244; JF: 22,385), but virtually no young birds were banded on Southampton Island, because nonbreeders were targeted with earlier banding there. Of these marked birds, 5,542 individuals were recaptured and 9,709 were recovered during the study. Very few marked birds were recaptured at BAF (48 across all age/sex classes) and most were from LPB (3,401 total). The best model was one where survival varied by region and age, with additive effects of age and sex on movement probability between each pair of regions. Annual AHY survival was 0.90, 0.92, 0.89, 0.88, and 0.79 for QMG, BAF, SOU, LPB and JAM, and 0,27, 0.16, NA, 0.28, and 0.47 for HY geese, respectively. Derived estimates of harvest rate were all ≤ 0.03 for AHY and ≤ 0.06 for HY geese. Males were more likely to switch breeding areas than females and juvenile birds were more likely to move than adults. There was a large asymmetric probability of eastward movement toward BAF from all other sites over the decade. This was consistent with a general eastward shift in recovery distribution of birds marked in every region.

The influence of local recruitment and immigration on increasing population trends of two Arctic-breeding goose species

Vijay P. Patil, U.S. Geological Survey, Alaska Science Center, Anchorage, AK, USA 99508.E-mail: vpatil@usgs.gov
Jerry W. Hupp, U.S. Geological Survey, Alaska Science Center, Anchorage, AK, USA 99508. E-mail: jhupp@usgs.gov
David H. Ward, U.S. Geological Survey, Alaska Science Center, Anchorage, AK, USA 99508. E-mail: dward@usgs.gov
Tim Obritschkewitsch, ABR, Inc. —Environmental Research & Services, Fairbanks, AK, USA 99708.
E-mail: timo@abrinc.com

Snow goose populations on the Arctic Coastal Plain of Alaska have increased rapidly in recent years. This increase has led to the establishment of new breeding populations, including nesting colonies on the Colville River Delta (CRD), which is a historically important breeding area for Black Brant. Expanding Snow Goose populations on the CRD and across the Arctic Coastal Plain could negatively affect Black Brant through competition and habitat degradation, as has occurred in the Canadian Arctic. To better understand the demographic drivers of Snow Goose and Black Brant population dynamics on the CRD, we estimated population growth rates and associated demographic parameters (survival, age-specific breeding probability, fecundity, and immigration rate) for both species using Bayesian Integrated Population Models. This approach allowed us to combine information from aerial surveys, nest monitoring, and mark-recapture studies, all conducted from 2011 through 2017. Although Snow Geese were rarely observed on the CRD prior to 2003, aerial surveys during the brood-rearing period in 2017 detected nearly 20,000 Snow Geese on the Delta, compared to fewer than 6,000 Black Brant. Since 2011, Black Brant on the CRD increased rapidly (18% year^{-1}), but the average rate of increase in the Snow Goose population was twice as fast (36% year^{-1}). High gosling growth rates for both species indicate that local brood-rearing habitat can currently support continued population growth. The rapid increase in Snow Geese was associated with high average fecundity (0.74 goslings at fledging per nesting female) and first-year apparent survival after fledging (0.44) relative to Black Brant (average fecundity = 0.52, average first-year apparent survival = 0.22). First-year survival for Black Brant has declined steadily over the last decade throughout Alaska. On average, the immigration rate for Snow Geese (0.5) was higher than for Black Brant (0.32). These results suggest that Black Brant may be less resilient than Snow Geese to future reductions in local recruitment, which could occur as a result of habitat degradation, competition for nesting areas, or environmental variability. Moreover, as long as Alaskan Snow Goose populations are sustained by immigration, local management interventions may have limited effectiveness unless they are maintained over time. Future work will quantify the sensitivity of population growth to environmental variation and population density of both species, and will investigate connectivity between the CRD and other Snow Goose populations.

Evaluating Spatiotemporal changes in Wintering Harvest Distribution of Midcontinent White-Fronted Geese

Callie B. Moore,* University of Arkansas, Division of Agriculture, Arkansas Agricultural Experiment Station, Monticello, AR 71656, USA. E-mail: moorecb@uamont.edu
Douglas C. Osborne, University of Arkansas, Division of Agriculture, Arkansas Agricultural Experiment Station, Monticello, AR 71656, USA. E-mail: osborne@uamont.edu

Since the mid-1900s large scale land use changes, specifically loss of habitats and an increase in agriculture production, have occurred within the mid-continent states and provinces of North America. Subsequently, bird populations, particularly waterfowl have been forced to adapt. The shift of snow goose (*Anser caerulescens*) populations from historical wintering areas in salt marshes along the Gulf Coast to irrigated rice fields and other agricultural crops in more northern latitudes is well documented. Conversely, ecological response of other goose populations, including greater white-fronted geese (*Anser albifrons*) is not. Our goal was to quantify and define temporal changes in distribution of white-fronts within the Central and Mississippi Flyways during winter. We used recovery records (n = 11,814) obtained from the U.S. Geological Survey's Bird Banding Laboratory to calculate a utilization distribution (UD) for each hunting season from 1974 to 2016 (n = 42) using the adehabitatHR package in program R. The extent of inter-seasonal overlap between UDs was estimated using the Bhattacharyya's affinity (BA). Based on pair-wise comparisons of seasonal distributions, we classified three time eras: historic, transient and present. We merged recoveries from all seasons in each era to create 95% and 50% UDs for each era and calculated BA overlap for each pair-wise comparison. We conducted a randomization analysis in program R to assess our classification procedure for grouping years by testing whether years within eras were statistically valid. We found significant spatial separation between both the 95% and 50% UDs for all era comparisons (P = <0.001). All null distributions produced an overlap value > the observed overlap, indicating that each era was significantly different. We used ArcGIS 10.3.1 (ESRI) to calculate the median center of band recovery locations for each season and measured the distance between centers to describe the magnitude and direction of shifts. This revealed that the central tendency of our recoveries followed a northeasterly path from coastal Texas into the Mississippi Alluvial Valley over the past four decades. Our results suggest, like snow geese, mid-continent white-fronts have altered their spatial use during winter in response to habitat loss in historical wintering areas, which makes them increasingly reliant on inland agricultural habitats. This knowledge will have implications on management of waterfowl foraging resources on the wintering grounds, may prompt changes in modeling winter waterfowl energetics, and help to accurately account for competition with ducks.

Migration Chronology, stopover duration, and winter distribution of Midcontinent White-Fronted Geese

Douglas C. Osborne, University of Arkansas, Arkansas Agricultural Experiment Station, Monticello, AR 71656, USA. E-mail: osborne@uamont.edu
Ryan J. Askren, University of Illinois, Urbana-Champaign, IL 61801, USA. E-mail: raskren2@illinois.edu

Midcontinent white-fronted geese (*Anser albifrons*) stage in large numbers in Prairie Canada during fall migration to obtain energetics needed to reach the wintering grounds. Since 1990, an annual survey, the fall aerial inventory has been conducted in the region to count the number of white-fronts. Our study aimed to assess migration chronology and proportion of the population counted by the inventory. We deployed satellite transmitters on nonbreeding and failed nesting white-fronts (n = 10) in the Nunavut, Canada during 2014 and on nesting female white-fronts on the North Slope of Alaska during 2014 (n = 4) and 2015 (n = 11). Mean departure date from molting areas in the Canadian Arctic (3 September ± 1.8 days) was 7.9 days earlier than Alaska white-fronts (12 September ± 1.9 days). Mean arrival date of Nunavut white-fronts to the fall staging area (7 September ± 0.6 days) was on average 11 days earlier than Alaska white-fronts (18 September ± 2.5 days). During 2014, 100% of white-fronts marked in the Nunavut were located within the survey area during the survey period, whereas only 50.0% (2014) and 77.8% (2015) of white-fronts from Alaska occurred in the survey area during the survey period, respectfully. Trends of count data from fall inventory guide regulatory frameworks and harvest management strategies in the Central and Mississippi Flyways, however our data suggest the fall inventory may be missing a large portion of breeding adult and hatch-year white-fronts from the North Slope of Alaska. We suggest evaluating the fall inventory sampling design to include a framework that would allow for statistical estimation of population abundance, inclusion of a second survey period to capture late migrating white-fronts including the primary breeding stock, or consider alternative approaches to informing harvest management strategies.

Shifts in light goose distribution and peak abundance within the Rainwater Basin during spring migration

Jeff Drahota, Biologist, Rainwater Basin Wetland Management District, U.S. Fish and Wildlife Service, Funk, NE 68847, USA. E-mail: jeff_drahota@fws.gov

Light goose (including Ross' and lesser snow geese) use of the Rainwater Basin (RWB) region in south-central Nebraska, USA, has increased dramatically over time. Early aerial surveys conducted by the U.S. Fish and Wildlife Service (FWS) indicated a total of 50 light geese were documented across the entire RWB area in 1964. A sudden increase in 1975 was noted when a total of 110,000 light geese were observed with no significant differences noted until 1983 when 210,000 were observed. Yet in 1984 a 213% increase was documented, indicating the first significant shift in spring migration by mid-continent light geese. In 1986, total light goose numbers throughout the spring migration bulged to just over 1 million were using the RWB as spring stop-over habitat, and by 1987 more than 50% of the peak goose abundance (1 day peak) was comprised of light geese. After 1989, light goose continued to dominate the spring goose use to the extent that the aerial spring greater white-fronted goose survey was terminated in 1993 due to bird-strike concerns associated with burgeoning light goose abundance within the RWB area. Light goose abundance continued to increase, and by 1999 they were 7 times more abundant than dark geese.

Since 2000, survey designs changed to include a more systematic aerial and ground coverage. Aerial surveys focused on evaluating habitat conditions and peak migration (+/- 3 days) and covered 95% of the entire RWB area and the surrounding lakes and rivers to provide a total population, and flock locations were mapped to facilitate spatial distribution evaluations. Ground survey efforts focused on RWB wetlands that were ponding or that frequently did pond water prior to spring migration incorporating a moving window screening process affording a mean sample size of 36.3 wetlands each spring representing a total of78% of the 10 km^2 plots that are distributed across the RWB area. Survey information provided an arrival data and a weekly mean abundance estimates for all waterfowl. Between 2000-2014, mean first arrival date was 16 February (range 1 February – 7 March). Mean peak abundance in south-central Nebraska was 1.57 million and occurred 6 March (range 20 February - 20 March). Presumably, these wide ranges in arrival dates and peak abundance during spring migration are influenced by climatic conditions and calendar date. I will discuss these variables and how they influence first arrival dates and peak light goose abundance within south-central Nebraska.

The Far East taiga forest: unrecognized inhospitable terrain for migrating Arctic-nesting waterbirds?

Xin Wang, State Key Laboratory of Urban and Regional Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing, China, 100085.
Lei Cao, State Key Laboratory of Urban and Regional Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing, China,100085; University of Chinese Academy of Sciences, Beijing 100049, China. E-mail: leicao@rcees.ac.cn
Anthony D. Fox, Department of Bioscience, Aarhus University, Kalø, Grenåvej 14, DK-8410 Rønde, Denmark.

The degree of inhospitable terrain encountered by migrating birds can dramatically affect migration strategies and their evolution, as well as influencing the way we develop our contemporary flyway conservation responses to protect them. We used telemetry data from 44 tagged individuals of four large-bodied, Arctic breeding waterbird species (two geese, a swan and one crane species) to show for the first time that these birds fly non-stop over the Far East taiga forest, despite their differing ecologies and migration routes. This implies a lack of suitable taiga refuelling habitats for these long-distance migrants. These results underline the extreme importance of northeast China spring staging habitats and of Arctic areas prior to departure in autumn to enable birds to clear this inhospitable biome, confirming the need for adequate site safeguard to protect these populations throughout their annual cycle.

Using CountEm to efficiently estimate flock size from aerial photographs

Josée Lefebvre, Canadian Wildlife Service – Québec region, Environment and Climate Change Canada, 801 - 1550, avenue d'Estimauville, Québec city, Québec, Canada, G1J 0C3. E-mail: josee.lefebvre@canada.ca
Marcos Cruz, Department of Mathematics, Statistics and Computer Science, University de Cantabria, Av. Los Castros s/n, E-39005 Santander, Spain. E-mail: marcos.cruz@unican.es
Matthew English, Canadian Wildlife Service - Atlantic region, Environment and Climate Change Canada, 17 Waterfowl Lane, Sackville, New Brunswick, Canada, E4L 1G6. E-mail: matthew.english3@canada.ca.
Scott Gilliland, Canadian Wildlife Service - Atlantic region, Environment and Climate Change Canada, 17 Waterfowl Lane, Sackville, New Brunswick, Canada, E4L 1G6. E-mail: scott.gilliland@canada.ca
Francis St-Pierre, Canadian Wildlife Service - Québec, Environment and Climate Change Canada, 801 - 1550, avenue d'Estimauville, Québec city, Québec, Canada, G1J 0C3. E-mail: francis.st-pierre@canada.ca

In Eastern Canada, we use ratio estimators to correct observer error in counts of flock size to estimate population size for Greater Snow Geese (GSGO) in the spring and Common Eiders (COEI) in the winter. Previous analyses indicated that observer's counts become highly variable for flocks greater than ~1,000 birds, and recommended that flock size for all flocks >1,000 birds be assessed using photographs to reduce variance of the population estimates. We assessed the open-source software CountEm to estimate flock sizes of GSGO and COEI from aerial photos. We used the slope and intercept of a linear log-log regression of the estimate on the manual count to evaluate the precision and accuracy of the CountEm estimate. CountEm underestimated the smallest and largest flocks (slope = 0.95; $p < 0.001$; intercept = 0; $p = 0.06$). The relative error on the estimates declined with flock size, and a minimum flock size between 700 and 1000 birds was required to reduce the CV of the estimate below 15%. Hence, we re-ran the linear model on all flocks > 700 birds, and CountEm provided precise and accurate estimates of the known counts (slope = 1.01; $p < 0.001$; intercept = 0; $p = 0.57$). Counting effort decreased rapidly between flocks of 1 - 300 birds, stabilizing at ~3% of the flock being counted in flocks > 300 birds. We examined flock sizes of COEI and GSGO from aerial surveys from 2003 to 2017, and out of 9,527 COEI flocks detected, only 4% of the flocks were greater than 700 birds, however, they accounted for 26% of the total birds. For GSGO, we detected 2,419 flocks surveyed of which 59% of the flocks were greater than 700 birds, accounting for 65% of the total. Counting large flocks is time consuming, and use of CountEm significantly reduces effort while providing unbiased count estimates for photographs of large flocks of birds.

City parks to polar bears; Long distance molt migrations of Canada geese (*Branta canadensis*) transmittered in Chicago

Ryan J. Askren,* University of Illinois, Illinois Natural History Survey, Champaign-Urbana, IL 61801.
E-mail: raskren2@illinois.edu

Tens of thousands of Canada geese (*Branta canadensis*) overwinter in Chicago with low mortality and little exposure to hunting throughout the annual cycle. During summer a portion of these Canada geese leave the safety of Chicago to make exceptional molt migrations to the Hudson Bay region of Canada. The undertaking of long distance migration is energetically taxing and dangerous. Harvest may be a significant source of mortality as geese are exposed to subsistence hunters in the north and open hunting in the upper Midwest. We studied movements of molt migrating Canada geese transmittered in the Greater Chicago Metropolitan Area to identify important stopover sites, timing of molt migration, and exposure to harvest mortality. We deployed 43 global positioning system transmitters on male and female Canada geese wintering in the urban parks of Chicago during winters of 2014 – 2016. We documented 18 molt migrations to the Arctic and Subarctic ($\overline{x}$ = 2,360 km) by 12 non-breeding or failed-breeding individuals. Canada geese departed Illinois for breeding and staging areas in eastern Wisconsin and southeast Ontario between February and June during 2015 – 2017 before continuing to molting areas within 20 km of the coast of western Hudson Bay in the first week of June. Spring and fall migration routes were generally similar with the exception of three transmittered geese that took a circuitous route through Minnesota in fall of 2017. The majority of migrants molted near Rankin Inlet, Nunavut (n = 5), while the furthest north individual molted near Repulse Bay, Nunavut. One individual made molt migrations in subsequent years, first to an offshore island of the Ungava Peninsula, Quebec and Polar Bear Provincial Park, Ontario the following year. During 2015 and 2016, molt migrants returned to the safety of Chicago between the last week in August and October with little mortality. In 2017 however, 4 of 6 (66.7%) molt migrants were shot by hunters in Minnesota (n =2), Wisconsin (n = 1), and Michigan (n = 1) suggesting mortality during molt migration can be significant but variable between years.

Planning and Implementation of Waterfowl Conservation in the Rainwater Basin region of Nebraska

John C. Denton, Ducks Unlimited, 2121 N. Webb Rd, Suite 309, Grand Island, NE 68803. E-mail: jdenton@ducks.org
Dana M. Varner, Rainwater Basin Joint Venture, 9325 S Alda Rd, Wood River, NE 68883. E-mail: dana_varner@fws.gov
Andrew A. Bishop, Rainwater Basin Joint Venture, 2550 N. Diers Ave, Grand Island, NE 68803. E-mail: andy_bishop@fws.gov

Each spring, millions of migrating waterfowl stopover in the Rainwater Basin region (RWB), including more than 7 million midcontinent light geese in some years. More than 80% of playa wetlands in this area have been lost, so the Rainwater Basin Joint Venture (JV) partnership works to improve, restore, and conserve these valuable habitats for the benefit of waterfowl and other wetland-dependent birds. Because resources are often limited, the partnership uses a number of planning tools to help make decisions that will provide the most benefit for each conservation dollar spent. The JV partnership uses the North American Waterfowl Management Plan to derive population goals for the spring migration period. These goals are used to determine caloric needs of migrating waterfowl, and thus, the amount of habitat needed to meet those needs. Since 2004, an inventory of all ponded water habitat available at the peak of snow goose migration has been compiled. This information is then combined with other geospatial data to develop prioritization models based on our understanding of the habitat needs and preferences of waterfowl migrating through the RWB. For example, parcels in an area of greater wetland density will be ranked higher as a potential conservation easement than an equivalent parcel in an area of lower wetland density. Another recently developed planning tool, the RWBJV Water Plan, will be used to increase the number of ponded acres in the region via targeted supplemental water deliveries, watershed restoration, hydrologic improvements, and other strategies. The JV partnership uses these tools, and others, to assist decision-makers in creating and conserving better habitats for migrating waterfowl.

Monitoring goose harvest as a product of ultra-liberal bag limits

Michael L. Szymanski, North Dakota Game and Fish Department, Migratory Game Bird Management, Bismarck, ND 58501, USA. E-mail: mszymanski@nd.gov
Joshua L. Dooley, U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Vancouver, WA 98683, USA. E-mail: joshua_dooley@fws.gov
Stephen C. Chandler, U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Onalaska, WI 54650, USA. E-mail: stephen_chandler@fws.gov
Robert V. Raftovich, U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Laurel, MD 20708, USA. E-mail: robert_raftovich@fws.gov
Kevin J. Kraai, Texas Parks and Wildlife Department, Waterfowl Program, Canyon, TX 79015, USA. E-mail: kevin.kraai@tpwd.texas.gov

Harvest monitoring for most waterfowl species in North America relies largely on "good faith" participation and reporting by the hunting public. Hunters are expected to fulfill a menagerie of requests: completing paper and electronic diaries, reporting band recoveries, and sending various parts from harvested birds through the mail. Generally, efforts expected of hunters are small and not time consuming; however, collecting parts from harvested geese can take a few minutes per bird sampled. Burgeoning North American goose populations have resulted in liberalization of both season length and bag limits. In the midcontinent, lesser snow geese (*Anser caerulescens caerulescens*) and Ross' geese (*Anser rossii*) have been declared overabundant resulting in promulgation of a Conservation Order and ultra-liberal bag limits as high as 50 birds/day during the regular 107-day hunting season. Temperate breeding Canada geese (*Branta canadensis*) have also become overabundant allowing for early September seasons and Management Take Programs with daily bag limits up to 15 birds, and liberal 107-day regular hunting seasons with daily bag limits up to 8 birds in some areas. Goose harvest has become more bi-modally distributed, with hunters either harvesting few or many geese. The greatest proportion of the total harvest now comes from hunters that shoot very large daily bags (e.g., for lesser snow geese and Ross's geese, daily bags often exceeding 20 birds). Methodology to address memory and prestige bias in harvest reporting, and current methods to collect bird parts to determine species composition may no longer be viable techniques to monitor harvest of some North American geese. Moreover, complications from issues related to ultra-liberal bag limits may be negatively affecting harvest monitoring efforts for other species of waterfowl (e.g., survey burn-out resulting in hunters not sending in duck wings, or running out of envelopes). Finally, problems with harvest monitoring for species with ultra-liberal bag limits and long seasons likely negatively biases indirect population estimates (i.e., Lincoln estimates) that are important for species lacking viable population surveys.

Evaluation of Federal Goose Harvest Surveys: some current issues and their implications on harvest and Lincoln estimates

Joshua Dooley, U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Vancouver, WA 98683, USA.
E-mail: joshua_dooley@fws.gov
Stephen Chandler, U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Onalaska, WI 54650, USA.
E-mail: stephen_chandler@fws.gov
Mark Otto, U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Laurel, MD 20708, USA.
E-mail: mark_otto@fws.gov
Robert Raftovich, U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Laurel, MD 20708, USA.
E-mail: robert_raftovich@fws.gov
Nathan Zimpfer, U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Laurel, MD 20708, USA.
E-mail: nathan_zimpfer@fws.gov

Harvest data are becoming more important in goose management. Indirect population estimates derived from these data (i.e., Lincoln estimates) are used or being considered as primary management indices in many goose management plans. Obtaining accurate goose harvest information and improving understanding of potential bias in harvest estimates is critical. Relative to band-recovery data, considerably less attention has been directed toward the evaluation of harvest data from Federal goose harvest surveys. We provide some summaries of goose harvest data collected to date and highlight some issues related to estimating harvest, age ratios, and variance. We overview some prior estimation methods and describe some new potential methodology to estimate sample proportions collected from the Parts Collection Survey (PCS) and species-specific harvest and variance estimates. Early- and late-season goose harvest estimates were generally biased low, and late-season age ratios for some goose species were biased toward adults. Temperate-nesting Canada geese appear oversampled in the PCS relative to other geese and with regard to priority goose information needs. In Canada and U.S. Flyways, fewer goose tail fan measurement data are currently being collected, or were collected differently in the past, which limits the ability to estimate harvest of goose species continentally or among Flyways. We describe a probability based simulation approach to estimate species and age proportions in the PCS and a Bayesian modeling approach to estimate species-specific harvest and variance estimates. Model-based harvest and variance estimates can differ from raw estimates and the 10 percent coefficient of variation (% CV) typically assumed when calculating Lincoln estimates, which can affect the ability to detect trends and changes in abundance from these indices. The issues highlighted should be considered concurrent with other on-going efforts to modernize Federal harvest surveys and improve information obtained from the Harvest Information Program (HIP).

Unobservable harvest mortality: treating harvest data as a process subject to imperfect detection

Cody E Deane*, Department of Wildlife and Biology, University of Alaska, Fairbanks, AK USA 99775.
E-mail: ced4183@gmail.com
Graham G. Frye, Department of Wildlife and Biology, University of Alaska, Fairbanks, AK USA 99775.
E-mail: ggfrye@alaska.edu

The fundamental consequence of imperfect detection is bias. Statistical methods for accounting for detection probabilities < 1 are one of the most important tools available to the ecological sciences. The capture-mark-recapture family of models falls within a more general class of hierarchical models that formally account for imperfect observability by modeling detection probability. However, when capture-mark-recapture data from harvested populations are analyzed in the Brownie, Seber, and the general class of multistate models, harvest data is not treated as a data type that is partially observable. For many exploited populations, the documentation of harvest mortality is incomplete. There is an observable portion comprised of those individuals that are shot, retrieved, and reported to researchers. In addition, there is an unobservable portion comprised of those individuals which are shot, retrieved, but not reported (non-reporting) or those which die due to injuries from being shot but are never retrieved (crippling loss). We present a method for formally treating harvest mortality as a partially observable process in Bayesian capture-mark-recapture models implemented in JAGS. We predicted and our results supported the conclusion that when unobservable harvest mortality is present in the data but unaccounted for in the modeling process, 1) survival rate point estimates are unbiased, 2) the variance of survival rates is overestimated, 3) both the point estimates and the variance of harvest mortality are underestimated, and 4) both the point estimates and the variance of natural mortality are overestimated. When assessing the additive and compensatory harvest mortality hypotheses with Bayesian capture-mark-recapture models that estimate process correlation, unobservable harvest mortality can cause variable bias in favor of additivity. This problem is present in published harvest analyses which have found support for over-additive harvest mortality when this biological mechanism is unlikely given the life-history characteristics of the study organisms. When high quality capture-mark-recapture data are available, the unobservable harvest mortality rate can be an identifiable parameter. In many other applications, estimating the portion of harvest mortality that is observable may be impossible. For these scenarios, the parameter representing the portion of harvest that is observable may be incorporated into the model as an informed prior in Bayesian capture-mark-recapture applications. Informed priors can be developed by using published reporting and crippling loss rates or possibly by ‘expert opinion.’ Our results indicate that the waterfowl management community would benefit from better knowledge of non-reporting and crippling loss rates.

Impact of recent changes in hunting regulation on seasonal survival of male and female Greater Snow Geese

Frédéric LeTourneux*, Department of Biology & Centre d'étude nordiques, Université Laval, 1045 Avenue de la Médecine, Québec, QC G1V 0A6, Canada. E-mail: frederic.letourneux.1@ulaval.ca

Gilles Gauthier, Department of Biology & Centre d'étude nordiques, Université Laval, 1045 Avenue de la Médecine, Québec, QC G1V 0A6, Canada. E-mail: gilles.gauthier@bio.ulaval.ca

Roger Pradel, CEFE, UMR 5175, CNRS, Montpellier, France. E-mail: roger.pradel@cefe.cnrs.fr

Josée Lefebvre, Canadian Wildlife Service – Quebec region, Environment and Climate Change Canada, 801-1550 Avenue d'Estimauville, Québec, QC G1J 0C3, Canada. E-mail: josee.lefebvre@canada.ca

Greater Snow Geese, like many other goose species in North America and around the globe, underwent dramatic population growth at the end of the twentieth century. In order to mitigate the impacts such a large population can have on arctic ecosystems and agriculture, wildlife management authorities have liberalized the hunting regulation for this species. A special spring harvest was opened in 1999 in Québec, and in 2009, a special winter harvest (called "Conservation Order") was opened in the United States. While we know the Québec spring harvest initially had a significant negative impact on survival of Greater Snow Geese, no study has looked at the recent impact of the Conservation Order in the US and the spring harvest in Canada. Using data from the 25-year monitoring program for this species on Bylot Island, Nunavut, we attempted to determine the relative impacts of each of these conservation actions on survival rate in both sexes. Using capture-recapture data from different sources (live recaptures and re-sights of neck-collared birds, hunting recoveries) in a multievent model framework, we measured survival on a seasonal basis, allowing a separation of the impact of hunting in the USA and in Québec. Preliminary results show a decrease in adult annual survival after the implementation of the 1999 spring hunt for both males and females, and a further decrease in annual survival after the implementation of the Conservation Order for females only. While seasonal survival for males changed little over the study period, female winter survival decreased during the Conservation Order. Interestingly, female spring survival, which decreased after implementation of the spring harvest in Québec, subsequently increased during the Conservation order in the USA. This may reflect some form of seasonal compensation in hunting mortalities as females hunted in winter may be those most prone to be attracted by decoys, thereby reducing the hunting mortality risk of those surviving in spring. This also suggests a differential vulnerability to hunting between males and females. Disentangling the effects of each management action on the survival of this population is important for assessing the success of current regulations in achieving their goals and whether revisions are warranted.

Current shortcomings and possible solutions to understanding process correlation estimates from Bayesian models for harvest inference

Cody E Deane*, Department of Wildlife and Biology, University of Alaska, Fairbanks, AK USA 99775.
E-mail: ced4183@gmail.com
Graham G. Frye, Department of Wildlife and Biology, University of Alaska, Fairbanks, AK USA 99775.
E-mail: ggfrye@alaska.edu
Mark S. Lindberg, Department of Wildlife and Biology, University of Alaska, Fairbanks, AK USA 99775.
E-mail: mslindberg@alaska.edu

Sustained harvest and the conservation of goose and duck populations are synergistic goals of North American waterfowl management. Science-based management towards these objectives is hindered by decades of inconsistent results assessing whether harvest mortality limits survival rates. Because harvest study designs are rarely experimental, hunting regulations generally track populations and make it difficult to convincingly describe the relationships between population density, harvest rates, and survival rates. Additional contention over published results stems from the inability to distinguish between models with poor fit to the data from evidence for 1) additive harvest mortality when natural mortality and harvest mortality are estimated parameters or 2) compensatory harvest mortality when survival and natural mortality are estimated parameters. The response of survival rates to hunting mortality is a structural uncertainty in current adaptive harvest management (AHM) models which are designed to reduce uncertainty in decision making processes. Further, AHM model results often conflict with results from capture-mark-recapture analyses, emphasizing the need for better understanding of harvest dynamics. Analytical solutions for modeling long-term, capture-mark-recapture data from harvested populations have focused on recent advances in Bayesian hierarchical methods. These models are becoming increasingly popular because they estimate process correlation (rho) between estimated parameters, which is useful for assessing hypotheses about harvest mortality. We examine the credibility of rho when estimated from data and provide guidance for interpreting this parameter that will assist interpretation of future results for harvested populations. The need for better understanding of rho arises from 1) apparent confusion about the interpretation of rho, 2) concern that rho is biased toward the value 0, and 3) there being little validation of these methods. Using simulated data and Bayesian models implemented in JAGS, we show rho can provide convincing evidence for both the compensatory and additive harvest mortality hypotheses when estimated from the same data. Because rho is a function of the variance and covariance of estimated parameters, this value is sensitive to multiple characteristics of the data that should be considered by researchers when interpreting results. The most important of these considerations is the sparsity of the data. Researchers should be especially cautious when interpreting rho when estimated from sparse data sets, even when only a portion of a time series is characterized by small sample sizes.

Estimating process correlations with capture-mark-recovery and capture-mark-recapture data: understanding life-history trade-offs in Pacific black brant

Thomas V. Riecke,* Program in Ecology, Evolution, and Conservation Biology, Department of Natural Resources and Environmental Science, University of Nevada, Reno, NV, USA 89557. E-mail: triecke@cabnr.unr.edu
Ben S. Sedinger, Program in Ecology, Evolution, and Conservation Biology, Department of Natural Resources and Environmental Science, University of Nevada, Reno, NV, USA 89557. E-mail: aglcfr@gmail.com
James S. Sedinger, Department of Natural Resources and Environmental Science, University of Nevada, Reno, NV, USA 89557.
E-mail: jsedinger@cabnr.unr.edu

Estimating correlations among demographic parameters of interest is a critical component of population demography, where linkages among parameters of interest can inform applied management actions. Recent analytical developments allow investigators to estimate process correlations among parameters such as survival and band recovery rates, natural and harvest mortality, or survival and breeding probability. Previously published parameterizations of these model types can lead to biased estimates of process correlations among demographic components due to inherent limitations of the logit scale. We examine the behavior of a variety of variance-covariance matrix priors, and present a method, stretching the logistic link function, which can be used to obtain unbiased estimates of these correlations in the BUGS language for lower-dimensional variance-covariance matrices given sufficient sample sizes. We robustly test this method using simulated capture-mark-recapture and capture-mark-recovery data. We subsequently use this novel method to examine process correlations among survival and breeding propensity of Pacific black brent at the population and individual level.

Selective harvest: evaluating differences in body condition of lesser snow and Ross's Geese during spring migration by harvest technique during the Light Goose Conservation Order

Drew N. Fowler,* Missouri Cooperative Fish and Wildlife Unit, School of Natural Resources, University of Missouri, Columbia, MO 65211, USA. E-mail:dnftgb@mail.missouri.edu
Mark P. Vrtiska, Nebraska Game and Parks Commission, Lincoln, NE 68503, USA. E-mail: mark.vrtiska@nebraska.gov
Elisabeth B. Webb, U.S. Geological Survey, Missouri Cooperative Fish and Wildlife Unit, School of Natural Resources, University of Missouri, Columbia, MO 65211, USA. E-mail: webbli@missouri.edu

Compensatory harvest mortality is generally a product of either density-dependent pressure or individual heterogeneity, and these mechanisms can work independently or synergistically to influence populations. Among light geese, the vast majority of harvest appears to be compensatory, despite a Light Goose Conservation Order (LGCO) initiated in 1999 to reduce expanding light goose population size. Uniquely, compensation in lesser snow geese is thought to be driven largely by extremely low harvest rates and an inability of harvest rates to exceed natural mortality rates, but it remains unclear what role individual heterogeneity in body condition of harvested light geese might play in compensating natural mortality. Previous studies reported hunter harvested cohorts of dabbling and diving ducks exhibited poorer body condition relative to the overall population however, similar trends have not been evaluated for light geese. Thus, we examined potential differences in body condition of lesser snow (n = 756) and Ross's geese (n = 125) harvested over decoys and geese from the general population that might provide insight for harvest susceptibility. We opportunistically collected light geese harvested over decoys by hunters and simultaneously collected paired random samples via jump or pass shooting during peak spring migration in Arkansas, Missouri, Nebraska, and South Dakota during the 2015 and 2016 LGCO. Specimens were assessed for body condition using standard lipid and protein proximate analyses and were adjusted for body size based on morphological measurements. We used general linear and mixed models to explain variation in total lipid and protein values within *a priori* model sets that included harvest method, harvest region, sex, age and year as predictors. In both lesser snow and Ross' geese, competitive models supported an effect of harvest method on variation in lipid and protein values. Juvenile and adult light geese harvested over decoys had reduced lipid and protein reserves relative to birds sampled randomly through jump shooting. As geese migrated north, individuals collected from both methods exhibited increased lipid reserves and lower protein reserves. Our results indicate management efforts to control population size through the LGCO harvest appears to target individuals of low intrinsic body condition. At current harvest levels, compensatory mortality is likely facilitated by not only insufficient quantity of harvest but also the quality of individuals, as harvest seems to contribute to the number of individuals that die annually, but not increase overall annual mortality.

Status of breeding and brood-rearing habitats of lesser snow geese at Southampton Island and Western Baffin Island, Nunavut

J. Todd Kemper, Canadian Wildlife Service, Edmonton, AB, Canada, T6B 1K5. E-mail: todd.kemper@canada.ca
Elizabeth Beck, Canadian Wildlife Service, Edmonton, AB, Canada, T6B 1K5. E-mail: elizabeth.beck@canada.ca
Joel Ingram, Canadian Wildlife Service, Winnipeg, MB, Canada, R3C 4W2. E-mail: Joel.Ingram@dfo-mpo.gc.ca
Kenneth F. Abraham, Ontario Ministry of Natural Resources and Forestry and Trent University, Peterborough ON, Canada K9L 0G2. E-mail: ken.abraham@ontario.ca

Habitat alteration caused by overabundant midcontinent lesser snow geese (*Chen caerulescens caerulescens*) has been well documented at La Pérouse Bay and elsewhere in coastal marshes of Hudson Bay, but little is known about the quality and sustainability of habitats in the areas that sustain the vast majority of breeding snow geese in the eastern Arctic of Canada (Baffin Island, Southampton Island). From 2014 to 2017, we sampled habitats at 199 sites on Southampton and Baffin Islands to document the present status of habitats and to establish a baseline for future monitoring/change-detection. For Southampton Island we used an existing Landsat classification to identify potential breeding and brood-rearing habitats that we classified as either: saltmarsh, mesic-wet graminoid tundra (freshwater marsh), and mixed-graminoid/heath tundra (uplands). This classification was used to constrain a random selection of sample sites, using a minimum separation distance between sites of 1km. For Baffin Island we used a draft Landsat classification to create three habitat strata: coastal saltmarsh, near-coastal hygric/mesic tundra, and inland mesic-wet graminoid tundra. We subsequently selected sites to create a geographically balanced network of sites within a 30km radius of the two primary nesting colonies. One-third of sites were assigned to inland mesic-wet graminoid tundra and 2/3 were assigned to the coastal and near-coastal strata (combined). At each site we used a combination of detailed and rapid protocols to measure ground cover composition (relative dominance of 13 categories of ground cover), forage height, forage biomass, proportion of stems grazed, detailed vascular plant composition, active layer depth, and goose fecal pellet count. These observations constitute a spatially explicit baseline record for future change-detection. Preliminary data analysis is ongoing, but indications to date are that: 1) at both Southampton and Baffin Island, habitat classifications based on dated Landsat imagery (or our interpretations of them) overestimated the present-day extent of saltmarsh communities, 2) evidence of goose herbivory – and associated modification of vegetation structure or composition – was evident at virtually all sites visited, 3) locally denuded areas are evident, and in some cases extensive (particularly at the eastern Southampton Island colonies), but 4) with the possible exception of tidal saltmarsh communities, there does not appear to have been widespread conversion of habitats to an alternate or 'denuded' state in the areas that sustain the majority of breeding lesser snow geese in the eastern arctic.

Rapid Evaluation of Lesser Snow Goose Habitat Degradation Using an Unmanned Aircraft Vehicle

Andrew Barnas,* Department of Biology, University of North Dakota, Grand Forks, ND, USA, 58202.
E-mail: andrew.barnas@und.edu
Christopher J. Felege, Department of Biology, University of North Dakota, Grand Forks, ND, USA, 58202.
E-mail: christopher.felege@und.edu
Gregory S. Vandeberg, Department of Geography, University of North Dakota, Grand Forks, ND, USA, 58202.
E-mail: gregory.vandeberg@und.edu
Robert F. Rockwell, Division of Vertebrate Zoology, American Museum of Natural History, New York, NY, USA.
E-mail: rfr@amnh.org
Susan N. Ellis-Felege, Department of Biology, University of North Dakota, Grand Forks, ND, USA, 58202.
E-mail: susan.felege@und.email.edu

In their northern breeding and staging areas, increasing lesser snow goose (*Anser caerulescens caerulescens*) populations have negatively impacted vegetation communities, resulting in decreased plant cover and increased barren ground. Monitoring the impact of goose foraging on vegetation communities is often done using ground based methods, which are logistically challenging in remote regions. Here we test the ability of a fixed-wing unmanned aircraft vehicle (UAV) to rapidly conduct vegetation assessments by comparison with data collected on the ground. We surveyed five plots on the ground with linear transects in 1999, 2010, and 2016, collecting cover information approximately every meter. Landcover was recorded as barren, graminoid, or shrub cover. UAV imagery was collected in 2016 in red, green, and blue (RGB) wavelengths over the same plots at 75, 100 and 120m above ground level and was classified into barren, graminoid or shrub classes in ArcGIS 10.4. Ground cover estimation from UAV imagery was done by the enumeration of pixels for each class type (barren, graminoid and shrub), and by extracting class type along the same linear transects performed on the ground. We used mixed models to estimate how the proportion of each landcover type changed over time, and to compare 2016 estimates between linear transects and UAV imagery. We estimated increased barren ground and generally decreased plant cover over time from ground data, but in 2016 we found small amounts of barren replaced with increased graminoid cover. We found similar results for both UAV methods of estimation, which when compared to 2016 ground based estimates generally overestimated barren and shrub, while underestimating graminoid cover. Interestingly, we found reduced overall accuracy at lower altitude surveys (72% at 75m) with higher image resolution than accuracy at higher altitude surveys (81.3% at both 100 and 120m). UAVs may be an important tool for future monitoring in arctic regions, though technological and regulatory limitations need consideration before large-scale implementation. Future habitat evaluation studies should examine the use of multispectral imagery, combined with more sophisticated classification methods (e.g. Random Forest classifiers).

Spring temperature, migration chronology, and nutrient allocation to eggs in three sympatric species of geese: Implications for Arctic warming

Jerry W. Hupp, U.S. Geological Survey, Alaska Science Center, Anchorage, AK, USA 99508. E-mail: jhupp@usgs.gov
David H. Ward, U.S. Geological Survey, Alaska Science Center, Anchorage, AK, USA 99508. E-mail: dward@usgs.gov
David X. Soto, Department of Earth and Environmental Sciences, KU Leuven, Leuven, Belgium. E-mail: david.soto@kuleuven.be
Vijay P. Patil, U.S. Geological Survey, Alaska Science Center, Anchorage, AK, USA 99508. E-mail: vpatil@usgs.gov
Keith A. Hobson, University of Western Ontario, Department of Biology, London, ON, Canada N6A 5B7.
E-mail: khobson6@uwo.ca

Birds that nest in the Arctic acquire egg nutrients either from endogenous reserves of fat and protein (capital) that they carry during migration, or from the income of foods consumed upon or near the completion of migration. The relative contribution from each source is influenced by temporal and environmental constraints on a female's ability to secure reproductive nutrients by foraging near her nesting area in early spring. Advancing Arctic phenology may alter those constraints. We examined the sources of egg nutrients, chronology of migration and nesting, and relationships between spring temperature and nutrient allocation to eggs in three sympatric species of geese that nested in northern Alaska. Compared to lesser snow geese (*Chen caerulescens caerulescens*), and greater white-fronted geese (*Anser albifrons frontalis*), black brant (*Branta bernicla nigricans*) marked with geolocators arrived in the Arctic at later dates, had fewer days after their arrival until the onset of incubation, and were more likely to initiate rapid follicle development during migration. Based on measurement of stable isotopes (δ^{13}C, δ^{15}N), brant derived more of their egg macronutrients from endogenous reserves, compared to snow geese and white-fronted geese. Smaller body size may result in foraging and thermoregulatory limitations that constrain arrival of brant in the Arctic, reduce the time available for them to secure exogenous nutrients for eggs, and require a relatively larger investment of endogenous nutrients. Brant invested more endogenous nutrients in their eggs when spring temperatures were warmer and nest initiation was earlier, likely because they used capital to initiate follicle development earlier during migration in years when phenology was early. Snow geese and white-fronted geese invested less capital in their eggs when spring temperatures were warmer, likely because of improved foraging opportunities after they arrived in the Arctic. Global warming may reduce the quality of marine habitats where brant acquire endogenous reserves, and could increase their reliance on those reserves in years of advanced Arctic phenology. Conversely, Arctic warming in the near future may favor the reproductive strategies of snow geese and white-fronted geese by improving foraging conditions during their relatively longer pre-nesting period.

Linking black brant gosling growth and spatial nutrient dynamics of brood-rearing area grazing lawns in the Yukon-Kuskokwim River Delta

Lindsay G. Carlson*, School of Forestry and Natural Resources, University of Arkansas at Monticello, Monticello, AR, USA, 71655. E-mail: lgcarlson@aggiemail.usu.edu

Cody E. Deane, Department of Biology and Wildlife and Institute of Arctic Biology, University of Alaska, Fairbanks, Fairbanks, AK, USA, 99775. E-mail: ced4183@gmail.com

Fledgling mass is the most important predictor of first winter survival for juvenile Pacific black brant (*Branta bernicla nigricans*), a key vital rate for population growth. Goslings are nutritionally limited and must consume high-quality forage (*Carex subspathacea*) in order to grow and store energy before autumn migration. Tutakoke River Colony (TRC) brant move their goslings to brood rearing areas (BRAs) up to 40 km from the nesting colony, within five days after hatch and typically show high (75%) fidelity to their selected BRA. Some BRAs consistently produce the largest goslings; given that gosling mass is a strong predictor of survival, it seems that adults should prefer quality BRAs and abandon inferior ones. First-winter survival has declined from 0.50 to < 0.25 over the last two decades. During the same period, the number of nesting pairs at TRC has declined from a maximum of ~8,000 in 2000 to <4,000 in 2015. A growing body of literature suggests that these declines may be linked to a feedback mechanism regulated by the quality and availability of forage during brood rearing. The lagged effect of population decline, especially with years of almost total nest failure, may have resulted in a decline in the available aereal extent of high-quality forage such as *C. subspathacea* grazing lawns, as grazing pressure was decreased. Subarctic grazing lawns must be maintained by consistent, annual herbivory. Previous studies have shown that exclosing grazing lawns reduces their extent and nutrient content. The inability of the TRC brant population to recover may be a result of an insufficient quality or quantity of forage to support gosling growth, and thereby, recruitment required to maintain the breeding population. Our study examined forage quality within each BRA by measuring the carbon to nitrogen (C:N) ratio of grazed and exclosed vegetation during brood rearing in 2017. We quantified extent based on grazing lawn width and cover. Based on preliminary results, we found that BRAs with the greatest grazing lawn extent (lawn width and cover in 2017) also produced the largest goslings in 2017. Interestingly, we found that BRAs with the least grazing lawn extent produced not only the smallest, but the fewest goslings. BRAs such as the Tutakoke Camp and Kash-Tut historically supported hundreds of broods, but have been partially abandoned due to reduced site fidelity or breeding failure by adults who attempt to utilize these BRAs.

Relationship between spring migration and vegetation phenology in Greenland white-fronted geese

Stephanie A. Cunningham,* School of Natural Resources, University of Missouri, Columbia, MO 65211, USA. E-mail: sacdc5@mail.missouri.edu

Mitch D. Weegman, School of Natural Resources, University of Missouri, Columbia, MO 65211, USA. E-mail: weegmanm@missouri.edu

Bart M. Ballard, Caesar Kleberg Wildlife Research Institute, Texas A&M University-Kingsville, Kingsville, TX 78363, USA. E-mail: bart.ballard@tamuk.edu

The Greenland white-fronted goose (*Anser albifrons flavirostris*) population has declined markedly over the past 20 years due to persistently low productivity. Recent studies have investigated the relationship between herbivores and vegetation phenology, as satellite-derived measures of vegetation have been used as proxies to estimate key points in vegetation growth. Life-history theory predicts that movement of migratory herbivores should coincide with the timing of peak resource quality to maximize herbivore reproductive success. We tested the hypothesis that successfully breeding Greenland white-fronted geese (i.e., those observed associating with young during the subsequent winter) would match the timing of their movements during migration with peak nutrient quality, whereas non-breeding or unsuccessful breeders (i.e., those not observed associating with young during the subsequent winter) would exhibit greater mismatch between timing of movements and peak nutrient quality. In March 2012 and 2013, we fitted 15 adult male Greenland white-fronted geese with backpack GPS tracking devices that recorded one location per day throughout spring migration and the summer breeding season. We used the normalized difference vegetation index (NDVI) derived from moderate resolution imaging spectroradiometer data to measure the onset of spring, as well as the timing of peak vegetation nutrient quality, which corresponds to approximately 50% of the maximum NDVI value for a given year. We calculated the difference in timing between goose presence at key locations throughout spring migration and the date of greatest vegetation quality. Our results indicated that both successful breeding (n = 2) and unsuccessful or non-breeding (n = 13) Greenland white-fronted geese consistently arrived on staging and breeding areas, and departed from wintering and staging areas earlier than peak nutrient quality. At staging areas, successful breeding birds arrived 8 and 46 days early, and unsuccessful or non-breeding birds arrived 8 ± 7.26 and 36 ± 15.24 days early in 2012 and 2013, respectively. Successful breeding birds arrived on the breeding grounds 3 and 11 days prior to the date of peak vegetation quality, compared to an average of 16 ± 5.64 and 13 ± 3.62 for unsuccessful or non-breeding birds in 2012 and 2013, respectively. Geese also departed wintering and staging areas prior to peak vegetation biomass. A greater sample size of tagged individuals is required to robustly test whether the mismatch in Greenland white-fronted goose presence and peak nutrient quality during spring migration explains variation in productivity of these birds, and recent deployments of tracking devices will help facilitate this.

Clutch investment drives offspring growth and survival in a long-lived bird

Cheyenne R. Acevedo,* Department of Natural Resources and Environmental Science, University of Nevada, Reno, NV 89557, USA. E-mail: cheyenne.acevedo13@gmail.com
Thomas V. Riecke, Program in Ecology, Evolution, and Conservation Biology, University of Nevada, Reno, NV 89557, USA. E-mail: triecke@cabnr.unr.edu
Alan G. Leach, Program in Ecology, Evolution, and Conservation Biology, University of Nevada, Reno, NV 89557, USA. E-mail: aglcfr@gmail.com
Madeleine Lohman, Department of Natural Resources and Environmental Science, University of Nevada, Reno, NV 89557, USA. E-mail: madeleinelohman@gmail.com
James S. Sedinger, Department of Natural Resources and Environmental Science, University of Nevada, Reno, NV 89557, USA. E-mail: jsedinger@cabnr.unr.edu

The black brant (*Brant bernicla nigricans*) is a small, arctic-nesting goose, occurring in coastal estuaries and wetlands along the Pacific coast. Brant populations on the Yukon-Kuskokwim Delta have declined substantially since the 1980's, and populations remain significantly below historic levels. To better understand the effects of maternal investment in clutches on offspring pre-fledging survival and growth, we analyzed correlates of gosling survival and growth rates collected at the Tutakoke River Brant Colony (TRC) from 1987-2007. We restricted our analyses to 22,201 releases with 2,922 direct recaptures, and 2,685 known age goslings. We built hierarchical models to estimate the effects of position in the laying sequence, egg volume, and temporal variation on black brant pre-fledging survival and growth rates. We provide evidence for the ultimate regulation of clutch size in black brant through declining marginal value of additional offspring. We found that predicted gosling mass and gosling survival decreased with position in the laying sequence, regardless of clutch size. Egg volume had a positive effect on gosling survival rates ($\beta = 0.149$, 95% CRI: 0.048, 0.249, f-value = 0.998), and gosling growth rates increased within egg volume ($\beta = 0.626$, 95% CRI: 0.469, 0.738, f-value = 1.00). Gosling survival ($\beta = -0.188$, 95% CRI: -0.280, -0.098, f-value = 1.00) and mass ($\beta = -1.286$, 95% CRI: -1.435, -1.132, f-value = 1.00) decreased with hatch date. There was a long-term decline in gosling growth ($\beta = -0.123$, 95% CRI: -0.287, 0.041, f-value = 0.943) and survival ($\beta = -0.061$, 95% CRI: -0.145, 0.011, f-value = 0.951) from 1987 to 2007. These findings indicate effects of reproductive investment on offspring growth and survival, as well as potentially diminishing returns of increased maternal reproductive investment.

Using light level geolocation to understand spring migration chronology of Canada and Cackling geese

Frank B. Baldwin, Manitoba Wildlife and Fisheries Branch, Box 24, 200 Saulteaux Crescent, Winnipeg, MB, Canada R3J 3W3. E-mail: Frank.Baldwin@gov.mb.ca
James O. Leafloor, Canadian Wildlife Service, 150 - 123 Main Street, Winnipeg, MB, Canada R3C 4W2. E-mail: Jim.Leafloor@canada.ca
Christopher Nicolai, US Fish and Wildlife Service, 1340 Financial Blvd, Reno, NV, 89502. E-mail: Chris_Nicolai@fws.gov
Amélie C. Roberto-Charron, University of Manitoba, 50 Sifton Rd, University of Manitoba, Winnipeg, MB, Canada R3T 2N2. E-mail: arobertocharron@gmail.com

Two morphologically similar populations of Canada geese (*Branta canadensis)* and one population of Cackling geese (*Branta hutchinsii*) nest in or migrate through Manitoba, Canada. Similar to many jurisdictions, temperate-nesting Canada geese have undergone rapid and sustained population increases in southern Manitoba, leading to a variety of agricultural, economic and aesthetic concerns. Attempts to manage their growth through harvest have been complicated by commingling of populations during fall migration, and adult harvest rates remain below thresholds required to stabilize the population. Regulatory changes to permit harvest during March are being considered, and understanding migration chronology of each population has emerged as a key information need in order to 1) focus harvest pressure temporally on temperate nesting Canada geese and 2) minimize incidental effects on northern populations, which do not exhibit similar patterns of population growth. Towards these objectives, we deployed 450 light-level geolocators on adult female geese from three populations, beginning in 2016. This ongoing study will provide information important for population and harvest management in Manitoba, but will also generate a variety of ancillary data, such as breeding propensity, timing of nest initiation, and spring and fall migration routes/staging areas. Collectively, this information will greatly improve our ecological understanding of these populations.

Increases in Numbers of brood-rearing and molting Brant and Snow Geese on the western Beaufort Sea Coast of Alaska, 1994–2017

Robert M. Burgess, ABR, Inc.—Environmental Research & Services, Fairbanks, AK 99708, USA. E-mail: bburgess@abrinc.com
Tim Obritschkewitsch, ABR, Inc.—Environmental Research & Services, Fairbanks, AK 99708, USA. E-mail: timo@abrinc.com
Brian Person, North Slope Borough Department of Wildlife Management, Utquigvik, AK 99723, USA. E-mail: brian.person@north-slope.org
Robert J. Ritchie, ABR, Inc.—Environmental Research & Services, Fairbanks, AK 99708, USA. E-mail: britchie@abrinc.com

In 2017, we conducted the twenty-third year of brood-rearing surveys for Brant (*Branta bernicla*) and Lesser Snow Geese (*Chen caerulescens caerulescens*) in coastal habitats on the Beaufort Sea coast between Utqiaġvik and Fish Creek, just west of the Colville River delta. The molting population of Brant in the survey area comprises locally breeding birds and a large contingent of molt migrants. Brood-rearing adults largely segregate from molting adults without goslings, thus coastal surveys in late July provide reasonable estimates and trend data for the locally breeding population of Brant in years of high gosling production. Focusing on years in which productivity was high over the 24-year survey period (1994–1997 and 1999–2017), the locally breeding population of Brant appears to have increased from around 1,500 birds to around 4,500 birds between the mid-1990s and 2017. Over all years, an average of 10,074 adult Brant without broods occurred in the survey area and numbers have increased from several thousand prior to 2001 to a peak of 21,853 birds in 2013 (and 21,058 in 2017). Brood-rearing Snow Geese in the survey area nested primarily in the Ikpikpuk River delta colony. Because there is no influx of molt migrant Snow Geese into the region, the brood-rearing surveys provide good and uncomplicated estimates of both breeding population and local productivity. Numbers of brood-rearing and molting Snow Geese in the survey area have increased dramatically over the past 24 years. Snow Geese were so uncommon as to not be recorded in 1994 and the first observations of large numbers of Snow Geese comprised 198 adults with 232 goslings in 1995. Numbers of adult Snow Geese have increased to over 35,000 in 2017. Snow Goose brood densities have increased dramatically near Smith Bay since 1995 (primarily associated with the Ikpikpuk colony). Numbers of both molting and brood-rearing Snow Geese also have increased substantially on the eastern end of the survey area, near Kogru River and Garry Creek and in the Fish Creek delta on Harrison Bay. It is likely that in some years some of the broods recorded along Harrison Bay originated from small and irregularly used nesting sites between Cape Halkett and Fish Creek, and, in recent years, from the growing colony on the Colville River delta that appears to be expanding into the Fish Creek delta.

Use of geolocators in waterfowl: example of assessing movement and staging locations of Canvasback (*Aythya valisineria*) in the Pacific Flyway

Nathan A. Cook,* University of Nevada, Reno, Reno, NV 89557, USA. E-mail: nathancook@nevada.unr.edu
Chris A. Nicolai, US Fish and Wildlife Service, 1340 Financial Blvd., Reno, NV, 89502, USA. E-mail: chris_nicolai@fws.gov
Kevin T. Shoemaker, University of Nevada, Reno, Reno, NV 89557, USA. E-mail: kevintshoemaker@gmail.com

Understanding the geographical extent and timing of wildlife movements enables resource managers to meet the habitat needs of target species efficiently and effectively. Historically, information about waterfowl movements and year-round habitat use have been derived primarily from mark-recovery data in which birds are trapped and marked with metal leg bands that are subsequently reported via hunter harvest. Such banding efforts typically provide few data points for individual birds, and are therefore not ideal for estimating migration paths, stopover sites and timing of movements. Here, we use archival light-level geolocators – which enable researchers to track individual locations on the basis of estimated daily twilight times -- to build a more complete understanding of the geography and timing of migratory movements for canvasback (*Aythya valisineria*) in the pacific flyway. During 2015-2016, 79 geolocators were placed on canvasback using two alternative attachment methods (leg-band mounts vs. nasal-saddle mounts) during spring migration (February - March) near Reno, NV. Four of these geolocators (from three males and one female), were successfully recovered from hunters. After their initial capture in Reno, all four canvasback remained in Western Nevada or California for 10 to 45 days. Three of the four (2 males and 1 female) migrated to breeding sites in southern Canada (Alberta and Saskatchewan, via stopover sites in Utah and Colorado), while one male migrated to a breeding site in Alaska. During spring migration, canvasbacks made an average of 4.25 stops with an average stopover duration of 15.9 days. Fall migration or molt began in mid-August, following molt, and canvasback made an average of 6 stops (often including a northward molt-migration), lasting an average of 19 days, on their way to wintering sites in California's Central Valley and San Francisco Bay area. Recovery of nasal saddle-mounted geolocators was significantly lower than leg band-mounted devices. This study demonstrates the value of geolocators for assessing year-round habitat use for waterfowl populations. This information complements standard band-recovery approaches, and enables waterfowl managers to ensure that the spatial and temporal distributions of habitats are conserved appropriately for the migratory behavior of Canvasback and other key focal species.

Temporal Variation in Survival of Atlantic Brant and its Relation to Hunter Harvest

Kevin W. Dufour, Canadian Wildlife Service, 115 Perimeter Road, Saskatoon, SK S7N 0X4, Canada.
E-mail: kevin.dufour@canada.ca
Kathryn M. Dickson, Canadian Wildlife Service (retired), 351 St. Joseph Blvd, Hull, QC K1A 0H3, Canada.
E-mail: dicksonkm@rogers.com
James O. Leafloor, Canadian Wildlife Service, 123 Main Street, Suite 150, Winnipeg, MB R3C 4W2, Canada.
E-mail: jim.leafloor@canada.ca
Theodore C. Nichols, New Jersey Division of Fish and Wildlife, 2201 County Route 631, Woodbine, NJ, USA.
E-mail: ted.nichols@dep.nj.gov

Knowledge of how and why survival rates vary over time and in relation to mortality factors such as harvest by hunters is central to the management of exploited waterfowl populations. We analysed banding, recapture, and recovery data derived from >15,000 adult Atlantic brant (*Branta bernicla hrota*) marked and released on Southampton Island and Baffin Island, Nunavut, during the period 2001-2014. Objectives of our analysis were to (1) provide baseline, contemporary survival rate estimates for adult brant, (2) evaluate potential changes (trends) in survival over time, and (3) explore the relationship between adult survival and annual harvest by hunters. We used joint analysis of recapture and recovery data for survival estimation, which further allowed us quantify rates of fidelity to the sampled areas, in this case, molting areas on Baffin and Southampton. We also developed models using the Brownie parameterization to estimate annual band-recovery rates (an index of harvest rate), and used Markov Chain Monte Carlo methods to estimate the process correlation (ρ) between survival and recovery rate, where negative process correlation is indicative of additive harvest mortality and no correlation is expected if harvest mortality is largely compensatory to other mortality factors. Our best supported recapture-recovery model allowed survival rates to vary among years but assumed no differences in survival with respect to banding origin. Adult annual survival rate estimates ranged from 0.758 (± 0.019 SE) to 0.931 (± 0.010 SE), averaging 0.846 (± 0.054 SE) over all years. In general, there was little indication of a trend in survival rate estimates over time, and models explicitly incorporating linear and quadratic time trends in survival were poorly supported by the data. However, there was a strong inverse relationship between adult survival and harvest of adult brant in the US (where most Atlantic brant are harvested), with adult US harvest explaining roughly 71% of the annual variability in adult survival based on an analysis of deviance. Our estimated process correlation between survival and recovery rate similarly indicated an additive effect of harvest mortality on total mortality (ρ = -0.268). Fidelity of adults to molting areas varied among years but generally exceeded 0.80. Our results indicate that survival rates of adult Atlantic brant are dynamic and that hunter harvest appears to be an important factor governing those rates. This finding reaffirms a need for careful harvest management for brant and continued monitoring of survival rates, harvest levels, and population status.

Demographics and harvest characteristics of participants in the Nebraska Light Goose Conservation Order, 2016-2017

Alexander D. Engel, Nebraska Game and Parks Commission, Lincoln, NE 68503, USA and Nebraska Cooperative Fish and Wildlife Research Unit, School of Natural Resources, University of Nebraska, Lincoln, NE, USA. E-mail: alex.engel@nebraska.gov
Alexis D. Fedele, Nebraska Cooperative Fish and Wildlife Research Unit, School of Natural Resources, University of Nebraska, Lincoln, NE, USA. E-mail: afedele@unl.edu
Mark P. Vrtiska, Nebraska Game and Parks Commission, Lincoln, NE 68503, USA. E-mail: mark.vrtiska@nebraska.gov

The Light Goose Conservation Order (LGCO) was implemented in 1999 to reduce populations of lesser snow geese (*Chen caerulescens cearulescens*) and Ross's geese (*C. rossii*). However, little data is available regarding the demographics of participants in the LGCO. Obtaining demographic information on LGCO participants may provide insight to variations in effort, harvest methods and intensity of harvest among participants. Harvest decisions may impact the effectiveness of the LGCO; for example, preliminary data indicates that light geese harvested over decoys had reduced lipid and protein reserves relative to birds sampled randomly through jump shooting (D. Fowler, Missouri Coop Unit, unpublished data). Thus, we examined participant demographics and harvest characteristics (e.g., harvest method, days afield) during the 2016 and 2017 LGCOs. Names and addresses were obtained from the Harvest Information Program and individuals were stratified into four groups based on anticipated level of participation and experience. An online survey was emailed to potential participants to estimate participation, effort, methods, and harvest of light geese during the LGCO. Survey questions asked about the number of days participated, number of light geese harvested, and what method of harvest was used (i.e. sneaking/jumping, pass shooting, over decoys, or other). We examined differences in demographic and harvest characteristics among participants categorized as either primarily using decoys or those primarily sneaking or pass shooting based on their reported harvest. Over 1,000 individuals responded to the survey each year of the study (n = 1,160 in 2016 and n = 1,062 in 2017). Of those, 688 indicated that they participated in the LGCO (n = 340 in 2016 and n = 348 in 2017) and 87 indicated they participated, but did not harvest any geese, (n = 38 in 2016 and n = 49 in 2017). Mean age of those primarily using decoys was 48, compared to 39 for those primarily sneaking or pass shooting. Decoy participants harvested fewer geese per day than sneaking or pass shooting but spent more days afield. Differences in participation methods may impact the effectiveness of the LGCO and may require new or unique harvest methods.

Do nutrient acquisition strategies differ among spring migrants depending on breeding area destination? A test using lesser snow geese

Drew N. Fowler,* Missouri Cooperative Fish and Wildlife Unit, School of Natural Resources, University of Missouri, Columbia, MO 65211, USA. E-mail:dnftgb@mail.missouri.edu
Keith A. Hobson, Department of Biology, University of Western Ontario, London, Ontario, Canada N6A 5B7. E-mail: khobson6@uwo.ca
Mark P. Vrtiska, Nebraska Game and Parks Commission, Lincoln, NE 68503, USA. E-mail: mark.vrtiska@nebraska.gov
Elisabeth B. Webb, U.S. Geological Survey, Missouri Cooperative Fish and Wildlife Unit, School of Natural Resources, University of Missouri, Columbia, MO 65211, USA. E-mail: webbli@missouri.edu

Long distance migratory birds use flexible strategies to cope with the energetic costs of migration and acquire sufficient nutrients at migration stopover sites. Length of migration and individual body size can determine the extent of endogenous reserves allocated to reproductive efforts and individuals of species breeding at varying latitudes may rely on different nutrient acquisition strategies during spring migration in preparation for breeding. Midcontinent lesser snow geese (*Chen caerulescens caerulescens*) breed across 30 degrees of latitude in Canada; however, it is not clear if migration length influences nutrient acquisition decisions during early spring migration. We used deuterium isotopic values (δ^2H) in feathers of lesser snow geese collected during early spring migration 2015 and 2016 to establish subarctic and arctic sub-population association for 756 birds based on the previous year's molt location. We assessed rates of lipid and protein acquisition among four regions during early spring migration within the Mississippi and Central flyways and evaluated whether differences in body size among sub-populations contributed to explaining variation in rates of nutrient storage during spring migration. Spring harvest of lesser snow geese is common throughout the Mississippi and Central flyways and while subarctic nesting lesser snow geese make up approximately 10% of the total midcontinent population they experience higher harvest rates compared to arctic nesting snow geese. Understanding potential differences in nutrient acquisition strategies among lesser snow goose sub-populations related to tradeoffs in body size and migration distance may in part explain disproportionate spring harvest susceptibility.

Emperor Goose Nest Success on Kigigak Island, Yukon Delta NWR during Summer 2017

Randall Friendly,* U.S. Fish and Wildlife Service, Yukon Delta National Wildlife Refuge, Bethel, AK 99559 USA. E-mail: randall.friendly@gmail.com
Bryan L. Daniels, U.S. Fish and Wildlife Service, Yukon Delta National Wildlife Refuge, Bethel, AK 99559 USA. E-mail: bryan_daniels@fws.gov

The Emperor Goose (*Anser canagicus*) is an endemic goose of Alaska and Russia. Emperor geese winter along the Alaska Peninsula and Aleutian Islands, and breed primarily in the Yukon Delta National Wildlife Refuge (YDNWR). Beginning in the early 1980's, aerial surveys documented a population decline that led to harvest restrictions and closures implemented in 1985. In 2016, surveys indicated the population reached a threshold that would allow the reopening of Emperor goose harvest. With the opening of a hunting season, and an annual population growth rate of 2% over the previous 30 years without hunting, managers and biologists had concerns about the level of harvest the population could sustain, as well as the number of young being produced to sustain the breeding population at current levels. With the Yukon Delta being the primary breeding location for Emperor geese, YDNWR began monitoring clutch size, nest success, nest initiation dates, and adult survival of Emperor geese on Kigigak Island, YDNWR, Alaska. We tested the time of day on trap success of nesting Emperor geese to increase efficiency in subsequent years. In 2017, out of 143 Emperor goose nests monitored, mean clutch size was similar to historic studies at 5.16 eggs, nest success was 81.6%, and 18% unsuccessful. Nest predators were the highest cause of nest failure with 16% being depredated. Mean nest initiation date was a full week earlier than recorded on the Yukon Delta from 1982-1986, with a mean nest initiation date of 15 May 2017. We found no significant difference in capture times of nesting geese between morning and afternoon trap sessions, although more geese were captured in the afternoons. With limited prior information on Emperor goose nest success for Kigigak Island, we will use the results of this study as a basis moving into the future while tracking individual marked goose survival and nest success.

Co-Management in Waterfowl Harvest Decisions: Update on the Status of Emperor Geese in Alaska

Charles Frost, U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Anchorage, AK 99503, USA. E-mail: charles_frost@fws.gov
Erik Osnas, U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Anchorage, AK 99503, USA. E-mail: erik_osnas@fws.gov
Julian Fischer, U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Anchorage, AK 99503, USA. E-mail: julian_fischer@fws.gov
Eric Taylor, U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Anchorage, AK 99503, USA. E-mail: eric_taylor@fws.gov

Emperor geese (*Anser canagicus*) are maritime birds that occur in coastal areas of western Alaska and eastern Russia. U.S. Fish and Wildlife Service aerial surveys indicated emperor goose abundance in Alaska declined in the late 1970s and early 1980s. Consequently, emperor geese were closed to fall/winter (sport) and spring/summer (subsistence) harvests in Alaska in 1986 and 1987, respectively, to increase population size. From 1985-2016, emperor goose abundance increased about 2% per year and in 2015 the population index reached a level at which legal harvest could be considered based on guidelines established by federal, state, and native Alaskan representatives. In 2016, the U.S. Fish and Wildlife Service engaged in co-management negotiations with the Alaska Native Caucus and Alaska Department of Fish and Game (collectively called the Alaska Migratory Bird Co-management Council, or AMBCC) for the consideration of an open hunting season. Primary points of contention were how many emperor geese could or would be harvested in the event of a legal hunting season, how to monitor the population, and at what population level should harvest be curtailed or closed. We developed a decision model that optimized the season closure threshold over the expected utility elicited from decision-makers. The underlying theta-logistic population model forecasts the annual population under reasonable harvest levels that promote sustainability. This decision-theoretic framework represents a novel approach to migratory waterfowl management in Alaska with the potential for extension to other species of geese in Alaska and across the country. The AMBCC and Pacific Flyway Council subsequently allowed a customary and traditional spring-summer subsistence season and a limited fall-winter season of emperor geese. Alternative designs for the spring-summer subsistence hunt (e.g., season length, bag limits, permit only hunts, egg harvest, and regional harvest quotas) will be discussed if survey level declines to within 5,000 birds above the closure threshold. In order for either hunt to remain open, the total bird index from the Yukon-Kuskokwim Delta Coastal Zone Survey (flown each year in late May) must remain above 23,000 emperor geese, as specified in the Alaska Migratory Bird Co-Management and Pacific Flyway Management plans for emperor geese. The 2017 survey estimated 30,087 (SE 2,030) emperor geese on the breeding grounds, which is consistent with a sustained open season for 2018.

The influence of grazing on lowland vegetation communities in a freshwater arctic ecosystem: an exclusion experiment

Dana K. Kellett,* Department of Biology, University of Saskatchewan, Saskatoon, SK, Canada S7N 5E2, Environment and Climate Change Canada, Prairie and Northern Wildlife Research Centre, Saskatoon, SK, Canada S7N 0X4. E-mail: Dana.Kellett@Canada.ca
Ray T. Alisauskas, Department of Biology, University of Saskatchewan, Saskatoon, SK, Canada S7N 5E2, Environment and Climate Change Canada, Prairie and Northern Wildlife Research Centre, Saskatoon, SK, Canada S7N 0X4. E-mail: Ray.Alisauskas@ec.gc.ca

Large populations of lesser snow and Ross's geese (*Anser caerulescens caerulescens* and *A. rossii*; collectively, light geese) have modified vegetation communities over extensive scales in coastal saltmarsh and freshwater ecosystems in subarctic and arctic regions. We investigated influence of habitat use by light geese on lowland habitats preferred by nesting, brood-rearing, and molting geese in a freshwater ecosystem in Canada's central arctic. Control and treatment plots (n=18 pairs) exposed and not exposed to grazing by geese (hereafter, grazed and ungrazed), respectively, were located within the large nesting colony at Karrak Lake and in brood-rearing habitats at distances of 15 km, 30 km, 45 km, and 60 km from Karrak Lake. We used mixed models to assess differences in above- and below-ground biomass, plant species composition, and soil properties between grazed and ungrazed plots, while controlling for random site effects. As predicted, total dry above-ground biomass was higher in ungrazed (7.5 g (95% CI: 5.8-9.3 g) than grazed plots (2.9 g (1.1-4.7 g), p<0.001). Total dry below-ground biomass was also higher in ungrazed (4.0 g (95% CI: 2.9-5.2 g) than grazed plots (2.9 g (1.8-4.0 g), p=0.03). Below-ground biomass was not significantly influenced by amount of above-ground biomass (p=0.75), however, suggesting that despite removal of above-ground biomass by grazing geese, below-ground reserves remain available for potential regeneration of grazed areas. Based on point-intersect surveys, graminoid species were more prevalent on ungrazed (73.7% (62.0-85.3%)) than grazed plots (49.2% (37.6-60.8%), p=0.003)), whereas moss species (living and dead) were more prevalent on grazed (39.9% (28.1-51.6%)) than ungrazed plots (13.8% (2.1-25.5%), p<0.001)). Soil temperature was higher in grazed (6.3ºC (5.3-7.4ºC)) than ungrazed plots (4.9ºC (3.9-6.0ºC), p<0.001)), suggesting that presence of vegetation impeded soil warming.

Linking behavior, growth, and survival: understanding long-term shifts in black brant fecundity

Madeleine G. Lohman,* Department of Natural Resources and Environmental Science, University of Nevada, Reno, NV 89557, USA. E-mail: madeleinelohman@gmail.com
Thomas V. Riecke, Program in Ecology, Evolution, and Conservation Biology, University of Nevada, Reno, NV 89557, USA. E-mail: triecke@cabnr.unr.edu
Cheyenne R. Acevedo, Department of Natural Resources and Environmental Science, University of Nevada, Reno, NV 89557, USA. E-mail: cheyenne.acevedo13@gmail.com
Alan G. Leach, Program in Ecology, Evolution, and Conservation Biology, University of Nevada, Reno, NV 89557, USA. E-mail: aglcfr@gmail.com
James S. Sedinger, Department of Natural Resources and Environmental Science, University of Nevada, Reno, NV 89557, USA. E-mail: jsedinger@cabnr.unr.edu

Shifts in animal behavior in response to changing environmental conditions can impact population trends. Pacific black brant nesting in the four major colonies on the Yukon-Kuskokwim Delta have declined substantially (~50%) since the turn of the century. Pacific black brant are specialist herbivores on *Carex subpathacea* (Hoppner's sedge) during development, where *C. subspathacea* density and quality can affect gosling growth, which subsequently affects pre- and post-fledging survival, as well as adult size and breeding probability as an adult. We used Bayesian mixed-effects models and 1,750 hours of long-term (1987 – 2015) behavioral data to examine shifts in brant behavior during brood-rearing, and examine relationships between gosling behaviors and growth and survival rates. Here we show that locomotion behaviors have increased ($\beta = 0.05$, 95% CRI 0.032 – 0.068) while resting behaviors have decreased ($\beta = -0.024$, 95% CRI -0.041 – -0.007), potentially in response to long-term shifts in forage availability and brood density. Concurrently, gosling growth rates have declined substantially ($\beta = -0.01$, 95% CRI -0.198 – -0.014). These results have important implications for future colony viability, where continued shifts in brood-rearing behavior fail to compensate for reduced forage availability.

Comparing aerial survey and Lincoln estimates of temperate breeding Canada goose abundance in Michigan

Benjamin Z. Luukkonen,* Michigan State University, East Lansing, MI 48824, USA. E-mail: luukkon3@msu.edu
Scott R. Winterstein, Michigan State University, East Lansing, MI 48824, USA. E-mail: winterst@msu.edu

Aerial surveys are commonly used to obtain abundance estimates for waterfowl populations, which are important for modelling population dynamics and setting harvest regulations. Lincoln indices are used to monitor goose abundance, particularly for arctic breeding geese, where it is costly to implement aerial surveys. However, the accuracy of Lincoln indices is rarely compared with other approaches of estimating abundance. Spring aerial surveys have been used to estimate abundance of waterfowl breeding in Michigan, USA since 1991. We used the Lincoln (1930) method to estimate pre-hunting season abundance of Canada geese (*Branta canadensis maxima*) in Michigan using banding and direct recovery data. Our goal was to compare Lincoln estimates to aerial survey estimates. Only direct recoveries obtained in September were used in the analysis because molt migrant Canada geese leave Michigan in late May and early June to molt remiges in the subarctic, return in late September and early October, and therefore are not present during banding. Molt migrant geese are counted in the breeding waterfowl survey but banding occurs after molt migrants have left. Thus, Lincoln estimates provide abundance estimates for Canada geese breeding in Michigan while the breeding waterfowl survey also includes molt migrants. Lincoln estimates were 2.78 times greater for total geese and 1.85 times greater for adults than were the breeding waterfowl survey estimates. Coefficients of variation averaged 15.48 and 13.58 for breeding waterfowl survey estimates and Lincoln estimates of total geese, respectively. Larger Lincoln estimates are expected as hatch year geese are not included in the breeding waterfowl survey. Lincoln estimates provide abundance of adult and hatch year geese as both cohorts are banded while the breeding waterfowl survey occurs before young hatch and only provides an estimate of adult abundance. Results suggest that aerial survey estimates may be biased low, and Lincoln estimates provide more information including estimates of juvenile goose abundance and productivity rates. Lincoln estimates have promise for estimating abundance of difficult to survey waterfowl populations such as arctic breeding geese and may be more cost-effective than aerial surveys for monitoring temperate breeding Canada geese when banding operations are part of annual monitoring programs.

Implementing Lessons Learned from a Century of Goose Research and Management: A Management Plan for Mississippi Flyway Canada Geese

David R. Luukkonen, Michigan Department of Natural Resources and Michigan State University, Department of Fisheries and Wildlife, East Lansing, MI 48823 USA. E-mail: luukkon1@msu.edu
James O. Leafloor, Environment and Climate Change Canada, Canadian Wildlife Service, MB, R3C 4W2, Canada. E-mail: jim.leafloor@canada.ca
Rodney W. Brook, Ontario Ministry of Natural Resources and Forestry, Peterborough, ON, K9L 1Z8, Canada. E-mail: rod.brook@ontario.ca
Kenneth F. Abraham, Ontario Ministry of Natural Resources and Forestry (Emeritus) and Trent University, Environment and Life Sciences Graduate Program, Peterborough, ON, K9L 0G2, Canada. E-mail: ken.abraham@ontario.ca
Frank Baldwin, Wildlife & Fisheries Branch, Sustainable Development, MB, R3J 3W3, Canada. E-mail: frank.baldwin@gov.mb.ca
James R. Kelley, U.S. Fish and Wildlife Service, Bloomington, MN, 55437, USA. E-mail: james_r_kelley@fws.gov

Canada geese (*Branta canadensis*) and cackling geese (*Branta hutchinsii*) were formerly managed under 5 separate management plans in the Mississippi Flyway (MF) based on breeding ground and wintering affiliations, but management of these stocks has now been unified under one management plan approved by the MF Council in 2017. The MF formerly recognized 3 subarctic-breeding Canada goose populations (Eastern Prairie, Mississippi Valley, and Southern James Bay Populations), and historic management and monitoring was successful at recovering and maintaining abundance of these subarctic-breeding geese. Rapid expansion of temperate-breeding Canada geese beginning during the 1990s resulted in unprecedented abundance and harvest as well as escalating conflicts between geese and people, which reduced the imperative to manage subarctic-breeding geese for high harvest potential. Also, mixing of Canada and cackling goose stocks on fall migration and wintering areas reduced effectiveness of harvest zones formerly established to regulate harvest of subarctic-breeding Canada geese during traditional hunting seasons. Special early and late hunting seasons established during the 1990s were effective in creating additional hunting opportunities for temperate-breeding Canada geese, but these additional hunting seasons did not stop population growth. Next, MF Council partners began liberalization experiments during traditional hunting seasons to further increase harvest of temperate-breeding Canada geese while monitoring impacts on subarctic-breeding Canada geese and cackling geese. In addition, the MF Council stabilized regulations long enough (3-5 years) to assess biological and social impacts of regulatory changes. Experience gained from regulation experiments resulted in adoption of harvest rate thresholds for protecting subarctic-breeding Canada geese, which, if exceeded, would trigger discussion and renegotiation of hunting season frameworks if necessary to protect these stocks. The current management plan is intended to provide for unified management of Canada geese that allows for flexibility to adopt simple, liberal, and stable regulations that can enhance long-term benefits of Canada geese to people in the MF. In addition to monitoring distribution and abundance, the plan includes monitoring survival and harvest rates of all goose stocks as well as hunter participation and indices of conflicts between geese and people. Numbers of goose hunters in the MF are declining while conflicts between geese and people are increasing, so hunter participation and indices of conflict between geese and people will be monitored to better understand the human dimensions of goose management for informing future management strategies.

Grit Use by Arctic Geese in the Mississippi Alluvial Valley of Arkansas

B. Cody Martin,* University of Arkansas at Monticello, School of Forestry and Natural Resources, Monticello, AR 71656, USA. E-mail: bcm22830@uamont.edu
Daniel C. Oden, University of Arkansas at Monticello, School of Forestry and Natural Resources, Monticello, AR 71656, USA. E-mail: dco24392@uamont.edu
Ethan R. Massey, University of Arkansas, Division of Agriculture, Arkansas Agricultural Experiment Station, Monticello, AR 71656, USA. E-mail: masseyer@uamont.edu
Lindsay G. Carlson, University of Arkansas, Division of Agriculture, Arkansas Agricultural Experiment Station, Monticello, AR 71656, USA. E-mail: lgcarlson@aggiemail.usu.edu
Callie B. Moore, University of Arkansas, Division of Agriculture, Arkansas Agricultural Experiment Station, Monticello, AR 71656, USA. E-mail: moorecb@uamont.edu
Douglas C. Osborne, University of Arkansas, Division of Agriculture, Arkansas Agricultural Experiment Station, Monticello, AR 71656, USA. E-mail: osborne@uamont.edu

Grit sites are used by waterfowl managers to supplement areas where grit may be limited; however, little is known about optimal grit size for arctic geese. Increasing our understanding of grit use may aid managers in providing grit material of appropriate size when stocking supplemental grit foraging sites. We analyzed gizzard content (n = 176) from greater white-fronted geese (*Anser albifrons*), snow geese (*Anser caerulescens*), and Ross's geese (*Anser rossii*) that were collected during October-February 2016-2017 in the Mississippi Alluvial Valley of Arkansas. Contents of the gizzard were incinerated in a muffle furnace to isolate grit from food items and other organic material. Grit was then sorted into five size classes through a series of sieves, and weighed by granular size class. We used linear models and analysis of variance to test for differences in total grit mass and mass by size classes among species, sex, age, and body size, and other spatial and temporal covariates. We selected the most parsimonious models based on Akaike Information Criteria (AIC) and found geese preferentially selected grit between sizes 0.125–1.000 mm, regardless of species, age, sex, or body size. Total weight of grit differed by species and body size. White-fronts had the largest body size and the greatest total amount of grit, snow geese were similar to white-fronts in body size, but consumed less grit, Ross' had the smallest body size and the least total amount of grit. The best model included an interaction term of species and body size, suggesting that larger birds within the same species still consumed a greater amount of grit than their smaller counterparts. There was a significant difference between age classes for two species however; though juveniles had smaller body sizes than adults, juvenile SNGO and ROGO ingested greater total amounts of grit than adults, though our conclusions are limited by a small sample size of juveniles. Habitat type and dominant food type found in the esophagus was not a predictor of grit size used; therefore, food sources such as rice, corn, grass, and roots do not require different sizes or amount of grit for successful digestion. Additionally, total grit consumption and size selection did not vary over the season; a mean of 6.4 g of grit of sizes ranging from 0.125–1.0 mm was used most often by all species throughout the winter. Waterfowl managers should incorporate this information into the management of grit sites.

Changes in Harvest Rates and Harvest Distribution of Canada Geese Nesting in Northeastern California

Andrea Mott, California Fish and Wildlife, Sacramento, CA 95811, USA. E-mail: almott228@gmail.com
Dan Skalos, California Fish and Wildlife, Sacramento, CA 95811, USA. E-mail: Dan.Skalos@wildlife.ca.gov
Melanie Weaver, California Fish and Wildlife, Sacramento, CA 95811, USA. E-mail: Melanie.Weaver@wildlife.ca.gov

The use of area specific regulations, or "zones", is a common approach for assigning harvest regulations for waterfowl populations. Geese have shown the tendency to change spatial use in winter when hunting seasons occur, creating some difficulty in using zones to manage harvest. In California, Canada geese (*Branta canadensis*) that breed in the northeastern high-desert are considered to be a historic nesting population which is monitored through aerial surveys and band recovery data. Breeding survey estimates of this population have declined by as much as 50% during the 2000s and has caused concern to managers. Our assessment of direct band recoveries shows that harvest rates of this population have nearly doubled from 5% to 10% since the 1990s. Harvest rates in the Northeastern waterfowl management zone (NEZ) have increased from 4% in the mid-1990s to 6% currently. Harvest rates in the Balance of State zone (BOS) increased from 1% to 4% over the same period. Further investigation of all recoveries indicates a shift in harvest distribution from the NEZ to areas in the BOS. Historically, the BOS accounted for 15% of recoveries, which increased to nearly 45% during the 2000s. The NEZ accounted for 75% of total recoveries between 1965 and 1995, which declined to 55% since this time. Concurrently, recoveries from areas outside California declined from 35% in the 1950s to near zero now. Changes in distribution from the NEZ to BOS during winter may account for the increase in harvest rate of this population. Bag limits and season lengths for Canada geese are more liberal in the BOS as populations in this area have expanded considerably. Reasons for changing wintering distribution are not understood as little is known about landscape changes in the range of this population. A more focused study of spatial use and migratory timing may provide managers the information necessary to make adjustments to harvest regulations to reduce harvest rates if need be. Such a study may also shed light on the mechanisms that caused these geese to shift wintering distribution.

Changes in Atlantic brant incubation behavior as a result of increased competition

Clark Nissley,* Waterfowl and Upland Gamebird Research Program, Department of Entomology and Wildlife Ecology, 249 Townsend Hall, University of Delaware, Newark, DE 19713, USA. E-mail: can@udel.edu
Christopher K. Williams, Waterfowl and Upland Gamebird Research Program, Department of Entomology and Wildlife Ecology, 249 Townsend Hall, University of Delaware, Newark, DE 19713, USA. E-mail: ckwillia@udel.edu
Kenneth F. Abraham, Emeritus Research Scientist, Ontario Ministry of Natural Resources & Adjunct Professor, Trent University, Wildlife Research and Monitoring Section, 2140 East Bank Drive, DNA Building Peterborough, ON, Canada K9J 7B8. E-mail: ken.abraham@ontario.ca

Atlantic brant populations are known to fluctuate; however, productivity surveys on the wintering grounds indicate the number of young in flocks has declined in recent decades. This may be indicative of a limitation on the breeding grounds and possible competition with expanding lesser snow geese (*Chen caerulescens caerulescens*) and cackling geese (*Branta hutchinsii*). We studied the interactions occurring between brant, snow geese, and cackling geese on the coast of East Bay, Southampton Island in the summers of 2014 and 2015. We monitored behaviors, time budgets, reproductive success, and foraging habitats where the breeding of these three species overlaps in order to establish if pre-emptive, interference, exploitative, or apparent competition is occurring between the species, thereby reducing brant reproductive success. Using the identified nests, we calculated a proportion of nests within brant homeranges. In 1979, 88.5% of Atlantic brant had at least 2 other brant nests within 200 m of their nest (assumed home-range overlap). By 2010 that number decreased to 18.4% and 13.6% in the 2014, but rebounded slightly to 26.9% in 2015. In contrast, in 1979 only 5% of Atlantic brant had at least 2 or more cackling goose nests within 200 m of their nest. By 2010, that number increased to 46.1% and dipped slightly in 2014 to 40.9% overlap. In 2015, due to the lower number of cackling goose nests, only 16.7% of brant nests included 2 or more cackling goose nests within 200 m. Even though there were a lower number of nesting cackling geese in 2015, we still found 39% of 2014 brant home ranges were occupied by a cackling goose nest (<200 m) showing the strong overlap in preferred habitat. We compared historical brant incubation activity budgets between 1979, 2014, and 2015. Male brant spent less time feeding in 2014 vs. 2015 (23.3% vs. 33.4%) as well as less time engaged in locomotive behaviors (swimming/walking) (1.2% vs. 4.3%). Females were separated into two categories: females on the nest and females off the nest. Females on the nest spent more time alert in 2014 vs. 2015 (17.0% vs. 4.1%). Females on the nest also spent more time engaged in nest construction behavior in 2014 vs. 2015 (2.3% vs. 6.9%). Females off the nest in 2014 vs. 2015 spent less time feeding (73.8% vs. 89.6%) and less time flying (1.4% vs. 0.6%), but more time alert (11.7% vs. 2.9%) and more time preening (5.4% vs. 1.2%).

Breeding Population Trends of Canada Geese in California, 1993 – 2017

Matt Prinzing, California Fish and Wildlife, Sacramento, CA 95811, USA. E-mail: m_prinz@ymail.com
Dan Skalos, California Fish and Wildlife, Sacramento, CA 95811, USA. E-mail: Dan.Skalos@wildlife.ca.gov
Melanie Weaver, California Fish and Wildlife, Sacramento, CA 95811, USA. E-mail: Melanie.Weaver@wildlife.ca.gov

The annual California Department of Fish and Wildlife waterfowl breeding population survey has monitored Canada geese (*Branta canadensis*) since 1993. We used these data to characterize geese into three population segments based on differences in survey strata. We delineated the population in northeastern California, the Central Valley population and the San Francisco Bay – Delta population as being unique groups. For each group, we modeled survey estimates across years and used interaction effects up to $year^6$ to assess nonlinear trends, then ranked models using AIC_c. The Northeastern segment was best fit by the $year^3$ model, indicating cubic patterns of population change between 1993 and 2017. This population averaged 55,418 between 1993 and 2002 and declined by 50% over the next 10 years. This segment has since recovered to a 3-year average of 47,956 and is growing at a rate of 18% per year. The Central Valley segment was best fit by the $year^2$ model and has grown from less than 1000 in the early 1990's to a 3-year average of 11,459. This population is growing at a rate of 3.4% per year. The San Francisco Bay – Delta population was best fit by the year model indicating linear growth. This population segment has increased from less than 1000 to a 3-year average of 3000 and is growing at a rate of 9% per year. Despite the extreme drought events in California's recent history, these populations continue to show positive population growth. It is unclear as to what has caused the recent increase in Northeastern California populations as favorable types of human development are uncommon throughout their range. In the Central Valley and San Francisco Bay – Delta, human development such as small ponds, wastewater treatment facilities and drinking water reservoirs have likely contributed to population growth in these regions, as development has been extensive since 1993. Continued survey monitoring, banding and landscape analysis would likely aid in understanding the recent changes in these populations.

Effects of Season and Sex on Organ Size, Muscle Mass and Esophageal Contents in Wintering Pacific Greater White-fronted Geese

Dan Skalos, California Fish and Wildlife, Sacramento, CA 95811, USA. E-mail: Dan.Skalos@wildlife.ca.gov
John M. Eadie, University of California, Davis, CA 95616, USA. E-mail: jmeadie@ucdavis.edu
Daniel Yparraguirre, California Fish and Wildlife, Sacramento, CA 95811, USA.
E-mail: Daniel.Yparraguirre@wildlife.ca.gov
Shaun Oldenburger, Texas Parks and Wildlife, Austin, TX 78744, USA. Email: Shaun.Oldenburger@tpwd.texas.gov
Melanie Weaver, California Fish and Wildlife, Sacramento, CA 95811, USA. E-mail: Melanie.Weaver@wildlife.ca.gov
Craig Ely, U.S. Geological Survey Alaska Science Center, Anchorage, AK 99503, USA. E-mail: Craig_Ely@usgs.gov
Joseph P. Fleskes, U.S. Geological Survey Western Ecological Research Center, Dixon, CA 95620, USA.
Email: Joe_Fleskes@usgs.gov

Migratory birds exhibit changes in various tissues in relation to seasonal influences. We collected Pacific greater white-fronted geese (*Anser albifrons frontalis*) wintering in California for body composition analysis where we weighed and measured major muscles, organs and extracted esophageal contents to explain dietary characteristics. We modeled effects of collection day from linear to quintic polynomial to explain seasonal changes in organ tissues and diet. We also tested for differences in sexes as geese display sexual dimorphism. For seasonal dietary characteristics, we modeled esophageal dry mass of food contents seasonally, by sex and by food type (cereal grain or green forage). In general, muscle and organ weights were heavier in males than females. We found that muscles (pectoralis and combined leg muscles) and gizzards were lightest upon arrival. Flight muscles enlarged prior to spring migration while leg muscles atrophied, similar to gizzards. Livers were heaviest during periods of high fat content in midwinter and just prior to spring migration in April. Intestinal length (small, large and cecum) decreased from arrival to midwinter then began to increase rapidly as goose diets shifted from cereal grain to green forage. Wet gonadal weights were consistently low throughout the winter until late March, when a rapid increase in the mass of these tissues occurred about one month before breeding migration. Esophageal dry mass declined from October to December and increased from late February thru April. Goose diets consisted of cereal grain from October thru mid-February, then began to shift to green forage. By mid-March goose diets were nearly all green forage. Our study highlights the dynamic nature of tissue fluctuation and diet composition in wintering Pacific greater white-fronted geese.

Range shifts, climate change and human disturbance: predicting impacts on long-distance migratory herbivores

Richard A. Stillman, Department of Life and Environmental Sciences, Bournemouth University, Poole, Dorset, BH12 5BB, United Kingdom. E-mail: rstillman@bournemouth.ac.uk
Ellie M. Rivers, Department of Life and Environmental Sciences, Bournemouth University, Poole, Dorset, BH125BB, United Kingdom. E-mail: riverse@bournemouth.ac.uk
Whelan Gilkerson, Pacific Watershed Associates Inc., PO Box 4433, Arcata, CA 95518-4433, USA.
E-mail: whelang@pacificwatershed.com
Kevin A. Woods, Department of Life and Environmental Sciences, Bournemouth University, Poole, Dorset, BH125BB, United Kingdom. E-mail: woodsk@bournemouth.ac.uk
Duncan Golicher, Department of Life and Environmental Sciences, Faculty of Science and Technology, Bournemouth University, Poole, Dorset, BH12 5BB, United Kingdom. E-mail: golicherd@bournemouth.ac.uk
Bart A. Nolet, Department of Animal Ecology, Netherlands Institute of Ecology (NIOO-KNAW), AA Wageningen, The Netherlands. E-mail: b.nolet@nioo.knaw.nl
Preben Clausen, Department of Bioscience – Wildlife Ecology, Aarhus University, Grenåvej 14, Building 8412, H.146, 8410 Rønde, Denmark. E-mail: pc@bios.au.dk
David H. Ward, U.S. Geological Survey, Alaska Science Center, 4210 University Drive, Anchorage, AK 99508-4626, USA.
E-mail: dward@usgs.gov

Climate change is leading to worldwide shifts in the distribution of biodiversity, and fundamental changes to global animal migrations. Some geese may alter their migration, as warmer temperatures allow them to winter closer to their northern latitude breeding grounds. However, such decisions are not without risks, including the increased energy demands of remaining in colder regions. In this study, we used an individual-based model to predict the effects of environmental change on Black Brant (*Branta bernicula nigricans*) and Taverner's Cackling Goose (*Branta hutchinsii taverneri*) that forage on eelgrass (*Zostera marina*) at the Izembek Lagoon complex in southwest Alaska. Both geese use this site during fall migration, with brant also present in spring and increasingly, over winter. The model predicted that the eelgrass within the site could potentially support a doubling of brant and cackling geese in fall, but no increase of the brant population in winter or spring. Changes in the extent and timing of ice coverage or future changes in sea level rise had only minor effects on the proportion of time feeding or the rates of mass gain. The model was most sensitive to changes in eelgrass abundance. A more than 20% reduction in eelgrass biomass decreased the rate of mass gain of brant in spring, and increased the rate of mass loss of brant in winter and reduced the proportion of winter and spring brant that could successfully emigrate. The increased feeding time during these seasons was not sufficient to compensate for the reduction in consumption rate caused by reduced biomass. We also evaluate the response of goose populations to increase in disturbances within each season and discuss the consequences of these predictions in the face of natural and human sources of change.

Designing a photographic survey to estimate fall population size of black brant at Izembek National Wildlife Refuge

Sarah J. Thompson USGS Alaska Science Center, 4210 University Drive, Anchorage, AK 99508. E-mail: sjthompson@usgs.gov
Paul L. Flint, USGS Alaska Science Center, 4210 University Drive, Anchorage, AK 99508. Email: pflint@usgs.gov
Julian Fischer, USFWS Migratory Bird Management, 1011 E Tudor Road, Anchorage, AK, 99503.
E-mail: Julian_fischer@fws.gov
Dennis Marks, USFWS Migratory Bird Management, 1011 E Tudor Road, Anchorage, AK, 99503.
E-mail: Dennis_marks@fws.gov

Accurate estimation of population size is required for sound management decisions. During fall staging, nearly the entire population of Pacific black brant (*Branta bernicla nigricans*) concentrates at Izembek Lagoon in western Alaska before moving to wintering grounds. Taking advantage of this opportunity, an aerial ocular census has been conducted at Izembek since 1976. However these ocular counts are highly variable both within and among year replicates, resulting in low power to detect trends in population size. High variability may be caused by a number of issues such as bias in flock size estimation, incomplete detection or double counting flocks that move during the survey. To address these biases, an experimental videographic survey was undertaken in 1991, with the goal of comparing results to those generated by the ocular survey conducted in the same year, with limited success. With advances in digital photography and file storage capability, photographic surveys are increasingly practical. We conducted trial surveys in 2016 and 2017 to test equipment and camera settings and to serve as the basis for future survey design parameters. During 2017 trial surveys, more than 10,000 photographs were acquired per replicate using a systematic transect design, covering approximately 12% of the lagoon area. Counts of brant vary from 0 to >700 brant per photo (not all photographs have been processed), with the vast majority of photographs having 0 brant. Within most photographs, brant are clearly visible and can be easily distinguished from other species (e.g. cackling goose [*Branta hutchinsii*]). The goals of our efforts are to assess the feasibility of a photographic survey to estimate brant abundance at Izembek Lagoon, to develop automated/computerized or manual count procedures for photographs, and to compare results of the ocular census to estimates generated by the photographic techniques. Trial surveys will be used to estimate the minimum sample of photographs that would constitute a successful photographic survey, including stratification and optimal sample allocation. We will provide initial estimates of population size for comparison with ocular aerial census counts.

Breeding Ground Affiliation and Non-breeding Distribution of Midcontinent Greater White-fronted Geese Captured during the Non-breeding Period

Jay A. VonBank,* Caesar Kleberg Wildlife Research Institute, Texas A&M University–Kingsville, Kingsville, TX, 78363, USA.
E-mail: jay.vonbank@students.tamuk.edu
Bart M. Ballard, Caesar Kleberg Wildlife Research Institute, Texas A&M University–Kingsville, Kingsville, TX, 78363, USA.
E-mail: bart.ballard@tamuk.edu
Kevin J. Kraai, Texas Parks and Wildlife Department, Canyon, TX, 79015, USA. E-mail: kevin.kraai@tpwd.texas.gov
Mitch D. Weegman, University of Missouri, Columbia, MO, 65211, USA. E-mail: weegmanm@missouri.edu
Daniel P. Collins, U.S. Fish and Wildlife Service Region 2, Albuquerque, NM, 87102, USA. E-mail: dan_collins@fws.gov

Previous research investigating non-breeding distribution and movements of midcontinent greater white-fronted geese (*Anser albifrons frontalis*; hereafter white-fronts) relative to their breeding ground affiliation has primarily relied on banding efforts conducted on breeding areas with subsequent band encounters on wintering areas, and to a lesser extent, on technologically-limited tracking studies. Recent advances in tracking technologies now allow frequent and fine-scale information to be gathered remotely. We deployed Global Positioning System tracking devices using Global System for Mobile communication (GSM) technology to determine breeding ground affiliation and non-breeding distribution of midcontinent white-fronts. We captured white-fronts in three regions of Texas in 2016-2017: the Rolling Plains, South Texas Brush Country, and Lower Texas Coast. We modeled non-breeding distribution of white-fronts (n = 37) using dynamic Brownian Bridge movement modelling based on 60,615 GPS locations, spanning 1,424 goose-days, collected 25 October – 28 February, 2016–2017. We then gathered location information during summer from 13 AHY female and 3 AHY male white-fronts to determine breeding ground affiliation. We grouped individuals into four breeding ground affiliations: North Slope (n = 7), Western Nunavut/Northwest Territories (n=5), Central Nunavut (n = 3), and Interior Alaska (n = 1). We summed individual movement distributions by breeding ground affiliation, and found that individuals from each breeding ground affiliation spent time in several wintering regions, including the Mississippi Alluvial Valley, Texas/Louisiana Chenier Plain, Texas Gulf Coast, Rolling Plains, and South Texas Brush Country, revealing a high degree of admixture on wintering areas among breeding affiliations. White-fronts captured in the Rolling Plains summered in Interior and North Slope Alaska, Western Nunavut/Northwest Territories, and Central Nunavut, Canada. White-fronts captured in the South Texas Brush Country and Lower Texas Coast regions summered in the Northwest Territories and Nunavut, similar to white-fronts that were marked in the Rolling Plains. As the non-breeding distribution of white-fronts is perceived to have shifted northeastward into the Mississippi Alluvial Valley, we continue to see large-scale movements of white-fronts from several breeding grounds among wintering regions, which may have implications for future management strategies for white-fronts.

Tracking trends in light goose abundance on Louisiana coastal wildlife refuges using aerial waterfowl surveys

James M. Whitaker, Louisiana Department of Wildlife and Fisheries, Rockefeller Wildlife Refuge, Grand Chenier, Louisiana 70643. E-mail: jwhitaker@wlf.la.gov

Joseph R. Marty, Louisiana Department of Wildlife and Fisheries, Rockefeller Wildlife Refuge, Grand Chenier, Louisiana 70643. E-mail: jmarty@wlf.la.gov

Lesser snow geese (*Anser caerulescens*) historically wintered in the Central Valley in California and coastal Louisiana and Texas. Recent evidence from Louisiana's mid-winter waterfowl surveys suggest that fewer light geese (e.g., lesser snow geese and Ross's geese [*A. rossii]*) and fewer dark geese (e.g., Greater white-fronted geese [*A. albifrons*]) are overwintering in the coastal marshes of Louisiana. We analyzed 12 years (2004-2016) of coastal refuge aerial survey data from four coastal Louisiana state-owned wildlife refuges including Marsh Island Refuge, State Wildlife Refuge, White Lake Wetlands Conservation Area, and Rockefeller Wildlife Refuge to investigate long term trends in light goose abundance. Total light goose abundance on Marsh Island Refuge decreased 99% from approximately 20,700 geese (SE= ±9,257) in 2004 to 133 geese (SE= ±77) in 2016. On State Wildlife Refuge, total light goose abundance decreased 88% from approximately 34,000 geese (SE= ±15,205) in 2004 to 4,050 geese (SE= ±2,338) in 2016. Total light goose abundance on White Lake Wetlands Conservation Area decreased 86% from 5,750 geese (SE= ±2,875) in 2004 to 833 geese (SE= ±481) in 2016. On Rockefeller Wildlife Refuge, light goose abundance increased 1,700% from 128 geese (SE= ±64) in 2004 to 2,300 geese (SE= ±1,328) in 2016. Light goose abundance on three of the four state-owned wildlife refuges, declined precipitously over the past 12 years. Coastal marsh land loss, increased salinities, shoreline erosion, and warmer winters; coupled with anthropogenic changes (e.g., increased rice production) may help explain the decline in light goose abundance in Louisiana coastal marsh habitats. We believe that light geese may alternatively be utilizing riceland habitats in the Mississippi Alluvial Valley because of the high energy food resources that rice and moist-soil seeds provide for migrating and wintering waterfowl.

Notes

Notes