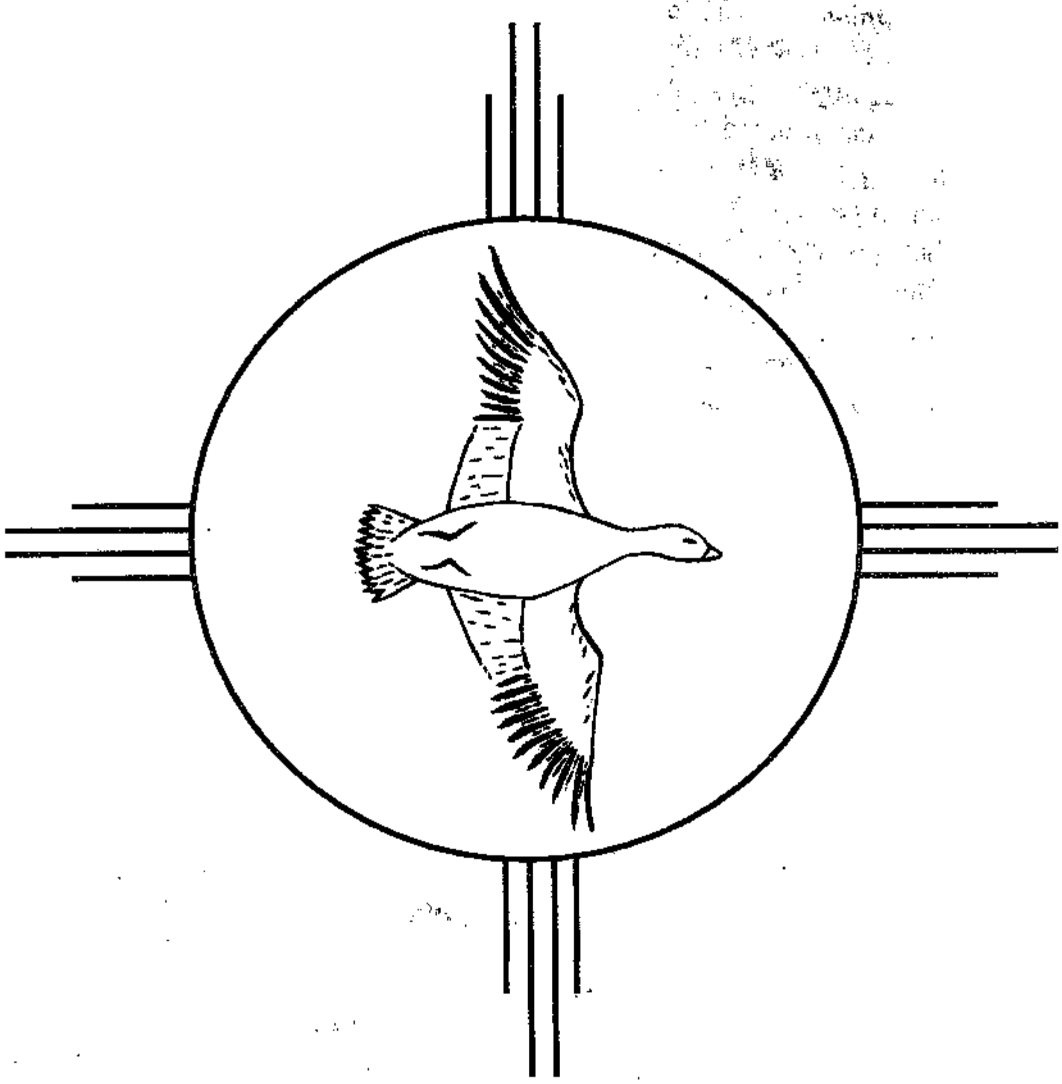
SHERATON OLD TOWN - ALBUQUERQUE, NEW MEXICO

8TH NORTH AMERICAN ARCTIC GOOSE CONFERENCE AND WORKSHOP

JANUARY 9-14, 1995



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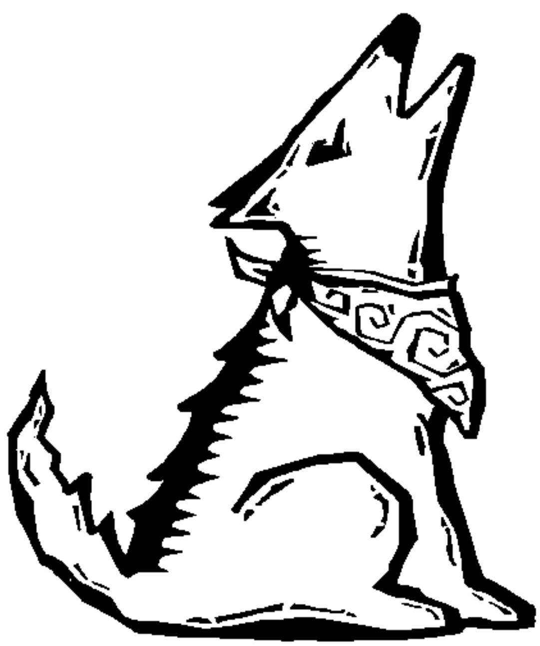
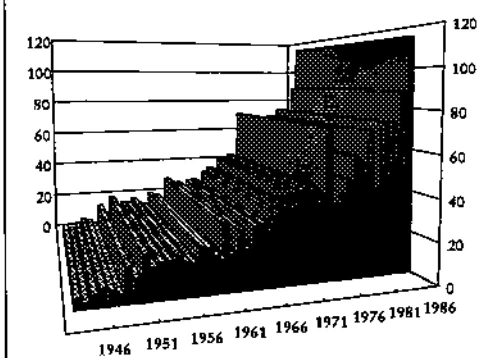


8TH NORTH AMERICAN ARCTIC GOOSE CONFERENCE AND WORKSHOP

WELCOME TO ALBUQUERQUE!

We would like to take this opportunity to formally welcome you to the 8th North American Arctic Goose Conference & Workshop! Beginning with the 7th conference held in 1992 in Vallejo, California, the Conference has considerably expanded its scope, both in terms of species represented, and the aspects of goose biology and management discussed.

The growth of interest in the biology and management of arctic-nesting geese since the 1940's has been extraordinary, throughout the northern hemisphere. The number of papers in the primary scientific literature on some aspect of the biology or management of arctic-nesting geese has grown exponentially, with approximately 90-110 papers being published annually in recent years. These papers range in subject from fundamental measures of variation in reproductive output, to recent advances in satellite telemetry and analysis of population genetic structure using new molecular techniques. Given the measurable energy and dedication of the many people currently involved with arctic-nesting geese, there is little reason to expect this general trend to change in the foreseeable future.



Number of arctic-goose papers by year

Plenary Speakers

Dr. Jeff Black
Wildfowl & Wetlands Trust
Slimbridge, Gloucester, England

Dr. Dave Ankney
University of Western Ontario
London, Ontario, Canada

Dr. Bob Jefferies
University of Toronto
Toronto, Ontario, Canada

Dr. Jim Sedinger
University of Alaska
Fairbanks, Alaska, USA

Dr. Robert Rockwell
American Museum of Natural History
New York, New York, USA

Dr. Don Rusch
University of Wisconsin
Madison, Wisconsin, USA

Traditionally, emphasis in North America has been on basic biology of geese on the breeding grounds, and enumeration and management of geese in the winter. However, it is increasingly clear that real understanding of the biology and management of goose populations requires a broader perspective, equally concerned with both breeding and wintering ecology. The 8th edition of the Arctic Goose Conference has been structured to reflect this philosophy, and our invited plenary speakers and workshop participants were selected to give as broad a representation as possible of the different and equally important aspects of goose biology.

It is our sincere hope that the paper and poster presentations, in conjunction with several practical workshops, will continue the significant broad scale interactions between waterfowl managers and research scientists initiated in Vallejo in 1992.

Conference Staff

Honorary Chairperson

Graham Cooch
Department of Fisheries & Wildlife Sciences
New Mexico State University

Chairpersons

John Taylor
US Fish & Wildlife Service
Bosque Del Apache NWR

Evan Cooch
Department of Biological Sciences
Simon Fraser University

Scientific Program

Evan Cooch (Chair)
Simon Fraser University

Ray Alisauskas
Canadian Wildlife Service

Gilles Gauthier
Laval University

Robert Rockwell
American Museum of Natural History

Workshops

Field Appraisals Workshop

Alex Dzubin
Saskatoon, Saskatchewan

Rod Drewien
US Fish & Wildlife Service

Survival Workshop

Jim Nichols (Chair)
National Biological Survey

Ken Pollock
North Carolina State University

Doug Johnson
Northern Prairie Wildlife Research Center

Bill Kendall
US Fish & Wildlife Service

Paul Flint
National Biological Survey

Management Policy Roundtable

Graham Cooch (Chair)
New Mexico State University

Dale Caswell
Canadian Wildlife Service

Fred Johnson
Migratory Bird Management Office

Bob Trost
Migratory Bird Management Office

Dick Kerbes
Canadian Wildlife Service

Local Organizers

Shirley Ensminger
US Fish & Wildlife Service
Bosque del Apache NWR

Terri Jones
US Fish & Wildlife Service
Bosque del Apache NWR

Peggy Mitchusson
US Fish & Wildlife Service
Bosque del Apache NWR

Mike Oldham
US Fish & Wildlife Service
Bosque del Apache NWR

Terry Tadano
US Fish & Wildlife Service
Bosqeu del Apache NWR

Field Trips

Don Ensminger
US Fish & Wildlife Service
Bosque del Apache NWR

Mike Gustin
New Mexico Dept. Fish & Game
Bernardo Waterfowl Manage. Area

Alberto Lafon
Universidad Autonoma de Chihuahua
Facultad de Zootecnia

Leroy Saavedra
US Fish & Wildlife Service
Bosque del Apache NWR

Mike Schwitters
Shoteau, Montana

Receptions/Luncheons/Banquets

Joan Cooch
Las Cruces, New Mexico

David Leal
US Fish & Wildlife Service
Albuquerque, New Mexico

Vendors

Jeff Honker
Southwest Natural & Cultural Heritage Assoc.
Albuquerque, New Mexico

Millie Kinser
Friends of Bosque del Apache NWR, Inc
San Antonio, New Mexico

Mexican Affairs

Sonja Najera
US Fish & Wildlife Service
Bitter Lake NWR

SPONSORS

It is probably unnecessary to point out that a scientific meeting of this magnitude would not be successful without the generous financial support of our sponsors (listed on the front cover), particularly in these times of growing fiscal constraint. We thank them all, and are confident that the increased interaction amongst old colleagues and new collaborations precipitated by this meeting will serve as ample evidence of solid investments.

The organizers of the 8th North American Arctic Goose Conference and Workshop would like to make special thanks to the members of the Management Board of the Arctic Goose Joint Venture (AGJV), who graciously accepted the significant burden of both initial direct funding to aid us in meeting early infrastructural costs, and with subsequent efforts at facilitating further fund-raising. Many of those sponsors noted below were arranged through the efforts of the AGJV. We would like to thank the members of the Management Board collectively for their generous support.

In recognition of the role played by the AGJV, both in fund-raising for this meeting and in coordinating funding for several new research programs, we have arranged a Special Session to open the proceedings, during which members of the AGJV Management and Scientific Committees will make presentations concerning the specific roles the AGJV is playing in current goose research, and discussion of future directions. It is clear that the AGJV, under the larger framework of the North American Waterfowl Management Plan (NAWMP), is positioned to play an increasingly important role in facilitating our understanding of the biology and management of Arctic-nesting geese, and the presentations in this Special Session will serve to make all people interested in Arctic-nesting geese more fully aware of their role.

North American Waterfowl Management Plan

Plan nord-américain de gestion de la sauvagine

Plan de Manejo de Aves Acuáticas de Norteamérica

GENERAL INFORMATION

Information

Welcome to the 8th North American Arctic Goose Conference & Workshop! The Conference Staff are here to help you. If you have any questions regarding any aspect of the Conference, do not hesitate to ask one of our volunteer staff members. The Conference Staff will be wearing special designation ribbons identifying them.

Registration

Registration will be held in the hotel lobby, 10 January from 4:00 PM to 8:00 PM, 11 January from 8:00 AM to 7:00 PM, and 12 January from 7:00 AM to 10 AM January. An information table will be staffed 13 January, from 8 AM - 7 PM, and 14 January, from 8 AM - 4 PM.

Name Tags

Your name tag is your pass for admittance to all activities at the hotel and must also be presented for service at luncheon buffets. Separate banquet tickets will be issued to those registered for this event for admittance to the New Mexico Museum of Natural History.

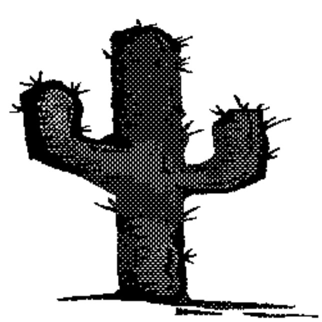
Events and Facilities

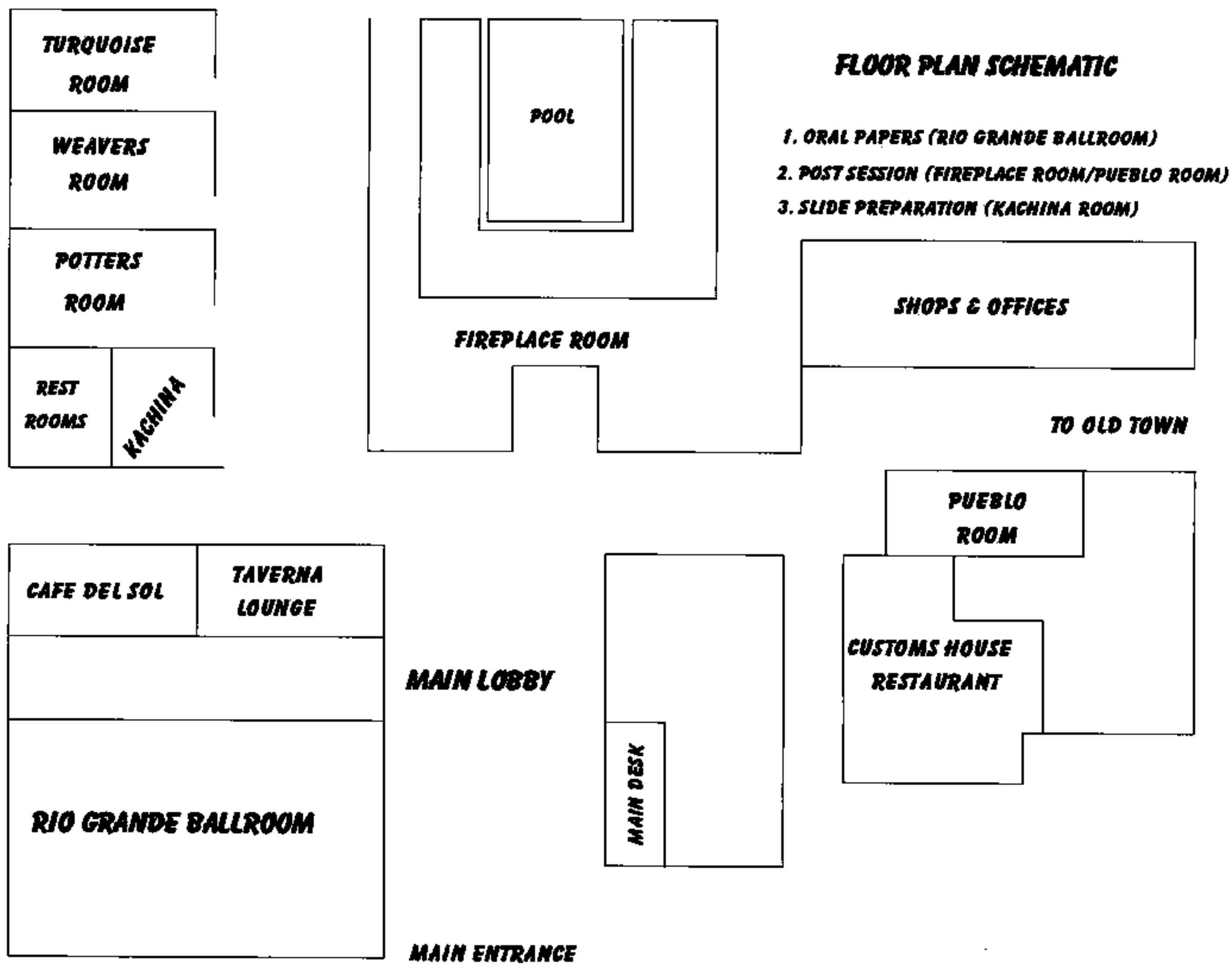
Please see the Schedule of Events on the following pages for specific times of events. A map of the Sheraton Old Town Hotel is included for your convenience. Paper sessions and workshops will be held in the Rio Grande Ballroom. Posters will be set up in the Fireplace Room for viewing on 12 and 13 January. The Opening Reception and the Poster Session reception will be held in the Pueblo Room.

Field Trips

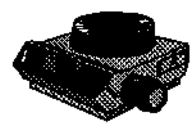
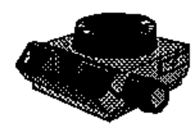
The Middle Rio Grande Valley Field Trip is scheduled for 11 January and will leave the hotel by chartered bus promptly at 8:00 AM, and return to the hotel at 6:00 PM. A luncheon will be served at the Bosque del Apache NWR. Persons attending this event must be registered.

The Mexican Highlands post-conference field trip is scheduled for 15 to 19 January. Departure from the hotel is at 7:00 AM on the 15th, returning to the hotel after 5:00 PM on the 19th. Persons attending this event must be registered.




FLOOR PLAN SCHEMATIC
1. ORAL PAPERS (RIO GRANDE BALLROOM)
2. POST SESSION (FIREPLACE ROOM/PUEBLO ROOM)
3. SLIDE PREPARATION (KACHINA ROOM)
TURQUOISE ROOM
WEAVERS ROOM
POTTERS ROOM
REST ROOMS
KACHINA
POOL
FIREPLACE ROOM
SHOPS & OFFICES
TO OLD TOWN
PUEBLO ROOM
CAFE DEL SOL
TAVERNA LOUNGE
MAIN LOBBY
CUSTOMS HOUSE RESTAURANT
MAIN DESK
RIO GRANDE BALLROOM
MAIN ENTRANCE

OVERVIEW OF MEETING SCHEDULE

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	9 Field Appraisals Workshop	**10** Field Appraisals Workshop	**11** Rio Grande Trip and General Registration *Opening Reception*	**12** Formal Session 1 	**13** Formal Session 2 	**14** Formal Session 3 
15 Meeting Close Mexican Highlands Trip (Departure)	**16** Mexican Highlands Trip	**17** Mexican Highlands Trip	**18** Mexican Highlands Trip	**19** Mexican Highlands Trip (Return)		

OVERVIEW OF FORMAL SESSION

Thursday (January 12)	Friday (January 13)	Saturday (January 14)
Special Session AGJV Presentation	*Plenary 3 (Sedinger)*	*Plenary 5 (Rockwell)*
<<break>>	Paper Session 3	Paper Session 5
Plenary 1 (Black)	*<<break>>*	*<<break>>*
Paper Session 1	Paper Session 3	Paper Session 5
Lunch	*Lunch*	*Lunch*
Plenary 2 (Ankney)	*Plenary 4 (Jefferies)*	*Plenary 6 (Rusch)*
Paper Session 2	Paper Session 4	Paper Session 6
<<break>>	*<<break>>*	***Closing Banquet***
Paper Session 2	Management Policy Roundtable	
Dinner / Survival Workshop	Dinner / Poster Session	

Thursday, January 12 - (Morning)

8:00 - 8:15 **Welcome and Introductions** - North American Arctic Goose Conference co-chairs, **John Taylor** (US Fish & Wildlife Service) and **Evan G. Cooch** (Simon Fraser University).

*** SPECIAL SESSION ***

8:15 - 9:45 ***Arctic Goose Joint Venture***

Gerry McKeating & Paul Schmidt - *History of the Development of the AGJV*

Kevin McCormick - *Native land claims in Canada and the AGJV*

Bob Trost & Dale Caswell - *Integration of science and management - what role for the AGJV?*

Paul Schmidt - *Future directions for the AGJV*

9:45 - 10:00 *<<<Break>>>*

10:00 - 10:45 **Plenary Session 1** - Dr. Jeff Black (Wildfowl & Wetlands Trust, United Kingdom)

Do Arctic Geese Benefit from Life-long Monogamy?

Paper Session 1 - Migratory & Wintering Ecology

Chair: *Sean Boyd, Canadian Wildlife Service*

10:45 - 11:00 **Choudhury, Sharmila & Jeff Black.** Divorce in Barnacle Geese: causes and consequences.

11:00 - 11:15 **Dahl, Ann, Christian Grue & David Manuwal.** Habitat use by Aleutian Canada Geese on wintering areas in central California.

11:15 - 11:30 **Robertson, Donna & Jerry Hupp.** Lesser Snow Goose habitat use and distribution during fall staging: a landscape level perspective.

11:30 - 11:45 **Takekawa, John, Dennis Orthmeyer, Masayuki Kurechi, Yutaka Sabano & Craig Ely.** Migration ecology of Greater White-fronted Goose populations along the north Pacific rim.

11:45 - 12:00 **Goudie, Ian, & Sean Boyd.** Residency and interchange of Brant during spring staging in coastal British Columbia.

12:00 - 12:15 **Sabano, Yutaka, Sachiko Uemura, Masayuki Kurechi, Alexandar Andreyev, Alexandar Kondratyev, Evgeny Syroechkovsky, Kostantine Litvin, Vasily Baranyuk, John Takekawa & Dennis Orthmeyer.** Restoration of Lesser Snow Geese to east Asia, an International Conservation Project.

12:15 - 1:15 *<<<lunch break>>>*

Friday, January 13 - (Morning)

8:20 - 8:30 **Morning Announcements**

8:30 - 9:15 **Plenary Session 3** - Dr. James Sedinger (University of Alaska - Fairbanks)

Environmental Conditions During the Growth Period Influence Future Fitness in Geese

Paper Session 3 - Post Hatch Ecology
Chair: *Paul Flint - National Biological Survey*

9:15 - 9:30 **Loonen, Maarten, Leo Bruinzeel & Rudi Drent.** Behavior and growth is directly influenced by family size: a manipulation experiment in Barnacle Geese.

9:30 - 9:45 **Lepage, Denis, Gilles Gauthier & André Desrochers.** Clutch manipulation in Greater Snow Geese: the causal relationship between hatch date, brood size and pre-fledging growth.

9:45 - 10:00 **Lesage, Louis & Gilles Gauthier.** Effect of hatch date and brood-rearing site on growth pattern and organ development in Greater Snow Geese.

10:00 - 10:15 **Slattery, Stuart & Ray Alisauskas.** Effect of fresh egg mass on gosling growth and survival in Ross and Lesser Snow Geese.

10:15 - 10:30 **Hill, Michael, C. Davison Ankney & James Leafloor.** Growth and condition of southern James Bay Canada Goose goslings on Akimiski Island, Northwest Territories.

10:30 - 10:45 <<<*Break*>>>

10:45 - 11:00 **Cooch, Evan, David Lank, Raleigh Robertson & Fred Cooke.** The cost of being larger: natural selection on sexually dimorphic growth in Lesser Snow Geese.

11:00 - 11:15 **Reed, Austin & Nathalie Plante.** Longterm decline in body mass, size and condition of Greater Snow Geese at a fall staging area.

11:15 – 11:30 **Fowler, Ada & Craig Ely.** Timing of molt in breeding adult Cackling Canada Geese on the Yukon-Kuskokwim Delta, Alaska.

11:30 - 11:45 **Gillespie, Murray, Andrew Didiuk & Donald Rusch.** Distribution and origin of non-breeding and nest-failed Canada Geese in northern Manitoba.

11:45 - 12:00 **Syroechkovsky, Evgeny, Kostatin Litvin & Elena Gyrtovaya.** Nesting ecology of geese and swans in the Novaja Zemlja region.

12:00 - 1:00 <<<*lunch break*>>>

Thursday, January 12 - (Afternoon)

1:15 - 2:00 **Plenary Session 2** - Dr. Dave Ankney (University of Western Ontario, Canada)

The Role of Nutrient Reserves in Reproduction by Arctic Geese

Paper Session 2 -Nesting & Breeding Ecology

Chair: *Jerry Hupp, National Biological Survey*

2:00 - 2:15 **Alisauskas, Ray**. Relation of continental productivity by Arctic geese to spring nutrition in prairie Canada.

2:15 - 2:30 **Bromley, Robert, Bruno Croft & Ray Bethke**. Pre-nesting behavior of White-fronted and Canada Geese in the central Canadian Arctic, 1990-1993.

2:30 - 2:45 **Afton, Alan, Delia Person & Ray Alisauskas**. Pre-hatch feeding by Ross and Lesser Snow Geese in a mixed breeding colony: the body size hypothesis.

2:45 - 3:00 **Carrière, Suzanne, Gilles Gauthier & Robert Bromley**. Spring feeding strategies of sympatric Canada and White-fronted Geese nesting in the central Canadian Arctic.

3:00 - 3:15 **Ganter, Barbara & Fred Cooke**. Nutrient acquisition, timing of breeding and clutch size in Lesser Snow Geese.

3:15 - 3:30 *<<<break>>>*

3:30 - 3:45 **Cooch, Evan, David Lank, Robert Rockwell & Fred Cooke**. Body size and breeding-propensity in Snow Geese: do runts wimp out?

3:45 - 4:00 **Gauthier, Gilles, Denis Lepage & Austin Reed**. Site infidelity in nesting Greater Snow Geese.

4:00 - 4:15 **Tremblay, Jean-Pierre, Gilles Gauthier, Denis Lepage & Andre Desrochers**. Relationship between nest site characteristics and nesting success in Greater Snow Geese.

4:15 - 4:30 **Eichholz, Michael, & James Sedinger**. Nutrient reserves and nest attentiveness of incubating Black Brant.

4:30 - 4:45 **Tombre, Ingunn & Kjell Einar Erikstad.** Breeding investment in Barnacle Geese: a manipulation of the reproduction costs.

4:45 - 5:00 **Bousfield, Marjorie**. Just how facultative is nest parasitism in Snow Geese?

7:30 - 10:00 ***Survival Workshop***
(Rio Grande Ballroom)

This workshop, conducted by several leading researchers, will discuss recent advances in theory and methodology of analysis of survival, including (a) estimation when their is non-independence among individuals, (b) movement/multi-state models, and (c) combining open and closed estimators. Basic familiarity with the concepts of mark-recapture analysis and other forms of estimation will be assumed.

Friday, January 13 - (Afternoon)

1:00 - 1:45 **Plenary Session 4** - Dr. Bob Jefferies (University of Toronto, Canada)

Multiple Stresses and Multiple Responses:
The Effects of a Large Scale Trophic Cascade
on the Resilience of Hudson Bay
Coastal Ecosystems

Paper Session 4 - Goose/Plant Interactions

Chair: *Craig Ely, National Biological Survey*

1:45 - 2:00 **Boyd, Sean.** Interaction between Lesser Snow Geese and three-square bulrush (*Scirpus americanus*) on the Fraser and Skagit River deltas.

2:00 - 2:15 **McWilliams, Scott.** Geese as small herbivores: digestive constraints and diet selection in spring-migrating geese.

2:15 - 2:30 **Beaulieu, Julien, Gilles Gauthier & Line Rochefort.** Growth responses of plants to goose grazing in a high Arctic environment.

2:30 - 2:45 **van der Wal, René.** Herbivore competition along a productivity gradient.

2:45 - 3:00 **Hupp, Jerry, Robert White, James Sedinger & Donna Robertson.** Retention time of forage, forage intake, and fecal output in Lesser Snow Geese.

3:00 - 3:15 **Kempka, Richard, Barbara Maurizi, Daniel Logan, Donald Youkey & Fritz Reid.** Utilizing spot multispectral imagery to assess wetland vegetation succession in the Copper River Delta, Alaska.

3:15 - 3:30 **Didiuk, Andrew, Robert Ferguson, Robert Jefferies & Dale Caswell.** Use of LANDSAT satellite imagery to map Lesser Snow Goose foraging habitat and to detect habitat degradation.

3:30 - 3:45 *<<<break>>>*

3:45 - 6:00 ***Goose Management Roundtable***
(Rio Grande Ballroom)

In general, management is often most visibly concerned when their are "too few" individuals of a particular species. However, the massive increases in numbers of some species, particularly in mid-continent North America, suggests that we may need to focus more broadly on the question of goose management: can there be too many geese? What should we do? How did we get here? This "round-table" discussion will begin with brief presentations by the organizers on past and present management policy, followed by discussion of new approaches to adaptive management. These presentations will be followed by a general public discussion.

7:30-9:30 ***Poster Session***
(Pueblo Room)

Friday, January 13 - (Poster Session)

1. **Orthmeyer, Dennis, & John Takekawa.** Habitat preferences for Greater White-fronted Geese in the Sacramento Valley, California.

2. **Mensik, Greg & Joseph Silveira.** Status of Ross' and Lesser Snow Geese wintering in Califronia, December 1992.

3. **Sullivan, Brian.** Breeding ground affiliation of Greater White-fronted Geese harvested in the Central and Mississippi flyways.

4. **King, Rodney.** Spring and fall distribution of Emperor Geese in southwest coastal Alaska.

5. **Schwitters, Michael.** Migrations of Arctic geese through Freezout Lake Wildlife Management Area, Montana.

6. **Boyd, Sean.** Abundance and distribution patterns of Lesser Snow Geese on the Fraser and Skagit river deltas.

7. **Ivey, Gary, Martin St. Louis & Bradley Bales.** Importance of southeast Oregon wetlands as migrational staging areas for Arctic geese.

8. **Gawlik, Dale & Doug Slack.** Effects of predation and competition on population and flock dynamics of wintering geese in Texas.

9. **Blouin, François, Jean-François Giroux, Jean Ferron, Gilles Gauthier & Jean Doucet.** Tracking the fall migration of Greater Snow Geese using satellute telemetry.

10. **Shimada, Tetsuo, Masayuki Kurechi, Nikolay Gerasimov, Alexander Andreev, Alexander Kondratyev, John Takekawa & Dennis Orthmeyer.** Migration of Anser fabalis and Anser albifrons in north-east Asia, with special reference to the population wintering in Japan.

11. **Baranyuk, Vasily.** The distribution of two subpopulations of Wrangel Island Snow Geese at the breeding and molting grounds.

12. **Kuznetsov, Sergei & Vasily V. Baranyuk.** The genetic differences between two subpopulations of Lesser Snow Geese nesting on Wrangel Island, Russia.

13. **Kostin, Igor & Johan Mooij.** Taymyr Peninsula White-fronted Geese: Population status, migratory routes, and wintering area.

14. **Hughes, Jack, Austin Reed, Linda Rancourt & Renée Bergeron.** Breeding ecology of Canada Geese near a newly created hydroelectric reservoir in northern Québec, 1992-1994.

15. **Bon, Ray & Ray Alisauskas.** Mass change in Ross' Geese during spring migration and nesting.

16. **Spaans, Bernard & Barwolt S. Ebbinge.** Brent Geese: The importance of body-reserves accumulated in the temperate zone for breeding in the high Arctic.

17. **Croft, Bruno & Ray Alisauskas.** Spring nutrient reserves of Small Canada Geese nesting in the central Canadian Arctic.

18. **Wilson, Deborah & Robert Bromley.** Alternative mechanisms linking lemmings and geese via shared populations.

19. **Armstong, Terry.** Antipredator strategies of Black Brant and Lesser Snow Geese.

Friday, January 13 - (Poster Session)

20. **Babcock, Christopher & Roger Ruess.** Patterns in soil respiration and nitrogen mineralization rates among salt-marsh forage plant communities across a coastal floodwater gradient in western Alaska.

21. **Abraham, Ken, Dale Humburg, Robert Jefferies & Robert Rockwell.** Distribution of Lesser Snow Goose nesting in southern Hudson Bay and its relation to forage plants.

22. **Jano, Andrew.** Vegetation change detection by multi-temporal analysis of LANDSAT MSS data.

23. **Skinner, Walter.** Recent climatic variability of importance to Arctic coastal ecosystems.

24. **Rockwell, Robert, Megan Owen, Paul Matulonis, Alex Dzubin, Robert Jefferies & Fawziah Gadallah.** Size, body condition and survival of Lesser Snow Geese on the southwest coast of Hudson Bay.

25. **Ganter, Barbara & Fred Cooke.** Individual philopatry and colony dynamics in a changing habitat.

26. **Lindberg, Mark, James Sedinger & Eric Rexstad.** Brood site fidelity of Black Brant, Tutakoke Rover, Alaska.

27. **Fowler, Ada & Craig Ely.** Timing of molt in breeding adult Cackling Canada Geese on the Yukon-Kuskokwim delta, Alaska.

28. **Ward, David, Eric Rexstad, James Sedinger & Neil Dawe.** Seasonal and annual survival of adult Black Brant.

29. **Smith, Art & Don Rusch.** Effects of violating the instantaneous sampling assumption on Jolly-Seber estimates.

30. **Schmutz, Joel, Margaret Peterson & Robert Rockwell.** Modeling the population dynamics of Emperor Geese.

31. **Syroechkovsky, Evgeny, Kostantin Litvin & Vasily Baranyuk.** Parameters used in Wrangel Island Snow Goose population monitoring.

32. **Strong, Laurence & Robert Trost.** Forecasting production of Arctic nesting geese by monitoring snow melt phenology with advanced Very High Resolution Radiometer Images.

33. **Butler, William, John Krouse, Robert Stehn & William Eldridge.** Nest numbers and aerial surveys: management tools for monitoring Dusky Canada Geese.

34. **Butler, William, Margaret Peterson & Robert Stehn.** Fall age ratio and annual production of Emperor Geese.

35. **Gerasimov, Nikolay & Masayuki Kurechi.** Prospects and problems for the restoration of Aleutian Canada Geese in Asia.

Saturday, January 14 - (Morning)

8:20 - 8:30 **Morning Announcements**

8:30 - 9:15 **Plenary Session 5** - Dr. Robert Rockwell (American Museum of Natural History)

Genetic Structure and Gene Flow - An Examination of Approaches

Paper Session 5 - Population Structure & Dynamics

Chair: *John Takekawa, National Biological Survey*

9:15 - 9:30 **Ely, Craig, Christopher Babcock & Ada Fowler.** Natal philopatry and sex-biased dispersal patterns in cackling Canada Geese.

9:30 - 9:45 **Johnson, Steve.** Immigration in a small colony of Lesser Snow Geese.

9:45 - 10:00 **Balogh, Gregory William Butler & Robert Stehn.** Geographic distribution and change in density of nesting geese on the Yukon-Kuskokwim Delta coast, Alaska, from 1985 to 1994.

10:00 - 10:15 **Hines, James & Richard Kerbes.** Survival of Lesser Snow Geese in the Pacific Flyway, 1986-1989.

10:15 - 10:30 **Turner, Bruce & Dick Kerbes.** Something about movement of Snow Geese.

10:30 - 10:45 *<<<Break>>>*

10:45 - 11:00 **Brault, Solange & Evan Cooch.** Demographic effects of density changes in Lesser Snow Geese.

11:00 - 11:15 **Ebbinge, Barwolt & Bernard Spaans.** The role of predators in determining nesting distribution of dark-bellied Brent Geese.

11:15 - 11:30 **Thompson, Jonathan, Michael Hill & C. Davison Ankney.** Skeletal maturation in Canada Geese: improving use of morphometric models for subspecific discrimination.

11:30 - 11:45 **Cathey, James, Loren Smith & Robert Baker.** Using microsatellite DNA to delineate the natal origin of Canada Geese.

11:45 - 12:00 **Baker, Alan & Gerald Shields.** Mitochondrial DNA control sequences and their use as markers in distinguishing subspecies of Canada Geese.

12:00 - 12:15 **Tegelström, Håkan & Göran Sjöberg.** Genetic consequences of the introduction of a small number of Canada Geese to Sweden.

12:15 - 1:15 *<<<lunch break>>>*

Saturday, January 14 - (Afternoon)

1:15 - 2:00 **Plenary Session 6** - Dr. Don Rusch (University of Wisconsin - Madison)

Adaptive Nature of Research and Management of North American Geese

Paper Session 6 -Science & Management

Chair: *Doug Slack, Texas A&M University*

2:00 - 2:15 **Leafloor, James, Ken Abraham & Donald Rusch.** Molt migration of Canada Geese and the interpretation of band recoveries.

2:15 - 2:30 **Smith, Arthur & Donald Rusch.** Environmental correlates of changes in band recovery distributions of SJBP.

2:30 - 2:45 **Walter, Scott & Donald Rusch.** Visibility bias on counts of nesting Canada Geese.

2:45 - 3:00 **Reed, Austin.** Interactions between Greater Snow Geese and their staging habitats in the St. Lawrence River: implications for developing management strategies.

3:00 - 3:15 **Ray, James** Populations, harvests and breeding ground affiliation of geese wintering in the high plains and rolling plains of Texas.

3:15 - 3:30 **Lobries, David & Todd Merendino.** The Rice Prairie Management Plan: a cooperative effort to address the needs of waterfowl and agriculture.

3:30 - 3:45 **West, Robin & Tom Rothe.** Managing subsistence harvest of Arctic Geese in Alaska.

3:45 - 4:00 *Closing Statement* - **E.G. Cooch**

6:00 - 10:00 ***Closing Banquet***

ABSTRACTS

Contributed papers

Abstracts are arranged alphabetically by first author (with the exception of Plenary Abstracts, which are listed in order of presentation).The abstracts were reformatted but otherwise printed as provided by the authors, except for minor editing for style and syntax. Information contained herein should NOT be cited without first obtaining author approval.

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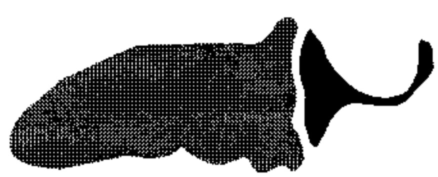

Do Arctic Geese Benefit from Life-long Monogamy?

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Previous work from two long-term goose projects have shown that there is a serious cost to losing a mate and pairing with a new one. From the Lesser Snow Goose *Anser c. caerulescens* project, Cooke et al (1981) were the first to show that clutch size was smaller in new pairs compared to previously established pairs. Similarly, Owen et al. (1988) showed that it took 2 years for new Barnacle Goose *Branta leucopsis* partners to match the reproductive performance of the average "population" value, and calculated that each mate change cost 15% of a birds potential lifetime productivity.

Until now, however, neither study has been able to demonstrate whether this was because of repairing with a younger, less experienced mate (cost of mate change effect), or because of the fine tuning within the pair bond (mate familiarity effect), or because of problems with lumping data across several seasons (cohort/year effects). Drawing from a sample of over 5000 Barnacle Goose pairs from a non-hunted population, with both male and female bearing individually marked plastic bands, we assess the significance of the pair bond by asking why certain pairs stay together and why others divorce. We quantify whether geese reproduce better by keeping the same partner and whether one type of partner is better than another. Some of the behavioral changes that evolve with increasing years with the same partner are described. We also test Johnson & Raveling's (1988) idea, arising from a study of pairs of Cackling Geese *Branta canadensis minima* which do not maintain close contact within wintering flocks, that mate fidelity should be related to the size of the goose; the Cackling Goose being one of the smallest races.

We show that geese suffer a 56% decline in reproductive success (measured in terms of recruits to the wintering grounds) after a change in mate, even when age and year problems were addressed. Similarly, after controlling for confounding variables, familiar partners continued to improve their reproductive output for six years, which normally means the whole pair bond tenure. Comparing mate fidelity across goose species, we found that small geese were more faithful than large geese, thus, not supporting Johnson & Raveling's ideas.

One of the mechanisms that geese apparently use for maintaining contact among thousands of flock members is their numerous vocalizations, given while foraging and in flight. We found that as pair duration increased, the proportion of "soft calls" declined, medium intensity calls increased slightly, and louder calls increased the most. The soft "contact" calls are thought to help maintain proximity between partners, while the loudest calls often precede aggressive interactions. The "older/experienced" pairs are thought to be better competitors because they tended to be located in the outer edge of foraging flocks where feeding performance may be at its best.

The Role of Nutrient Reserves in Reproduction by Arctic Geese

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Continuing from the earliest work on Arctic geese in the 1930's, evidence has accumulated to show, either directly or indirectly, that these birds rely heavily on nutrient reserves for egg production and body maintenance during incubation. Ryder (1970) hypothesized that this reliance was such that variation in size of reserves among females caused variation in clutch size. Subsequent research was either strongly supported (e.g., Ankney & MacInnes 1978), or was consistent with (Raveling 1979; Ankney 1984) Ryder's hypothesis.

Several recent studies, however, purport to call into question the importance of reserves to Arctic-nesting geese. Some authors have claimed to cast doubt on the view that size of reserves is a primary determinant of clutch size in Arctic nesting geese. In this presentation, I will argue that these studies have tended to suffer from: (1) inadequate sample sizes, and/or (2) inappropriate statistical analyses, and/or (3) misrepresentation of results, and/or (4) misunderstanding of the various roles of exogenous versus endogenous nutrients in regulation of waterfowl reproduction.

Furthermore, neither these researchers nor others have considered the possibility that failure to reach a nutrient-reserve threshold results in delayed breeding or non-breeding. This seems especially likely, given that non-breeding is common in those (few) goose species in which it has been investigated, and clearly is deserving of further research.

There is considerable interspecific variation in the amount of feeding by female geese after arrival on the breeding grounds. Feeding, per se, however, says nothing about the importance of nutrient reserves, let alone control of clutch size; a quick review of recent papers about nutrient reserves and clutch size in ducks provides ample evidence of this.

Skepticism and even heresy make valuable contributions to biology. To successfully challenge an established paradigm, however, requires adequate sample sizes, proper data analyses, and interpretations based not only on logic, but also on understanding of the processes under question. But, even challenges that are ultimately futile require proponents of the "conventional wisdom" to reexamine assumptions, rethink conclusions, and refine arguments - this, of course, is valuable too.

Environmental Conditions During the Growth Period Influence Future Fitness in Geese

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Geese are unusual among birds in that young complete their growth on diets comprised nearly exclusively of green plants. This diet reduces the total food intake of goslings, owing to digestive constraints, and reduces efficiency of retention of dietary protein and energy. These consequences of an herbivorous diet increase the potential for nutrient limitation of growth in the wild and increase the importance of relatively high quality food to support maximum rates of gosling growth.

Little attention has been paid historically to the role of food quality or abundance on breeding areas in the regulation of individual gosling growth rates or population dynamics of arctic-breeding geese. The general perception was that the huge expanse of tundra vegetation surrounding many breeding areas minimized the likelihood that food limited goose populations. A small number of studies in the 1970's, however, demonstrated substantial temporal and spatial variation in food quality on brood-rearing areas. These studies also demonstrated that goslings were able to discriminate among foods and they strongly preferred foods containing higher concentrations of key nutrients, especially protein. Foods providing high levels of nutrients typically represented a small proportion (<10%) of total biomass, thereby raising the possibility that availability of these less common, higher quality foods, might influence gosling growth and overall population parameters. Until the last decade, however, demographic and ecological data to examine the role of food on growth, fitness and population dynamics were lacking.

Long-term studies in three populations of geese, Lesser Snow Geese at La Pérouse Bay and elsewhere on the Hudson Bay coast, Barnacle Geese on Götland and Black Brant on the Yukon-Kuskokwim Delta, have provided clear evidence that nutrition during the growth period influences growth in these natural populations. Growth during the first summer, in turn, has numerous consequences. Goslings that are larger at then end of their first summer survive at a higher rate than smaller goslings. Body size of goslings is correlated with the size of these individuals as adults, implying that geese cannot fully compensate after fledging for slow growth before fledging. Body size of adult geese is correlated with their investment in eggs; consequently, early growth can affect clutch size in adults. For Brant, body size of goslings influenced the likelihood of breeding for those individuals that survived at least one year.

In all three studies, increases in population size have allowed for the study of the effect of population density on growth and demography. Gosling size in late summer has declined as density increased, which has been associated with lower first-year survival in later cohorts. For both Brant and Snow Geese, smaller individuals in later cohorts have produced smaller clutches, consistent with the relationship between body size and clutch size within cohorts. Declines in gosling growth have been related to the destruction of vegetation in preferred foraging areas for Snow Geese on he coast of Hudson Bay, but not for Brant in Alaska. Despite fitness advantages of remaining in traditional brood-rearing areas, adults continue to return to these areas, while new breeders may disperse into new areas, suggesting that uncertainty about the "quality" of alternative areas may have favored fidelity to brood-rearing areas in the past. The current fitness "advantage" of this strategy, however, appears to have declined.

Aside from their contribution too our understanding of the fitness implications of environmental regulation of growth, these studies are important for assessment of management strategies for geese. Widespread destruction of foraging habitat on the west coast of Hudon Bay likely reflects an instable interaction between geese and their foraging habitat. Negative density-dependent feedback on per capita productivity in goose populations suggests that maximum productivity, and consequently sustainable harvest, may occur at intermediate, rather than maximum population levels.

Multiple Sresses and Multiple Responses: The Effects of a Large Scale Trophic Cascade on the Resilience of Hudson Bay Coastal Ecosystems

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Trophic cascades mean runaway consumption within an ecosystem. They occur in communities where simple trophic ladders operate, rather than complex food webs, so forage plants are especially vulnerable when the one major herbivore in the system increases dramatically.

In the eastern Canadian Arctic, numbers of Lesser Snow Geese (*Anser caerulescens caerulescens*) have increased dramatically since 1970, probably as a result of anthropogenic influences. Increased use of agricultural crops, particularly rice and corn on the wintering grounds, together with reduced hunting pressure and the establishment of refugia along the flyways probably account for the increase. For example, estimates indicate that the La Pérouse Bay population has increased from 1800 pairs in 1968 to 23,000 pairs in 1991. In addition, the prevailing spring weather during the last fifteen years in the Hudson Bay region often has delayed the northward migration of birds because of late snow melt, unlike the pattern of snow melt in the 1970s. Intensive, destructive foraging by breeding and staging snow geese (and Canada geese!) on the snow-free southern and western coasts of Hudson and James Bays in spring has led to a loss of preferred summer salt-marsh grazing pasture via a positive feedback mechanism similar to the process of desertification, which results in hypersaline sediments and poor plant growth. In other coastal plant communities, moss carpets, peat barrens and bare sandy, gravel ridges are replacing fresh-water sedge communities and stands of lyme grass, where geese have pulled up the shoots of these graminoid species and eaten the swollen bases. These adverse effects of a terrestrial trophic cascade on vegetation are occurring at different sites along the coastlines of Ontario, Manitoba and the North-West Territories (a distance of 2,500 km).

Changes in the vegetaion where goose damage is severe can be detected by LANDSAT imagery (1974 →), although there are relatively few suitable images available because of cloud cover. Over-exploitation of coastal pastures can be correlated with the increase in mid-continent Lesser Snow Goose numbers and the increase in the geographical size of colonies, thereby linking bird numbers with habitat quality. The loss of preferred forage at local sites is correlated with a decline in gosling weight at fledging and in survivorship, and a decline in clutch size and fecundity. Some of the survivorship decline may be linked to disease (e.g., renal coccidiosis). Results from experimental feeding trials indicate that captive goslings in the first 20 days of life maintain or gain weight only on salt-marsh graminoids, the preferred forage species. They lose weight on alternative forage species. Some Canada goose populations appear to be showing similar responses to these changes in coastal habitats. There is also increasing evidence from natural history observations that other bird species have declined in numbers over the period, including wigeon, shoveler and some species of shore birds, possibly because of lack of vegetation or soil invertebrates in the bare sediments. There is a marked asynchrony between the recovery time for revegetation of these coastal marshes (c. 15-25 years) and the life expectancy of the geese. Plots established in bare sites at La Pérouse Bay in 1984 are only beginning to be revegetated ten years later. Hence, many components of these coastal ecosystems can be expected to be directly or indirectly adversely affected by this trophic cascade. Although there is evidence for habitat destruction by geese in the past on both Arctic breeding grounds and the wintering grounds, the present scale of destruction is linked to "runaway" consumption by populations of geese that appear to be at an all-time high in numbers.

What are the management implications of these findings? They include: (a) the need for both intensive long-term studies and for long-term monitoring of populations at the regional level; (b) close integration between different agencies at defining scientific and management objectives and pooling resources; (c) establishment of early-warning biological indicators of ecosystem deterioration; (d) close liason with the indigenous peoples of the area and support for spring hunting in the Hudson Bay region; (e) recognition that conservation measures which improve conditions at the local level may lead to adverse effects on the population 5000 km away; (f) the need for integration of scientific studies on the wintering and breeding grounds.

Genetic Structure and Gene Flow - An Examination of Approaches

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Virtually no species has a uniform geographical distribution across its range and few, if any, display random dispersal between either breeding seasons or generations. As a result, most species should be viewed as a structured set of colonies or populations. Natural selection, mutation and random drift tend to genetically differentiate the populations while gene flow maintains some level of genetic continuity, in effect, acting as an evolutionary glue for the species. While the theoretical importance of structured populations in evolutionary and ecological dynamics has been recognized for many years, it is only recently that field biologists have begun accumulating sufficient data to examine those theories and their implications. There is now broad agreement that the genetic structure of populations and species must be considered in any evaluation that is to have evolutionary, ecological, conservation or management relevance.

Gene flow is a key determinant of genetic structure. Unfortunately, its direct measurement and evaluation is fraught with logistic and technical difficulties. More often, workers assess the genetic structure of a set of populations and then draw inferences about the level of gene flow that may have led to the observed structure. The assessment is usually based on some form of molecular data which is often evaluated with metrics that estimate the genetic differences, divergences or distances among the populations. With additional assumptions, these distance estimates can be converted to measures or indices of gene flow.

As the type of genetic data has changed from allozymes to restriction length fragment polymorphisms (RFLP's) to actual DNA sequences, it has become possible to shift from distance measures to genealogical approaches that attempt to reconstruct the evolutionary sequence of events leading to an observed pattern of genetic differentiation. These approaches draw heavily on phylogenetic analyses using parsimony, vicariance biogeography and coalescence theory. Again, making assumptions regarding selective neutrality, molecular clocks and equilibrium, the geneological measures or topologies of relationship can be used to draw inferences regarding the pattern and extent of gene flow.

As an alternate to methods based on genetic data, there are methods of estimating population genetic structure based solely on ecological data. These methods combine data on life history variables (survival, fecundity and recruitment) with measures of interpopulation dispersal to project equilibrium estimates of genetic structure based on either distance or genealogy. When details on the precise pattern of dispersal among populations are lacking, more generalized geographic models (e.g. islands, stepping-stones) can be used. Ecological approaches can be used to provide reasonable estimates of genetic structure in situations where there has been insufficient time or funds for tissue sampling and genetic analysis.

Optimally, the two approaches should be combined. The ecological approaches provide testable null hypotheses for the genetic approaches - hypotheses generated in the absence of genetic information. Since the two approaches rely on somewhat different sets of assumptions, rejection of null hypotheses may lead to a clearer understanding of the processes underlying the evolutionary and ecological dynamics of structured natural populations.

Adaptive Nature of Research and Management of North American Geese

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North American geese are probably more abundant now than at any time in history. They rank first among species viewed by wildlife watchers and are a major part of the continental waterfowl harvest. Geese are among the most widely distributed birds in North America; breeding populations now exist in every province and territory of Canada and in 49 of the 50 United States. Historical market hunting and poor stewardship led to record low numbers of geese in the early 1900's, but subsequent season closures, refuges and better law enforcement stemmed the declines. The recoveries of most populations were due to research-management interaction in the mode we now call "adaptive management".

Most aggregations of wintering geese were overharvested in the early 1900's, particularly those populations that nested in temperate regions in close proximity to humans. By 1930, geese which nested in the northern parts of the deciduous forest, tall grass prairie and Great Plains were severely reduced or extirpated. Geese breeding in remote Arctic and sub-Arctic breeding ranges fared somewhat better, but were also reduced in number. Although hunting by humans decimated numbers of geese, human activity on the land also created the open landscapes preferred by geese. Cereal grains and pastures created new food sources for geese, and the development of mechanical pickers created an increased supply of waste grain. Improved wildlife law enforcement curtailed illegal hunting after the signing of the Migratory Bird Treaty in 1918 and development of the National Wildlife Refuges provided key sanctuaries. The stage was thus set for the recovery of goose populations.

Sporadic counts of migrating and wintering geese from the ground were supplemented by regular tallies from the air in the early 1950's. Winter inventories were implemented because the sub-Arctic and Arctic nesting areas of many populations were still unknown and aerial surveys of these remote areas were often impractical. Concentrations and regional assemblages of geese were designated as populations for management purposes even though some populations were known to be mixtures of 2 or more subspecies. Long-term cooperative banding programs led to improved understanding of breeding, migration and winter ranges. Spring surveys, designed to estimate numbers when subspecies and populations are reproductively isolated and geographically separated, began as experiments with the Eastern Prairie Population of Canada Geese, and have now expanded to include several others.

Continued research and incorporation of adaptive management principles led to better understanding of the diversity, distribution and population dynamics of geese in the 1970's. Awareness of differences in distribution and migration among species, subspecies and populations allowed managers to adapt and create new management models to more effectively control goose harvests. Improved harvest management led to stable or increasing numbers of geese, especially Snow Geese and Canada Geese. Populations of large southern forms grew about twice the rate of populations composed of smaller long-distance migrants.

Although small geese with long migrations have generally done less well than large geese with short migrations, some small geese have responded to intensive management. The future of diverse stocks of geese depends upon a database adequate to permit simultaneous protection of rare forms, responsible subsistence harvest and recreational hunting of abundant forms and control of erupting Snow Goose and Giant Canada Goose populations. Delineation of breeding ranges, spring surveys, harvest assessment and other information needs specified by the Arctic Goose Joint Venture offer the most realistic approach to population management and the conservation of diversity in geese. Ranges of most populations have been described and spring surveys are in place for some, but research on survey methods, origins and distributions of stocks and harvest management strategies is still required. Completion and continuation of sound spring surveys for each population of geese is a prerequisite for their conservation and management. Geese can no doubt be perpetuated without these basic data, but it is certain that rare forms will disappear, opportunities for subsistence and recreational hunting will diminish, salt-marsh destruction by Snow Geese will increase, and nuisance problems caused by large geese living in close proximity to humans will become more severe.

DISTRIBUTION OF LESSER SNOW GOOSE NESTING IN SOUTHERN HUDSON BAY AND ITS RELATION TO FORAGE PLANTS

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The mid-continent population of Lesser Snow Geese has nearly doubled since the mid 1970s and nesting colonies in the southern Hudson Bay region have increased concurrently. With the exception of sites in Manitoba, nesting Snow Geese have not been quantitatively surveyed since 1978. We surveyed the entire coastal region from Moosonee, Ontario on James Bay to the Caribou River near the Manitoba-Northwest Territories border in June 1993 and/or 1994. We documented the distribution of Snow Geese and determined above-ground biomass in the *Puccinellia-Carex* salt marsh zone where birds feed intensively. Our results indicate: (a) a dramatic increase in the geographic size of colonies and in numbers of nesting birds in extant colonies at Cape Henrietta Maria, Ontario and La Pérouse Bay, Manitoba since 1978; (b) several new colonies in Ontario and Manitoba established since the late 1970's; (c) the persistence of a small colony on Akimski Island, James Bay, N.W.T.; (d) a wide scattering of isolated pairs and small groups of nesting birds at river mouths along the James Bay and Hudson Bay coasts of Ontario and Manitoba. In 1993, an early (10 days post-hatch) and a late (40 days post-hatch) survey were conducted along the James Bay and the Ontario coasts, giving an estimate of the coastal brood rearing range of each colony at these two times and their geographic expansion over the season. New nesting colonies documented at Shell Brook and West Pen Island (Ontario) were probably established in the mid 1980s. Plant biomass determined at 75 sites was negatively correlated with goose numbers and indicators of goose use (grazing index, dropping index). Biomass ranged from around 5 g m^{-2} in heavily grazed areas to around 240 g m^{-2} in ungrazed areas. In 1994, a survey during the last week of incubation and first week of hatch was conducted over the entire region from Moosonee to Caribou River, and a second survey was conducted about 40 days post-hatch to photograph brood flocks. These provided a precise description of nesting colony boundaries and size in 1994. New nesting colonies were documented on the northwest James Bay coast and in northern Manitoba. Salt-marsh swards were in poor condition where high densities of geese were present. This nesting expansion in southern Hudson Bay is likely to adversely affect other birds, particularly Canada Geese and salt-marsh nesting and feeding shorebirds.

PRE-HATCH FEEDING BY ROSS AND LESSER SNOW GEESE IN A MIXED BREEDING COLONY: THE BODY SIZE HYPOTHESIS

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It has been widely accepted that Arctic-nesting geese spend little time feeding on the breeding areas before hatch, but instead rely primarily upon endogenous reserves accumulated during winter or spring migration. Several recent studies, however, have noted exceptions to this generalization; exogenous nutrients apparently are important during pre-laying, laying, and/or incubation for some species or populations. Accordingly, several hypotheses have been formulated to explain intra- and inter-specific variation in endogenous reserve storage and use by breeding geese. The mixed breeding colony at Karrak Lake, NWT, provides a unique opportunity to test the Body Size Hypothesis while controlling other potentially important factors. We compared time spent feeding by Ross (*Chen rossi*) and Lesser Snow Geese (*C. caerulescens caerulescens*) with 2 data sets: (1) 24-h time budgets from arrival through early incubation, and (2) during incubation recesses. As predicted, Ross geese fed for 1.5 h longer each day, on average, than did larger lesser Snow Geese. Extrapolated over the approximate 32 day period from arrival to hatch, Ross geese spent at least 2 more days feeding, on average, than did Lesser Snow Geese. We conclude that body size effects are fundamental to endogenous reserve storage and use by Arctic-nesting geese, but that other ecological factors may interact with body size to strongly influence intra- and interspecific variation in reserve storage and use.

RELATION OF CONTINENTAL PRODUCTIVITY BY ARCTIC GEESE TO SPRING NUTRITION IN PRAIRIE CANADA

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During 1983-84 and 1988-92, I studied Lesser Snow Geese in the corn agricultural zone of southern Manitoba. This is the last opportunity for this population of geese to feed on by-products of agriculture before they migrate over boreal forests to coastal marshes of James/Hudson Bays before nesting in Canada's eastern and central Arctic. Geese were collected early (11-18 April) and again later (1-5 May) while staging in southern Manitoba. Detailed dissections and chemical analyses were used to determine fat, protein and mineral composition of geese. Fat was the most dynamic nutrient reserve among years and during staging in southern Manitoba. Fat reserves increased an average of 202 g over all years of the study, but there was significant annual variation in amounts stored (e.g., 91 g in 1988 vs. 290 g in 1992). For all years considered, protein and mineral reserves did not change significantly during the staging period in southern Manitoba, although small declines (-23 g in 1992), or increases (60 g in 1988) in protein occurred in specific years. I used age ratios (immatures:adults) of blue and white phase Snow Geese killed by hunters in the Central and Mississippi Flyways as a measure of productivity. Productivity was positively related to fat reserves the previous April and May in southern Manitoba. Protein reserves were unrelated. These findings show that spring nutrition of geese in the agro-ecosystems of Prairie Canada is likely an important influence on annual number of young geese produced in the Arctic. This may have important implications for population dynamics of all geese nesting in Canada's Arctic: first, it warrants research on the spring prairie ecology of other species of Arctic-nesting geese; second, it suggests that nutrition in the annual cycle of Arctic-nesting geese is a modifier of population size that needs to be considered at least as important as other potential effects (e.g., Arctic weather, predation, hunting kill) commonly assumed to control annual goose numbers currently.

ANTIPREDATOR STRATEGIES OF BLACK BRANT AND LESSER SNOW GEESE

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Nest success of Black Brant and Lesser Snow Geese breeding at the Anderson River Delta, NWT, varied among years and between species due to variation in nest predation rates. The observed predation rates were sufficient to have important demographic consequences for these two populations. The two species also differed in the location and dispersion of their nests and incubation behavior. I examined the potential benefits of nest location and density to determine if they could account for the observed differences in nest success. Nest density significantly influenced nest success for Brant in one year but was unrelated to Snow Goose nest success. Similarly, nest location influenced nest success among Brant but not Snow Geese. These results suggest that local density and relative position of nests did not have consistent effects on variation in clutch survival for the two species. During incubation, female Snow Geese had higher nest attendance rates than did female Brant, and male Snow Geese were absent from their territories less than male Brant were. Since avian nest predators were opportunistic and made most attacks when nests were unattended, differences in nest and territory fidelity may explain some of the interspecific variation in nest success at this study site.

PATTERNS IN SOIL RESPIRATION AND NITROGEN MINERALIZATION RATES AMONG SALTMARSH FORAGE PLANT COMMUNITIES ACROSS A COASTAL FLOODWATER GRADIENT IN WESTERN ALASKA

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Plant communities of the outer Yukon-Kuskokwim Delta are susceptible to increased frequency of storm-driven floods with increasing sea level and storm energy. These plant communities contribute to the annual productivity of >400,000 geese, and changes in forage quality and availability could have large impacts on goose production and recruitment. This study concentrates on four communities dominated by the graminoids *Puccinellia phryganodes, Carex subspathecea, C. mackenziei*, and *Triglochin palustris*, all of which are important goose forage species. Fundamental to an understanding of nutrient fluxes through this grazing food web is information regarding the dynamics of soil decomposition processes by soil microbes. We sampled soils from these four communities at three positions across a 30 km coastal-to-inland transect, in preparation for experimental manipulation of floodwater salinities. Soils were incubated under constant laboratory conditions to determine turnover rates of nitrogen and carbon. In a full factorial analysis, soil respiration rates were significantly influenced by plant community type, landscape position, and sample depth, with significant 2-way interaction of factors. Soil water content, oxidation-reduction potential, and pH were also highly variable between communities and landscapes, but only soil water was found to significantly influence soil respiration rates. When water content was entered into the model as a covariate, significant variation in respiration could only be attributed to soil depth, and the 2-way depth interactions with community type and landscape position. Soil water content appears to be an important determinant of microbial activity, and soil salinity and organic matter quality are likely important factors in regulating the ratio of net carbon to nitrogen turnover. These factors are currently being studied through experimental manipulation of floodwater salinity. Responses of soil and plant nutrient processes to simulated storm surge flooding will provide information valuable in assessing potential ecosystem impacts of rising sea level.

MITOCHONDRIAL DNA CONTROL REGION SEQUENCES AND THEIR USE AS MARKERS IN DISTINGUISHING SUBSPECIES OF CANADA GEESE

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Mitochondrial DNA (mtDNA) polymorphisms detected with restriction fragment analysis of the whole molecule have been shown to provide diagnostic markers for most subspecies of Canada Geese (*Branta canadensis*) (Shields and Wilson 1987, Van Wagner and Baker 1990). However, this technique is of limited utility in the management and conservation of these subspecies because it requires good quality DNA from freshly sacrificed birds, and is time consuming and laborious. To provide a better genetic method of distinguishing subspecies from very small amounts of blood, feather bases, bones, or even partly degraded tissues sampled from hunter kills, we have been amplifying mtDNA of Canada Geese subspecies with the polymerase chain reaction (PCR) and sequencing it in the search for genetic markers. A previous sequencing study of part of the protein-coding cytochrome *b* gene had found markers distinguishing small and big subspecies of Canada Geese (Quinn, Shields and Wilson 1991), but could not differentiate between subspecies within each of these body size groups. We sequenced the faster evolving mtDNA control region to search for such markers, because in some other bird species individuals can be clearly allocated to subspecies with their control region haplotypes (Wenink et al. 1993). As for the cytochrome *b* gene, the small and big subspecies groups of Canada Geese can be clearly distinguished by multiple substitutions in their control region sequences. However, disappointingly few differences were found among subspecies in the big and small-bodied groups, indicating that diversity within each of these groups have evolved recently, probably within the last 10,000 years or so. Given this short time frame for the accumulation of diagnostic mutations, the best hope for the future is to isolate rapidly evolving microsatelite loci from genomic DNA. Because of their high mutation rate, these loci have been found in other animals to harbor large amounts of genetic variation, and can often be used to characterize subspecies and possibly individual populations by the suites of alleles they possess.

GEOGRAPHIC DISTRIBUTION AND CHANGE IN DENSITY OF NESTING GEESE ON THE YUKON-KUSKOKWIM DELTA COAST, ALASKA, FROM 1985 TO 1994

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Populations of geese nesting in the coastal zone of the Yukon-Kuskokwim Delta have increased since 1985. Increases have not been spatially uniform, and localized declines in nesting density occurred even in populations that showed considerable growth. Using new aerial survey techniques, we calculated geographic coordinates for all waterfowl observations. We mapped nesting distribution, density, and the rate of change in density. Using GIS analysis we compared nesting density distribution of Cackling Canada Geese (*Branta canadensis minima*), Emperor Geese (*Chen canagica*) and Black Brant (*Branta bernicla nigricans*) from 1985-1989 to those from 1990-1994 to identify areas of greatest change in nesting bird density and distribution. Overlays with surface geology, vegetation, and human activity data layers indicated relationships between these environmental factors and change in nesting goose density. Overlay of density and rate of change coverages indicate the degree to which changes in nesting density were density dependent.

THE DISTRIBUTION OF TWO SUBPOPULATIONS OF WRANGEL ISLAND SNOW GEESE AT THE BREEDING AND MOLTING GROUNDS

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The current number of Wrangel Island Snow Geese (WISG) in now about 65,000 - 75,000 birds. The majority of these birds nest in on main colony on Tundrovaya River Valley. The number of pairs nesting in small colonies near the Snowy Owls nest (up to 5-10%) depend on the lemming abundance. The individuals from the two subpopulations (northern - wintering in British Columbia and Washington, and southern - wintering in California) can be accurately discriminated by differences in the stain colors on the head feathers. The current proportion of birds in the two subpopulations (50:50) shows a decline of the southern population over the last 10 years. The number of geese from northern subpopulation is higher in the central part middle of the main colony and in small surrounding colonies. About 95% of WISG spend the posthaching period at the northern lowland part of the island (Tundra of the Academy). Broods moving from west to east can cross up to 100 kilometers before fledging. Goslings from earlier hatching and later hatching broods can be observed at the eastern part of molting grounds but the proportion of later goslings always as higher as more close to the main colony. There is no difference between distribution of birds from two subpopulations on the molting grounds.

GROWTH RESPONSES OF PLANTS TO GOOSE GRAZING IN A HIGH ARCTIC ENVIRONMENT

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The growth responses of plants to herbivory usually vary with the grazing regime experienced. As grazing pressure by Greater Snow Geese (*Chen caerulescens atlantica*) has been increasing on Bylot Island, NWT, in recent years, we studied the response of *Dupontia fisheri* and *Eriophorum scheuchzeri* to controlled grazing using captive goslings. We were particularly interested by (i) how the timing and the frequency of grazing affected plant growth, (ii) whether faeces stimulated plant growth after grazing, and (iii) whether the total non-structural carbohydrate reserve (TNC) in the below-ground parts of plants were affected by grazing. Neither grazing (presence or absence), faeces (presence or absence) or the regime (grazed once early, mid or late in the season, or on all 3 occasions) affected the above-ground phytomass or the net above-ground primary productivity of both species at the end of the season. The increment in productivity of *Dupontia* over a 2-week period was significantly affected by the timing of grazing, increasing from early to late in both single and multiple grazing treatments. The same tendency was observed with *Eriophorum* but differences were not significant. Above-ground height of tillers were significantly lower in grazed treatments compared to ungrazed ones and net above-ground height productivity was higher in grazed treatments although differences were not consistent among grazing regimes. None of the factors had a significant effect on the number of tillers. Total nitrogen content of grazed tillers was significantly higher than in ungrazed ones. The level of TNC in below-ground parts increased throughout the summer but at a significantly lower rate in grazed treatments. Over one season, the timing and the frequency of goose grazing had moderate effects on the growth of *Dupontia* and *Eriophorum*, whereas goose faeces had no effect. Although plants compensated for lost tissues, grazing did not enhance plant growth and interfered with the accumulation of TNC.

TRACKING THE FALL MIGRATION OF GREATER SNOW GEESE USING SATELLITE TELEMETRY

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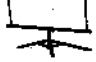
Approximately 4-5 weeks elapse between the departure of greater Snow Geese from their breeding grounds in the Canadian High Arctic and their first known staging area along the St. Lawrence River. The objective of our study was to determine the location and the number of stops as well as the habitat used by Snow Geese during their fall migration. Eventually, we want to compare the migration patterns of early and late nesters. In August 1993, we attached a Toyocom T-2038 satellite transmitter to 6 adult females using a back-mounted harness. The geese were tracked for distances varying between 130 and 2660 km but none reached the St. Lawrence river. The mass of the package (141 g or 6% of the mass of the goose) and its non-aerodynamic shape may have prevented the geese from completing their migration. Based on a repetition period of 90 sex and a duty cycle of 16 h off and 8 h on, the radios transmitted for an average of 82 ± 14 days and provided 6.7 ± 0.1 locations/goose/day. Overall, 75% of the 1720 locations were of class 1 or better which represents a potential accuracy of 1.2 km. From Bylot Island, the geese flew straight south, crossed Baffin Island and then followed the north-east shore of Foxe Basin. After reaching the Ungava Peninsula, they continued south within a narrow corridor between 72° and 74° of longitude. In 1994, we tested the Telonics ST-10 transmitter on captive birds. The 105 g aerodynamic package did not markedly affect the activity budget of the birds. One experimental goose spent 10% of its time placing the harness and the radio into its plumage. The package was therefore barely apparent and this should reduce drag in free-flying birds. No feather wear was observed after 5 weeks. In the fall of 1994, we tested this transmitter on 4 adult males captured at Cap Tourment in Quebec and tracked to the wintering grounds.



MASS CHANGE IN ROSS' GEESE DURING SPRING MIGRATION AND NESTING

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In Ross' Geese, nutritional ecology of spring migration and of breeding are not distinct. Nutrients for both phases of the annual cycle must be acquired simultaneously. When Ross' Geese arrive on the breeding territory there is little or no food available and egg laying typically begins within a few days. Ross' Geese were collected in Saskatchewan near the end of staging (May 12) in 1993 and 1994. Another sample was collected early in the staging period (April 29) in 1994. Geese were collected at Karrak Lake from arrival on nesting grounds until laying was complete. In 1993, a sample was taken at hatch. Both males and females gain significant weight while staging in Saskatchewan. Ovaries begin recrudescence on the prairies and their mass is correlated with body weight. Females continue to gain weight north of the prairies but males lose significant weight. Throughout laying, both males and females rapidly lose weight, and loss continues until hatch. These results show that staging habitat in Saskatchewan is important for nutrient storage in both sexes. Nothing is known about the ecology of Ross' Geese staging in areas of boreal forest or subarctic taiga where rapid follicular development begins. Further research on feeding ecology is needed in these areas.

JUST HOW FACULTATIVE IS NEST PARASITISM IN SNOW GEESE?

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Through habitat manipulation, nest visits and intensive observations of marked captive Lesser Snow Geese (*Chen c. caerulescens*) during the nesting season, the behavior of nest parasites was closely monitored. In the absence of total snow cover and with food available, all breeding females try to establish their own nests. Failure to do so leads to parasitism, but opening of previously unavailable areas allows the parasites to switch to laying in their own nests and then to nest normally. Parasites lay full clutches, with laying occurring at regular intervals, which vary from goose to goose, but little from year to year for a given female. Only extreme physical abuse appears to interrupt this laying. A nester may switch to laying parasitically in her nest site is lost before she has finished laying. Experienced nesters do on occasion become parasitic. The critical factor appears to be the coincidence of readiness to lay with available habitat. Thus, parasitism may be more prevalent early in the egg-laying period than later, if there are not set-backs in the onset of spring conditions. These behaviors and results are consistent with observations of wild geese and with results inferred from them.

ABUNDANCE AND DISTRIBUTION PATTERNS OF LESSER SNOW GEESE ON THE FRASER AND SKAGIT RIVER DELTAS

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The Lesser Snow Goose (*Anser c. caerulescens*) population wintering on the Fraser and Skagit deltas fluctuated considerably from year to year due to a highly variable recruitment rate. An increase in abundance in the 1980s coincided with a significant reduction in the proportion of the population harvested each year. Differential harvest rates probably account for the recent increases in the proportion of Fraser/Skagit geese on the Fraser delta in fall and in the proportion of Wrangel geese using the deltas in winter. The availability of Alaksen NWA on the Fraser delta or short-stopping by California birds during fall migration may also have contributed to these increases. At least half of the geese intending to winter in California staged on the Fraser and Skagit deltas in fall. However, the deltas supported a largely closed population from mid-November to March. This means that population dynamics can be modelled to determine the relative importance of recruitment and harvest. It also means that, by conducting photo counts each year and applying a crude survival rate, the minimum number of geese expected to return the following year can be predicted. Hunting regulations could then be adjusted to help maintain the population within defined limits. Snow Geese showed high site-fidelity and consistency in their distribution and movement patterns across years. These traditional patterns reflect important compromises developed over many years with respect to food quality and hunting disturbance. The highly traditional nature of Arctic geese means, however, that new habitat use patterns are slow to emerge when new opportunities arise.

INTERACTION BETWEEN LESSER SNOW GEESE AND THREE-SQUARE BULRUSH (*SCIRPUS AMERICANUS*) ON THE FRASER AND SKAGIT RIVER DELTAS

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The net, annual rate of production of bulrush rhizomes on the Fraser delta was largely offset by the amount consumed each year. Rhizome mass remained constant across years and it was only at a small fraction of its maximum level. Therefore, the interaction between Lesser Snow Geese (*Anser C. Caerulescens*) and bulrush was at a low level steady-state. The net, annual rate of production of rhizomes was constant across all biomass values measured. This suggests that, as patch biomass declines due to grubbing, rhizome production should remain high and at a maximum level. The interaction between growth and consumption should be stable at almost any plant biomass regardless of the shape of the consumption curve. Also, a reserve of deep (>20 cm) rhizomes should help maintain bulrush growth under high grubbing intensities. Rhizome mass and substrate dynamics were significantly affected by geese in the upper half of the bulrush zone. Tidal exposure and energy or nutrient returns probably explain the pattern. The mid to upper part of the bulrush zone is the most profitable place for geese to grub because the substrate is relatively soft and rhizomes have high (linear) densities. Profitable cover crops and lack of hunting probably explain the intense use of Alaksen NWA by geese in fall in recent years and the traditional, large-scale movement from the Fraser delta to the Skagit delta in mid-winter. The geese are tracking some food-related, profitability gradient but their distribution and movement patterns are probably modified to a great extent by hunters. Traditional patterns of habitat use and the fact that Alaksen NWA fields can support high numbers of foraging geese results in similar grubbing intensities in the bulrush zone each year and the constant rhizome mass observed.

DEMOGRAPHIC EFFECTS OF DENSITY CHANGES IN LESSER SNOW GEESE

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Since 1972 the La Pérouse Bay population of Lesser Snow Geese has increased from approximately 2000 pairs to >20,000 pairs. Associated with this increase in population size were significant systematic declines in various demographic parameters such as breeding propensity, clutch size, nest failure, brood loss, and first year growth and survival. We used age-classified matrix population models to investigate the effects of these changes on population dynamics of Snow Geese under low density (1973-1982) and high density (1987-1992) conditions. In each case we calculated the population growth rate, stable age distributions, and the sensitivity and elasticity of population growth rate (λ) to changes in each of the demographic parameters. While in the early phase (low-density) the population increased at a rate of approximately 9% per year, while during the late phase (high-density), population growth was negative ($\lambda<1$). Differences in parameter values resulted in a different sensitivity of the rate of population increase to these parameters in the two phases. In both instances, population growth rate is most sensitive to variation in survival rate of adults ≥ 5 years of age (reproductively mature adults). However, the sensitivity of this age class during the low-density phase was much lower than during the high-density phase. We also tested if we were able to reach the same conclusions by reducing the age-classified models to stage-based models (all breeding adults pooled into a single adult age class). Stage-structure models have the practical advantage of being less dependent upon the precision of the age-estimates. However, "pooling" age-classes may obscure demographic analysis if there is strong age-specificity in the sensitivity of population growth rate. In the present case, the 3-stage structure retained the high significance of the reproductive stage in the sensitivity analysis, but masked the predominant role played by the older adults in population growth, both in terms of adult survival and of first-year survival of offspring of older adults.

PRE-NESTING BEHAVIOR OF WHITE-FRONTED AND CANADA GEESE IN THE CENTRAL CANADIAN ARCTIC, 1990-1993

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From 1990-1993 we studied their pre-nesting behavior of *Anser albifrons frontalis* (WF) and *Branta canadensis hutchinsii* (CG) nesting in the central Arctic to determine the proportion of time spent feeding and to examine the importance of nesting ground food resources, and to compare the general pattern of behaviors within and between years. Pairs were observed for 20- to 30-minute bouts throughout the 24 h day. Behavior was recorded at 30 s intervals. Geese were observed 10 days prior to nest initiation in all years, but observations began earlier in 1992-93. Number of bouts observed varied annually (1990: n=51 and 10; 1991: n=60 and 34; 1992: n=107 and 140; 1993: n=77 and 74, for WF and CG respectively). Phenologically, spring 1990 was early, 1991 and 1993 were average, and 1992 was late. WF and CG females spent most of their time feeding (WF:4-year =59.7% SD=4.1; CG: =69.0 SD=10.0), suggesting that food was significant in meeting energy and nutrient requirements. Because WF fed the same (1991-93) or less (1990) than CG (P=0.007, df=1,3, F=7.3), we were unable to explain differences in incubation strategies. They were very similar in time alert (WF:=5.5% SD=3.2; CG:=6.6 SD=2.9), varying between years (P=0.0001, F=12.4) but not species (P=0.238). Males did not differ interspecifically or annually in time feeding (WF:=37.5% SD=1.2; CG:=39.1 SD=4.5; P=0.311), except that WF fed more in 1992 (P=0.003, F=4.7). Male CG were more alert than WF in 1990 and 1991 (WF:=28.0% SD=3.1; CG:=37.7 SD=6.3, P=0.004, F=8.6), and male CG were least alert in 1992 (P=0.011, F=3.8). Differences were also detected in time walking (both sexes), and time sleeping (females only). Most differences among years seemed related to the late spring of 1992. Overall, behavior of the two species was remarkably similar.

NEST NUMBERS AND AERIAL SURVEYS: MANAGEMENT TOOLS FOR MONITORING DUSKY CANADA GEESE

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The population of Dusky Canada Geese has declined in recent decades and is a concern in the Pacific Flyway. The decline has been attributed to many factors, but primarily to detrimental effects of vegetative succession on the Copper River Delta (Delta) following uplift from a major 1964 earthquake and an increase in predators. While management decisions regarding the dusky population are based primarily on wintering counts, the spring breeding pair survey of duskies on the Delta is being evaluated as a monitoring method. It also increases our understanding of nesting dynamics. The encroaching woody vegetation on the Delta since the earthquake may change detection rate on aerial surveys thus affecting our monitoring of distribution and abundance of breeding pairs over changing habitat through time. The US. Forest Service initiated sampling of nesting habitat with ground based nest plots using a stratified random design. Strata were determined from breeding pair densities on the aerial survey. Objectives of the effort were: 1) relate numbers of nests to aerial survey observations of breeding pairs, 2) to estimate the numbers and distribution of nests on the Delta, and 3) to determine nesting success and chronology, and identify predators. Sixty-three 300 x 300m random plots were sampled between 16 May and 21 June, 1994, in low, medium and high density strata, and on Egg Island, a known high density area. A total of 126 nests were located. The mean numbers of nests per plot were 1.2, 2.2, 3.5, 3.5 for low, medium, high density and egg island, respectively. Data indicate that numbers of nests are correlated with numbers of pairs observed on the aerial survey.

FALL AGE RATIO AND ANNUAL PRODUCTION OF EMPEROR GEESE

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Emperor Goose (*Anser canagica*) populations have declined from estimates of 139,00 in spring 1964 to a low of 42,200 birds in spring 1986; most recent spring indices vary from about 46,000 to 71,000 birds. The declining population size and continued importance of this species to the subsistence lifestyle of Yupik Eskimo's living on the Yukon-Kuskokwim Delta, Alaska, has prompted efforts to improve population management information for this species. Here we describe a method to obtain unbiased estimates of the fall age ratio of emperor geese and evaluate the utility of this method to estimate production and survival of geese. Photographs of flocks of emperor geese were taken at fall staging areas along the north side of the Alaska Peninsula, Alaska, from 1985 to 1993. The ratio of young to adult birds was determined by gray versus white coloration of head plumage. We calculated mean and standard error of the proportion of young stratified by lagoons using both self-weighted and weighted estimates. Mean and variance of proportion of young within each lagoon was based on Cochran's (1963:65) formula for estimation of proportions in cluster sampling, similar in formulation to combined ratio estimates. The annual proportion of young, using the weighted stratified estimates, had 95% confidence intervals of less than or equal to + 0.022 (+ 10% of the mean) in all years since 1987. This precision was achieved in years with >390 photographs and >10,000 geese classified. The combination of age ratio data with other spring and fall surveys provide production and survival information that are difficult to obtain for a species that experiences little sport harvest and ranges widely over remote geographic areas.

SPRING FEEDING STRATEGIES OF SYMPATRIC CANADA AND WHITE-FRONTED GEESE NESTING IN THE CENTRAL CANADIAN ARCTIC

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Spring feeding on the nesting ground is intensive in many Arctic-nesting populations of geese, significantly adding to the energy reserves necessary for laying and incubation. This study compares the spring feeding ecology of 2 species (*Anser albifrons albifrons* [WF] and *Branta canadensis hutchinsii* [CG]) on a shared nesting ground, near Walker Bay, Kent Peninsula, NWT, in 1993-94. The pre-nesting period was divided into 3 parts according to snow-melt phenology: before melting (snow cover [sc] > 80%, 7-10 d), during (sc = 20-80%, 3-7 d), and after (sc < 20%, 5-7 d). Both species fed intensively (55-80% of day by females) from arrival until incubation. Before snow-melt, they shared 1-20% of the study area (max. 400 pairs /km^2). Pairs used the only 2 available habitats, mud-flats and hummocks, opportunistically. CG and WF feces were mostly (50-70%) composed of *Puccinellia* ssp. fragments. WF, however, had a more diverse diet than CG and spent less time searching during feeding bouts than CG. During snow-melt, pairs dispersed (max. 10 pairs /km^2) as more habitats became available, and inter-specific differences in habitat and food use appeared. WF pairs used pond margins and ponds, grubbed more often, and ingested a higher proportion of rhizomes than CG. After snow-melt, WF pairs continued to grub in ponds, feeding on *Carex* and *Dupontia* rhizomes, while CG preferred both ponds and pond margins, grubbing *Carex* and *Dupontia* rhizomes, but also grazing their leaves and *Stellaria*. Differences in feeding strategies and habitat use between WF and CG in spring can be largely explained by differences in their beak morphology. Biomass within habitats did not significantly increase during the pre-laying and laying periods. Available biomass in pond margins (30-60 g/m^2) were 4-15 times higher than in habitats that were available earlier, and explained the preference of the former habitat by geese. Potential for inter-specific competition for food is highest before snow-melt, when food availability and diversity is the lowest and pair density is the highest.

USING MICROSATELLITE DNA TO DELINEATE THE NATAL ORIGIN OF CANADA GEESE

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We have been testing a procedure which compares highly variable sequences of microsatellite DNA in order to determine the geographical origin of Canada Geese (*Branta canadensis*) that winter in the shortgrass prairie (SGP) and tallgrass prairie (TGP) regions of the United States. By using the polymerase chain reaction (PCR), a tandemly repeated cluster of microsatellite DNA (GT/CA)n was examined in six groups of Canada geese. Groups ranged from the Smoke River (69°27'N,130°35'W), to Baffin Island (66°04'N,74°24'W), and were screened for genetic differences. The PCR primer pair designated TTUCG-1 was used to survey 380 Canada geese for genetic variability. We did find differences among goose populations, but have yet to identify a fixed marker for the different groups. Additionally, genomic DNA from goose tail fan muscle and quill pulp material was successfully extracted, amplified and scored for genetic variation. These tail fans were 2 years old, and received no special care other than being stored in a refrigerated room. Products obtained from tail fans had the same quality as products from fresh blood samples, making this method attractive for use in conjunction with the parts survey.

DIVORCE IN BARNACLE GEESE: CAUSES AND CONSEQUENCES

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Geese are generally thought to be faithful to one mate for life. Indeed, data from a long-term population study of over 4000 marked Barnacle Geese (*Branta leucopsis*) showed that 65% of birds had only one mate during their lifetime, with most cases of mate change were due to the death of one partner. Nevertheless, some individuals (3.5%) divorced their partners to pair with a new mate. We investigated the causes and consequences of divorce. We found significant advantages associated with mate fidelity, since breeding success increases with pair bond duration up to size years, and then stabilizes. Birds that stay with one mate produce more goslings than those which re-pair. The costs associated with changing partners include the risk of missing a breeding season and lower reproductive success in the first year with a new mate. We tested several hypotheses which have been invoked to explain why some birds choose to incur these costs. The suggestion that divorce in geese is due to accidental loss during migration was not supported, since most divorces occurred outside the migratory period. It has also been suggested that divorce occurs when there is a better option available for one or both partners, and the possibility of improving breeding performance. We found that reproductive failure did not increase the probability of divorce in geese. Divorce rate also did not increase with greater availability of unpaired birds in the population, e.g., with increasing mortality rate or higher recruitment rate of juveniles. Divorce occurred equally at all ages, but the probability of divorce decreased the longer the pair bond lasted. We discuss the evidence for and against the various divorce hypotheses by looking at the short and longer-term consequences of divorce in terms of reproductive success and qualities of previous and new mates.

THE COST OF BEING LARGER: NATURAL SELECTION ON SEXUALLY DIMORPHIC GROWTH IN LESSER SNOW GEESE

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Snow Geese (*Anser c. caerulescens*), like other species of geese, show no sexual dimorphism in plumage, but a small degree of sexual size dimorphism (SSD) both in gosling growth rates and size at fledging (Cooch et. al. 1991), and ultimately as physically mature adults (Davies et al., 1988; Cooke et al., in press). What determines the level of SSD found in Snow Geese? While there is little evidence that variation in body size affects fitness in adult female Snow Geese (Davies et al., 1988; Cooch et al., 1992; Cooke et al. in press), there is evidence that larger size of males may enhance the ability of their female partner to acquire nutrients prior to the spring migration to the breeding grounds (Ankney, 1977; Lamprecht, 1986; Black and Owen, 1989; Choudhury et al., 1992). In spite of this, the degree of SSD in Snow Geese is small, suggesting that natural selection may constrain larger male size. We present evidence for a detectable cost of larger size of males using data from the long-term study at La Pérouse Bay, Manitoba, Canada (58°4'N, 94°4'W). We show that male and female Snow Goose goslings differ in their pattern of growth and survival under varying feeding conditions. In general, males are significantly more sensitive to food limitation than females, showing a greater relative decrease in growth rate than female goslings both within and among years. Concurrent with a long-term decline in food abundance at La Pérouse Bay, there has been a significant decline in the frequency of male goslings at fledging. Within season analysis of fledging sex-ratio as a function of spatial differences in food abundance were consistent with this long-term trend: fewer male goslings when feeding conditions were poor. However, temporal analysis within-season did not support this general trend. We argue that differences among and within years reflect different reaction norms of male and female goslings to environmental change.

BODY SIZE AND BREEDING-PROPENSITY IN SNOW GEESE: DO RUNTS WIMP OUT?

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Davies et al. (1988) found that the mean body size of two- and three-year-old Lesser Snow Geese (*Anser c. caeruelscens*) at La Pérouse Bay, Manitoba, Canada ($58^{o}4$'N, $94^{o}4$'W) was smaller than that of older birds. They interpreted this is showing that smaller birds breed at younger ages. Unfortunately, this analysis was confounded by the long-term decline in body size, which was not considered in the analysis. Re-analysis showed that the pattern observed by Davies et al. could be explained because more recent cohorts, which were smaller on average, were under-represented in the older age classes used in the analyses (Cooch et al. 1992). However, since structural size may significantly affect various aspects of nutrient acquisition, which in turn might limit individual breeding propensity (as suggested by Alisauskas and Ankney 1990), we re-assessed the question of body size and probability of breeding directly, using capture-mark-recapture (CMR) approaches. The estimated recapture rate is in fact the product of 2 probabilities: the probability that an animal is seen if alive, and (for species such as Snow Geese) the probability that if alive that the animal breeds (if an animal does not breed, probability of being seen if alive = 0). If we assume that the probability of being seen is independent of size, then differences in p among large and small birds are equivalent to differences in breeding propensity. Using the principles of statistical parsimony (Lebreton et al. 1992), we tested recapture models which allowed breeding propensity to vary by age (2→5+) and by size class as a gosling. There was no significant improvement in model fit when size-specific parameters were included for either early or late-hatching birds, suggesting that small birds are equally likely to breed in a given season as large birds.

SPRING NUTRIENT RESERVES OF SMALL CANADA GEESE NESTING IN THE CENTRAL CANADIAN ARCTIC

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We studied the importance of spring staging and nesting areas for storage of nutrient reserves by arctic- nesting small Canada Geese *(Branta canadensis hutchinsii-parvipes)*. The role of nutrient reserves in reproduction before and after arrival on nesting grounds and its influence on subsequent productivity may enhance our ability to predict fall flight numbers for this population. Female Canada Geese (n=87) were collected at 6 different stages during the spring of 1994. Preliminary analysis indicated significant variation in body mass among stages ($P<0.001$, $F=15.15$). Pairwise comparison of means showed no substantial difference ($P>0.46$) in body mass between arrival (April 19, n=14, mean=2.63 ± (SD) 0.16 kg) and departure (May 4, n=9, mean=2.67 ± 0.18 kg) from staging in prairie Saskatchewan and the North Arm of Great Slave Lake (May 12, n=18, mean=2.61 ± 0.23 kg). The high body mass of geese evident upon arrival in Saskatchewan suggests that the winter grounds in the Texas panhandle or staging areas in Nebraska are important for migratory fattening. Body weight declined ($P<0.001$) during the last leg of migration from Great Slave Lake to nesting grounds on Kent Peninsula (May 23, n=21, mean=2.27 ± 0.27 kg). Mass increased ($P<0.001$) after arrival until the end of pre-nesting (May 29, n=13, mean=2.70 ± 0.24 kg) supporting other findings that the nesting area is a source of nutrients for breeding females. Birds collected at the end of laying were lightest (June 7, n=12, mean=2.16 ± 0.18 kg; $P<0.001$) suggesting that a significant portion of nutrient reserves were dedicated to egg production. Further detailed analysis will determine the relative importance of staging and breeding grounds to lipid and protein reserves and to egg-laying.

HABITAT USE BY ALEUTIAN CANADA GEESE ON WINTERING AREAS IN CENTRAL CALIFORNIA

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The threatened Aleutian Canada goose population has been monitored for almost 2 decades on both breeding and non-breeding areas. Still, habitat use of the migration and wintering areas has not been quantified. Habitat use by Aleutian Canada geese was monitored 1992 1994 at 2 locations in California: areas near Colusa and Modesto. A study area was delineated at each location and available habitat was identified within each study area. Habitat consisted of agricultural crops and pasture. Driving surveys were conducted within each study area to locate geese. When geese were located, the type and location of habitat, and number of geese present were recorded. Habitat use in relation to habitat availability will be presented. Ultimately, these results will be used with data on habitat selection criteria to develop an Aleutian Canada goose winter habitat management plan.

USE OF LANDSAT SATELLITE IMAGERY TO MAP LESSER SNOW GOOSE FORAGING HABITAT AND TO DETECT HABITAT DEGRADATION

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Nest building and foraging activities of Lesser Snow Geese result in physical damage to graminoid and other vegetation communities in proximity to their nesting colonies in the Canadian Arctic. Analysis of LANDSAT TM satellite imagery has proved effective in mapping of habitat types in proximity to nesting colonies, and in the detection of habitat degradation. Habitat degradation is in the form of complete loss of surface vegetation and exposure of underlying organic substrates. In some areas weathering and ice action can remove thin organic substrates and exposed mineral parent materials. Near Karrak Lake, NWT, the area of habitat degradation involves destruction of cotton grass meadows and stripping of most species of vegetation in upland sites. The area of degradation closely corresponds to the extent of the nesting colony with little evidence of degradation in foraging areas in adjacent areas. Along the west coast of Hudson Bay near Arviat, NWT, habitat degradation is more widespread with large areas of peat barrens in proximity to nesting colonies. The relative role of Snow Goose foraging activity and local moisture changes due to climate and isostatic uplift is not clear.

THE ROLE OF PREDATORS IN DETERMINING NESTING DISTRIBUTION OF DARK-BELLIED BRENT GEESE

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Arctic foxes are usually mentioned as the key factor causing the rather regular three-year cycle of Dark-bellied Brent Geese (*Branta b. bernicla*) on the Taymyr Peninsula: a good breeding season, followed by an almost completely failed breeding season, finally followed by an 'unpredictable' season in the year before the lemmings peak once more again (Roselaar 1979, Greenwood 1987, Summers & Underhill 1987). Arctic foxes would prefer lemmings and switch to bird eggs when lemmings are in short supply ('prey-switching-hypothesis', Underhill & Summers). In the first five years of a 6-year study along Lidia Bay, Taymyr, we examined the impact of Arctic foxes on Brent distribution and nesting success. Brent were predominantly found on small offshore islands together with large numbers of Taymyr Gulls (*Larus argentatus taimyrensis*), but smaller numbers were found to nest on the mainland tundra, mainly on riverbanks. Due to better feeding conditions on the riverbanks female Brent required less time off the nest to feed during incubation, than those females nesting on islands. Young goslings were raised along these riverbanks, also those from most island-nesting Brent. On the mainland tundra severe fox predation on Brent Goose nests occurred during lemming peak years (1991 and 1994), no to moderate fox predation in the 'unpredictable' years (1990 and 1993). In 1992 foxes were extremely numerous and prevented most geese from laying eggs by regular attempts to catch the prospecting geese during the time of nest territory establishment. This occurred both on the mainland and on the islands, where foxes could come over the ice, or even swimming short distances. Except for 1992 there was no fox activity on the islands, but Gulls did take some eggs, particularly in the years when lemmings were not abundant. Shortly after hatching, however, severe predation on goslings by Gulls did occur when winds were strong. These opposing selection pressures shaping Brent Goose's nest site choice have resulted in a strong preference for nesting on small islands inhabited by Gulls, but some individuals keep on trying to nest in the more risky, but rich-in-food situations on the mainland tundra. During lemming peak years here 'safe havens' are created by nesting Snowy Owls, and small numbers of Brent have been reported to nest successfully under such conditions.

NUTRIENT RESERVES AND NEST ATTENTIVENESS OF INCUBATING BLACK BRANT

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Sub-arctic nesting geese arrive on the nesting area with much of the lipids and protein needed for laying and incubating eggs (Ryder 1970; MacInnes et al. 1974; Ankney and MacInnes 1978; Raveling 1979; Ankney 1984). Because of their small size, Black Brant (*Branta bernicla nigricans*) are unable to store sufficient lipid before nesting to meet their energy needs during egg laying and incubation; thus they must supplement their reserves by feeding during egg laying and incubation (Ankney 1984). Nevertheless, nutrient reserves are important even in these species. Females with lower lipid and protein reserves at the onset of incubation are less attentive to the nest during incubation (Aldrich and Raveling 1983), which results in greater loss of eggs to predation (Harvey 1971; Inglis 1977). Density of nesting females may also affect nest attentiveness by allowing females in higher densities to be less attentive (Welsh 1988). While Aldrich and Raveling 1983 found less experienced Western Canada Geese (*Branta canadensis moffitti*) to have fewer nutrient reserves, and were therefore less attentive. We estimated nest attentiveness of Black Brant breeding at the Tutakoke River colony, Yukon-Kuskokwim Delta, Alaska using three different techniques (time budget observations, platforms placed under nests, and temperature sensitive artificial eggs). Nutrient reserves were indexed from residuals of body mass regressed against PC1 scores calculated from culmen, tarsus, and body lengths. Nest attentiveness varied significantly among females (58-91% attentiveness, $P=0.005$), and among 3 different areas within the nesting colony ($P=0.025$). Attentiveness significantly decreased as the number of days the female incubated increased ($P=0.038$). Residuals from the regression of mass against PC1 varied significantly among females of different ages ($P=0.034$). These residuals decreased significantly ($P=0.001$) throughout the 24 day incubation period. We believe that variation in nest attentiveness is due to variation in nesting density, age, and nutrient reserves of females.

NATAL PHILOPATRY AND SEX-BIASED DISPERSAL PATTERNS IN CACKLING CANADA GEESE

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We examined return rates of juvenile neck-banded cackling Canada Geese (*Branta canadensis minima*) on the Yukon-Kuskokwim Delta, Alaska during 1986 - 1993. Resighting rates of yearling (second summer) females and males were similar and varied from 10 - 20% among years of study. A female bias in return rate was apparent in subsequent years, although up to 4 percent of four-year-old males returned to breed on the study area. Observed patterns of dispersal are discussed in the context of the restricted breeding and wintering range of the population. Social units of this subspecies are also less stable than most arctic goose populations, and may influence dispersal potential. Further analysis of observations of birds on the wintering grounds will provide insight into proximal factors contributing to male dispersal and moderate gene flow.

TIMING OF MOLT IN BREEDING ADULT CACKLING CANADA GEESE ON THE YUKON-KUSKOKWIM DELTA, ALASKA

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Timing of wing molt was determined for collared Cackling Canada Geese (*Branta canadensis minima*) with goslings during the brood-rearing period on the Yukon-Kuskokwim Delta, Alaska. We found no consistent sex-related differences based on data collected from observations and captured birds. Molt stage of females was independent of their mates. In instances when there were obvious differences in molt within a pair, females were more advanced in wing molt 51% of the time and males were ahead 49% of the time. Preliminary analyses suggest that there was a positive correlation between gosling age (inferred from size and weight of goslings near fledgling) and the length of ninth primary of the male parent but not the female. These data are consistent with the view that breeding females delay molt to maximize weight gain immediately after hatch. Other investigations of arctic-nesting geese and swans have suggested that sex-related differences in the timing of wing molt maybe constrained by length of season, clutch/brood size, and brood defense. Further studies should emphasize questions of annual differences in timing of molt and the effects of other factors, such as forage quality and age, on timing of molt.

NUTRIENT ACQUISITION, TIMING OF BREEDING AND CLUTCH SIZE IN LESSER SNOW GEESE

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The potential contribution of early spring feeding conditions in the arctic to clutch size variation was examined in a population of Lesser Snow Geese *Anser caerulescens caerulescens*. The main questions were: (1) How much energy can female Snow Geese gain by feeding on the breeding grounds prior to incubation? (2) Can this energy gain influence a bird's decisions on clutch size and laying date? Energy intake by females between arrival on the breeding grounds and incubation was measured by behavioral observations and calorimetry of food samples. Energy gained in this period, even in cold years, is considerable and can be in the same magnitude as the cost of one or several eggs. Waiting periods before laying are not energetically costly, but beneficial. There was no difference in length of the pre-laying staging period nor in variance of laying dates in years when habitat was more or less restricted by snow cover; however, in years with late mean laying dates, the staging period was shorter than in early years. The timing of migration and follicle development is such that clutch size decisions are sometimes made during the last stages of migration, sometimes after arrival. In the latter case food conditions on the breeding grounds may greatly influence clutch size and laying date; in the former case they may still influence readjustments of clutch size after the initial decision. Nutrient limitation after arrival in the Arctic cannot sufficiently explain the environmental component of clutch size variation within and among years in the population. Resource accumulation for reproduction in Snow Geese is a continual process including food sources on the breeding grounds. The negative correlation between clutch size and laying date in Snow Geese can be explained by negative fitness consequences of late laying outweighing the benefits of delayed clutch initiation and accumulation of additional nutrients.

INDIVIDUAL PHILOPATRY AND COLONY DYNAMICS IN A CHANGING HABITAT

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In the Lesser Snow Goose colony of La Pérouse Bay, vegetation not only of brood-rearing habitat, but also of nesting habitat has been subject to long-term changes over the past 20 years. This is documented with vegetation maps of a 6 ha section of the nesting area recorded 17 years apart. The major changes include a severe reduction in grassy vegetation, an increase in areas covered by bare mud and by willows, and the complete disappearance of lyme grass. These changes may partially be attributed to goose feeding activities, partially to isostatic uplift. While the area contained 79 nests in 1976, there were no nests in it in 1993. t was investigated whether Snow Geese, which are generally highly philopatric to their breeding sites, show a decline in philopatry in a thus degraded habitat. Analyses (using program SURGE) of resightings of adults to certain regions of the colony showed that breeding philopatry remained unchanged. However, there is evidence of a lack of recruitment of young birds into formerly central and now degraded areas of the colony. Together with a small amount of relocation of adult birds this has led to a long-term shift of the colony as a whole.

SITE INFIDELITY IN NESTING GREATER SNOW GEESE

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Breeding philopatry is well developed in female ducks and geese with birds often coming back to nest within a few meters of previous year nest site. However, over a 7-year period, we found a very low level of nest site fidelity in Greater Snow Geese (***Chen caerulescens atlantica***) on Bylot Island, NWT. Here, we document this unusual behavior and discuss the reasons for it. Nests were searched for extensively during the laying period from 1988 to 1994 over a 65 km^2 area. Geese adopted 2 nesting strategies: some geese nested in dense colonies (up to 20 nests/ha) whereas others nested alone or in small groups (usually <10 nests). Colony size was highly variable ranging from 65 nests in 1989 to 295 in 1993. No colonies were found on the study area in 1992 and 1994. In those years, colonies were found 30 km south of the study area (colony size: 200 in 1992, >1000 in 1994). Colonies were established in different areas each year, some years around wet, lowland habitat, other years in dry upland habitat. Distance between the arithmetic center of colonies over successive years averaged 4.3 km on the study area. In years of late snow-melt (1992), snow may limit nest site availability, but in most years, suitable nesting areas were available several days before nest initiation. In years where Snowy Owls (*Nyctea scandiaca*) were nesting (1989 and 1993), goose colonies were clustered around owl nests, probably as a protection against nest predators. Although nesting in lowland areas may be the preferred strategy because of the abundant food available around the nest, upland nesting may be favored in years of high predation (1994, a year after a peak in lemming abundance). Selection of a new nest site every year may be favored over site fidelity because 1) of the high temporal and spatial variability in snow-melt and predation pressure in the high arctic, and 2) the long feeding period that takes place between arrival and start of egg-laying provides enough time for nest site prospecting. In contrast to their flexibility in nest site selection, Greater Snow Geese showed much less flexibility in their nest initiation date between years.

EFFECTS OF PREDATION AND COMPETITION ON POPULATION AND FLOCK DYNAMICS OF WINTERING GEESE IN TEXAS

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Examining the relative importance of processes such as predation and competition at several scales provides insight as to how birds balance conflicting demands in a complex environment. We investigated whether population density and number of conspecifics per flock (i.e., population and flock levels respectively) of sympatric Snow Geese (*Chen caerulescens*), Greater White-Fronted Geese (*Anser albifrons*), and Canada Geese (*Branta canadensis*) responded similarly to fluctuations in predation risk, numbers of potential competitors, and resource levels. Our results indicated that food (waste rice grain) most strongly influenced population density of White-Fronted Geese, whereas Snow and Canada geese were affected by hunting pressure and food (green vegetation and waste rice grain) indirectly through interactions. At the flock level, all three species exhibited patterns strongly indicative of a response to predation, with lesser effects from food and heterospecifics. The close link between Greater White-Fronted Geese and waste rice grain suggests that current declines in rice agriculture and the subsequent conversion of rice fields to pasture will likely impact populations of White-Fronted Geese more severely than those of either Snow or Canada Geese.

PROSPECTS AND PROBLEMS FOR THE RESTORATION OF ALEUTIAN CANADA GEESE IN ASIA

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In 1992, ornithologists in Kamchatka initiated an international collaborative project focused on the recovery of Aleutian Canada Geese (ACG) *Branta canadensis leucopareia* in Far East Asia. Breeding pens for ACG were built in the area of 0.5 ha in Yelizovo, Kamchatka. Nineteen adult ACG were imported from the USA in the fall of 1992. In the summer of 1993, 4 pairs of these translocated geese succeeded in rearing 19 goslings. Twelve of these goslings were released with some wild Bean Geese *Anser fabalis serrirostris* in the following fall, as a test. The remaining 7 juveniles were kept for the breeding stock for the future. In 1994 spring, 6 pairs laid eggs and reared 17 goslings. With an incubator, we believe that upwards of 40-50 goslings could be successfully hatched. In the fall of 1994, Yagiyama Zoological Park of Japan will contribute 3 additional pairs of ACG, which will increase the overall productivity of the captive population. The most promising sites for re-establishing a small population (200-250 birds) of ACG are Ekarma Island and Chirinkotan Island, where populations of ACG had been present until the beginning of 20th century, and the islands belonging to the northern Kurile Islands. Field stations for the ACG recovery project will be needed in southern Kamchatka. With continued international collaboration of researchers from the Russian Institute of Ecology, the Japanese Association for Wild Geese Protection, and the US Fish and Wildlife Service, successful re-establishment of this species is anticipated by the year 2000. However, there are significant obstacles which will need to be overcome before this goal is realized. There is presently a critical shortage of base funding from the Russian Academy of Science, which has not been compensated by additional funding from the US or other sources. Further, there is a real shortage of equipment at all facilities, although the JAWPG has contributed some materials to date.

DISTRIBUTION AND ORIGIN OF NON-BREEDING AND NEST-FAILED CANADA GEESE IN NORTHERN MANITOBA

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Since 1969, banding of the Eastern Prairie Population (EPP) of Canada Geese in northern Manitoba has provided large numbers of recaptures of previously marked geese. These recaptures have been obtained from flocks with and without goslings. The latter representing either flocks of molting geese which did not attempt to breed, or which lost clutches or broods. Geese without goslings are almost always associated with inland lakes and are rarely encountered along the coastline of Hudson Bay where flocks of geese with broods are numerous. The origin of recaptures in flocks of geese without goslings includes EPP geese and geese from more southerly populations, and the proportions of each origin vary among years. Multiple recaptures provide insight regarding fidelity of individuals to both molting and nesting areas.

RESIDENCY AND INTERCHANGE OF BRANT DURING SPRING STAGING IN COASTAL BRITISH COLUMBIA

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Pacific Black Brant (*Branta bernicla nigrans*) wintering along the Pacific Flyway stage in coastal areas of British Columbia during spring migration northward to breeding grounds in Russia, Alaska, and the western Canadian Arctic. Data from individual marked individuals allowed us to analyze the pattern of residency of individual birds at particular sites in coastal British Columbia, and the interchange of birds among sites, from 1990 to 1994. Our results indicated strong philopatry to specific spring staging areas, and very little interchange among sites in coastal British Columbia. We suggest that the Brant we observed demonstrated only a single stop-over at coastal sites between wintering and breeding grounds. Length of stay at traditional coastal sites during spring migration demonstrated a latitudinal gradient, ranging from 1.1 days in the south to 6.7 days in the northern locations. Explanations for this phenomenon might include greater disturbance levels in more southerly locations, variation in habitat quality among sites, and/or body condition of birds undertaking longer migrations. Overall, we estimated the population of staging Brant in our study areas to approximately 30,000-40,000 individuals. Undoubtedly, other minor staging areas exist in coastal British Columbia but the remaining whereabouts of the Pacific Flyway population during spring migration is poorly known at present. We suggest that a significant proportion of this population may undergo non-stop northward migration similar to the general case for Brant during fall migration.

GROWTH AND CONDITION OF SOUTHERN JAMES BAY CANADA GOOSE GOSLINGS ON AKIMISKI ISLAND, NORTHWEST TERRITORIES

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Since 1990, the number of breeding pairs of Southern James Bay Canada Geese (*Branta canadensis interior*) on Akimiski Island has declined by approximately 60 percent. There is evidence to suggest that poor growth of goslings on the island, possibly due to degradation of brood rearing habitats by Canada Geese and Lesser Snow Geese (*Chen caerulescens caerulescens*), is contributing to poor recruitment. This study was conducted to determine growth and condition of known age goslings. During 1993, 882 goslings were web-tagged at hatch and 141 recaptured in mass banding drives conducted during the adult remigial molt. Similarly in 1994, 1270 goslings were web tagged and 174 recaptured. In both years, we measured body mass, skull length, and tarsus length of recaptured web-tagged goslings. Only 94 recaptured web-tagged goslings were measured in 1993, whereas all recaptured goslings were measured in 1994. Recaptured goslings ranged in age from 37 to 52 days. In this paper, we present an analysis of the contributions of age, sex, capture date, and year to variation in structural size and condition (body mass corrected for age/size) of goslings. We discuss how our results relate to recruitment potential of Southern James Bay Canada Geese.

SURVIVAL OF LESSER SNOW GEESE IN THE PACIFIC FLYWAY, 1986-1989

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During the past few decades, Snow Geese have undergone considerable shifting of their winter distribution in western North America. Numbers of wintering birds have apparently increased in some areas (e.g., New Mexico, British Columbia, and Washington) and decline in others (California). Beginning in 1987, a major effort was made to neck-collar Lesser Snow Geese at all colonies that contribute to the Pacific Flyway population, primarily to determine the distribution of geese from different areas on migration routes and wintering grounds, but also as a secondary objective to document the survival of birds from differing colonies. Additional marking was carried out in 1986 and 1987 on the wintering grounds in the Fraser Delta and in New Mexico. In this report, we summarize the data on survival rates of geese banded at the different sites for the period 1986-1989. Analyses of neck-collar observations from wintering and staging areas were carried out using Jolly-Seber and related models. These analyses indicated a high probability of reobservation of geese (>70% for most areas and years), and relatively precise estimates of survival (CV's <5%). Survival differed significantly among years and areas and was generally higher in the east than the west. Our findings are discussed in relation to recent changes in the abundance of wintering Snow Geese in the Pacific Flyway.

BREEDING ECOLOGY OF CANADA GEESE NEAR A NEWLY CREATED HYDROELECTRIC RESERVOIR IN NORTHERN QUEBEC, 1992-1994

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We studied nesting and brood-rearing ecology of Canada Geese (*Branta canadensis interior*) in a low density breeding area under development for hydroelectric power in north-central Québec to evaluate the short-term effects of habitat loss resulting from the creation of a reservoir. Here we report results obtained in 1992 and 1993, before the flooding of the Laforge-1 Reservoir, and in 1994, after flooding. Nests and broods were located using a helicopter. Physical and vegetative characteristics of nest sites were recorded. Habitat use by broods was studied using observations of unmarked broods and by radio-tracking female geese captured on their nests. In 1993, 9 female geese were marked on nests, 5 within the future limits of the reservoir and 4 in adjacent areas; 5 additional females were marked during brood-rearing. Nest density varied from 0.9 nests/100km^2 in 1992 to 2.9 nests/100km^2 in 1993 and 1994. Nest success was low in 1992 (25%), but much higher in 1993 (73%) and in 1994 (74%). In all years, most nests were constructed on small mossy islets in ponds and string bogs. Brood-rearing habitats included bogs, but ponds and lakes bordered by sedge meadows dominated; we also recorded broods using forested habitat adjacent to these wetlands. Although observations were conducted up to about 60 days after hatch, marked geese were never observed more than 6.4 km from their nest sites. Home range size varied from 1.1 to 14.0 km^2 (n = 11). Nest density, nest site characteristics, nest success, and movements and habitat use by broods were similar in the years preceding and following creation of the reservoir. Of 5 female geese radio-marked in 1993 that were detected in the area in 1994 following creation of the reservoir, only 1 nested. The results of this study (which will continue in 1995) will provide a better understanding of the response by Canada Geese to habitat changes in a portion of the breeding range which has previously received little attention.

RETENTION TIME OF FORAGE, FORAGE INTAKE, AND FECAL OUTPUT IN LESSER SNOW GEESE

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We used a particle phase forage marker (cerium-141 chloride) to measure transit (TT) and total mean retention (TMRT) times of forage in captive Lesser Snow Geese (*Chen caerulescens caerulescens*) (n = 16) as they fed on tall cotton-grass (*Eriophorum angustifolium*) stembases in an arctic tundra staging area. We concurrently measured foraging behavior and fecal output (n = 12). Turnover of body water was studied in 4 birds. Mean TT was 0.92 hr (SD = 0.34) and TMRT was 1.42 h (SD = 0.34). On average, geese fed during 58% of the 8.3 h trials and produced 59 g of dry fecal matter/bird. Based on cellulose and lignin markers, mean apparent dry matter digestibility was 0.42 (SD = 0.06) and forage intake averaged 102 g dry mass/bird/trial. These estimates are conservative if geese partially digested cellulose. After correcting fecal output for TMRT, forage intake averaged 16 g/h. Turnover of body water occurred in 1.3 days. These results are indicative of the hyperphagic condition of Snow Geese during autumn staging on the coastal plain of the Beaufort Sea. On a daily basis, a goose may consume approximately 740 g (wet mass) of cotton-grass stembases over a 10-h period in the afternoon and evening when soils are not frozen and underground forage is available. The forage requirements of Western Canadian Arctic Snow Geese during their 2-4 week staging period are substantial. Snow Geese in this population require a large autumn staging area because of their high forage demands, and due to spatial and temporal heterogeneity in food availability.

IMPORTANCE OF SOUTHEAST OREGON WETLANDS AS MIGRATIONAL STAGING AREAS FOR ARCTIC GEESE

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Major wetland basins in southeast Oregon which are important to arctic geese include Summer Lake, Harney, Warner, and Goose Lake basins. These areas serve as important spring and fall migrational staging areas for Lesser Snow Geese (*Chen caerulescens*) (including the Wrangel Island, Russia, Banks Island, Canada, and the North Slope, Alaska populations), Ross' geese (*C. rossii*) from the central Canadian arctic, Tule White-Fronted Geese (*Anser albifrons gambelli*), and Greater White-Fronted Geese (*A. a. frontalis*) from Alaska. They also receive some use by Cackling Canada Geese (*Branta canadensis minima*), lesser Canada Geese (*B. c. parvipes*), and Taverner's Canada Geese (*B. c. taverni*). Summer Lake Wildlife Area is important as a fall staging area for Snow Geese, with fall peaks of up to 75,000 birds in early November. Summer Lake is particularly important to Wrangel Island birds. Geese widely disperse to wetland basins in spring with Harney Basin, including Malheur National Wildlife Refuge and Summer Lake Wildlife Area being important spring use areas. Spring peaks of over 100,000 Snow and Ross' Geese combined have been documented in late March in both the Summer Lake Harney basins. The Harney Basin is particularly important to spring staging Ross' geese, with peaks of up to 40,000 being counted in early April. Other wetland basins are primarily used in spring by white geese, with use depending on wetland conditions. Use of southeast Oregon by Greater White-Fronted Geese is highest in spring, when these birds are widely dispersed in all wetland basins in the area. Tule White-Fronted Geese use the Summer Lake Basin, Warner Basin, Chewaucan Marsh, Sycan Marsh and Harney Basin as spring staging sites during April, and primarily use Summer Lake and the north end of the Harney Basin as fall staging sites in September. In September up to 75% of the Tule Goose population has been counted at Summer Lake and Harney Basin.

VEGETATION CHANGE DETECTION BY MULTITEMPORAL ANALYSIS OF LANDSAT MSS DATA

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Since 1972, the Landsat series of satellites have been providing frequent, low-resolution, digital imagery of the surface of the Earth. The resulting long-term historic record has the potential to detect and quantify changes occurring in the landcover, an approach that is especially valuable in the study of remote and inaccessible areas. As part of a larger study on the effect of dramatically increased Lesser Snow Goose populations on the coastal ecosystems of the Hudson Bay region, remote sensing techniques are used to determine changes in the coastal vegetation between 1974 and 1992. Cloud-free Landsat Multispectral Scanner imagery of the Cape Henrietta Maria area, acquired on July 12, 1974, July 24, 1983 and July 8, 1992, was used in the study. In addition, a higher resolution Landsat Thematic Mapper image, recorded on August 1, 1989 was also available to provide finer detail. Initial results are promising, degradation of coastal salt marshes and an attendant increase of moss carpets are recognizable on the sequence of satellite imagery. Comparison of enhancements, vegetation indices and classifications have been utilized in the study. Depending on the final results, an extension of this remote sensing study to other significant Snow Goose nesting areas, such as Akimiski Island and La Pérouse Bay, is considered.

IMMIGRATION IN A SMALL COLONY OF LESSER SNOW GEESE

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The Lesser Snow Goose (*Anser c. caerulescens*) colony on Howe Island, near Prudhoe Bay, Alaska, is the only established nesting colony of this species in the United States, and it is the only nesting colony of Snow Geese in proximity to an active oil filed. We banded virtually all brood-rearing Snow Geese in the study area in late July 1980-1993. During this 14-year period the Snow Goose population expanded from 39 to 412 nesting pairs. Based on mark-recapture data from the banding programs, we estimated that immigration rates for females and males were 12.8 ± 4.39% and 60.7 ± 12.85%, respectively. Exceptionally high immigration rates for males were recorded in 1990 and 1993, when large numbers of 2 and 3-year old females (banded in our study area as goslings) returned with unbanded mates from other populations. Most female immigrants probably enter the population as yearlings. The origins of immigrants is unclear because of limited banding at neighboring colonies. Resightings of neckbanded Howe Island geese indicate that some have emigrated to Wrangel Island, Russia, and others to Banks Island and Anderson River Delta, NWT. As of 1993, the contribution of immigrant females and their progeny to the growth of the nesting population of females was 26.4% (110 of 417).

UTILIZING SPOT MULTISPECTRAL IMAGERY TO ASSESS WETLAND VEGETATION SUCCESSION IN THE COPPER RIVER DELTA, ALASKA

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The Copper River Delta is one of the largest contiguous wetlands on the Pacific Coast of North America, occupying 283,000 ha. This is an incredibly dynamic wetland system, with an estimated 100 million metric tons of sediment deposited annually on the Delta or into the Gulf of Alaska. The 1964 earthquake, measuring 9.2 on the Richter scale, uplifted the entire Delta 1.8-3.4 meters. Since the uplift, succession is occurring rapidly on the old salt marsh, with much of the grass/sedge community shifting to willow/alder. Mud flats lifted above the mean high tides are slowly being colonized by vegetation (mostly *Carex lyngbyaei*). Understanding the success of vegetation on the Copper River Delta will aid in habitat management for geese and other waterbirds. This paper describes an analysis of vegetation succession utilizing SPOT imagery. In addition to providing migrational habitat for millions of shorebirds and ducks, the Delta supports nearly the entire world's population of dusky Canada geese, and 10% of the world's trumpeter swan population. Prior to the 1964 earthquake (1953-1964), population estimates for the dusky average 15,000 birds. Populations levels have increased to over 21,000 birds by the early 1980's, but have declined drastically since that time. To better understand changes in habitat during the period of dusky Canada goose population decline, an analysis of vegetation communities was conducted. After field collection from more than 600 vegetation sites between 1992-1994, LANDSAT maps were developed. Alder/willows stands and mixed shrub trees made up over 48,110 ha or some 17% of the landscape scene. The 1964 tectonic uplift has resulted in a successional shift from palustrine emergent wetlands to palustrine shrub/scrub type.

SPRING AND FALL DISTRIBUTION OF EMPEROR GEESE IN SOUTHWEST COASTAL ALASKA

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Virtually all of the worlds population of Emperor Geese (*Chen canagicus*) stage during spring and fall migration in southwest coastal Alaska. These geese are concentrated mainly along 560 km of the Alaska Peninsula. During staging Emperor Geese are concentrated in seven major estuaries on the north side of the Alaska peninsula, and on two estuaries in northern Bristol Bay. The population of Emperor Geese has declined by more than half in the last two decades to approximately 53,000 in the spring of 1993. Distribution of Emperor Geese has remained relatively stable in major staging areas throughout the period 1981-93 and distribution differences between spring and fall within a bay does not appear to be significant. A thirteen year mean was calculated for spring and fall. Major use (80 percent of the total population) is found to occur in 4 bays on the Alaska Peninsula. The highest percentage use occurs in Nelson Lagoon-Port Moller Bays (29.6 and 36.9 in spring and fall respectively). However, the highest density of use occurs in Cinder River Lagoon (200 Emperor Geese/km^2) during fall and Seal Island Lagoon (170 Emperor Geese/km^2) during spring. Nine major staging areas are compared over the 13 year study and demonstrate the significance of these estuaries to the survival of Emperor Geese during migration.

TAYMYR PENINSULA WHITE-FRONTED GEESE POPULATION STATUS, MIGRATORY ROUTES AND WINTERING AREA

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A collaborative Russian-German field study of the Taymyr population of White-fronted Geese was initiated in 1989. This study focused primarily on: (a) a broad-level description of the physiography of the region, (b) basic breeding biology (timing of arrival, feeding, nest density, predation, weather etc), (c) morphometric and demographic analysis of molting geese (sex and age class, stage of molt, body mass, length of bill), and (d) the effect of hunting as a major factor influencing the size of the migrating population. Since the start of the field study, more than 800 individuals have been marked at the molting sites with a red and green-colored leg band as well as white neck-collars. Of these marked birds, there were a large number of winter resightings throughout Europe, including Belgium, Germany, Great Britain, Kasachstan, the Netherlands, Romania, Russia, Sweden and Turkey. Band recoveries and winter resightings have changed a number of traditional views on both the migratory routes and the relative changes in numbers of White-fronted Geese in Europe.

THE GENETIC DIFFERENCES BETWEEN TWO SUBPOPULATIONS OF LESSER SNOW GEESE NESTING ON WRANGEL ISLAND, RUSSIA

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The comparative electrophoretical analysis of proteins of two subpopulations of Lesser Snow Geese (*Anser caerulescens caerulescens*) nesting on Wrangel Island and wintering in British Columbia and California Valley was done. The eight polymorphic gene loci were analyzed. These loci have from two to six alleles.The statistical analysis of these data showed that there are genetic differences in allele frequencies of the studied gene loci between these two subpopulations. Genetic differences were found also between males and females of both subpopulations. The high intensive gene flow from Banks Island and Anderson River Snow Geese (through males) to south wintering W.I. geese was found. The same gene flow but more lower was found in north wintering W.I. geese. Genetic distances between subpopulations is supported by these gene flows but if take to account the gene exchange between southern and northern geese calculated by Syroechkovsky et all., it equals 9% per generation, and distance between southern and northern females, as more conservative parts of subpopulations, equals 0.024 (Rogers, 1972) it can be suggested that these subpopulations have merged recently.

MOLT MIGRATION OF CANADA GEESE AND THE INTERPRETATION OF BAND RECOVERIES

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We examined recaptures of foreign-banded Canada geese in northern Ontario from 1974-1992 to describe the age, sex, and origins of molt migrants found along the James and Hudson Bay coasts. We also examined early September recoveries of geese banded in northern Ontario to explore the hypothesis that most early September recoveries are molt migrant giant Canada geese (*Branta canadensis maxima*). Of 220 recaptured geese that were banded as goslings (June-August), 2 were recaptured as goslings, 118 (54%) as yearlings, 39 (18%) as 2 year olds, and 61 (28%) as 3+ year olds. Fifty-one percent of recaptures were males. Molt migrants originated from 28 different states and 6 different provinces, though 52% were banded in Ohio and Michigan. Southern Ontario, Indiana, Illinois, Kentucky, and Wisconsin each contributed about 5% of recaptures. More than 90% of early September recoveries of geese banded in northern Ontario were geese banded as adults; we suggest that most were molt migrant Canada geese.

CLUTCH MANIPULATION IN GREATER SNOW GEESE: THE CAUSAL RELATIONSHIP BETWEEN HATCH DATE, BROOD SIZE AND PRE-FLEDGING GROWTH

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Hatch date and brood size are two factors affecting gosling pre-fledging growth and survival in Arctic-nesting geese. However, studies conducted so far have not been able to separate the relative importance of parental phenotypic traits (e.g., intrinsic quality, age, breeding experience), and of factors extrinsic to parents (food availability and quality, social dominance of larger broods) in affecting gosling growth. For instance, the hatch date effect on growth rate has usually been explained by the seasonal decline in food availability or quality, but early nesting birds may also adopt a better habitat use strategy with their brood than late nesting ones (Hughes et al. 1994, J. Wildl. Manage. 58:536-545). We manipulated Greater Snow Goose (*Chen caerulescens atlantica*) clutches (n=318 nests) on Bylot Island (NWT) to determine the contribution of parental phenotype in explaining variability in gosling growth. We conducted 2 clutch exchange experiments in 1993 and 1994: (1) between paired early-late nests (hatch date increased or decreased by 4 days), and (2) between paired small-large clutches (addition or removal of 2 eggs). Goslings were web-tagged at hatch and recaptured 5 weeks later in mass banding drives. All goslings captured (tagged or not) were weighed and measured (culmen, head, tarsus and 9th primary). Covariance models applied to all goslings in 1993 using the length of the 9th primary as an estimation of age showed a strong effect of date on body size (PC1) and mass, with early-hatching goslings growing faster than late-hatched goslings. With recaptured experimental goslings, we examined the relationship between size or mass, and the number of days or eggs manipulated (after factoring out hatch date and brood size effects). Gosling size and mass were not affected by the parents (early or late) that raised them, but goslings from larger clutches had faster growth, even if raised by parents which originally laid a smaller clutch. We conclude that parental phenotype is of little importance in explaining the variation in growth rate associated with hatch date or brood size.

EFFECT OF HATCH DATE AND BROOD-REARING SITE ON GROWTH PATTERN AND ORGAN DEVELOPMENT IN GREATER SNOW GEESE

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Growth rate in geese is among the fastest of all precocial birds and appears to be especially sensitive to the feeding conditions encountered during the brood-rearing period. A general observation is that late-hatched goslings grow at a smaller rate than early-hatched goslings. In this study, we evaluated if late-hatched goslings adjusted their growth pattern to compensate for their slower growth rate compared to early-hatched goslings in Greater Snow Geese (*Chen caerulescens atlantica*). We collected 48 early-hatched (EH, mean age = 42.4 d) and 48 late-hatched goslings (LH, mean age = 34.8 d) separated equally among sexes in 4 banding drives conducted in different areas on Bylot Island, NWT, in August 1993. Age was estimated using 9th primary length. Goslings were autopsied and the dry mass and fat content of digestive organs, major muscle masses and the remaining carcass were determined. Comparisons were made by analysis of covariance using total body ashes as a covariable to evaluate the relative development of various organs between EH and LH goslings. Thus, all results reported are corrected for size differences between the two groups. EH goslings were heavier and their breast muscles were considerably heavier than LH goslings, but leg muscles were similar in both groups. Mass of digestive organs were similar except liver which was heavier in LH than in EH goslings. Body fat was extremely low and similar in both groups (<1% of body mass on average) which shows that: (1) fat accumulation in preparation of the fall migration has not yet started in either group and (2) all assimilated energy is used for growth only. Our results suggest that LH goslings do not adjust the growth of their various body parts in order to attain flying stage as early as possible, albeit at a smaller size. There was a strong site effect in the degree of development of various body parts which supports the hypothesis that gosling's growth is dependent on the feeding area used during the brood-rearing period.

BROOD SITE FIDELITY OF BLACK BRANT, TUTAKOKE RIVER, ALASKA

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Recent studies (Larsson and Forslund 1992, Cooch et al. 1993, Sedinger et al. unpubl.) suggest that early growth and development, survival, and subsequent reproductive performance may be affected by the environment that geese experience as goslings (i.e., brood rearing areas). Although numerous studies have examined fidelity to nesting areas (Anderson et al. 1992) few studies have examined the fidelity of geese to specific brood rearing sites (but see Cooke and Abraham 1980, Findlay and Cooke 1982, Lessels 1985). In addition, previous estimates of fidelity were potentially biased by a confounding of survival and emigration. From 1987 to 1993 we examined fidelity of Black Brant (*Branta bernicla nigricans*) to specific brood rearing areas of the Tutakoke River colony, Alaska. We used a multistate modeling approach and program MS-SURVIV (Brownie et al. 1993) to obtain estimates of fidelity and test specific hypotheses about dispersal patterns. Capture histories for individual birds were obtained by recapturing previously marked Brant during the flightless period. We obtained fidelity estimates for adult and immature (natal site fidelity) males and females. All age and sex classes, except immature males, exhibited high fidelity to previous brood rearing areas. Preliminary data on the correlation between brood rearing and nesting areas is also presented.

THE RICE PRAIRIE MANAGEMENT PLAN: A COOPERATIVE EFFORT TO ADDRESS THE NEEDS OF WATERFOWL AND AGRICULTURE

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The Texas Rice Prairies and adjacent coastal marshes, extending from the middle to upper Texas coast and inland approximately 60 miles, are recognized as internationally significant habitat for mid-continent migratory waterfowl. In excess of 2 million ducks and geese overwinter in or migrate through this region. Historically, the "rice prairies" were dominated by tall grass species. The majority of wintering waterfowl, especially geese, were dependent on coastal marshes. As the prairies were cultivated many waterfowl species took advantage of the abundance of waste grain and water areas. Recent winter population estimates for snow (>1 million birds), white-fronted (250,000 birds), and Canada geese (75,000 birds) indicate that population levels meet or exceed goal levels of the Texas Mid-Coast Initiative of the Gulf Coast Joint Venture. Unfortunately the ability of the Rice Prairies to continue to support millions of migratory waterfowl may be in jeopardy. Expansion of the city of Houston, which borders the rice prairies on the east, will convert cropland into residential and industrial areas. Also, as land is taken out of production it becomes overgrown with brush and loses its value to waterfowl. Winter survey data indicate that goose use of a particular rice prairie decreases as rice acreage is lost, therefore, as agricultural uses shift from rice to other crops the ability of these areas to support large concentrations of wintering geese declines. Expansive areas (>30,000 acres) are required to maintain large wintering concentrations of geese. As these large landholdings are broken up (sold to several owners) and as land use within these areas changes, the ability of these areas to support large concentrations of wintering geese also declines. In our presentation of The Rice Prairie Plan we will discuss their importance to wintering waterfowl, outline problems and issues facing agriculture and waterfowl, detail management recommendations and research needs, and discuss the cooperation among private landowners, state and federal agencies, and conservation groups that is necessary to conserve this critical habitat area.

BEHAVIOR AND GROWTH IS DIRECTLY INFLUENCED BY FAMILY SIZE: A MANIPULATION EXPERIMENT IN BARNACLE GEESE

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We conducted a manipulation study of family size in Barnacle Geese (*Branta leucopsis*) on Spitsbergen to examine the effect of variation in family size on gosling growth, potentially mediated through variation in parental vigilance and family dominance. At hatch, natural family size was manipulated by switching two goslings from one family to another family. Adult males of enlarged families had a higher attack frequency and won relatively more interactions than males with reduced families. The dominance of larger families was directly related to family size since it declined significantly when family size decreased due to predation of goslings. The vigilance behavior was also affected by the manipulation. Both male and female were more vigilant in enlarged families compared with reduced families. Together with a switch in habitat choice these observed differences resulted in a positive effect on both gosling growth and adult female weight. Fitness consequences of these differences will be shown within the same population.

GEESE AS SMALL HERBIVORES: DIGESTIVE CONSTRAINTS AND DIET SELECTION IN SPRING-MIGRATING GEESE

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Geese are small herbivores with relatively unspecialized guts. As such, they are expected to digest little of the fiber in plants and be highly selective in their choice of plant food. For small geese like Cackling Canada and Ross' geese, these allometric effects should be even more pronounced. Using controlled feeding trials with wild-caught geese, we characterized the digestive constraints associated with eating fibrous plants. When cackling geese were fed low or high fiber forage (alfalfa or grass, respectively), digestive efficiency was relatively high and similar between diets. Surprisingly, cackling geese digested as much as 30% of the acid detergent fiber in both diets. Intake rates were 64% higher for geese eating the low fiber diet. Mass-specific length and mass of all regions of the gut were similar for the two diet groups. Apparently, cackling geese eating high fiber food achieved similar efficiencies as geese eating low fiber food at the expense of reduced intake rates. These differences in intake rates require geese in the wild to spend more time feeding when eating higher fiber food(s) like grasses. We found that diet selection of cackling and Ross' geese during spring was best explained by a hierarchical model: avoid secondary compounds first, then select plant species and plant parts low in fiber and high in protein. As expected, geese selected high quality plant material compared to other herbivores. Ross' geese, however, consistently ate more plants which were lower in quality (e.g. sedges, older grass) than plants eaten by cackling geese. In summary, if geese select a diet relatively high in fiber they are able to digest constituents of cell wall, but at a significant cost in terms of rate of food intake. Geese compensate for this reduction in food intake by increasing time feeding; however, there are limits to this strategy, especially when risk of predation or disturbance is high or when daylight is short.

STATUS OF ROSS' AND LESSER SNOW GEESE WINTERING IN CALIFORNIA, DECEMBER 1992

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Estimating the Ross' goose (*Anser rossi*) population wintering in California is difficult because they often occur in large mixed flocks with lesser Snow Geese (*Anser c. caerulescens*). In the early 1950's the Ross' population estimate was 2,000. From the mid 1950's to the mid 1970's, surveys yielded estimates of 13,000-34,000 Ross' geese. In 1975, McLandress discovered an undetected segment of the population wintering in the Sacramento Valley, resulting in a dramatic increase (106,400) in the Ross' estimate. California Department of Fish and Game surveys during the late 1980's indicated over 200,000 Ross' geese in the Central Valley. Recent Ross' breeding grounds data also reflects an increasing population trend, with as many as 1,777,400 breeding adults recorded in 1988. In December of 1992, our cooperative effort produced a comprehensive estimate of the proportions and numbers of lesser snow and Ross' geese wintering throughout California. This effort involved an aerial survey to obtain total number and distribution. and ground count data to establish species ratios. Survey data sets were analyzed by weighing flock species ratios to flock population estimates to obtain an estimate of the number of Ross' and lesser Snow Geese in each flock sampled. Numbers were totaled and species ratios calculated by geographic sub-unit. The number of Ross' geese and Snow Geese estimated in each subunit were totaled and the proportion of each species was calculated for the entire state. The December 2, 1992 aerial survey produced an index of 598,100 white geese. Species ratios (collected between 11/30 and 12/4/92) resulted in a combined weighted total of 63 percent snow and 37% Ross' geese. Thus, the 1992-93 estimate of Snow Geese wintering in California was 376,814 and the Ross' goose estimate was 221,286. Replicate samples (three per white goose flock) resulted in 34.8±6.3 percent (mean±S.D.) Ross' geese. Within flock variation was relatively low compared to among flock variation. Changing sizes and distribution of the various wintering white goose populations in California necessitate future operational surveys to differentiate Wrangel Island and Western Canadian Arctic lesser Snow Geese and Ross' geese.

HABITAT PREFERENCES FOR GREATER WHITE-FRONTED GEESE IN THE SACRAMENTO VALLEY, CALIFORNIA

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Habitat availability and use by Greater White-fronted Geese (*Anser albifrons*) were determined for geese wintering in the Sacramento Valley of California, from 1988-90. The Sacramento Valley of California winters more than 60% of the Greater White-fronted Geese in the Pacific Flyway. Habitat availability was documented in the Sacramento Valley from 27 aerial transects totaling 819 km. The 500,000 ha of habitat resources varied in their composition and availability through early, mid and late winter (Wilk's =0.21, F=21.61 (df=6,1110),P<<0.01). Agricultural crops made up 60% of the habitats available and rice was the most available crop type. Greater white-fronted geese were captured and radio-marked in the Klamath Basic of northern California during fall migration. They were located and habitat use recorded in the Sacramento Valley. Habitat use varied by period (early, mid, and late) and crop type (Wilk's =0.96, F=5.10 (df=8,2254), P<<0.01). Flooded, harvested rice was preferred in all three periods, while dry harvested rice was only preferred in the late winter when flooded rice was less available. Green crops and fallow fields were not preferred at any time.

POPULATIONS, HARVESTS AND BREEDING GROUND AFFILIATION OF GEESE WINTERING IN THE HIGH PLAINS AND ROLLING PLAINS OF TEXAS

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The High Plains and Rolling Plains of Texas (HRPT) comprises approximately 69,000 mi^2, an area roughly the size of Oklahoma, and are used by millions of migrating and wintering birds. Because of its importance to migrating and wintering waterfowl, the HRPT has been included in the Playa Lakes Joint Venture, a habitat initiative of the North American Waterfowl Management Plan. I reviewed trends in populations and harvest, and breeding grounds affiliation of geese in the HRPT. Trends in estimates of dark and white geese were analyzed using data from December and January surveys during 1974-1994. Estimated numbers of dark geese ranged from 34,400 (1975) to 529,200 (1992) during January surveys and from 24,400 (1981) to 551,700 (1993) during December surveys. Estimated numbers of white geese ranged from 300 (1989) to 23,800 (1994) during January surveys and from 200 (1975) to 21,500 (1990) during December surveys. Estimates of both dark and white geese increased (P<0.0006) during 1974 to 1994 for both the January and December surveys. Harvest estimates from the state harvest survey during 1982-1993 increased (P=0.03) for dark geese but not for white geese. Harvest trends (1982-1993) for dark geese reflected population levels estimated during January (P=0.03) and December (P=0.02) surveys and harvest trends of white geese reflected population levels estimated during December (P=0.06) surveys. From 1987 to present, geese have been observed in the HRPT from banding sites in the Alaskan arctic, and in the western, central and eastern Canadian arctic. Goose populations in the HRPT are at all time high levels. However, waterfowl biologists in Texas are concerned with potential disease losses associated with the concentration of large numbers of geese onto a limited number of water areas. Management efforts should emphasize the continued availability and quality of traditional goose habitats and securing additional habitat through acquisition or private lands enhancement programs.

INTERACTIONS BETWEEN GREATER SNOW GEESE AND THEIR STAGING HABITATS IN THE ST. LAWRENCE RIVER: IMPLICATIONS FOR DEVELOPING MANAGEMENT STRATEGIES

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For many centuries Greater Snow Geese (*Anser caerulescens atlanticus*) have stopped off in a portion of the St. Lawrence River estuary during both spring and fall migrations. This traditional staging area is characterized by freshwater intertidal marshes dominated by the bulrush *Scirpus americanus*. Before the 1970's, the entire flock frequented this area, feeding almost exclusively on *Scirpus* rhizomes to lay down energy reserves to fuel the final stage of their migration. The goose population has increased regularly from the turn of the century, and since the early 1970's, when it surpassed 100,000 individuals, the geese have expanded their staging range and have increasingly sought food on adjacent agricultural land. But even with the current population exceeding 500,000, the geese have continued to make intensive use of the traditional *Scirpus* marshes. From a management perspective, two issues emerge. The large concentration of geese in close proximity to urban agglomerations provides important socio-economic benefits which deserve to be maintained. On the other hand, the large and increasing goose population causes economic loss to some farmers and has the potential of causing long-term degradation of natural habitats. This paper reviews this evolving relationships between the geese and their staging habitats, and attempts to show how research and surveys are contributing to the development of management strategies.

LONGTERM DECLINE IN BODY MASS, SIZE, AND CONDITION OF GREATER SNOW GEESE AT A FALL STAGING AREA

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We examined 25,027 greater Snow Geese *Anser caerulescens atlanticus* shot by hunters at the main fall staging area on the St. Lawrence River, Quebec, from 1975 to 1992, to discover whether there were significant annual variations or long-term trends in body mass, size and condition in this increasing population. Mean annual body mass and culmen length (an indicator of body size) of all sex and age categories showed important annual fluctuations and overall declining trends over time: mass declined by an average of 16 g/yr (SE=2g) for a total of 271 g (9%) over 17 years in adults and 12 g/yr (SE = 1g) for a total of 207 g (8%) in juveniles. Culmen length declined by 0.06 mm/yr (SE = 0.01mm) for a total of 0.93 mm of 16 years in both adults and juveniles, a decline of 1.4 and 1.5%, respectively. Body mass adjusted for culmen length declined by an average of 13 g/yr (SE = 1g) in adults and 7 g/yr (SE = 0.4g) in juveniles, suggesting declining body condition. We suggest that a reduced per capita availability of food for goslings on Arctic brood-rearing areas is responsible for these declines by provoking lower growth rates and reduced final size. With continued population growth, we predict further deterioration of body condition of the geese and an eventual increase in the mortality of juveniles during fall migration.

LESSER SNOW GOOSE HABITAT USE AND DISTRIBUTION DURING FALL STAGING: A LANDSCAPE LEVEL PERSPECTIVE

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We developed a logistic regression model that identified Lesser Snow Goose (*Chen caerulescens caerulescens*) feeding habitat on the coastal plain of the Arctic National Wildlife Refuge (ANWR) at a fine-grained scale of resolution. We used the model to assess the availability of microhabitats relative to large scale patterns of surface relief at random locations (n = 192) throughout the ANWR. Approximately 3% of the area sampled was classified as suitable feeding habitat. Potential feeding habitat primarily occurred in areas with thermokarst pits and water tracks, and was less likely to occur in low center polygons, wet meadows, and uplands. We compared surface relief at Snow Goose feeding areas to paired random plots (n=49). Feeding areas had more thermokarst pits interspersed with uplands, and less low center polygon and wet meadow than random areas. We quantified patterns of surface relief and soil moisture on aerial photography and a Landsat-TM based habitat map of the ANWR coastal plain to predict the location and distribution of habitat patches. The wide distribution of Snow Goose flocks across the ANWR likely reflects the patterns of forage availability. Snow Geese on the ANWR require a large staging area because forage sites are patchy, comprise a small percentage of the tundra, and require 4 years to recover after feeding.

SIZE, BODY CONDITION AND SURVIVAL OF LESSER SNOW GEESE ON THE SOUTHWEST COAST OF HUDSON BAY

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Although the size and survival of fledgling Snow Geese reared within La Pérouse Bay has declined over the past 10 years, goslings hatched within La Pérouse Bay but reared elsewhere were found to be larger and displayed higher survival. Two reasons appear to account for this decline. First, there was more salt-marsh forage available in these areas and the vegetation had not been as heavily grazed. Second, preliminary evidence indicates that diseases are common where densities of birds are high and available forage is low. Results from experimental feeding trials also indicate that gosling weight gains are low when feeding on vegetation other than salt-marsh species. In more detailed studies of proximal relations between forage availability and Snow Goose success along the southwest coast Hudson Bay, we examined the size and condition of Snow Goose fledglings and the availability and condition of forage along a 100 km strip of coastline centered at La Pérouse Bay and extending from Thompson Point, south of Cape Churchill, to the Seal River, north of Churchill. We also sampled several inland sites south of La Pérouse Bay. Randomly collected fledgling Snow Geese were measured and necropsied. Above-ground biomass and percent grazing were evaluated from plants sampled at and adjacent to banding sites. Fledgling to adult ratios were determined both from banding records and aerial counts. With few exceptions, our preliminary analyses indicate that size and condition of fledgling Snow Geese increased with distance from La Pérouse Bay, as did reproductive success measured as fledgling to adult ratios. The quantity and condition of forage also increased with distance from La Pérouse Bay. It is important to note, however, that areas within 10-15 km of La Pérouse Bay are beginning to show signs of the type of habitat degradation typically resulting from grubbing and overgrazing by Snow and Canada geese. With one exception, the incidence of renal coccidiosis was high where high densities of birds occurred. These preliminary results indicate the multiple responses that fledglings may be expected to show as multiple stresses increase in severity.

RESTORATION OF LESSER SNOW GEESE TO EAST ASIA, AN INTERNATIONAL CONSERVATION PROJECT

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One hundred years ago, there was a large population of Lesser Snow Geese breeding on the Arctic Coast of Russia and wintering in Japan. There is, however, concern about possible extinction of this species from Asia because the population has drastically decreased, owing to strong hunting pressure and human development in goose habitats. Following the first meeting for the Restoration of Snow Geese to East Asia in January 1993, we have initiated a cooperative international project to preserve this species in Asia. We adopted the cross-fostering method of von Essen (1982,1991), using White-Fronted Goose as the foster parents for Snow Geese. In 1993, 100 eggs were obtained from the Snow Goose colony on Wrangel Island and transported to Lower Anadyr in North-East Siberia. 41 eggs were added to 6 White-front nests. Of the remaining eggs, 43 goslings were hatched in incubators and released in a lake used by molting White-fronts. One successful cross-fostered family was observed in August prior to autumn migration. Aerial and ground surveys were conducted in the Lower Kolyma, twice in 1993 and 1994 summer, to examine historically used areas that might be suitable for future translocations. In 1993, 25 White-fronts and 104 Bean Geese were captured and marked with neck collars, near the Snow Goose sightings. Three marked Bean Geese were resighted in winter in Korea, 1993/1994. In 1994, 88 Snow Geese were captured and marked with neck collars, including 18 goslings, which were marked with plastic tarsus bands. Six males were marked with PTTs (miniature satellite transmitters). In February 1994, 36 White-fronts were captured near Lake Izunuma in Japan, and 10 geese were marked with PTTs. We could trace the spring migration route for six birds. Three birds flew to (62.4-62.8N, 175.5-179.9E) on the Bering sea coast, two birds to (56.6-58.2N,162.0-162.4E) on the east coast of Kamchatka peninsula, and another to (54.3N, 155.8E) on the west coast of Kamchatka peninsula.

MODELING THE POPULATION DYNAMICS OF EMPEROR GEESE

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Emperor goose (*Chen canagica*) populations in Alaska declined from the mid 1960s to the mid 1980s and since then have increased little. Managers need to know how various actions, especially harvest management, would affect the recovery of this species to former levels. We constructed a population model that evaluated the relative effect on population growth (*R*) and fall age structure (*AS*) of sequentially altering mean values of various survival and reproductive parameters. Altering adult survival had markedly greater relative effects (0.75-0.93) on *R* than did comparable changes in either juvenile survival or reproductive (0.04-0.15) parameters. We found the opposite pattern for relative effects on AS. Using the best available data for emperor geese, our model estimates of *R* and *AS* did not match independent estimates from aerial surveys. We examined other biologically plausible parameter sets and still found poor fit between model predictions and survey data. We investigated covariance in parameters, presumed to be non-existent in most population models, and found that it can alter predictions of *R* and *AS*. Despite these poor agreements between model predictions and survey estimates, our model is useful because estimates of relative effects were relatively insensitive to what parameter set we used. Using an assumption of additive mortality, our model demonstrates how harvest management, through alteration of survival rates, can affect a population response. This response to management should be differentiated from annual fluctuations, which may be affected as much by overall production as it is to survival due to possibly greater stochastic variation in production.

MIGRATIONS OF ARCTIC GEESE THROUGH FREEZOUT LAKE WILDLIFE MANAGEMENT AREA, MONTANA

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Historically, Freezout Lake Wildlife Management Area (WMA), Montana (47°40'N,112°01'W) has hosted significant numbers of white geese during spring and fall migrations. Since 1989 the author has aggressively monitored marked Arctic geese transiting the area (>3200 records from 1500 neckbanded individuals). These observations allow assessments of the populations represented, their numbers, and the timing of the migrations. For lesser Snow Geese (*Anser c. caerulescens*), approximately 25% of the individuals in both spring and fall were marked from the Sag River Delta, Alaska, while 50% of the individuals in both spring and fall were marked in the Western Canadian Arctic. Approximately 50% of the spring sub-group is comprised of Wrangel Island birds, presumably those wintering in California. Small Canada Geese were only occasionally seen (21 collared individuals in 5 years), with no observations at all of White-fronted geese. Snow geese were typically first seen in mid-March in spring, peaked near the end of March, and were absent by late April. Typically, 150,000-300,000 Snow Geese were observed in spring. In contrast, by mid-April, 50% of white geese were Ross, with virtually 100% white geese being Ross by the end of April (approximately 15,000-25,000 individuals). Small Canada Geese were seen only in early March, with approximately 1,000-2,000 individuals seen. In fall, numbers were similar to spring for both Snow and Ross, with first arrivals by mid-October, peaking in early November, and were absent by mid-November. There was some tendency for Ross to move through earlier. Small Canada Geese moved through in mid- to late-November. While at Freezout Lake WMA, all species were observed feeding on waste barley, with some consumption of spring and winter wheat. Using data from radio-marked geese in spring, 1992, the average stay was 4.25 days (range 2-8 days).

MIGRATION OF ANSER FABALIS AND ANSER ALBIFRONS IN NORTH-EAST ASIA, WITH SPECIAL REFERENCE TO THE POPULATION WINTERING IN JAPAN.

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We have been marking Bean Geese *Anser fabalis* to research their flyways as part of a Japan-Russia joint research program since 1984. To date, we have recorded approximately 30,000 observations of individually collared geese. During 1984-1993, 1074 Bean Geese were caught and marked with a neck-collar in Kamchatska, Anadyr and Kolyma Lowland. Among 543 *Anser f. middendorfi* marked at L.Zubezudkan (55°16'N,156°3'E), 311 *Anser f. serrirostris* and 37 *Anser f. middendorfi* marked at L.Makobetskoe (52°00'N,156°38'E) in Kamchatska, nearly 90% were subsequently observed in Japan. Nearly all *Anser f. middendorfi* marked at L.Zubezudkan were found to migrate south along the west coast of Honshu, as far south as L.Biwa (35°09'N,136°03'E), by way of the east coast of Sakhalin Island. Nearly all of the *Anser f. serrirostris* marked at L.Makobetskoe were found to migrate to L.Kejyonuma (38°38'N,140°58'E). Three *Anser f. serrirostris* marked in Kolyma were found on the west coast of Korea. Recently, we have initiated a companion project on White-fronted Geese jointly with researchers, which has involved the use of satellite transmitters since 1991. Since 1991, 121 birds have been marked in Anadyr, and 25 in Kolyma. In the winters of 1983-84 and 1993-94, 42 additional birds were marked in the vicinity of L.Izunuma in Japan. Satellite transmitters were put on 11 birds in Anadyr in 1992 and 1993, and on 10 birds in Japan in 1993 and 1994. Eighteen non-breeders marked in Anadyr have been observed in Japan. Among them, one non-breeding male with a satellite transmitter migrated to the Naoli River (46°7'N,132°5'E) in China, and one non-breeder was found around Junam Reservoir (35°20'N,128°40'E) and two near Cholwon Basin (38°15'N,127°13'E) in Korea. Three birds with satellite transmitters were found near Khatyrka (62°15'N,175°10'E) and Meynypil'gyno (62°36'N,176°,40'E) in southern Chukotskii region.

RECENT CLIMATIC VARIABILITY OF IMPORTANCE TO ARCTIC COASTAL ECOSYSTEMS

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Recent evidence suggests that variations in climatic conditions over recent decades in northern Canada have strongly influenced trophic interactions along the shores of Hudson and James Bays between a herbivore population (lesser Snow Geese) and the coastal vegetation on which the birds feed. Maps of recent annual and seasonal Northern Hemisphere temperature changes between 1961 and 1990 identify large regions of warming and cooling. Regions of warming, as shown in the annual average temperature map, range from 0.1 to 0.8C per decade with the most intense warming confined to the mid-latitude continental land areas of central, western, and northwestern North America and central Asia. Regions of cooling range from -0.1 to -0.6C per decade are confined to the north Atlantic Ocean-Baffin Bay and central Pacific Ocean, as well as the eastern Mediterranean Sea. The annual average is dominated by the winter, spring, and summer seasons. The autumn season, however, shows expanded cooling to cover much of North America and Europe. A steep spatial gradient in temperature is apparent during spring between a large region of strong positive anomaly in western North America, and a smaller region of strong negative anomaly in northeastern North America. Colder than normal conditions to the northeast of Hudson Bay has resulted in migrating geese staging along the shores of Hudson Bay and James Bay in addition to the presence of breeding populations of geese in these areas. Climate data are analyzed for stations along the shores of Hudson and James Bays for key periods during initiation of nests, incubation, and brood rearing. Changes in mean surface air temperature and total precipitation are examined for the spring (May 20 to June 20) and summer (June 20 to August 15) seasons over the recent decades. Also, snow and ice boundary maps derived from satellite imagery and measured snow cover data are analyzed to provide an indication of the changing nature of the northward retreat of the snowline in this region during spring and its likely affect on goose populations.

EFFECT OF FRESH EGG MASS ON GOSLING GROWTH AND SURVIVAL IN ROSS' AND LESSER SNOW GEESE

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Ross' and Lesser Snow geese face similar environmental constraints when provisioning eggs with nutrients and rearing broods. However, interspecific differences in neonate body size and associated metabolic constraints could influence how these conditions affect young. We compared the influence of fresh egg mass on gosling growth and survival in these sympatric species. Fresh egg mass was estimated from egg measurements by using species-specific regression equations. Egg mass affected gosling survival in only Ross' geese. By 21-33 days of age Ross' goslings from heavier eggs were structurally larger and more likely to be recaptured than were goslings from lighter eggs, but no such correlations existed for Snow Geese. Thus, egg mass can affect fall flight and fitness of Ross' Geese under some environmental conditions.

ENVIRONMENTAL CORRELATES OF CHANGES IN BAND RECOVERY DISTRIBUTIONS OF SJBP

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We used linear regression techniques to examine possible relationships between selected environmental variables to a northward shift in Southern James Bay Population (SJPB) Canada goose (*Branta canadensis interior*) band recovery distributions in 1957-1990. Forward stepwise regression results in a model (R^2=66.2%, F=14.2,P<<0.001) that described the mean annual recovery latitudes of geese as a function of crops in southern and central regions, mid-latitude weather, and area of refuge. The crops in Alabama and Tennessee and weather at Lexington., Kentucky and Indiana and the index to refuge area were positively related to the recovery latitudes. The band recovery distribution shifted northward rapidly through 1969 and appeared to stabilize thereafter, suggesting different models might be fitted to the two series of data. Band recovery distribution was positively related to refuge area (R^2=60.7%, F=16.5, P=0.002) in 1957-1969, and inversely related to weather at Toledo, Ohio (R^2=47.2%, F=16.97, P<0.001) in 1970-1990. Alternative hypotheses were also examined. Effects of sanctuary, food availability, and weather on distributions of other goose populations should be investigated.

EFFECTS OF VIOLATING THE INSTANTANEOUS SAMPLING ASSUMPTION ON JOLLY-SEBER ESTIMATES

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This is a review of the potential biases introduced into Jolly-Seber open population estimates when continuous samples are analyzed. Although continual data collection is commonly employed, it violates the assumption of "instantaneous" sampling. Few studies have addressed the resulting impacts on biases and variance. A review of the literature led to the following summary points. 1) Sampling period observations are usually assumed to be uniform or nearly so, so that the midpoint-to-midpoint temporal periods are assigned to the survival rate estimates; 2) Any deviation from uniformity of the observations can result in biased population estimates and temporal distributions of survival rate periods is not very clear; 3) Multiple observations of the same individual during a sampling period can produce unknown impacts on variance and bias; 4) Use of between-sampling period observations to supplement the previous resighting estimate can be used to provide a more precise survival rate estimate. Neckbanding is a popular continual sampling technique used with larger waterfowl in North America. Observations are continually gathered by observers throughout the United States and lower Canada. More than 750,000 observations for Canada geese migrating into/through the Mississippi Flyway have been accumulated to date. The data base contains observations covering much of the year, particularly during the migration and wintering periods. This period encompasses the hunting season, which can drastically affect goose survival. Estimates of survival before, during, and after the hunting seasons, or within parts of the hunting season are useful for goose managers. However, such analyses require nearly continuous sampling to accumulate observations sufficient for robust survival analyses.

BRENT GEESE: THE IMPORTANCE OF BODY-RESERVES ACCUMULATED IN THE TEMPERATE ZONE FOR BREEDING IN THE HIGH ARCTIC

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Dark-bellied Brent Geese migrate in the end of May from their spring staging areas in the Wadden Sea (Netherlands, Germany and Denmark), through the White Sea to the breeding grounds on the Taymyr Peninsula, northern Siberia, a distance of 4500 km. Average spring body-mass of female Brent Geese just before departure from the spring staging area is positively correlated with breeding success as measured in the subsequent autumn in years that are favorable with respect to wind during spring migration and inferred fox predation on the breeding grounds. In successful years females returning with offspring had on average been heavier at spring departure than those failing to raise offspring. Measurements of changes in female body-mass from the onset of pre-migratory fat deposition till hatching in mid-July, coupled to estimated flying costs, show that birds have to refuel during migration and that it is impossible for females to produce eggs and incubate when they leave the spring staging area with low body-mass. To register female body-mass changes and timing of feeding recesses during incubation, electronic weighing scales were installed under nesting geese. A body-mass loss of 25 g per day was measured for an incubating female White-fronted Goose, that did not feed at all during incubation. In Brent Geese body reserves after egg-laying are clearly insufficient to complete incubation without supplementary feeding. In 1994 the average daily feeding time of seven females Brent Goose varied from 129 to 279 minutes and body-mass loss was on average 5.3 g per day over the entire 25 day incubation period.

FORECASTING PRODUCTION OF ARCTIC NESTING GEESE BY MONITORING SNOW MELT PHENOLOGY WITH ADVANCED VERY HIGH RESOLUTION RADIOMETER IMAGES

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The remoteness and extensive distribution of habitats for Arctic nesting geese makes the acquisition of direct, quantitative goose productivity data expensive and difficult. Manual interpretation of snow cover on nesting areas from Advanced Very High Resolution Radiometer (AVHRR) images has been used for indirect, qualitative forecasts of goose production. Recent technological developments in remote sensing and digital image processing can be used to improve the monitoring of snow melt phenology on Arctic nesting areas. The developments include improvements in the georegistration of images to map projections, the discrimination between optically thin clouds and snow using the short-wave infrared (3.5 -3.9 m) reflectance factor, and the ability to estimate the fractions of land cover classes in each pixel of an image using mixture models. We are analyzing AVHRR images from May and June for each year from 1979-1994 to estimate the proportion of snow, snow-free land, and water at nesting areas and to estimate the date at which nest sites become available. We are developing regression models to relate habitat conditions derived from AVHRR images to production indices from surveys of geese during migration, on wintering areas, and from harvest surveys. The regression models will allow mangers to make indirect, quantitative forecasts of the immature/adult ratio of geese prior to the fall flight.

BREEDING GROUND AFFILIATION OF GREATER WHITE-FRONTED GEESE HARVESTED IN THE CENTRAL AND MISSISSIPPI FLYWAYS

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I compared mean longitude of banding locations for greater white-fronted geese banded during the breeding season and harvested in the Central Flyway (east-tier states), Mississippi Flyway (west-tier states), Alberta and Saskatchewan to determine breeding ground affiliation. Mean longitudes of banding locations for geese harvested in Louisiana and Arkansas were further east than for geese harvested in all other states/provinces, suggesting that geese harvested in these 2 states were affiliated with more easterly breeding areas. Mean longitudes of banding locations for geese harvested in other states/provinces were similar, suggesting that geese harvested in these states/provinces were affiliated with the same breeding areas. Limitations of the analysis, recommendations for future research, and implications for management of mid-continent greater white-fronted geese are discussed.

PARAMETERS USED IN WRANGEL ISLAND SNOW GOOSE POPULATION MONITORING

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Productivity of Arctic geese prior to arrival on the wintering grounds is potentially a useful tool for management. During the 26 year study of Wrangel Island Snow Geese (WISG), we attempted to determine the various environmental and demographic factors which would allow us to predict the percentage of young on the wintering grounds (%JUV). One such parameter (K) was the percentage of 4 egg clutches in the total population sample. Annual variation in K correlated strongly with the sum of spring daily maximum temperatures (r=0.78,n=13), with the percentage of adult birds breeding (r=0.94,n=24) and with %JUV (r=0.70,n=17). A low value of K is a reliable predictor of a low percentage of young arriving on the wintering grounds. A second parameter (B) was the percentage of 4-gosling broods just before the birds leave Wrangel Island. This parameter was positively correlated with %JUV (r=0.87,n=14). A multiple regression including both K and B in the model provided excellent prediction of %JUV (R=0.95,n=14). This relationship allows us to predict the percentage of young birds arriving on the wintering grounds as early as August. However, we were able to achieve even greater predictive precision using a "combined coefficient - S", where S = (KB)/100. Using S instead of K and B independently, the correlation increased to 0.96 (n=14). Further, S is strongly positively correlated with the percentage of yearlings among geese returning to Wrangel Island in the following year (r=0.85,n=13). We believe that these parameters, which are easily measured in the field, will enable us to develop a robust simulation model of this population. In addition, we suggest that this approach may also be useful in population monitoring of other species of Arctic-nesting geese.

NESTING ECOLOGY OF GEESE AND SWANS IN THE NOVAJA ZEMLJA REGION

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In 1994, with the financial support of the National Geographic Society, we began the investigation on the comparative ecology of Arctic-nesting geese and swans. The main goals of the project were (a) to compare the ecology of some species of Arctic geese and swans in northern and southern parts of their ranges, and (b) to compare and contrast adaptations to Arctic conditions. We chose the southern island of Novaja Zemlja, Vaigach Island and Jurors Peninsula as the study area. The species studied were: Tundra Swan (*Cygnus columbianus bewickii*), the Bean Goose (*Anser fabalis rossicus*), the White-fronted Goose (*Anser albifrons albifrons*), and the Barnacle Goose (*Branta leucopsis*). The Pukhovy Zaliv of the southern island of Novaja Zemlja (72o40'N,52057'E) was the base point location of our 1994 studies. All four species have been found nesting in this area. The spring of 1994 was very cold and late. The nesting of geese in the study area took place in late June-early July, much later than in more southern areas (Vaigach Island). The nest density and clutch sizes were both extremely low. The maximum clutch size of Bean Geese on Novaja Zemlja was 4 eggs, while in Vaigach Island clutches very often contained >4 eggs. It was notable that geese in the northern art of their ranges nested mainly high in the mountains up to 200 m above sea level, while lower elevation wetlands, typical of nesting habitat in nesting of southern areas, was used primarily for feeding.

MIGRATION ECOLOGY OF GREATER WHITE-FRONTED GOOSE POPULATIONS ALONG THE NORTH PACIFIC RIM

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Greater white-fronted geese (*Anser albifrons*) have the widest Holarctic breeding distribution of all Arctic nesting geese, extending across Alaska, Canada, Greenland, and Russia. Yet, only four subspecies of greater white-fronted geese are currently recognized: two large populations are classified into European (*A. a. albifrons*) and North American (*A. a. frontalis*) subspecies spanning vast continental regions, while relatively few geese comprise the Greenland (*A. a. flavirostris*) and Tule (*A. a. gambelli*) populations. The continental European and North American subspecies are separated along an indistinct line somewhere in the glacial refugia known as Beringia. Between 1987-1994, we conducted radio telemetry studies to examine migration ecology of populations along the North Pacific Rim, including the Pacific coast of North America and East Asia. Our research examined breeding populations from southcentral Alaska (Cook Inlet Lowlands), southwestern Alaska (Bristol Bay Lowlands), and westcentral Alaska (Yukon-Kuskokwim Delta), and for the first time in 1994, we radio-marked an Asian population from the easternmost wintering area at Lake Izunuma, Japan. All North Pacific Rim populations followed similar migration patterns. Their spring staging areas were relatively close to their wintering grounds, and they flew over large expanses to reach their breeding areas. Their migration routes tended to follow the Pacific coast, although interior staging areas were available to them. For example, greater white-fronted geese from Japan were expected to migrate to the Arctic coast of Siberia, but the geese marked with satellite transmitters settled along the Pacific coast on the northern Kamchatka Peninsula or on the Bering Sea south of the Anadyr River Delta. Our results indicate that as many as four discrete populations of greater white-fronted geese inhabit the North Pacific Rim, isolated either spatially or temporally. We discuss the current taxonomic status of these populations, their potential recognition as subspecies, and implications of our findings for successful management of these populations.

GENETIC CONSEQUENCES OF THE INTRODUCTION OF A SMALL NUMBER OF CANADA GEESE TO SWEDEN

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The origin of the Swedish Canada Goose (*Branta canadensis*) population, as well as of the populations in Norway and Finland, was probably no more than 5 individuals, introduced to two Swedish localities in the 1930's. The Canada Geese breeding in Sweden, Norway and Finland are isolated from other European as well as from North American populations. Translocations of individuals from the original localities to other areas, especially during the 1950's and 1960's, resulted in the establishment of local breeding groups. Considering the background of the population, with several consecutive founding events, one would expect a certain depletion of genetic variability. Today, the species numbers well over 50,000 individuals only in Sweden, where the distribution is fairly continuous over large areas. The Swedish and Finish populations have developed regular migration patterns and winter in the area around the southern part of the Baltic Sea. For this investigation, we performed DNA fingerprinting on blood samples collected from Canada Geese from two areas in Central Sweden, as well as from samples of a flock of predominantly *B. c. maxima* origin in an area in southern Ontario. We also compared the results with populations, suspected of having gone through some founding events, of two other species: Barnacle geese (*Branta leucopsis*) and Lesser white-fronted geese (*Anser erythropus*). The restriction enzymes used were Hae III and Hinf I, and the DNA probes used were M13 and 33.15. The level of fingerprint band sharing between Swedish Canada Geese, both between lakes within areas, as well as between areas, was very high for a natural bird population. The Ontario Canada Geese showed a much lower level of band sharing, while in other species, band sharing was at an intermediate level. The Swedish Canada Geese appear to have lost a large number of alleles and show a considerable reduction in heterozygosity due to the low number of founder individuals and repeated founding events.

SKELETAL MATURATION IN CANADA GEESE: IMPROVING USE OF MORPHOMETRIC MODELS FOR SUBSPECIFIC DISCRIMINATION

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Expanding Giant Canada Goose (*Branta canadensis maxima*) populations have led to additional hunting seasons in many areas. There is concern however, over potential harvest of Interior Canada Geese (*B. c. interior*) during special early hunting seasons. Thus, several morphometric discriminant function models have been developed to determine subspecific harvest composition. However, researchers who include measurements from all age cohorts in these models are assuming that growth of Hatch Year (HY) birds is finished. This study was done to determine if skeletal maturation was complete in HY Canada Geese during an experimental early goose season (6 - 14 Sept. 1993) in southern Ontario. We separated HY birds from After Hatch Year (AHY) birds by presence of an enlarged bursa in the former group and measured tarsus, midtoe, culmen, bill height, bill width, skull length, skull height, and skull width on hunter-killed specimens (N = 158). Univariate analyses showed that mean culmen of HY males and HY females did not differ ($P \leq 0.05$) from that of AHY males and AHY females, respectively. Thus, we used culmen to separate Interiors from Giants using the cutoffs reported by Merendino et al. (1994). Bill height, bill width, skull length, skull height, and skull width were significantly smaller ($P \leq 0.05$) in HY males than in AHY male Giants. Tarsus length, bill width, skull height, and skull width were ($P \leq 0.05$) smaller in HY female than in AHY female Giants. Skull height and bill width were ($P \leq 0.05$) smaller in HY than in AHY male Interiors, whereas only bill width was smaller in HY as compared to AHY female Interiors. Inclusion of adults and immatures in discriminant function analyses resulted in misclassification of many HY Giants as Interiors, thereby inflating harvest estimates of Interiors. Inclusion of HY birds in such analyses requires that morphological character(s) be structurally mature in HY birds. Therefore, research into when growth of morphological characters is completed in various subspecies, is imperative. Until this is done, only AHY birds should be analyzed. Ultimately, genetic analyses may provide the most accurate technique for separating subspecies, and perhaps even populations, of Canada Geese.

REGULATION OF PARENTAL EFFORT: AN EXPERIMENTAL STUDY OF THE HIGH ARCTIC BARNACLE GEESE

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We examined the cost of incubation in high Arctic Barnacle Geese (*Branta leucopsis*) by manipulating the length of the incubation period by ± 5 days. Unmanipulated clutches were used as controls. Females with prolonged incubation suffered a higher egg-loss to predators than controls and geese with shortened incubation. However, daily egg-loss was similar for all categories. Body condition at hatching was lower among females with prolonged incubation than among females in the control group and females with shortened incubation. Females with prolonged incubation did not increase their feeding effort to compensate for mass loss, suggesting that the available body reserves before egg-laying is not the only ultimate control of clutch size in barnacle geese. The degree of parental investment did not affect adult survival or the date of arrival to the breeding ground the following season. Accordingly there is no evidence from this study that barnacle geese invest in young to the expense of own survival or future fecundity. We propose that breeding female geese retrain some reserves to shorten the incubation period to minimize the risk of egg-predation and/or as a buffer against increased breeding expenditure during years of inclement weather.

RELATIONSHIP BETWEEN NEST SITE CHARACTERISTICS AND NESTING SUCCESS IN GREATER SNOW GEESE

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Nesting success is an important fitness component in Arctic-nesting geese and may be greatly influenced by nest site characteristics. Because greater Snow Geese (*Chen caerulescens atlantica*) showed a high annual and temporal variability in their selection of nest sites, we examined the relationship between nest site characteristics and nesting success at the Bylot Island, NWT, colony. Predation by Arctic fox (*Alopex lagopus*) was the main cause of nest failure. Nests of the main colony found in 1993 ($n = 220$) were monitored from the end of laying until hatching. Nests were mapped with a GPS receiver. Nest density averaged 4.2 nests/ha. The colony was clustered around a snowy owl (*Nyctea scandiaca*) nest, the arithmetic center of the colony being only 66 m away from the owl's nest. There was a weak but significant relationship between start of egg-laying and distance from the owl's nest, but no relationship with clutch size. Nesting success declined with distance from the owl's nest but this may have been confounded by nest density which also declined from distance to owl's nest. Habitat and micro-habitat characteristics of each nest were sampled after hatching. Nesting success was lower in areas with a high density of ponds but sample size was small ($n = 15$ nests). Vegetation or micro-topography around the nest site was not associated with success. Nesting success was high in 1993 (89%) compared to previous years (74%, average 1989-92), possibly because of the predator-free area maintained by the owl around its nest, and may account for the lack of relationship between nesting success and nest site characteristics. The same data were collected on a larger sample of nests ($n = 305$) and a greater diversity of habitats in 1994, a year without nesting owls but with a high density of foxes. Under such conditions, nesting success dropped to 41%. This should help us to better evaluate the effect of nest site characteristics per se on nesting success.

WINTER DISTRIBUTION AND MOVEMENTS OF WRANGEL ISLAND, WESTERN AND CENTRAL ARCTIC LESSER SNOW GEESE AND ROSS' GEESE

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Winter distribution, and intra- and inter-flyway movements both within and across years were determined from observations of individually identifiable neckbanded geese. The Wrangel Island Snow Goose Population segregates in winter into two discrete segments with 54% wintering in Washington-British Columbia versus 46% in California. The Western Arctic Snow Goose population overwinters primarily in the Central Valley of California (73%) with smaller percentages in Southern California (5%) and the Western Central Flyway (22%). Snow Geese from the Central Arctic winter from Louisiana to California, but variable affinities of this population, depending on banding location, warrant its segregation into Eastern and Western Central Arctic stocks. The Western segment overwinters primarily in the Western Central Flyway (80%) whereas the Easter stock is distributed more evenly between the Western Central Flyway (52%) and Texas and Louisiana (44%). Ross' Geese also exhibit a wide distribution but most winter in California (81%) with smaller percentages in Southern California (2%) and the Western Central Flyway (16%). Where previous data exist, band recoveries are used to examine temporal changes in distribution. Within season movements of Wrangel Island Snow Geese between the Washington-British Columbia and California wintering areas occur in both directions but rates of exchange are low. Neckband sightings show that most Wrangel Island Snow Geese wintering in California return north via Prairie Canada. Pair formation during winter affords a mechanism for mixing, and indirect sightings indicate some changes in colony affiliation of Western Arctic and Wrangel Island geese which share California wintering areas. A segment of Western Arctic Snow Geese wintering in the Western Central Flyway arrives via California and accounts for most of the movement between the Pacific and Central Flyways. Ross' Geese also exhibit interflyway movements.

HERBIVORE COMPETITION ALONG A PRODUCTIVITY GRADIENT

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The salt-marsh of Schiermonnikoog Island, The Netherlands, extends eastward, leaving salt-marsh parts from 0 to 100 years of age adjacent to each other. Over time clay accumulates as does nitrogen, a limiting nutrient. Above-ground biomass increases with salt-marsh age, creating a gradient of primary productivity. Brent Geese (*Branta bernicla bernicla*) and Barnacle Geese (*Branta leucopsis*) use the salt-marsh as spring staging area to fatten up for their journey towards the Russian Arctic. Also resident herbivores Hare (*Lepus europaeus*) and Rabbit (*Oryctolagus cuniculus*) use the salt-marsh. Classical theory predicts herbivore density to increase when productivity increases and to become constant at higher productivity because of predator control. In order to determine herbivore distribution along the salt-marsh productivity gradient, year-round dropping counts were performed. Contradictory to classical theory, herbivore density decreased at high productivity. This decrease was not due to predator control. We hypothesize this was due to decreased forage efficiency. Since there is large overlap in areal use and diet composition between the four herbivores, they can compete for the same resources. However there are large timing differences. When the geese invade the salt-marsh hare grazing pressure decreased significantly, and increased again after the geese left. When geese were excluded experimentally, both hare and rabbit grazing pressure increased. So geese "suppress" hares and rabbits. But we are dealing with a gradient of primary productivity. Relative grazing impact (consumption/total biomass) decreased strongly over productivity. Manipulation of the system by herbivores is therefore bound to lower productivity levels. When grazing ceases, principal food plants are outcompeted by taller plant species, possibly via light competition. Light availability decreases with increasing productivity, but herbivores delay this process. During spring hare and rabbit were "suppressed" by geese but in the long run, geese will facilitate by opening up the vegetation and keeping large parts of the salt-marsh in suitable conditions where hare and rabbit can graze during most of the year when geese are absent.

VISIBILITY BIAS ON COUNTS OF NESTING CANADA GEESE.

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The apparent high visibility of goose nests in arctic habitats has often led researchers to assume that single ground counts approach complete inventories of the nesting geese in a given area. Accurate density estimates are often needed for population modeling and estimates of natality and survival, but no studies to date have attempted to measure the visibility bias which may be inherent in these counts. Annual nest counts have been conducted from 1976-94 near Cape Churchill in northern Manitoba as part of an ongoing study of the breeding ecology of Eastern Prairie Population (EPP) Canada geese (*Branta canadensis*). We estimated visibility bias from 2 independent searches of the same areas on subsequent days in 1993 and 1994. Nests located by the first crew were discreetly marked with individually-numbered tags so that all nests could be classified as being observed by one or the other crew or by both crews. A modification of the Peterson estimator was used to estimate both visibility bias and unbiased nest density. Individual crews located on average 77% (±2.9%) of active and 39% (±5.3%) of destroyed nests, or only 71% (±1.0%) of all nests present. Single counts seem to be reliable indicators of trends in breeding parameters in our study, but we recommend visibility bias during nest counts be estimated where accurate density estimates are required.

SEASONAL AND ANNUAL SURVIVAL OF ADULT BLACK BRANT

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The population size of Black Brant (*Branta bernicla nigricans*) has declined over the last 30 years. We estimated seasonal and annual survival rates of adult brant to identify periods of high mortality and to assess effects of harvest management decisions. Survival estimates were calculated from resightings of tarsus-marked Brant. Geese were banded in 1986-91 at the Tutakoke River colony on the outer fringe of the Yukon-Kuskokwim Delta and resighted each fall, 1990-93, at Izembek Lagoon, Alaska, each winter, 1990-93, in Mexico, each spring, 1991-93, at Humboldt Bay, California and Vancouver Island, British Columbia, Canada, and each summer, 1987-93, at the breeding colony. We used the data to estimate 6 annual and 3 seasonal (2 fall, 1 winter, 2 spring, and 1 summer period(s)) survival rates. Band loss was minimal and did not contribute to model bias. Survival estimates varied by sex and by sex among seasons. Annual survival estimates ranged from 0.60 to 0.87 and were similar to levels reported for adult Atlantic brant (*B. b. horta*).

MANAGING SUBSISTENCE HARVEST OF ARCTIC GEESE IN ALASKA

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Subsistence hunting of five species of Arctic geese has occurred in Alaska for thousands of years. The majority of the harvest has occurred in spring and during late summer and early fall, outside of the legal frameworks provided for in the 1916 Migratory Bird Treaty between the United States and Canada. Efforts currently under way to amend the treaty could have profound effects on the future management of Arctic geese. We examine historical and current subsistence harvest levels of Arctic geese in Alaska and evaluate the effectiveness of the cooperative Yukon-Kuskokwim Delta Goose Management Plan in the recovery of some depleted goose populations. We also discuss future opportunities to cooperatively manage Arctic geese with an amended treaty, and we identify critical research needs to help managers make informed decisions during any future management transitions.

ALTERNATIVE MECHANISMS LINKING LEMMINGS AND GEESE VIA SHARED PREDATORS

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How do lemming population cycles and goose breeding success interface? This interaction, mediated by shared predators, could take one of two forms:

1) *indirect mutualism*: an abundance of one prey type (lemmings) leads to reduced predation on the other (geese), or
2) *apparent competition*: an increase in the number of predators in response to a high density of one prey type (lemmings) results in increased predation on the other (geese).

Which relationship prevails may vary among different geographical areas and different years, depending on the behavior of prey and predators, the timing of changes in lemming population density, and phenological events like snowmelt. The functional and numerical responses of predators to changes in prey density are affected by their mobility and prey preferences, and by the relative availability and vulnerability of alternative prey types. On the breeding grounds, geese may be most susceptible to predation during the egg laying and early incubation periods. Lemmings appear most vulnerable during snowmelt, when their nests are exposed and burrows flooded. The timing of these seasonal events relative to each other, and to changes in the density of lemmings, could alter both the strength and direction of the interaction between the two prey types. This poster outlines some alternative hypotheses of the nature of the relationships among lemmings, geese, their predators, and environmental factors. These hypotheses form the basis of field research being conducted at Walker Bay on the Kent Peninsula in the Northwest Territories of Canada.