

SECOND NORTH AMERICAN DUCK SYMPOSIUM & WORKSHOP

***OCTOBER 11-15, 2000,
Saskatoon, Saskatchewan
Canada***



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WELCOME TO SASKATOON



Downtown Saskatoon,, with South Saskatchewan River, bridges, and Delta-Bessborough Hotel (The "Castle"; just above the centre of the photograph).

Welcome to Saskatoon*, Saskatchewan, Canada, for the 2nd North American Duck Symposium and Workshop. The principal objectives of the meeting are to provide scientists, managers and administrators with current knowledge about the biology and management of ducks, and to foster an open exchange of ideas about the future of waterfowl research and management in North America and world-wide. The symposium has attracted interest from recognized and "up-and-coming" scientists and managers with diverse backgrounds and interests from around the globe. The committees have worked hard to provide an exciting and stimulating program, and we further hope you find the accommodations and entertainment to be truly enjoyable.

This symposium is patterned after the 1st North American Duck Symposium, held in Baton Rouge, Louisiana, in 1997. It features presentations on topical issues challenging individuals charged with duck management and research. The conference program includes invited plenary lectures by five internationally recognized speakers, 70 contributed verbal presentations, four educational workshops, and a poster session featuring more than 70 posters. In addition, an opening reception, banquet with multicultural entertainment, and optional full-day field trips to prairie locations are available to registered participants. Check the web site for further information about the program, the symposium sponsors, Saskatoon, and the province of Saskatchewan...

Check out the web site for the 2nd North American Duck Symposium:

<http://www.extension.usask.ca/go/DuckSymp2>

* The name Saskatoon comes from the Cree Indian name "Mis-sask-quah-toomina" for what we know today as Saskatoon berries.

INVITED PLENARY SPEAKERS

(alphabetical order)

Dr. John Eadie

University of California - Davis

**From the arcane to the applied: can evolutionary ecology
offer any useful insight to waterfowl management?**

Dr. James Nichols

United States Geological Survey, Laurel, Maryland.

Population limitation and regulation in ducks.

Dr. Lewis Oring

University of Nevada - Reno

**Conservation crises among ducks:
threatened and endangered species of the world.**

Dr. James Ringelman

Ducks Unlimited Inc., Bismarck, North Dakota

**Duck recruitment in agricultural and forested landscapes:
empirical field studies.**

Dr. Jay Rotella

Montana State University, Bozeman

**Modeling duck population dynamics:
recent advances and future challenges.**

SYMPOSIUM SPONSORS



***Canadian Wildlife Service
Environment Canada***



***U.S Geological Survey -
Northern Prairie Wildlife Research Centre***



U.S. Fish and Wildlife Service



***North American Waterfowl
Federation***



Ducks Unlimited Canada

Atlantic, Central, Mississippi and Pacific Flyway Councils

Alberta NAWMP Partners

Co-Sponsors

Delta-Bessborough Hotel



University Of Saskatchewan



***Saskatchewan Wetland
Conservation Corporation***



California Waterfowl Association



Delta Waterfowl Foundation

City of Saskatoon

***Great Western Brewery,
Saskatoon***

***Minnesota Waterfowl Association
South Carolina Waterfowl Association
Wetland Habitat Alliance of Texas***

SCIENTIFIC PROGRAM COMMITTEE

Robert Clark, Chair

Canadian Wildlife Service, Prairie & Northern Wildlife Research Center, Saskatoon, SK

Alan Afton

Department of Fisheries and Wildlife, Louisiana State University, Baton Rouge, LA

Ray Alisauskas

Canadian Wildlife Service, Prairie & Northern Wildlife Research Center, Saskatoon, SK

Michael Anderson

Ducks Unlimited Canada, Oak Hammock Marsh, MB.

Todd Arnold

Delta Waterfowl Foundation, Portage la Prairie, MB.
(Present address: Ducks Unlimited Canada, Oak Hammock Marsh, MB)

Robert Cox

USGS - Northern Prairie Wildlife Research Centre, Jamestown, ND

Robert McLandress

California Waterfowl Association, Sacramento, CA

Thomas Nudds

Department of Zoology, University of Guelph, Guelph, ONT.

Mark Petrie

Institute for Wetland & Waterfowl Research, Memphis, TN

Jay Rotella

Department of Biology, Montana State University, Bozeman, Montana

Graham Smith

U. S. Fish & Wildlife Service, Laurel, Maryland

Local Organizing Committee

Robert Clark, Conference Chair

Canadian Wildlife Service, Prairie & Northern Wildlife Research Center, Saskatoon, SK

Ray Alisauskas

Canadian Wildlife Service, Prairie & Northern Wildlife Research Center, Saskatoon, SK

Kim Eskowich

Ducks Unlimited Canada, Melfort, SK

Peter Jonker

Extension Division, University of Saskatchewan , Saskatoon, SK

Robert MacFarlane

Saskatchewan Wetland Conservation Corporation & Ducks Unlimited Canada, Regina SK

(Present address: Nature Conservancy of Canada, Regina, SK)

Daniel Nieman

Canadian Wildlife Service, Prairie & Northern Wildlife Research Center, Saskatoon, SK

Eric Woodsworth

Canadian Wildlife Service, Prairie & Northern Wildlife Research Center, Saskatoon, SK

With special thanks to: Robert Brua, Kevin Dufour, Garry Gentle, Stephen Leach,
Blayne Petrowicz, Jack Smith

Student Awards Committees

Student Travel Award Judges:

Paul Flint, USGS - Anchorage

Patrick Weatherhead, University of Illinois

James Leafloor, Ontario Ministry of Natural Resources

J. Barry Grand, Auburn University

Brian Gray, Ducks Unlimited Canada

Student Travel Award Recipients (\$600.00 Cdn each)

Glen Benoy, University of Guelph

Grace Bottita, Trent University

Elizabeth Loos, University of Louisiana - Lafayette

Eric Osnas, Indiana University

Kenneth Richkus, Louisiana State University

Poster and Paper Presentation Judges :

Trent Bollinger, University of Saskatchewan

David Duncan, Canadian Wildlife Service, Edmonton

Grant Gilchrist, Canadian Wildlife Service, Yellowknife

Frank Rohwer, Louisiana State University

James Sedinger, University of Alaska - Fairbanks

Rodger Titman, Macdonald College - McGill University

Names of winning graduate students (3 verbal and 3 poster presentations, valued at \$400.00 Canadian each) will be announced at the Banquet, and posted on the web site after the meeting.

SYMPOSIUM ARTIST

Robert Billings, a Canadian-born wildlife and sportsman artist, resides in Melfort, Saskatchewan. His love of the outdoors includes hunting, fishing, and canoeing, and gives him a special ability to bring images to life on canvas, whether his subject is wildlife or landscapes.

Robert's works have been selected by Ducks Unlimited for both national limited edition and provincial art programs. Pheasants Forever selected his work in both their 1996 and 1997 Print of the Year Program. He continues to donate his work to these and other organizations to help raise funds for wildlife habitat.



Elegant male northern pintails fly over a backdrop of cattails, wetland, wheat field, grain elevator and rising sun, all hallmarks of the Canadian prairies...

2nd North American Duck Symposium & Workshop

PROGRAM*

WEDNESDAY, 11 OCTOBER 2000

1900-2200 REGISTRATION AND WELCOMING RECEPTION - Foyer & Adam Ballroom

THURSDAY, 12 OCTOBER 2000

0730-1030 REGISTRATION - Foyer, Conference Level

0800-0820 Welcoming remarks - Adam Ballroom

SPECIES OF CONCERN, HERE AND ABROAD - ADAM BALLROOM

Chair: **Gerald McKeating**, Canadian Wildlife Service, Edmonton, Alberta

- 08:20-08:40** Andy Green, Baz Hughes, Simon Delany & Des Callaghan - Globally threatened ducks world-wide, and species of concern in Europe.
- 08:40-08:55** Barry Grand, Robert F. Rockwell, Paul Flint & Margaret Petersen - A global perspective on spectacled eider populations.
- 08:55-09:10** Margaret Petersen, Paul Flint, Christian Dau, James Hines & James Nichols - Annual survival and site fidelity of Steller's eiders molting along the Alaska peninsula.
- 09:10-09:25** Dan Rosenberg & Michael Petrula - Tracking the movements of surf and white-winged scoters with satellite telemetry.
- 09:25-09:40** Ian Goudie, Gregory Robertson, Fred Cooke & Cyndi Smith - Annual survival rates of harlequin ducks moulting and wintering in the Strait of Georgia, British Columbia.
- 09:40-09:55** Mark Petrie, C. Davison Ankney, Patrick Kehoe, Scott Stephens, John Coluccy & Ron Drobney - A review of single-factor explanations for declines in black ducks.
- 09:55-10:20** BREAK

Chair: **Andy Green**, Donaña Biological Station, Sevilla, Spain

- 10:20-10:35** Margaret MacCluskie, Glen Fox & Michael Anderson - Assessment of contaminants in lesser scaup nesting in the boreal forest, and implications for their population decline.
- 10:35-10:50** Paul Flint, Barry Grand, Tom Fondell & Julie Morse - Population dynamics of greater scaup on the Yukon Delta.
- 10:50-11:05** Robert Cox & Felicia Sargeant - Diets and nutrient reserves of female northern pintails during spring migration in Nebraska.
- 11:05-11:20** Michael Miller, Dennis Orthmeyer, Joseph Fleskes, Michael Casazza, William Perry & John Takekawa - Spring migration of northern pintails: an application of satellite telemetry.
- 11:20-12:00** Plenary Lecture by Lewis Oring - Conservation crises among ducks: threatened and endangered species of the world.
- 12:00-13:00** ***Lunch - hosted by Alberta NAWMP Partners***

* The first person listed will present the paper. Refer to Abstracts for addresses of presenters. Names of graduate students eligible for presentation awards are underlined.

OPEN SESSION “A” - ADAM BALLROOM

Chair: **Alan Afton**, Louisiana State University, Baton Rouge

- 13:15-13:30** Josh Ackerman - Of mice and mallards: the indirect effects of coexisting prey on waterfowl nest success.
- 13:30-13:45** Ann Dahl, Terry Schafer, Kathy Baer, Ronald Reynolds, Michael Johnson & Glen Sargeant - The relation of mallard nest numbers on constructed islands to upland perennial cover in North Dakota.
- 13:45-14:00** Jovette Bouchard - Intraspecific nest parasitism in red-breasted mergansers.
- 14:00-14:15** Jeff Pelayo & Robert Clark - Experimental test of the consequences of egg size in ruddy ducks.
- 14:15-14:30** Dana Kellett, Katherine Drake & Ray Alisaukas - Incubation constancy in king eiders: influence of body condition and implications for nesting success.
- 14:30-14:45** Grace Bottitta, Grant Gilchrist & Erica Nol - The influence of body condition on incubation constancy of arctic common eiders (*Somateria mollissima*) nesting on Southampton Island, Nunavut.
- 14:45-15:15** BREAK

Chair: **Scott Petrie**, Long Point Waterfowl & Wetlands Research Fund, Port Rowan, Ontario

- 15:15-15:30** Karla Guyn & Robert Clark - Vegetative and thermal characteristics of northern pintail nest sites in Alberta: implications for nest selection and survival.
- 15:30-15:45** Gregory Robertson, Grant Gilchrist & Keith Hobson - Habitat use, population structure and condition of common eiders wintering in the Belcher Islands, Nunavut.
- 15:45-16:00** Daniel McAuley, Jerry Longcore & David Clugston - Dynamics of wetland use by breeding American black ducks and mallards.
- 16:00-16:15** Dave Koons & Jay Rotella - Lesser scaup breeding ecology in the Canadian parklands: a population in peril.
- 16:15-16:30** Sean Boyd, Matt Evans, Saul Schneider & Barry Smith - Natal return and survival rates of Barrow's goldeneye in British Columbia.
- 16:30-16:45** Michael Anderson, Mark Lindberg & Robert Emery - Factors affecting growth of canvasback ducklings.

OPEN SESSION “B” - BATTLEFORD ROOM

Chair: **Kathy Dickson**, Canadian Wildlife Service, Hull, Quebec

- 13:15-13:30** Ken Reinecke, Mark Petrie, Dean Demarest & Tom Moorman - Variation of winter body mass of mallards in the Mississippi delta.
- 13:30-13:45** Bart Ballard, Jonathan Thompson & Mark Petrie - Nutritional ecology of northern pintails wintering on the Laguna Madre of Texas.
- 13:45-14:00** Dale Humburg, Douglas Helmers, Amanda McColpin & Karen Bataille - Managing migration habitats in an altered landscape.
- 14:00-14:15** Stephen Havera, W.L. Anderson & B.W. Zercher - Ingestion of lead and nontoxic shotgun pellets by ducks in the Mississippi flyway.
- 14:15-14:30** Shannon Badzinski, C. Davison Ankney & Scott Petrie - Influence of tundra swans on duck foraging behavior at Long Point, Ontario.
- 14:30-14:45** Scott Manley & Richard Kaminski - Values of winter-flooded ricefields in the Mississippi alluvial valley: more than waterfowl habitat
- 14:45-15:15** BREAK

Chair: **Graham Smith**, USFWS, Laurel, Maryland

- 15:15-15:30** Matthew Perry - Anthropogenic factors affecting diving duck distribution and abundance in Chesapeake Bay.
- 15:30-15:45** David Rodrigues, Antonio Fabio & Maria Figueiredo - Monthly survival rates of a European resident mallard (*Anas platyrhynchos*) population during the shooting season.
- 15:45-16:00** Kjell Sjöberg, Hannu Pöysä, Johan Elmberg & Petri Nummi - Resource limitation at the brood stage in mallards.
- 16:00-16:15** Hannu Pöysä, Johan Elmberg, Kjell Sjöberg & Petri Nummi - Habitat selection and distribution of breeding mallards: what do they reveal about population limitation?
- 16:15-16:30** Bruce Pollard, Kevin Devito & Brad Arner - Waterbird communities in the Taiga Plain of northeast British Columbia: linking attributes with patterns of duck distribution.
- 16:30-16:50** Gary Stewart, Michael Anderson, Brad Arner, Rod Fowler, Dave Kay, Ken Lumbis, Henry Murkin, Lee Moats, J.B. Pollard, Fritz Reid & A.J. Richard - Affecting waterfowl conservation in the western boreal forest.
- 17:00-** **POSTER SESSION** (Food, drinks, music) - **CONFERENCE FOYER**
[Poster abstracts are listed at the back of this booklet.]
Sponsored by U.S.G.S. - Northern Prairie Wildlife Research Centre

FRIDAY, 13 OCTOBER 2000 - ADAM BALLROOM

08:00-08:05 House-keeping issues/announcements

DUCK RECRUITMENT IN AGRICULTURAL AND FORESTED LANDSCAPES

Part A - Field studies

Chair: **Richard Kaminski**, Mississippi State University

- 08:05-08:45** Plenary Lecture by James Ringelman - Duck recruitment in agricultural and forested landscapes: empirical field studies.
- 08:45-09:00** Kenneth Richkus & Frank Rohwer - Nesting ecology of northern pintails in the intensively farmed prairies of southern Saskatchewan: are females caught in an ecological trap?
- 09:00-09:15** David Howerter, Jay Rotella, James Devries, Robert Emery, Brian Joynt, Michael Anderson & Llwellyn Armstrong - Landscape attributes predict hatching rates for ducks in the aspen parklands.
- 09:15-09:30** James Devries, Robert MacFarlane, Andrew Hak & Paul Thoroughgood - Use of fall and spring-seeded cereal crops for nesting by northern pintail and other waterfowl in southern Saskatchewan.
- 09:30-09:45** Christopher Hine, Aaron Yetter, Stephen Havera, Michelle Horath, Elizabeth Whetsell & Lynn Anderson - Mallard nesting ecology in central Illinois.
- 09:45-10:00** Ronald Reynolds & Charles Loesch - Federal wetland protection programs: how do they impact breeding duck population in the Prairie Pothole Region?
- 10:00-10:30** BREAK

Chair: **Robert McLandress**, California Waterfowl Association, Sacramento

- 10:30-10:45** Pamela Pietz, Gary Krapu, David Brandt & Robert Cox - Factors affecting survival of mallard and gadwall ducklings in prairie pothole landscapes.
- 10:45-11:00** Glen McMaster, James Devries & Stephen Davis - An integrated evaluation of cropland conversion in the Missouri Coteau of Saskatchewan: productivity of pintails and other grassland birds.
- 11:00-11:15** Paul Castelli, Robert Raftovich & Nathan Zimpfer - Breeding ecology of eastern mallards in a New Jersey estuary.
- 11:15-11:30** Brian Davis, Richard Kaminski, Bruce Leopold & Robert Cox - Survival and causes of mortality of wood duck hens and ducklings in Mississippi and Alabama.
- 11:30-11:45** Michael Phillips, David J. Horn, William Clark, Rolf Koford, Marsha Sovada & Raymond Greenwood - Predator selection of landscape features in landscapes with contrasting grassland composition in North Dakota.
- 11:45-12:00** Kevin Podruzny, James Devries, Llewellyn Armstrong & Jay Rotella - Long-term response of northern pintails to wetlands and agriculture in Canadian prairie-parklands.
- 12:00-13:00** *Lunch - hosted by Canadian Wildlife Service*

Part B - Modeling duck population dynamics

Chair: **Karla Guyn**, Ducks Unlimited Canada, Winnipeg, Manitoba

- 13:15- 13:55** Plenary Lecture by Jay Rotella - Modeling duck population dynamics: recent advances and future challenges.
- 13:55-14:10** Ray Alisauskas, Dana Kellet, Vanessa Anderson & Katherine Drake - Survival in female king eiders nesting at Karrak Lake, Nunavut
- 14:10-14:25** Todd Arnold, Michael Anderson, Michael Sorenson & Robert Emery - Survival and philopatry of female redheads breeding in southwestern Manitoba.
- 14:25-14:40** Llewellyn Armstrong & James Devries - Incorporating heterogeneity in nest survival estimation.
- 14:40-14:55** Gian Dodici, Rolf Koford & Guy Zenner - Evaluation of the productivity of mallards in northern Iowa.
- 14:55-15:30** BREAK

Chair: **Jean-Pierre Savard**, Canadian Wildlife Service, Quebec City

- 15:30-15:45** Rich Finger, Bruce Dugger & Stefani Melvin - Nesting ecology of mottled ducks in Florida.
- 15:45-16:00** John Citta, James Devries, Dave Howerter & Mark Lindberg - Breeding season survival of mallard hens in Canadian prairie-parklands.
- 16:00-16:15** Steve Hoekman, Scott Mills, David Howerter, James Devries & I.J. Ball - Sensitivity analysis of the life cycle of mid-continent mallards.
- 16:15-16:30** Shane Gabor, Steven Hokeman & Mark Petrie - Demographic analysis of mallards in eastern North America.
- 16:30-16:45** Tina Yerkes & Marten Koops - A spatially-explicit population model of northern pintails.

EVENING WORKSHOP SESSIONS (19:00-)

- 19:00-20:30** **Improving the scientific basis for managing ducks** (Michael Anderson, Fred Johnson)
Statistical hypothesis testing - forget it? (Douglas Johnson)
- 20:00-21:30** **Duck community ecology** (Thomas Nudds, Hannu Pöysä)
Recent advances in survival analysis (Gary White)

SATURDAY, 14 OCTOBER 2000 - ADAM BALLROOM

08:00-08:05 House-keeping/announcements

EVOLUTIONARY ECOLOGY AND MANAGEMENT

Chair: **Gary Hepp**, Auburn University, Alabama

- 08:05-08:45** Plenary Lecture by John M. Eadie - From the arcane to the applied: can evolutionary ecology offer any useful insight to waterfowl management?
- 08:45-09:00** Dean Demarest, Mark Vrtiska, Kenneth Reinecke, Barbara Lercel & Richard Kaminski - Age-assortative pairing in wood ducks and mallards.
- 09:00-09:15** Elizabeth Loos - Do patterns of nest attendance and female condition influence the risk of nest predation?
- 09:15-09:30** Michael Brasher & Richard Kaminski - Sociability of male mallards: evaluating indicated breeding pair criteria to estimate mallard populations.
- 09:30-09:45** Peter Blums & Robert Clark - Patterns and trade-offs in reproductive effort and success of ducks revealed by path analysis.
- 09:45-10:15** BREAK

Chair: **Bruce Batt**, Institute for Wetland & Waterfowl Research, Memphis

- 10:15-10:30** Matthew Evans, David Lank, Fred Cooke & Sean Boyd - Brood-rearing habitat selection by Barrow's goldeneye and its effect on duckling growth, survival, and return rates.
- 10:30-10:45** Pamela Garrettson, Frank Rohwer, Kenneth Richkus & William Johnson - Factors affecting nest abandonment by North American dabbling ducks.
- 10:45-11:00** Grant Gilchrist, Gregory Robertson & James Lovvorn - Foraging ecology of common eiders wintering at polynyas in the Belcher Islands: constraints imposed by ice, darkness and tidal currents.
- 11:00-11:15** Keith Hobson & Len Wassenaar - Stable isotopic (δD , $\delta^{13}C$, $\delta^{15}N$) assessment of migration in waterfowl.
- 11:15-11:30** Carolyn Bonta - A comparative study of incubation rhythms and nest microclimate of structure-nesting and ground-nesting mallards.
- 11:30-11:45** Robert Gates, Gary Anderson, Edward Zwicker, Andrew Selle, Daniel Ryan & Robert Kawula - Breeding behavior of tree cavity-nesting wood ducks.
- 11:45-12:00** Gary Hepp - Can hiding nest boxes reduce brood parasitism and increase nesting efficiency of wood ducks?

12:00-13:00 ***Lunch - hosted by U.S. Fish and Wildlife Service & the Atlantic, Mississippi, Central & Pacific Flyway Councils***

'TOP-DOWN' AND 'BOTTOM-UP' PERSPECTIVES ON DUCK POPULATION LIMITATION AND REGULATION

Chair: **Ronald Kirby**, USGS-Northern Prairie Wildlife Research Centre, Jamestown, North Dakota

- 13:15-13:35** Fred Johnson - Adaptive harvest management and perspectives on learning.
13:35-13:55 James Sedinger - Adaptive harvest management and mortality processes in ducks.
13:55-14:10 Jeff Lawrence, Dale Humburg & Fred Johnson - Adaptive harvest management and modeling mallards.
14:10-14:25 Nathan Zimpfer, Michael Conroy & Christopher Fomesbeck - Development of an adaptive harvest management protocol for American black ducks.
14:25-14:40 Diane Eggeman, Fred Johnson & James Dubovsky - Harvest management models for mallards breeding in eastern North America.
14:40-15:00 BREAK

Chair: **C. Davison Ankney**, University of Western Ontario, London

- 15:00-15:15** John Eadie, Edward Burns, Mike Eichholz & Mark Petrie - Energy limitation on the wintering grounds: what do we know and what do we assume?
15:15-15:30 Glenn Benoy - Using large-scale field experiments to test for food limitation in migratory waterfowl during the breeding season.
15:30-15:50 Johan Elmberg, Kjell Sjöberg, Hannu Pöysä & Petri Nummi - Positive association in nesting mallard and teal: resource limitation and interspecific competition in the light of census data and a depletion experiment.
15:50-16:10 Frank Rohwer - The impact of predators on duck production: what we know and what we wish we knew.
16:10-16:50 Plenary Lecture by James Nichols - Population limitation and regulation in ducks.
17:30-18:15 ***BUSES LEAVE FOR BANQUET AT THE WESTERN DEVELOPMENT MUSEUM FROM THE DELTA-BESSBOROUGH HOTEL***
22:00-23:30 ***BUSES RETURN TO DELTA-BESSBOROUGH HOTEL FROM WESTERN DEVELOPMENT MUSEUM***

Sunday, 15 October 2000

TOURS - Allan Hills or Last Mountain Lake National Wildlife Area (Leaving Delta-Bessborough Hotel; times to be announced)

HOCKEY - Rutherford Arena, University of Saskatchewan (Leaving Delta-Bessborough by bus at 10:00)

DUCK COMMUNITY ECOLOGY WORKSHOP - Salon Batoche (0800-1200)

[AVIAN BOTULISM WORKSHOP - MONDAY, 16 OCTOBER 2000]

ABSTRACTS: SPECIES OF CONCERN, HERE AND ABROAD

Globally threatened ducks world-wide, and species of concern in Europe.

*ANDY J. GREEN, Doñana Biological Station, Sevilla, Spain; BAZ HUGHES, Wildfowl & Wetlands Trust, Slimbridge, UK; SIMON DELANY, Wetlands International, Wageningen, Netherlands; DES CALLAGHAN, Wildfowl & Wetlands Trust, Slimbridge, UK.

Using the latest IUCN criteria for globally threatened status, the Threatened Waterfowl Specialist Group has identified 22 species plus 12 subspecies of duck threatened with extinction at a global level. This is in addition to 5 species and 5 subspecies that have gone extinct since 1600. We present a review of the factors causing and predicting threatened status, the biogeography of threatened taxa and prospects for future conservation measures. We highlight the need to focus more research on non-migratory ducks, which are relatively more threatened than migratory ones. Almost nothing is known about the ecology of most threatened ducks. In addition, we present a review of the current population trends of ducks declining in Europe (including non-threatened species), based mainly on winter counts from the International Waterbird Census coordinated by Wetlands International. We pay particular attention to those species shared with North America, and discuss to what extent their conservation problems are shared between the two continents.

A global perspective on spectacled eider populations.

*JAMES B. GRAND, USGS., Alabama Coop. Fish Wildl. Res. Unit, Auburn Univ., AL; ROBERT F. ROCKWELL, Am. Mus. Nat. Hist., New York, NY; PAUL L. FLINT & MARGARET R. PETERSEN, USGS, Alaska Biol. Sci. Ctr., Anchorage, AK.

We examined source-sink relationships among 3 local populations on the Yukon-Kuskokwim Delta, Alaska (YKD): lower Kashunuk River (KR), Kigigak Island (KI), and a large composite population consisting of the remainder of the YKD nesting population. We also considered a global metapopulation using 3 populations: YKD, North Slope of Alaska, and Russia. In regional scale simulations, we used estimates of annual population growth rates based on demographic data from KR and KI, and an estimate for YKD based on USFWS survey data. We examined density-dependent metapopulation models with dispersal rates ranging from 0 to 2%. With dispersal as low as 0.1%, the KR population declined initially but eventually began to increase due to immigration from source populations. Due to immigration and the high growth rate at KI, that population was sustained above carrying capacity. When dispersal rates exceeded potential growth of the large source population, the metapopulation eventually began to decline. In our global model we assumed that the same inherent growth rate for each population. To simulate competition for winter resources, we allowed carrying-capacity fluctuate randomly. Under these conditions the variability in population growth and the extinction probability of the small population was increased. Furthermore, the metapopulation was stable. Thus, there was a strong tendency for stability among the subpopulations, consequently limiting the likelihood of recovery without a decrease in growth rate or size of another population.

Annual survival and site fidelity of Steller's eiders molting along the Alaska peninsula.

PAUL L. FLINT & *MARGARET R. PETERSEN, USGS-Anchorage, AK.; CHRISTIAN P. DAU, USFWS, Anchorage, AK; JAMES E. HINES & JAMES D. NICHOLS, USGS, Laurel, MD.

Populations of Steller's eiders (*Polysticta stelleri*) molting and wintering along the Alaska Peninsula have declined since the 1960's. We captured and marked a large sample of Steller's eiders molting in 2 lagoons along the Alaska Peninsula between 1975-97. We used mark recapture analysis techniques to estimate annual survival and movement probabilities within and among lagoons for male and female eiders. Estimates of annual survival (\pm SE) were 0.899 ± 0.032 for females and 0.765 ± 0.044 for males. Both sexes showed high rates of fidelity to specific molting locations (>95%) within lagoons; yet we found no evidence that annual probability of survival differed among groups molting in different locations either within or among lagoons. We found weak evidence that annual survival decreased between the periods 1975-81 and 1991-97. The lower survival of males compared to females is unusual for waterfowl and may result in a female-biased sex ratio. We conclude that a decrease in adult survival may have initiated the long-term population decline. Further, a shortage of males may be limiting reproductive potential.

Tracking the movements of surf and white-winged scoters with satellite telemetry.

*DANIEL H. ROSENBERG & MICHAEL J. PETRULA, Alaska Dept. Fish & Game, Anchorage. We studied the distribution, seasonal movements, and migration patterns of surf scoters (*Melanitta perspicillata*) and white-winged scoters (*M. fusca*) with satellite telemetry. Using floating mist-nets, we captured ducks in Prince William Sound, Alaska from 1998-2000. A veterinarian surgically implanted satellite transmitters in a total of 43 surf scoters and 23 white-winged scoters. Post-surgical mortality rates in 1998 and 1999 were 52%. In 2000, we focused efforts on identifying the causes and reducing mortality of implanted birds. Movements of scoters were monitored every two to four days. For surf scoters we identified nesting areas in the Yukon and Northwest Territories of Canada, and the Yukon Flats National Wildlife Refuge, Alaska. Molting areas were identified in Norton and Kotzebue Sound and Kuskokwim Bay (mouth of the Kuskokwim River) in western Alaska. Wintering areas were identified in Prince William Sound and British Columbia. For white-winged scoters we identified nesting areas in the Northwest Territories; molting areas in the Beaufort Sea (Canada), lower Cook Inlet, and Bristol Bay, Alaska; and wintering areas in Prince William Sound and the Alaska Peninsula. We also obtained information on the timing and routes of migration.

Annual survival rates of harlequin ducks moulting and wintering in the Strait of Georgia, British Columbia.

*R. IAN GOUDIE, Dept. Biology, Memorial Univ., St. John's, Nfld; GREGORY J. ROBERTSON, Can. Wildl. Serv., Mount Pearl, Nfld; FRED COOKE & CYNDI M. SMITH, Ctr. Wildl. Ecol., Dept. Biol. Sci., Simon Fraser Univ., Burnaby, BC.

Between 1993 and 1999, 3385 moulting Harlequin Ducks from three sites were captured and banded with uniquely-coded coloured tarsal bands in the Strait of Georgia, British Columbia. We used capture-mark-resight analyses to estimate apparent annual survival rates and re-sight probabilities for spring 1995 to spring 2000 at a staging site where birds aggregated over Pacific Herring spawn. Annual local survival rates for the spring-to-spring period were high at 0.869 ± 0.011 SE for males and 0.796 ± 0.019 SE for females, suggesting strong fidelity to a spring staging site. Model fit was generally very good. Both sexes showed time and site variation in local survival, and this variation may be related to the scale and frequency of Pacific Herring spawn in the Strait of Georgia which influences the number of Harlequin Ducks frequenting Hornby Island in spring, the area where our resighting efforts were concentrated.

A review of single-factor explanations for declines in black ducks.

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Although the midwinter inventory indicates a 60% decline in continental black duck numbers since 1955, the survey masks regional variation in the status of breeding black duck populations. For example, black duck populations in the Atlantic provinces and eastern Quebec have remained stable or have increased over the past 40 years, while the number of black ducks breeding in Ontario and southwestern Quebec significantly declined over the same period. We challenged the following single-factor hypotheses for declines in black ducks to account for regional variation in the status of breeding black duck populations; 1) loss of breeding habitat, 2) loss of wintering habitat, 3) over harvest, 4) competition and/or hybridization with mallards. These hypotheses propose different mechanisms to account for regional variation in population status that are synonymous with testable predictions (e.g. breeding habitat hypothesis predicts greatest loss of breeding habitat where black ducks have declined). Tests of these predictions indicate that of the 4 hypotheses, only competition and/or hybridization with mallards is consistent with regional variation in the status of breeding black ducks. Our review indicates that increases in eastern mallards have contributed to declines in black ducks.

Assessment of contaminants in lesser scaup nesting in the boreal forest and implications for their population decline.

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Populations of scaup counted on the annual Breeding Population Survey have been declining since 1987. Thus, the population status of this species is of considerable concern to waterfowl researchers and managers. One explanation for the scaup decline is that females experience lower survival and/or reproductive success partly as a result of exposure to contaminants on wintering areas and/or on migration corridors. We surveyed contaminants in lesser scaup females and their eggs to determine if contaminants might be contributing to the population decline. In 1999 we collected females and eggs from 6 boreal forest sites in Alaska and Canada and from 3 sites in the prairie parklands. We analyzed eggs from 51 clutches and 10 nesting females for mercury, selenium, cadmium and lead and a broad suite of organochlorine contaminants. Our results indicate low levels organochlorines, and heavy metals in eggs. Likewise, heavy metal concentrations in livers and kidneys of adult females was low. Although our sample size of adult females was small, we found very low levels of contaminants in all females, consistent with the low contaminant levels the much larger sample of eggs. We conclude that while contaminant levels in eggs were low, we could not measure egg survival that could be adversely affected by contaminants. Our small sample of hens provides no support that females are contaminated to any significant extent with the broad suite of contaminants we measured, or that toxicologically significant amounts of contaminants were transferred to their eggs. Our data do not support the hypothesis of failed nesting due to contaminant loads, however we have no data regarding more subtle potential effects of contaminants such as reduced breeding propensity of females.

Population dynamics of greater scaup on the Yukon Delta.

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From 1990 through 1999, we collected information regarding the survival, nesting ecology, and productivity of Greater Scaup (*Aythya marila*) on the Yukon-Kuskokwim Delta. From 1991-99, we located 943 nests, radio-marked females for re-nesting studies, estimated duckling survival, and leg-banded females to examine nest site fidelity and annual survival. Mayfield estimates of nest success ranged from 7 ? 51% across years and 51% of females attempted a re-nest following loss of their first clutch. Duckling survival was estimated at 22%. Based on recaptures of marked females, annual survival was estimated at 79%. Using a stochastic model drawing directly from our distributions of clutch size and nesting success combined with our estimates of re-nesting potential and duckling survival, we calculated that, on average, breeding females produced 0.34 young females per nesting season. We combined this result with our estimate of adult survival, and an assumed estimate of first-year survival, to examine the growth rate of the population and the relative contributions of demographic parameters to that growth rate. Similar to the recent trend from aerial survey data, the population projection model suggests our study population is stable ($\lambda = 1.005$). Under these conditions the predicted stable age distribution of breeding females (i.e., the nesting population) is 16% 1-year old, 5% 2-year old first time breeders, and 79% 2-year old and older, experienced breeders. The relative effects of reproductive success and adult survival on population growth rate were 0.203 and 1.000. Thus, adult survival had 5 times the influence of reproductive output on λ for our population.

Diets and nutrient reserves of female northern pintails during spring migration in Nebraska.

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Female northern pintails (hereafter, pintails) arrive on breeding areas with large amounts of stored fat and use these reserves to produce their first clutch of eggs. Because pintails are not prolific re-nesters, nutrient-reserve dynamics during spring migration may be important in determining recruitment. We studied diets and nutrient reserves of pintails in the Rainwater Basins and central Platte River Valley, Nebraska, during February-March, 1998 and 1999. Although pintails consumed a wide variety of foods, diets ($n = 130$ esophagi with >5 food items) were dominated by corn (75% aggregate dry mass), smartweed (*Polygonum* spp.) seeds (10%), and barnyard grass (*Echinochola* spp.) seeds (7%). Animal foods made up only 2% of diets. Body condition (body mass adjusted for body size, an index of fat reserves) of pintails ($n = 157$) increased during spring in 1998, but the increase was interrupted by a sharp decrease in body condition at the onset of a severe snowstorm in early March. Body condition of pintails showed no relation to date

during 1999. Overall, body condition of pintails less than 1 year old was 35 g less than that of older birds. Data on specific nutrient reserves (fat, protein, and mineral) of pintails, which were not available at the time of this abstract, also will be presented. Our study indicates that body condition of pintails during spring may show considerable variation in relation to weather and among years.

Spring migration of northern pintails: an application of satellite telemetry.

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The estimated breeding population of northern pintails in North America remains well below the objective set by the North American Waterfowl Management Plan, despite several years of excellent wetland habitat conditions in critical prairie nesting areas of Canada and the U.S. Additional information on pintail ecology, including "cross-seasonal effects" of winter and spring habitat conditions on ultimate productivity, is needed by managers to facilitate development of conservation programs to remedy low pintail populations. We have begun a 4 year project funded by Tuscan Research Institute through Ducks Unlimited, Inc. and the California Waterfowl Association, to document pintail spring migration routes leading from California, and to determine ultimate distribution of breeding populations relative to prairie habitat conditions (May Pond numbers and distribution), May Survey strata (proportion of pintails recorded within surveyed regions), and perennial botulism lakes (proportionate exposure rate). We will determine the geographic link between wintering, migration, nesting and post-nesting/molting areas, which will lay ground work for integrated field studies, and we will characterize the habitats of pintail use areas and determine land ownership status. We marked 41 adult female pintails with satellite transmitters in January 2000 in the northern Central Valley of California, the principal Pacific Flyway and continental wintering region for this species during late winter. We have begun to collect location data and will report on first year results.

INVITED PLENARY LECTURE

Conservation crises among ducks: threatened and endangered species of the world.

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Ducks have been domesticated, collected and hunted; and have suffered from habitat alteration and extirpation, as well as introduction of toxicants, competitors, predators and pathogens. During man's early history, duck species went extinct due primarily to collection of eggs, young and adults. From 1600-1900 duck extinctions involved the Mauritian Shelduck, the Mauritian Duck, the Mariana Duck and our own Labrador Duck. In the 20th century, however, extinctions were induced primarily by habitat alteration associated with burgeoning human populations. The Auckland Island Merganser went extinct in 1905 due, largely, to man's introduction of mammalian predators. All four of the ducks now considered on the verge of extinction by IUCN (i.e., CR = critically endangered), Madagascar Pochard, Brazilian Merganser, Pink-headed Duck and Crested Shelduck, have suffered enormously from severe habitat loss and/or degradation. Similarly, the two additional duck species considered endangered (EN) by IUCN (Madagascar Teal and White-winged Wood Duck) have suffered severe habitat loss. Of these six CR and EN species, two are Madagascar endemics, one is Brazilian, and three occur in Asia.

IUCN lists 19 additional waterfowl species as vulnerable (VU), including 15 species of ducks. These 15 illustrate the nature of conservation issues facing ducks. The primary cause of population decline, overall, is habitat loss and degradation, especially associated with intensive agriculture and other forms of "economic development." For six species (Marbled Teal, White-headed Duck, Ferruginous Duck, Baer's Pochard, Freckled Duck and West Indian Whistling Duck) wetland drainage has been identified as the primary reason for population decline – four in Eurasia, one in the West Indies and one in Australia; and, in the case of two additional island endemics, drainage plus predator introduction (Brown Teal, New Zealand; Hawaiian Duck, Hawaii) has been identified as the source of population decline. One species, the Baikal Teal, suffered population reduction due, primarily, to its great vulnerability to hunting and collection during migration and on the wintering grounds. Three riverine species suffer from hydroelectric programs, and water quality declines due to logging, mining, etc. (Salvadori's Teal, New guinea; Blue Duck, New Zealand; Scaly-sided Merganser, NE Asia). The Laysan Duck, a small island endemic, was nearly extinct in the 19th century due to collecting, hunting and rabbit introduction/denudation. Today, a population in the 100s survives. The remaining VU species are Spectacled Eider and Stellar's Eider. North American populations of Spectacled Eider have

suffered steep declines due to lead ingestion on the breeding grounds while Russian populations probably are stable. Stellar's Eider may have suffered steep declines in the Aleutians but most of the species' breeding range is outside North America where population data are inconclusive.

The vulnerability of certain western hemisphere ducks not yet considered threatened or endangered will be discussed relative to oil pollution, prey extirpation, hybridization, and habitat degradation.

OPEN SESSION "A"

Of mice and mallards: the indirect effects of coexisting prey on waterfowl nest success.

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Nest predation is recognized as the most important factor influencing waterfowl nest success. Although the use of alternate prey to buffer predation on nests may be a viable alternative to current waterfowl management techniques, the impact of coexisting prey populations on nest predation rates is poorly understood. I studied the influence of coexisting prey populations (i.e., rodents) on mallard (*Anas platyrhynchos*) nest success within upland habitats in California. Among six 14 to 27 ha upland fields, mallard nest success was positively correlated with rodent abundance in both 1998 ($R^2 = 0.69$, $p = 0.04$) and 1999 ($R^2 = 0.87$, $p = 0.01$). There was a significant interaction between year and rodent abundance on mallard nest success ($p = 0.01$). When rodent populations were low overall (mean of fields in 1998 = 1.24 rodents per 100 trap nights), predators appeared to respond more strongly to small changes in rodent densities (slope = +9.93) than when rodent populations were large (mean of fields in 1999 = 58.82 rodents per 100 trap nights; slope = +0.49). I tested the alternative explanation that large rodent populations indicate dense nest-site vegetation (i.e., dense nesting cover) which increases mallard nest success by reducing a predator's ability to find nests. However, I detected no relationship among fields between mallard nest success and nest-site vegetation features ($p > 0.05$). By increasing the diversity and abundance of coexisting prey species (e.g., rodents), managers may be able to buffer predation pressure on waterfowl nests due to the behavioral responses (e.g., prey switching) of shared predators to alternate prey.

The relation of mallard nest numbers on constructed islands to upland perennial cover in North Dakota.

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Constructed islands can provide excellent nesting sites for upland nesting ducks if properly constructed and managed. Islands are costly to build and should be placed in areas that assure the greatest use by nesting ducks. We studied mallard nesting on constructed islands in North Dakota during 1996 and 1997 to identify factors that influence numbers of mallard nests on islands. We concluded that the amount of perennial cover in uplands surrounding the island was the best predictor of numbers of mallard nests on islands (1996: $R^2=0.5757$; 1997: $R^2=0.5952$). Results indicated that numbers of mallard nests on islands were related to amount of perennial cover even after accounting for other sources of variation ($P=0.0135$). We recommend that new islands be built in areas with low amounts of competing perennial cover in the surrounding uplands. We also evaluated the ability of a mallard productivity model in predicting the numbers of mallard nests on islands. We found that the mallard model adequately predicted relative numbers of nests and would be useful in comparing potential island sites.

Intraspecific nest parasitism in red-breasted mergansers.

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Intraspecific nest parasitism is common among waterfowl. Several factors play a role in making parasitism a frequent occurrence in ducks: Duck nests are easily detected by parasites, they have large clutches which hatch synchronously giving parasites many opportunities to find unattended nests before the start of incubation, the presence of genetic relatedness among females may reduce the costs of being parasitized, and lastly, duck offspring are precocial, therefore parental costs are low, in turn lowering the costs. The Red-breasted Merganser exhibits intraspecific nest parasitism, and rates of occurrence of this behaviour has been documented. However, as with other species, neither the identity nor the tactics of parasitic females have been confirmed. My objectives in this study are to identify parasitic females within a Red-breasted Merganser colony, as well as to determine factors influencing this behaviour. In order to identify parasitic females, genetic analysis testing for parentage between incubating hens and the eggs in their nests, will be performed. Traditionally, this involves having to take blood samples from females and all chicks. I have collected and extracted DNA from nest materials such as feathers and egg membranes, a method, which is slowly proving to be more practical. My research population is one which has been studied since the early 1980s, located in Kouchibouguac National Park, New Brunswick

Experimental test of the consequences of egg size in ruddy ducks.

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Large egg size is believed to confer strong survival advantages for newly-hatched birds, but most studies of egg size and survival of precocial birds have so far failed to control for confounding maternal effects. Accordingly, we cross-fostered complete broods in a population of wild ruddy ducks (*Oxyura jamaicensis*) to separate effects of egg size from maternal influences. During two years of study, 40 broods consisting of 244 marked individuals were switched, at random, among nests. Data were analyzed using known fate models in program MARK. Most duckling mortality occurred during the first two weeks after hatch (78% of losses in 1998 and 89% in 1999). In 1998, there was a decline in survival with advancing hatching date and an increase in survival with increasing foster female body size. In 1999, offspring survival increased with brood size, advancing hatching date, and larger egg size. Offspring condition was also related to larger egg size and individuals in better condition survived longer than those in poor condition. We hypothesize that selective mortality of small egg phenotypes is related to smaller offspring size and reduced energy reserves at hatch, which may reduce survival during unfavorable conditions. To our knowledge, this is the first attempt to sort out causal relationships between egg size and offspring survival in a wild, precocial bird species.

Incubation constancy in king eiders: influence of body condition and implications for nesting success.

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During 1995-2000, we studied body mass dynamics and incubation behaviour of king eiders at Karrak Lake, Nunavut. Among waterfowl, king eiders have one of the highest reported mass loss rates during incubation, showing strong reliance on endogenous reserves. King eiders lost 30% post-laying body mass during 23 days incubation, weighing 1,610 g (95% C.I.: 1559 g - 1661 g) after egg laying and 1,128 g (954 g - 1303 g) at hatch. Variation in amount of stored reserves during incubation may influence incubation constancy, ultimately influencing nesting success. At Karrak Lake, king eiders nest primarily on islands, where terrestrial predators are lacking but avian predators are prevalent. When attending nests, king eider females can effectively defend eggs from avian predation. We predict that females in better body condition will exhibit higher nest attendance and consequently, lose fewer eggs to avian predators.

The influence of body condition on incubation constancy of arctic common eiders (*Somateria mollissima*) nesting on Southampton Island, Nunavut.

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In breeding birds, the ability to successfully raise offspring is often influenced by the level of their energy reserves, particularly among waterfowl species that fast during incubation. In 1998 and 1999, we examined the costs of reproduction among common eiders (*Somateria mollissima*) nesting in the Arctic, in relation to their energy reserves. Clutches were switched pairwise between nests to shorten or prolong the length of incubation by five days (1998, n=30; 1999, n=40). We predicted that experimentally extended hens would: 1) take more frequent incubation breaks of longer duration, 2) have a significantly lower body condition at hatch than females with shortened incubation, and 3) have a higher probability of nest failure, than either control or shortened. We quantified the incubation constancy of hens through behavioural observations and by placing Remote Incubation Monitoring Systems (RIMS) in thirty-eight nests. The length of time spent off the nest per incubation recess as well as the number of recesses increased significantly with day of incubation for all treatments (ANOVA: recess minutes, number of recesses: $F_{1,219}=16.54$, $p=0.001$). Incubating females were weighed to determine rate of mass loss during incubation (1998, n=40; 1999, n=69). Experimentally extended hens were in poorer body condition at hatch (ANOVA, $F_{2,23}=7.35$, $p=0.003$) and also had a higher probability of nest failure ($\chi^2=6.19$, $df=1$, $p=0.016$).

Vegetative and thermal characteristics of northern pintail nest-sites in Alberta: Implications for nest selection and survival.

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We studied nesting northern pintails in mid-grass prairie of southern Alberta to evaluate whether nest-site selection patterns and processes were based on vegetative features, female characteristics, or whether site selection was based on nest microclimate. Pintail nests ($n = 114$) were dominated by short-grass, and often (33%) located in depressions. Discriminant function analysis (DFA) revealed that nest-sites had less moss and short-grass, and greater shrub cover than random sites, and nests were more frequently found in depressions. DFA also showed that failed nests ($n = 77$) tended to be closer to shrubs ($23 \text{ m} \pm 51 \text{ SD}$) than successful nests ($59 \pm 82 \text{ SD}$, $n = 29$), whereas nests of SY females ($n = 28$) had more mid-grass and short grass than ASY females ($n = 42$). Microclimatic data were collected simultaneously at 28 pintail nest-sites and 28 neighboring random sites. Nest-sites were cooler ($25.4 \pm 0.19 \text{ }^\circ\text{C}$) than random sites ($27.3 \pm 0.20 \text{ }^\circ\text{C}$) during daylight hours ($F = 20.52$, $df = 1$, 7361 , $P = 0.0001$) but did not differ at night ($F = 2.34$, $df = 1$, 7361 , $P = 0.13$). Thirty-minute mean temperatures exceeded the upper lethal limit ($41 \text{ }^\circ\text{C}$) for embryonic development more often at random sites (17% of the time) than at nest-sites (12 % of the time; $\chi^2 = 78.5$, $df = 1$, $P = 0.001$). In summary, pintails exhibited non-random nest-site selection based on vegetation. Furthermore, in southern Alberta, where lethal egg temperatures are relatively common, females also exhibited nest microclimate selection perhaps to accrue advantages for developing embryos.

Habitat use, population structure and condition of common eiders wintering in the Belcher Islands, Nunavut.

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We studied the ecology of Hudson Bay Common Eiders wintering in the Belcher Islands, Nunavut, for three winters (1998-2000). Eiders used two type of habitats, small recurring polynyas and the landfast ice floe edge. Polynyas were always available for the eiders, while the size and presence of open floe edges were variable and depended strongly on wind and current. Eiders wintering in polynyas were predominately young birds, while adult eiders were present at the floe edges. There were differences among floe edges as well, with relatively more adult eiders found at a large floe edge in the southern part of the Belcher Islands. At the same floe edge, adult eiders tended to be further offshore, compared to young birds. Eiders foraging in polynyas consumed typical benthic prey, while eiders at the floe consumed pelagic prey (especially sandlance) in addition to benthic food items. Eiders collected from the floe edge tended to be in better condition than eiders collected in polynyas. Although an ephemeral habitat, adult eiders preferred the dynamic floe edge system, probably because the floe edge offered ample food when open and reduced vulnerability to Inuit hunters.

Dynamics of wetland use by breeding American black ducks and mallards.

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The American black duck (*Anas rubripes*) has declined during the past several decades. Recently, this decline has been attributed to competition with mallards (*Anas platyrhynchos*). Data from single, annual waterfowl surveys have been used to document black duck and mallard habitat use. We studied sympatric black ducks and mallards in northern Maine during breeding to document wetland use. We observed ducks from elevated platforms on wetlands to determine numbers and species using each wetland over time; 80% of the wetlands were visited >2 times; mean total time / wetland was 267 min + 15 (SE). Upon arrival, and at 5-min intervals during a visit, we recorded the number of indicated pairs of each species. For each wetland, we determined the most frequently observed grouping of black ducks and mallards recorded during all intervals (e.g., 1 BD pair-9 intervals; 2 MA pairs and 1 BD pair-22 intervals; 0 pairs-3 intervals). One pair, 1 lone male, or no ducks were present during 34% of the intervals. All wetlands, except 1, had >2 different combinations. On most wetlands the predominant grouping was not observed during >40% of the intervals. On average, the number of indicated pairs observed during random 5-min intervals was less than half of the total black duck pairs [2.0 (0.35) vs. 4.4 (0.77), $P = 0.009$], total mallard pairs [1.1 (0.18) vs. 2.6 (0.34), $P = 0.0001$], and pairs of both species combined [3.2 (0.46) vs. 7.0 (0.99), $P = 0.0001$] as determined for each wetland based on total observations. On wetlands used by both species, random counts missed 1 or both species 51% of the time. Of the 63 wetlands observed, 53 were used by both species; random visits detected both species on only 26 wetlands.

Lesser scaup breeding ecology in the Canadian parklands: a population in peril.

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While many duck populations have increased in recent years, lesser scaup (*Aythya affinis*) numbers have not. The continental lesser scaup population is at an all time low. Much of the decline has occurred in the boreal forests of Canada where the majority of lesser scaup breed. Yet, we hypothesized that historically important 'hot spot' breeding locales in the parklands, such as Erickson, Manitoba have also experienced population declines. Analysis of May Breeding Pair Survey data confirm that the Erickson scaup population has declined. We hypothesized lowered reproduction as the primary cause of the local population decline. Comparisons with historical estimates of clutch size, egg size, egg hatchability, nest success, re-nesting rate, and duckling survival indicate that several vital rates may be lower now than in the 1970s. Recent data from radio-marked females indicate that female breeding-season survival is low and that the large majority of mortality occurs while females are on nests. Possible causes for observed patterns and management solutions will be discussed.

Natal return and survival rates of Barrow's goldeneye in British Columbia.

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We investigated annual return and survival rates for known-age Barrow's Goldeneye, starting with HY birds. Over four years from 1995-1998, we marked 288 male and 241 female Class IIC-III ducklings with nasal disks on a study area near Riske Creek, B.C. Each year from 1996-1999, we surveyed 120+ ponds on a weekly basis from April to August to record the presence of marked birds. Average first year return rate was estimated at 33% (range = 18-53%) for females but only 6% (range = 0-19%) for males. Using the program MARK, we estimated the local annual survival rate of females at 34% in three of the four years but 73% in one year (1997 to 1998). For males, survival rate was only 8% and 55% in the same years. The reason for the high variability in survival rates is unknown. Compared to marked males, females were encountered 2-3 times more often per bird on the study area in their second year and they were recorded on twice as many ponds. These observations suggest that, although young males return to their natal area, they are much more transient than females and this may partially account for their lower apparent return and survival rates. This is one of the first studies to assess return and survival rates for known-age Barrow's Goldeneye; we hope to continue the work for at least one more year.

Factors affecting growth of canvasback ducklings.

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We examined effects of wetland conditions, hatching date, and breeding density on growth of Canvasback (*Aythya valisineria*) ducklings by measuring weight, and culmen and tarsus length of ducklings captured in southwestern Manitoba, Canada. Tarsus length reached asymptotic size faster than culmen length and weight. All 3 growth metrics were negatively related to hatching date, but ducklings exhibited compensatory growth for tarsus length and weight. Therefore, at older age classes, individuals that hatched late had a similar tarsus length and weight as individuals that hatched early. Duckling growth varied annually and ducklings were smaller in years with average or dry wetland conditions than in wetter years. We observed no difference in growth of ducklings from a control block and those ducklings raised on a study block with experimental enhanced densities suggesting that density-dependent factors were not limiting development of ducklings. The relationship between growth metrics and the factors we measured were complex, exhibiting sex- and measurement-specific variation. Additional studies that simultaneously measure growth and food availability are needed. Because growth was not affected by density, and density did not affect other fitness characteristics, we suggest that prairie parkland habitats can support a higher density of Canvasback broods under average environmental conditions.

OPEN SESSION B

Variation of winter body mass of mallards in the Mississippi delta.

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Consequences of variation in winter habitat quality have proven difficult to investigate in waterfowl. However, measurements of winter body mass are relatively easy to obtain and provide a means of generating hypotheses for further study. We combined measurements of winter body mass for 533 hunter-killed mallards obtained in the Mississippi Delta during December 1999 and January 2000 with data from studies in winters 1979-80 through 1982-83. We used analysis of variance to assess effects of sex (M, F), age (HY, AHY), winter (1979-80, 1980-81, 1981-82, 1982-83, 1999-2000), and time period (Dec, Jan) on variation in body mass. Effects of sex and age were as expected, and variation among years was consistent with previous interpretations that winter water levels affect food supplies and consequently body mass. In contrast to previous analyses, there was a significant winter x time period interaction ($P = 0.018$), suggesting that decreases in body mass between early and late winter varied among years. The decrease in body mass (77.3 ± 10.0 [SE]) between early and late winter 1999-2000 was the largest observed, and a linear contrast indicated this decrease was greater ($P = 0.013$) than the mean decrease for winters 1979-80 through 1982-83. Thus, concerns for adequacy of winter food supplies in the Mississippi Delta remain, despite progress made in implementing the North American Waterfowl Management Plan. Our results and those of a recent study in Mississippi suggesting that food resources in rice fields may have decreased over time highlight the need for further assessment of food resources and their consequences for demographics.

Nutritional ecology of northern pintails wintering on the Laguna Madre of Texas.

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In North America, northern pintails (*Anas acuta*) winter predominantly in areas under cultivation for rice production. However, declining rice acreage along the western Gulf Coast is reducing the capacity of the rice prairies to support wintering pintails. Based on availability and proximity to the rice prairies, we surmise that pintails will increasingly use coastal estuaries and lagoons as the remaining rice prairies present less optimal habitat conditions. However, forced emigration of pintails to coastal habitats, where food may be less available or where birds may feed on foods that have poor nutritional characteristics, may have unforeseen effects on survival and fecundity. We evaluated the ability of

coastal lagoons to support wintering pintails by investigating body composition and diet of birds currently wintering on the Laguna Madre of Texas during October-February 1997-98 and 1998-99. Ingesta-free body mass showed a consistent decline (females: $r = 0.50$, $P < 0.001$; males: $r = 0.53$, $P < 0.001$) from arrival in October through departure in late February. Nutrient reserves were catabolized by male (lipid: $r = 0.43$, $P < 0.001$; protein: $r = 0.48$, $P < 0.001$) and female (lipid: $r = 0.42$, $P < 0.001$; protein: $r = 0.47$, $P < 0.001$) pintails throughout winter. The diet of pintails wintering on the Laguna Madre consisted of foods that provided less metabolizable energy than most foods consumed in freshwater environments. Consequently, pintails wintering on the Laguna Madre depart from wintering sites in poor body condition relative to pintails wintering in rice producing regions.

Managing migration habitats in an altered landscape.

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Modern wetland restoration and management strategies largely have been developed in the context of highly altered systems. The Missouri River, for example, has lost 8% of the river length, >50% of the river surface area, 98% of the sandbars, and 63% of the floodplain forest as 95% of the native vegetation was converted to agriculture during the last century. We determined waterbird use of 140 basins along 900 km of the Missouri River in Missouri, Kansas, Nebraska, and Iowa during March-September 1995-1998. The relative use of different basins by more than 70 waterbird species and 768,700 individuals showed that a comprehensive restoration and management strategy will be necessary; however, management for waterfowl was not necessarily exclusive of other waterbird species. Disparate use among habitat types and years by dabbling ducks, coot, wading birds, and shorebirds was explained by annual differences in seasonal flooding and frequent perturbations by landowners. Seasonal wetlands, for example, were flooded <50% of the time but were mowed, tilled, or cropped >70% of the time during March to September. A full complement of passive and controlled management regimes will necessary to ensure that the seasonal needs of migrating waterbirds are met. Restoration strategies that favor intensive management to ensure food production, and extensive infrastructure that provides water management capabilities to ensure food availability are complemented only in some years by seasonal wetlands on private land. Although the timing of inundation generally corresponded to snowmelt, rainfall, and flooding events, the influence of mainstem reservoirs on river levels and basin alteration by farmers had significant effects on wetland availability. Realistic strategies for intensively managed wetlands versus highly altered seasonal basins should be based on an understanding of the relative impact of altered wetland processes versus physical changes in basin condition.

Ingestion of lead and nontoxic shotgun pellets by ducks in the Mississippi flyway.

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We examined the extent to which ingested nontoxic (steel and bismuth-tin) shotgun pellets replaced toxic (lead) pellets in hunter-harvested ducks in the Mississippi Flyway during the 1996 and 1997 hunting seasons (fifth and sixth years after nationwide conversion to nontoxic shot). Gizzards were collected from 16,651 ducks and processed for the presence of pellets. Prevalences of ingested pellets were 8.9% for 15,147 mallards (*Anas platyrhynchos*), 12.7% for 749 ring-necked ducks (*Aythya collaris*), 4.3% for 579 scaups (*A. collaris* and *A. marila*), and 9.7% for 176 canvasbacks (*A. valisineria*). For gizzards with ingested pellets, 68% of mallards, 45% of ring-necked ducks, 44% of scaups, and 71% of canvasbacks contained only nontoxic pellets. Using Bellrose's (1959) original formula, we estimated that nontoxic shot reduced lead poisoning mortality in Mississippi Flyway mallards by 64%. Ingestion of 2 toxic pellets was reduced by 78%. For all ducks in North America, an estimated 1.4 million in the 1997 fall flight of 90 million were spared from fatal lead poisoning. Only 1.1% of 1,318 gizzards with shot-in pellets contained toxic pellets, and only 1 toxic fishing sinker was found in the 16,651 duck gizzards.

Influence of tundra swans on duck foraging behavior at Long Point, Ontario.

*SHANNON S. BADZINSKI & C. DAVISON ANKNEY, Dept. Zool., Univ. Western Ontario, London.; SCOTT A. PETRIE, Long Point Waterfowl & Wetlands Research Fund, Port Rowan, Ont. Few data exist concerning how tundra swans (*Cygnus c. columbianus*) and other waterfowl interact during spring and fall migration. Thus, in fall 1998 we initiated a three year investigation concerning influence of tundra swans on aquatic vegetation and behavior of staging waterfowl at Long Point, Ontario. One objective of this research was to investigate how feeding activities of tundra swans affected diurnal foraging behaviors of staging ducks during spring and fall migration. Focal individual sampling was used to quantify behaviors of ducks feeding near (< 3m) and far (> 30m) from feeding and non-feeding tundra swans. Foraging (i.e., paddling, dabble, head-under, neck-under, and tip-up) and non-foraging (i.e., rest, head-up, alert, locomotion, maintenance, and inter/intraspecific aggression) behaviors were recorded every 10s for 10min. All instances of tundra swan-duck interactions and alert behaviors occurring between sampling intervals also were recorded to quantify these more subtle and/or rare behaviors of short duration. Mallard (*Anas platyrhynchos*) and black duck (*Anas rubripes*) were the primary focal species because they were the most abundant species that overlapped spatially and temporally with tundra swans during migration at Long Point. Results will be discussed in relation to energetics, foraging ecology, and distributions of staging waterfowl at Long Point, Ontario.

Values of winter-flooded ricefields in the Mississippi Alluvial Valley: more than waterfowl habitat.

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Winter management of rice fields in the Mississippi Alluvial Valley (MAV) can resolve important challenges in natural resource conservation and waterfowl management. We evaluated combined effects of post-harvest rice field treatment (standing stubble or disked) and winter flooding on selected environmental, agricultural, and waterfowl food variables. Winter-flooded rice fields conserved soil and nutrients while increasing quality of runoff waters, especially when rice fields were not disked in fall. Flooding also reduced rice straw and retarded growth of winter weeds. Less straw and weeds leads to less tillage and herbicide application in spring, contributing to a combined savings of \$54/ha. These collective attributes make winter flooding of rice fields a beneficial environmental and agricultural practice. In fields infested with red rice (a nuisance rice strain), seed viability can be reduced to <10% by spring by not disking after harvest (i.e., leave seeds on ground to germinate in fall-winter). Waterfowl food resources were similar among rice field treatments, but accessibility of resources for waterfowl would be less without flooding. Biomass of aquatic invertebrates exhibited great potential to increase by late winter in response to flooding. Conversely, a significant decrease in waste rice (>80%) occurred between harvest and early winter, which may have negative implications on foraging carrying capacity of rice fields for waterfowl. Although no combination of post-harvest treatment and winter-water management was optimal for all conservation and agricultural challenges, winter flooding and specific post-harvest conditions effectively address important challenges in soil conservation, water quality, spring-field preparation, and provision of waterfowl habitat in rice fields and possibly other croplands in the MAV.

Anthropogenic factors affecting diving duck distribution and abundance in Chesapeake Bay.

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Diving ducks wintering in Chesapeake Bay during the last 50 years have accounted for 23% of Atlantic Flyway and 9% of North American populations based on aerial surveys. Continental and local factors have affected these populations. Numbers of ruddy ducks and 5 pochard species have declined, whereas, goldeneye and sea duck (scoter and oldsquaw) populations have remained stable. The bufflehead is the only diving duck species that has increased in numbers. Loss of submerged aquatic vegetation (SAV) due to degradation of water quality, has been a contributing factor, although, many other factors related to human population increases have been implicated in the changes in the distribution and abundance of diving ducks. Patterns of hunters have changed due to declines in Canada goose populations, and changes in hunting have affected diving ducks, especially sea ducks. Changes in the quantity and quality of available foods in the Chesapeake Bay and species-specific responses to changes are likely contributing to population declines. The percentage of invertebrates in the diet of most pochards and ruddy ducks has increased as SAV declined. The redhead did not alter food preference for SAV, and populations of this species have declined from over 100,000 to less than 1000. New food habits research is being conducted to further explain the changes in distribution of diving ducks in Chesapeake Bay that are related to habitat conditions. Anthropogenic factors affecting diving duck populations include

direct and indirect causes, including excessive development of Bay tributaries, increased year-round boat traffic, and increased levels of contamination.

Monthly survival rates of a European resident mallard (*Anas platyrhynchos*) population during the shooting season.

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We estimated monthly survival rates along the shooting season through the use of Cormack-Jolly-Seber models applied to capture/recapture/resight data of a Portuguese resident Mallard population. A total of 795 young males, 417 adult males, 209 young females and 169 adult females were captured and nasal marked. Resights amounted to more than 10000. We modelled data and obtained estimates through the use of program MARK. The results confirmed an expected low survival rate of juveniles. However, the differences in shooting mortality between adults and juveniles were significant only during the first month, when juveniles had about the half of the adults' apparent survival rate (0.79 ± 0.036 and 0.489 ± 0.073 for adult males and females, respectively, and 0.265 ± 0.026 for juveniles of both sexes). During the remaining months of the shooting season, both age classes had similar survival rates, for each sex class. The high mortality of juveniles occurred mainly during the first shooting month and especially during the first shooting days. Post breeding dispersion of juveniles also was concentrated in the same period. The survival rate of adult females also was significantly lower than that of adult males during the first month. This suggests that regulations for protecting moulting areas should be improved, since an important proportion of adult females still are moulting in late August, September and early October.

Resource limitation at the brood stage in mallards.

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Mallard ducklings imprinted on humans were used as tools to quantify the quality of duck habitats in the boreal region in northern Sweden. The background to this experimental study is that many lakes in Fennoscandia are lacking breeding mallards. In two study areas in southern Finland with 35 and 51 lakes, 71% and 69% were unoccupied by mallard broods in long-term data. Our hypothesis was that lakes without mallard broods were too poor to raise young in. Change in body mass of imprinted ducklings were noted before and after 6 hour foraging periods in 11 lakes regarded as poor habitats and in 11 lakes regarded as rich habitats according to measurements of total phosphorus concentration in the water. The ducklings foraging on poor lakes gained significantly less body mass than those feeding on rich lakes. However, at night, when ducklings of both groups had equal and free access to pellet food, ducklings that had been feeding on a poor lake that day gained more mass than those that had been feeding on a rich lake. The observational data, as well as the experiments indicate that many boreal lakes are inferior breeding habitats for mallards at the brood stage. The results of body mass change are supported by individual behavior of the ducklings in the experiment situation. Ducklings foraging on poor lakes moved more than those foraging on rich lakes. On the other hand, they picked more from the water surface and from vegetation, indicating a richer supply of food items for the ducklings in the richer lakes.

Habitat selection and distribution of breeding mallards: what do they reveal about population limitation?

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The distribution of individuals among habitats and habitat-specific breeding output are basic elements for understanding population limitation and regulation. We studied the connection between habitat selection and population limitation in breeding mallards on boreal lakes in Sweden and Finland with experimental and long-term observational data. Wing-clipped mallards were introduced on breeding lakes before migratory wild mallards arrived to test 2 alternative hypotheses of habitat selection, namely ideal preemption and conspecific attraction. The ideal preemptive rule was rejected while the conspecific attraction rule was to some extent supported. However, by combining the results of the introduction experiment with those from an experiment done with mallard ducklings to measure habitat quality, we found that only good-quality lakes attracted wild mallards, whereas poor-quality lakes did not. Long-term observational data from 35 lakes, classified into rich and poor based on shore vegetation, revealed that breeding pairs prefer rich lakes over poor, breeding success also being better there than on the poor lakes. In accordance with the experimental findings, density on the rich lakes increased with overall population density while that on the poor did not. However, breeding success did not show clear density dependence. Our results indicate habitat-specific limitation of breeding numbers, though this may not translate to limitation at the population level.

Waterbird communities in the Taiga Plain of Northeast BC: linking wetland attributes with patterns of duck distribution.

*J. BRUCE POLLARD, Inst. Wetland & Waterfowl Res., Stonewall, MB; KEVIN J. DEVITO, Dept. Biol. Sci., Univ. Alberta, Edmonton, AB; BRAD ARNER, DU Can.. Prince George, BC. Investigations of breeding waterbird communities were initiated in near Fort Nelson, BC (58.8 N, 122.7 W) in 1998 and continued in detail in 1999. Aerial breeding pair and brood surveys in 1999 identified a diverse waterfowl assemblage associated with wetlands in the region, and generally high occupancy rates of individual wetlands. Communities were dominated numerically by mallard, lesser scaup, ring-necked duck, green-winged teal, wigeon and bufflehead. Comparison of pair to brood ratios indicated low apparent production by scaup relative to ring-necked ducks, although no cause for this lower production is immediately evident. Successful breeding by other species of interest such as scoters and trumpeter swans was also documented in both years, although effort by these species was relatively low. Water chemistry attributes were evaluated in mid-summer on a subset of 108 of the 121 waterfowl survey basins. Analyses of these samples, and those taken from other northern sites, indicate that paradigms commonly held for wetlands on the boreal shield do not hold for sites situated on the boreal and taiga plain. Although boreal shield wetlands are typically classified as dystrophic and nutrient poor, we documented consistently high pH (median = 7.6) and total phosphorus values (mean=0.048 mg TP/l) for the sites surveyed. The uniformly high productivity values inferred from these observations suggest that, contrary to conditions in Eastern NA, limitations in wetland quality are less likely to limit waterfowl production in the region. Additional work is proposed for mid-summer 2000 to further identify attributes of wetland and upland soil and water chemistry that lead to the high productivity values observed.

Affecting waterfowl conservation in the western boreal forest.

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Western Boreal Forest (WBF) fens, marshes, riparian wetlands, shallow lakes, floodplains and deltas are among the most productive wetland ecosystems on the continent. In Canada, this 2.6 million-km² ecosystem is second only to the Prairie Pothole Region in terms of waterfowl use. Twelve to fourteen million ducks and geese, comprising upwards of 40% of the waterfowl annually surveyed, are found breeding in boreal and taiga habitats of Alaska, the Canadian Territories and the northern forested habitats of western Canada. Millions more use the area for molting and staging.

Ducks Unlimited recognized the importance of the WBF region in 1994 when it ranked it number 3 in priority of the 26 most important, limiting and threatened waterfowl habitat areas on the continent. In recent years, increased activity by forestry, oil and gas, hydroelectric, mining, agricultural and recreational interests has greatly expanded the impacts on this forest ecosystem, the consequences of which remain largely unknown. Cumulative impacts also include regional climate change scenarios, altered fire frequency and atmospheric acidification. The WBF Initiative was established in 1997 to proactively build partnerships with Industry, Government Agencies, Universities, Foundations, Aboriginal Groups and others that share Ducks Unlimited's goal of protecting these important boreal wetland systems and sustaining their critical values and functions. This paper will present an overview of the Initiative and initial partnerships to carry out GIS-based TM satellite imagery landcover inventory and mapping, water-bird and water quality monitoring and adaptive research projects in boreal Alberta, British Columbia, Yukon and Northwest Territories.

DUCK RECRUITMENT IN AGRICULTURAL AND FORESTED LANDSCAPES PART A - FIELD STUDIES

INVITED PLENARY LECTURE

Duck recruitment in agricultural and forested landscapes: empirical field studies.

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Empirical field studies -- collections, observations, and marking -- have been the mainstay of duck science for over 70 years. Beginning in the 1930s, biologists collected breeding ducks to understand their food habits and unravel the importance of wetland resources to duck recruitment. Observations of duck behavior led to a recognition of territoriality and home range during breeding. These works underscored the value of dynamic wetland communities and laid the foundation for our wetland management and protection programs. Subsequent observational studies of nesting success and nest site selection shifted our focus to the uplands and the importance of predation to duck demography. Studies using visual and radio markers improved upon our knowledge by providing less biased information on movements and nest and brood survival. What does the future hold? Studies focused on key vital rates, particularly hen and nest survival, should and undoubtedly will receive increased attention. New technology such as satellite telemetry and geographic information systems will enable us to expand our research to better understand large-scale, landscape effects. As we struggle to solve perplexing problems of duck population declines, we will venture out of familiar habitats and into the great unknown of places like the western boreal forest. However, the most significant advances will not arise from new technology or new study sites, but from the way we formulate and address our questions. The power of experimentation, while admittedly difficult to implement in our field, has great potential for increasing our understanding of duck recruitment. As the distinction between research and management fades under the paradigm of adaptive management, management experiments could and should become more commonplace. Lastly, and perhaps most significantly, new analytical procedures and a fresh mindset provide huge opportunities to move out of the box of traditional hypothesis testing and into the realm of evaluating competing models of duck recruitment. This "information-theoretic" approach and its objectivity in evaluating competing models will provide the foundation for substantial advancement in our understanding of duck recruitment in agricultural and forested landscapes.

Nesting ecology of northern pintails in the intensively farmed prairies of southern Saskatchewan: are females caught in an ecological trap?

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Many dabbling ducks have made remarkable population recoveries in recent years of excellent water conditions on the prairies. However, Northern Pintails have increased only slightly and remain 30% below their long-term average. We hypothesized that a major reason for the slow population growth of pintails is due to the expansion of minimum tillage farming. We tested the hypothesis that crop stubble serves as an ecological trap for breeding pintail hens. We examined nest-site selection, nest success, and re-nesting potential of Pintails in a highly agricultural landscape in 1998-2000.

Pintails (57%) nested significantly more frequently in crop stubble than Mallards (21%). Pintails nested in habitats in proportion to their availability, while Mallards avoided crop stubble and showed a preference for roadside ditches and pond margins. Pintails chose nest sites with significantly lower visual obstruction readings than Mallards. Mayfield nest success estimates were significantly lower in crop stubble (0.3-2.9%) than ditches and pond margins (5.9-15.5%) and pastures and hayfields (6.3-36.9%). Renesting propensity of pintails was significantly higher in 1999 (72%, n=57) than 1998 (52%, n=21). Renesting propensity was negatively associated with date of clutch loss. Renest intervals average 10.5 days (range 7-28 days) and were weakly positively correlated with incubation stage at clutch loss. Results from this study strongly support the hypothesis that crop stubble serves as an ecological trap for pintails. Programs such as cropland conversion to pasture, fall-seeded crops, zero-till seeding with at least 12 inch spacing between seed drills, and chemical fallow have great potential to improve nest success of Pintails.

Landscape attributes predict hatching rates for ducks in the aspen parklands.

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Habitat fragmentation resulting from agricultural activities often has been cited as a cause for reduced reproductive success of grassland-nesting birds including ducks. Understanding how habitat configurations affect demographic parameters is essential for making better decisions about habitat preservation and restoration. Using duck (*Anas* spp.) nesting data from 10, 65-km² study areas ($n \gg 5000$ nests) dispersed throughout the aspen (*Populus tremuloides*) parklands of south-central Canada, we built models to predict hatching rates using generalized linear mixed modeling techniques. Using a hierarchical approach, we constructed separate models using landscape metrics generated for 3 different habitat classification regimes and 3 different spatial extents. We then searched for an emergent model that included important variables from multiple extents and classifications. Habitat patch size, shape, and type were important predictors of hatching, as were distance from habitat edge, distance from nearest wetland, and distance from nearest farm sites. Inclusion of variables from >1 spatial extent significantly improved our ability to predict hatching rates.

Use of fall and spring-seeded cereal crops for nesting by northern pintails and other waterfowl in southern Saskatchewan.

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Pintails accept sparse nesting cover and are prone to nesting in grain stubble. More than other species, this trait puts pintail nests at risk of loss to spring cultivation/seeding especially in areas where pintails are common nesters. Fall-seeded cereal crops are a cropping alternative that requires fewer tillage operations and planting occurs in the fall when there is no conflict with the duck nesting period. During 1998 and 1999, we examined pintail and other waterfowl use and nest success in fall- and spring-seeded cereal crops in southern Saskatchewan. Over 2 years, we nest searched 4170 acres of fall rye and winter wheat and 3850 acres of spring seeded wheat, barley and oats in areas with relatively high historic pintail counts. Pintail and mallard were the most common species found in 1998 whereas pintail, mallard, northern shoveler, and blue-winged teal were common cropland nesters in 1999. Pintail nest density in fall cereals was 1 nest/19 acres and 1 nest/38 acres in 1998 and 1999 respectively. Pintail nest density in spring cropland was 1 nest/100 ac and 1 nest/476 ac in 1998 and 1999 respectively. Mayfield nest success over both years was greater in fall-seeded cropland (22%) than in spring-seeded cropland (3%). We suspect pintail use of spring stubble and changes in cultivation practices in prairie Canada may be contributing to reduced reproductive success.

Mallard nesting ecology in central Illinois.

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The nesting habits of mallards (*Anas platyrhynchos*) have been investigated on the primary production areas of the northern United States and Canada and in some states, such as California. Although mallards have increased their range in recent years and now nest in every county in Illinois, limited research has been done to determine the nesting biology of mallards in the state. We used radio telemetry to examine the nesting behavior of mallards in central Illinois during 1998 and 1999. Thirty-eight and 43 hen mallards were equipped with radio transmitters during the 1998 and 1999 breeding seasons, respectively. Mallards initiated 1.1-1.7 nests/hen beginning 22 April and 6 May. The Kaplan-Meier product limit estimator modified for staggered entry was used to calculate survival of hens, nests, broods, and ducklings. The hen survival rate was 0.55-0.67 during the nesting season. Nest success was 0.21. Broods were monitored up to 20 days posthatch and brood survival was 0.81. Duckling survival was 0.39-0.50. Estimated mallard recruitment exceeded hen mortality in 1998 but not in 1999.

Federal wetland protection programs: how do they impact breeding duck populations in the Prairie Pothole Region?

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Pressure to drain wetlands in crop fields presents a constant and increasing threat to breeding ducks in the Prairie Pothole Region (PPR) of the U.S. Presently, there are two principle federal programs that restrict drainage of wetlands in the PPR (1) the U.S. Fish and Wildlife Service (FWS) "Small Wetland Acquisition Program", and (2) the U.S. Department of Agriculture (USDA) "Swampbuster" provisions of farm legislation since 1985. USDA restrictions have come under frequent attack by agriculture interests who have proposed alternatives that could have detrimental effects on breeding duck populations. We used models developed from breeding duck population surveys conducted in North Dakota during 1987-98, and digital wetland data, to estimate the average number of breeding ducks that settle in wetlands protected by these federal programs within a 8 county area of North Dakota. We also simulate the impact on duck populations from reduced USDA protection of wetlands based on two recent proposals (1) exempt wetlands <0.4ha (1ac), and (2) exempt wetlands that are farmed 6 of 10 years. Our results show that the FWS program provides perpetual protection for a substantial wetland base for breeding ducks, but if proposed changes in the USDA program are enacted the average breeding duck population in our study area could decline by over 50%. Considering the entire PPR of the U.S., reducing "swampbuster" protection could present a serious threat to North American duck populations.

Factors affecting survival of mallard and gadwall ducklings in prairie pothole landscapes.

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To estimate recruitment more accurately, waterfowl biologists need measurable predictors of duckling survival. We examined survival rates of mallard ducklings in eastern North Dakota and western Minnesota (1988-94) and gadwall ducklings in eastern North Dakota (1992-94) when water conditions ranged from extremely dry (1988-92) to extremely wet (1993-94). We evaluated effects of several variables on survival, including (1) percent of seasonal wetland basins containing water, (2) percent of upland in perennial cover, (3) occurrence of rain on the current or 2 previous days, (4) minimum ambient temperature averaged over the current and 2 previous days, (5) hatch date, (6) duckling age, (7) brood size, and, for mallards only, (8) hen age. We radio-tracked 179 mallard ducklings (>2,000 exposure days) from 69 broods and 215 gadwall ducklings (>2,900 exposure days) from 95 broods. Thirty-day survival rates were 35% for mallard ducklings and 53% for gadwall ducklings. Preliminary results suggest that mallard duckling survival was related to duckling age and, when seasonal ponds were abundant, to minimum temperature. Gadwall duckling survival appears to be related to duckling age and minimum temperature, and, when seasonal ponds were abundant, to rain. Effects of radio-transmitters on survival were tested using additional data from 311 mallard and 528 gadwall ducklings without radios. We developed methods for testing radio effects, and are evaluating potential interactions between effects of radios and other variables.

An integrated evaluation of cropland conversion in the Missouri Coteau of Saskatchewan: Productivity of pintails and other grassland birds.

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Implementation of cropland conversion programs under the North American Waterfowl Management Plan within Saskatchewan includes the option of converting cropland to forages for hayfields or spring grazed pasture with deferred grazing on native pasture. Since 1998 the joint Ducks Unlimited Canada (DUC) and Saskatchewan Wetland Conservation Corporation cropland conversion program has seeded 10,029 pasture and 16,271 hayfield acres. In 1999 and 2000 we evaluated waterfowl and songbird productivity in hayfields meeting the criteria of the cropland conversion program within the DUC Pintail Initiative target area. In 1999, we located 424 nests of 8 waterfowl species and 158 nests of 16 other species at 24 hayland sites. Northern Pintail nests comprised 14.2% of the total waterfowl nests. Apparent waterfowl nest density averaged 0.179 nests/acre. Nest density for combined waterfowl as well as pintail and Mallard increased with increasing proportion of cropland surrounding the study sites. Mayfield nest success for waterfowl averaged 20% and varied both among species (range = 0.07 - 0.37) and study sites (0.0001 - 0.714). Mayfield nest success for all waterfowl decreased with increasing complexity of grass patch shape. Haying was delayed in 1999, which minimized the impact of this activity on nesting birds. The results of 1999 will be compared with those of the 2000 field season.

Breeding ecology of eastern mallards in a New Jersey estuary.

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During recent decades, mallard (*Anas platyrhynchos*) numbers have increased dramatically in eastern North America, yet few studies of their breeding ecology are published. We studied the breeding ecology of 159 radio-telemetered eastern mallard hens in the Great Bay estuary and adjacent uplands of Atlantic, Ocean, and Burlington counties, New Jersey from 1990 to 1992. The Kaplan-Meier estimate of survival of radio-telemetered hens from 1 April to 30 September was 0.702 (SE = 0.050). Mayfield nest success and hen success did not differ statistically by habitat, hen condition, or year ($P > 0.10$). Mayfield nest success was 0.303 (SE = 0.048) and hen success was 0.455. Mean clutch size at hatch was 6.8 (SE = 0.54). We will present brood and duckling survival estimates calculated from observations of telemetered hens and their broods. We will present habitat use and home range estimates calculated with minimum convex polygon and adaptive kernel methods from location data from telemetered hens.

Survival and causes of mortality of wood duck hens and ducklings in Mississippi and Alabama.

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Survival of female ducks and their young is vital to annual recruitment, especially of hunted species. Therefore, we studied survival and causes of mortality of radiomarked wood duck (*Aix sponsa*) hens that nested in boxes and their ducklings that used palustrine emergent, scrub-shrub, aquatic bed, and forested wetlands at Noxubee National Wildlife Refuge (NWR) in Mississippi from 1996-99 or similar habitats in the Tennessee-Tombigbee Rivers (TTR) system in Alabama in 1998 and 1999. We monitored broods daily and estimated duckling survival to 30 days post hatch. We radiomarked 89 hens at Noxubee NWR and 46 females at TTR. Hen survival was high; a composite estimate for both areas and all years was 90% (SE = 0.04). We radiomarked 434 ducklings during the study. Duckling survival at Noxubee NWR was 19% (SE = 0.02, 57/302); at TTR, duckling survival was 24% (SE = 0.05, 31/132). A diversity of predators caused mortality of ducklings, but avian and aquatic predators were most important in both areas and all years. At Noxubee NWR in 1996, great-blue herons (*Ardea herodias*) accounted for most avian predation of ducklings. At Noxubee NWR in 1997-1999, importance of avian and aquatic predators of ducklings ranged from 28-45% and 31-53%, respectively. However, depredation of ducklings by these predators varied among wetland environments at Noxubee NWR. In addition to herons, other primary avian predators included red-shouldered hawks (*Buteo lineatus*) and barred

owls (*Strix varia*); aquatic predators included spotted gars (*Lepisosteus oculatus*), cottonmouths (*Agkistrodon piscivorus*), and snapping turtles (*Chelydra serpentina*). At TTR in 1998 and 1999, mortality of ducklings from avian and aquatic predators ranged from 33-47% and 14-21%, respectively. Additionally, unidentified species of mammals (14%) depredated ducklings at TTR in 1998. Mortality of wood duck ducklings was significantly higher than that of wood duck hens during brood rearing. Hence, annual recruitment of these wood duck populations seems more limited by duckling than hen survival. Ongoing analyses will evaluate temporal, physiological, and environmental covariates of duckling survival. Our management goals are to identify habitats that maximize duckling survival to optimize future placement of nest boxes and develop a population model for box nesting wood ducks in southeastern United States.

Predator selection of landscape features in landscapes with contrasting grassland composition in North Dakota.

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We investigated how differences in the composition of the landscape affected habitat selection and movement patterns of red fox (*Vulpes vulpes*) and striped skunk (*Mephitis mephitis*). We observed nightly movements of the predators on 41.44 km² areas in North Dakota during 1996-97. We selected landscapes that contained either 10-15% nesting habitat (Low Grassland Landscapes, LGL) or 40-50% nesting habitat (High Grassland Landscapes, HGL). Predator movements were influenced by wetland edges and large blocks of grassland, but there was high variability in speed, turning angle and fractal dimension of the pathways. Grassland cores were more frequently selected by fox in LGL than in HGL. Selection of grassland-wetland edges and grassland-cropland edges by both species varied depending on the landscape context. Mayfield estimates of nest success were lower in LGL ($S = 0.06$ and 0.07) compared to HGL ($S = 0.11$ and 0.25), which is consistent with the above patterns of selection of landscape features by predators. Observations of predator behavior in relation to landscape features may allow us to predict the spatial characteristics of concentrations of successful waterfowl nests and suggest landscape level management strategies.

Long-term response of northern pintails to wetlands and agriculture in Canadian prairie-parklands.

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Between 1955, and the late 1970s, northern pintail populations tracked the abundance of spring ponds in USFWS/CWS surveys. Declines in both northern pintails and ponds were evident during droughts in the 1980s. With the return of abundant water to the prairies in the early to mid 1990s, however, northern pintails remain below the long-term average of 4.4 million birds and well below the 6.3 million population goal set by the North American Waterfowl Management Plan. Previous studies investigating pintail responses to wetlands and/or agriculture only considered pintail responses at large geographic scales (e.g., prairie-wide, stratum level). Thus, we investigated the effects of wetland and moisture dynamics and changes in agricultural practices on pintail numbers (1961-96) at local scales (i.e., 18 mile long survey segments) to assess whether relationships held and, more importantly, to identify areas historically important to positive pintail responses. Statistics Canada Quintennial Census of Agriculture data gathered at the Consolidated Census Subdivision level provided information on agricultural practice change. We employed random coefficient models to assess at what scale (local, stratum, or prairie-wide) responses were important. Many of the relationships seen at large geographic scales did not hold well at local scales. Identification of factors from long-term databases that explain both system-wide as well as local changes in populations is essential to management of the species.

PART B - MODELING DUCK POPULATION DYNAMICS

INVITED PLENARY LECTURE

Modeling duck population dynamics: recent advances and future challenges.

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There has been a great deal of recent development in theoretical and empirical studies of population dynamics. Theoretical and technical advances improve our ability to frame and evaluate alternative models of observed population change. Modeling is typically done to either increase understanding of a population's structure and dynamics or to use what is already known about a population to forecast or project possible future population states. Either population size or birth and death components may be modeled. Often only portions of the life cycle are considered in modeling efforts. Progress in modeling allows more rigorous work with both individual- and cohort-based approaches and permits more realistic incorporation of variation and spatially explicit processes. Rapid advances in remote sensing, geographic information systems, and the merging of these tools with population models provide powerful new tools. Population modeling is also improving because of important recent advances in our ability to estimate various population parameters with mark-resight methodologies and excellent software tools. Accordingly, rigorous estimates of vital rates are available for models of those duck populations that are intensively studied. Models of portions of the life cycle are the most common in ducks, especially models of processes on the breeding grounds and the effects of harvest on populations. Duck population modeling can be improved by considering new developments and by taking better advantage of the full suite of available tools.

Survival in female king eiders nesting at Karrak Lake, Nunavut

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Only 72 King Eiders were reported to have been banded from 1941 to 1994 of which there have been only 4 recoveries. Therefore, an ongoing study examining survival and reproduction in an island-nesting population of King Eiders was initiated in 1995 at Karrak Lake (67° 14' N, 100°15' W), in the Queen Maud Gulf Bird Sanctuary, Nunavut (formerly Northwest Territories). In 1996, we started capturing King Eiders on neighboring Adventure Lake. Over 5 years (1995-99), 157 females were captured during incubation, individually marked and released. Overall, there have been 280 encounters of marked females at these two lakes. Using multistate models for years (1996-1999) that we had capture data from both lakes, we estimated survival ($f = 0.84$, 95%CL: 0.73 - 0.91) and annual movement rates from Karrak to Adventure L. ($y_{\text{Karrak}} = 0.05$, 95% CL (0.02 - 0.17) and from Adventure to Karrak L.. ($y_{\text{Adventure}} = 0$, 95%CL: 0 - 0). These estimates suggest high philopatry, particularly at Adventure L., and possibly high breeding propensity once females begin to nest. Continued marking of ducklings will provide critically-needed composite estimates of first (juvenile) and second (subadult) year survival. Continued marking and recapture also will provide the opportunity to examine survival in response to meteorological conditions during winter in the Bering or Chucki Seas where many King Eiders winter, and during spring in the Beaufort Sea.

Survival and philopatry of female redheads breeding in southwestern Manitoba.

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We used combined recovery-resighting models to estimate survival (S), reporting (r), resighting (p), and fidelity (F) probabilities of female redheads (*Aythya americana*) breeding in southwestern Manitoba during 1983-93. We banded and nasal-marked 194 hatch-year (HY) and 150 after-hatch-year (AHY) females during 1983-90 and subsequently obtained 298 resightings and 27 band recoveries during 1984-93. Annual resighting rates ranged from 0.233 to 0.689 (SE = 0.095 and 0.122, respectively) for HY females returning as yearlings and from 0.448 to 0.896 (SE = 0.126 and 0.047) for AHY females. We suspect that most age-related variation was due to annual variation in field efforts, with some additional effect of temporary emigration (i.e., lower breeding philopatry during drought years). Recovery data were sparse, and band reporting rates were best modeled as a constant ($r = 0.082$, SE = 0.020) across years and age classes. Breeding site fidelity ($F = 1$ - permanent emigration) averaged 0.724 (SE = 0.211) for HY females and 0.922

(SE = 0.078) for AHY females. Annual survival rates were best modeled as constants, averaging 0.495 (SE = 0.136) for HY females and 0.710 (SE = 0.063) for AHY females. For AHY females, this estimate was close to a local survival estimate based only on resightings (0.655, SE = 0.024), but local survival of HY females (0.353, SE = 0.044) greatly underestimated true survival. Our data suggest that temporary and permanent emigration are important processes affecting local redhead populations, and that failure to model these processes can lead to substantial underestimates of survival, especially among HY females.

Incorporating heterogeneity in nest survival estimation.

*LLWELLYN M. ARMSTRONG & JAMES H. DEVRIES, Instit. Wetland Waterfowl Res., DU Canada, Oak Hammock Marsh, MB.

Traditionally, biologists have relied on the Mayfield method to yield nest success estimates which account for the age at which nests are first encountered. While effective at reducing the positive bias associated with this type of late entry to the risk set, this method relies heavily on assumptions of a fixed mortality rate among nests and constant risk throughout a nest's lifetime. In the past, incorporation of varying survival rates has necessitated increasing stratification of the sample and engendered greater uncertainty in the associated estimates. Natarajan and McCulloch (1999) recently proposed the use of random effects models to estimate nest survival in the presence of covariates and various sources of heterogeneity. Based on quasi-likelihood fitting algorithms, these methods can accommodate nest-level and time-varying covariates and allow for likelihood-based model comparisons. Methods will be illustrated with data collected on 19 study sites (representing over 3000 waterfowl nests) during the Prairie Habitat Joint Venture Assessment Study (1993-1998).

Evaluation of the productivity of mallards in northern Iowa.

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Mallards are attracted to the Prairie Pothole and Parkland region of the northern United States and Canada because of their high density of wetlands, and there is a correlation between the number of wetlands present in spring and the mallard population. Intensive agriculture in Iowa has resulted in a 95% reduction in the number of wetlands and upland habitat available to breeding mallards. Additionally, human activity has increased the patchiness of the landscape resulting in many small and linear (e.g. road side or drainage ditch right of ways) patches. As part of the Prairie Pothole Joint Venture the Iowa Department of Natural Resources has established a goal of protecting and enhancing 76,200 hectares of wetlands and surrounding habitat in the Prairie Pothole Region of northern Iowa. We tracked female mallards during the breeding season in 1998-2000 to investigate the breeding ecology of mallards in a 124 km² wetland complex in northern Iowa. Female mallard daily survival rates was estimated to be 0.9976 ± 0.0004 se (DSR) and did not differ between 1998 and 1999. Apparent nest success was 21% in 1998 and 13% in 1999 while hen success was 35% and 27% in 1998 and 1999 respectively. In both 1998 and 1999, mallards nesting in block habitat were more likely to have a successful nest compared to those birds nesting in linear habitat (P=0.04). Habitat specific nest occurrence (nest-site selection), and habitat-specific nest survival rates, will also be reported. Current estimates of mallard reproductive parameters in northern Iowa indicate that continuing land acquisition in the southern Prairie Pothole Region should maintain the integrity of the mallard population breeding in Iowa.

Nesting ecology of mottled ducks in Florida.

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Almost nothing is known about the breeding biology of *Anas f. fulvigula*, the subspecies of Mottled Duck restricted to peninsular Florida. During 1997-99 we attached radio-transmitters to 90 female Mottled Ducks to locate and characterize nest sites, estimate productivity and estimate breeding season survival rates. Mean nest initiation varied among years. Nesting occurred relatively early in wet as compared to dry years. Vegetation height at nests averaged 68.8 ± 6 cm, modal canopy cover was 100%, and median distance of nests from water was 138 m. Modal clutch size was 10 (range = 7-14) and nest success was 9.5%. Survival of non-breeding females during a 17 week period from late January to June was 0.920 (95% C.I. = 0.813-1.026). Data support the hypothesis stating nest initiation in Mottled Ducks is influenced by rainfall rather than temperature. Vegetation characteristics at nests were similar to vegetation

characteristics reported in other parts of the species range, but dominant plant species differed and nests were located farther from water than previously reported. Low nest success suggests Mottled Duck population productivity is low, possibly constrained by high predator densities and agricultural operations.

Breeding season survival of mallard hens in Canadian prairie-parklands.

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Recent sensitivity analysis indicates that breeding season survival may be one of the most important parameters for population dynamics of mallards. However, few studies have quantified survival during the summer or identified factors that affect hen survival. We marked between 110 and 137 mallard hens with radio transmitters at each of 19, 65 km² sites in the prairie parklands of Canada and tracked these individuals daily during the summers of 1993-1998 to examine factors affecting summer survival probability. We used program MARK to estimate hen survival and information theoretic approaches to select among competing models that described factors affecting survival probability. We investigated the relation between hen survival and time (3 month period generally representing prenesting and nesting), hen age, upland habitat treatments, longitude, and habitat features of the study site. The best approximating model indicates that hen survival was positively related to the percentage of wetlands on a study site and negatively related to longitude (i.e., survival probability declined from east to west). Our data did not support a relationship between hen survival and age or habitat treatments. Weekly hen survival at the mean of the percent wetland and longitude covariates was 0.986 (SE = 0.0013), 0.974 (SE = 0.0018), and 0.990 (SE = 0.0014) for the first, middle, and last periods of the breeding season, respectively.

Sensitivity analysis of the life cycle of mid-continent mallards.

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Relationships between vital rates and the population growth rate (λ) are critical to understanding and managing wildlife populations. Studies of mallards (*Anas platyrhynchos*) have focused on how vital rates respond to environmental conditions and management, but inference to the relative importance of individual vital rates remains weak. We used a stage-based matrix model of female mallards to compare the importance of vital rates to λ . For each vital rate, we estimated the mean and process variation (biological variation across space and time) for females breeding on ~70 km² sites in the Prairie Pothole Region. We conducted analytic sensitivity analysis to predict the relative influence of future changes in vital rates on λ and variance decomposition analysis to assess the proportion of variation in λ explained by process variation in each vital rate. Sensitivity was highest for nest success and survival of adult females during the breeding and non-breeding seasons; hence, equal absolute changes in these vital rates would be predicted to result in the largest change in λ relative to other vital rates. Variation in breeding parameters was driving variation in λ : vital rates explaining the most variation were nest success (45%), survival of adult females during the breeding season (22%), and survival of ducklings (14%). Survival of adult females outside the breeding season accounted for only 5% of variation in λ . Predation processes on the breeding grounds appear to be the primary proximate factors limiting population growth.

Demographic analysis of mallards in eastern North America.

*T. SHANE GABOR, Inst. Wetland Waterfowl Res., Stonewall, MB; STEVEN T. HOEKMAN, Montana Coop. Wildl. Res. Unit, Missoula; MARK J. PETRIE, Ducks Unlimited, Memphis, TN. We constructed an annual, stage based matrix model for eastern mallards using estimates of breeding season vital rates from sites in eastern Canada (3 in south-eastern Ontario and 1 in west-central New Brunswick) and estimates of annual survival from banding data. We conducted sensitivity analysis to predict the relative influence of changes in individual vital rates on the population growth rate (λ) and we projected λ for each breeding site to assess annual demographic performance. Sensitivity was highest for survival of adult females outside the breeding season and moderate for nest success and survival of adult females during the breeding season; hence, equal absolute changes in these vital rates would be predicted to result in the largest change in λ relative to other vital rates. For 3 of 4 sites, projected λ 's of ~ 1 indicated that recruitment was equal to annual mortality. Although nest success at these sites was generally above the level thought sufficient for population maintenance in the prairies (15%), increased recruitment appeared to be counterbalanced by higher non-breeding mortality. In contrast to mid-continent mallards, eastern mallard populations appear to be most strongly influenced by changes in non-breeding survival rather than nest success and generally had higher projected population growth rates.

A spatially-explicit population model of northern pintails.

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Prior to the 1980s, Northern Pintail (*Anas acuta*) population numbers exhibited a strong correlation with May pond numbers. This pattern dissociated after 1980 and remains uncoupled despite the record increases in May ponds in the 1990s. It is uncertain why these oscillations have occurred and why pintail populations have failed to respond despite improved habitat conditions. We developed a spatially explicit population model to explore possible mechanisms for this observed dissociation. We model a system where the pintail population breeds across five strata ranging from south to north, roughly corresponding to the U.S. prairies (e.g. North and South Dakota, Montana), the Canadian prairies, the Canadian parklands, the western Northwest Territories, and Alaska. Potential mechanisms for the observed dissociation include agricultural practices (conversion of grasslands) in the prairies, the influence of predators, and dispersal patterns of pintails among the five strata. Additionally, we explore the 'boom-trickle' hypothesis that has been proposed as a predator mechanism of dissociation, particularly among variable May pond conditions. Finally, we examine potential 'sources and sinks' of recruits and the effect on the metapopulation.

EVOLUTIONARY ECOLOGY AND MANAGEMENT

INVITED PLENARY LECTURE

From the arcane to the applied: can evolutionary ecology offer any useful insight to waterfowl management?

JOHN M. EADIE, Dept. Wildl., Fish & Cons. Biol., Univ. Calif.-Davis.

Natural selection acts on individuals, individuals comprise populations, and waterfowl management is concerned with maintaining sustainable, harvestable populations of ducks and geese. Despite the simplicity of these observations, it is remarkable how rarely efforts have been made to explore their linkage, or to examine the utility of doing so. Can ideas in evolutionary ecology provide insight into population level processes, and if so, are those insights of any utility to waterfowl managers? I will argue for the affirmative and will draw from a number of studies in our own lab and elsewhere to make this case. Specifically, I will consider 3 scales of interaction where integration of ideas in evolutionary ecology, population biology and waterfowl management may be profitable. These include: (1) linking individual behavioral decisions to population dynamics, and hence to management of key habitat resources; (2) linking behavioral and ecological interactions of predators & prey to community dynamics, and hence to management of waterfowl nesting success; and (3) linking density-dependent foraging decisions of individuals (ideal free foraging) with landscape level patterns of habitat use, and hence to management plans for habitat enhancement, restoration and acquisition efforts. My central message is that failure to consider the evolutionary context of the birds we manage may reduce the effectiveness of our management actions; in some circumstances, it could lead us to prescribe management plans that are entirely counter-productive.

Age-assortative pairing in wood ducks and mallards.

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Pairing with individuals of the same age may occur actively, presumably for adaptive reasons, or passively as a consequence of mate availability. This phenomenon has not been unequivocally addressed in waterfowl, due in part to disagreement over validity of designs and analytical techniques employed. We investigated age-assortative pair formation in wood ducks (*Aix sponsa*) and mallards (*Anas platyrhynchos*) using winter pairing data from captive flocks of freely associating, wild-strain birds of two ages (adult=17-19 months; immature=5-7 months). We compared the observed frequency of pairs having members of the same age against an expected distribution established through repeated simulation that assumed random pairing of each flock's mate pool. Construction of appropriate mate pools is critical to deriving expected frequency distributions, but often relies on untestable assumptions. For completeness, available mate pools in randomization procedures modeled age-sex distributions of a) paired individuals within flocks; and b) all individuals within flocks. Regardless of mate pool used, results for both species strongly indicated nonrandom pair formation, with individuals disproportionately selecting mates of the same age in 4 of 4 years ($P < 0.005$). Results support the argument that like-aged assortative pair formation in waterfowl may result from active, homotypic selection, while challenging hypotheses that predict waterfowl should preferentially select older, more experienced mates. Alternative explanations describing the pattern as a passively occurring phenomenon are explored and refuted.

Do patterns of nest attendance and female condition influence the risk of nest predation?

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I monitored incubation behavior of 129 female Blue-winged Teal in North Dakota in 1995-1997 to test hypotheses concerning the use of endogenous reserves, incubation constancy, and nest success. Daily incubation constancy averaged $81 \pm 8\%$, and females took an average of 3 ± 1.2 incubation recesses per day. To test the hypothesis that females that allocate substantial endogenous reserves to incubation can maintain higher incubation constancy, I weighed 64 females early in incubation and again just prior to hatch. Females that lost more weight during incubation had higher incubation constancy than those that lost less weight ($P = 0.001$). Early incubation weight was not related to incubation constancy ($P = 0.13$). Females that lost more weight during incubation took fewer recesses than females that lost less weight ($P = 0.003$). Initial weight was not related to recess frequency ($P > 0.25$). I tested the hypothesis that incubation constancy influences risk of nest predation by using analysis of covariance that compared successful and unsuccessful females while controlling for the influence of incubation stage on constancy. Successful females had higher incubation constancy than females whose nests were depredated ($P = 0.0001$). Predation was the only important source of nest failure in my study. In addition, females that maintained higher incubation constancy had shorter incubation periods ($P < 0.01$), which reduces the period that eggs are exposed to predators. Higher recess frequency did not influence nest success ($P > 0.25$). This study is the first to clearly demonstrate the suspected linkage between weight loss, incubation constancy, and nest success in birds.

Sociability of male mallards: evaluating indicated breeding pair criteria to estimate mallard populations.

*MICHAEL G. BRASHER & RICHARD M. KAMINSKI, Dept. Wildl. Fish., Mississippi St. Univ..

Surveys of North American breeding duck populations are conducted annually by U.S. and Canadian biologists. Counts of pairs, lone males, groups of 2-4 males, and mixed-sex groups are used to estimate breeding duck populations. Commonly referred to as indicated breeding pairs (IBPs), observed pairs, lone males, and groups of 2-4 males are assumed to represent breeding pairs; ducks in mixed-sex groups are believed to represent a nonbreeding component of populations. Although IBP criteria have been used for decades to estimate breeding duck populations, no study has

evaluated these criteria using radiomarked birds. We captured, radiomarked ($n = 90$), and visually observed paired and unpaired male mallards (*Anas platyrhynchos*) in Manitoba in 1998 and Saskatchewan in 1999 to evaluate the accuracy of IBP criteria. Sociability was recorded as a male's occurrence in 1 of the above 4 social classes. During both years combined, paired males were observed most frequently (40-90%) with a female. When annual surveys are traditionally conducted in Prairie-Parkland Canada (i.e., mornings, 1-25 May), unpaired males were observed either alone or in groups of 2-4 males >70% of the time. These results suggest that unpaired males may be falsely enumerated as IBPs, potentially inflating estimates of breeding population size. We suggest approaches to improve survey accuracy.

Patterns and trade-offs in reproductive effort and success of ducks revealed by path analysis.

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Female characteristics, timing of breeding, brood and duckling attributes, and weather conditions have been hypothesized to affect duckling survival and recruitment in birds. Thus, we studied reproductive success of northern shoveler (*Anas clypeata*), tufted duck (*Aythya fuligula*) and common pochard (*A. ferina*) on the Engure Marsh, Latvia (over 16 years), and then developed structural equation models and used path analysis to explore the nature and relative strength of direct and indirect effects of ecological, morphological and environmental variables on duckling survival and local recruitment (using broods as the unit of measurement). Band recoveries ($n=729$) of ducklings, banded at hatch and harvested in the early postfledging period, provided a relative index of duckling survival for diving duck species. Recaptures ($n=571$) of nesting females (banded at hatch) in subsequent years provided recruitment data. Overall, hatching date had the strongest and most consistent direct effect; duckling survival and recruitment generally declined with hatching date but patterns varied among species. There were no direct effects of female age on survival/recruitment; age effects were translated indirectly via female and brood characteristics. There was negative association between brood size and mean duckling mass for all 3 species, supporting the hypothesis that trade-offs occur between offspring size and number within and among waterfowl species. Similarity between final path models for duckling survival and recruitment suggests that survival to fledging may provide a valid means of measuring recruitment probability. Our results have important implications for natural selection on timing of breeding and egg size/clutch size trade-offs in waterfowl.

Brood rearing habitat selection by Barrow's goldeneye and its effect on duckling growth, survival, and return rates.

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Obtaining a suitable nest site is generally of paramount importance to breeding success in secondary cavity nesting birds. Barrow's Goldeneye, however, is a cavity nesting duck that defends exclusive brood rearing areas on ponds, and this defense has been interpreted as defense of food, suggesting that variation in pond quality is also quite important. We indexed the aquatic macroinvertebrate prey abundance available to Goldeneye ducklings on 30 ponds in 1997 and 1998. Variation in invertebrate abundance was strongly positively correlated among ponds between years, thus ponds vary predictably in their probable annual productivity. Neither initial clutch size nor pre-fledging duckling survivorship correlated with a pond's invertebrate abundance. However, ducklings raised on ponds with higher productivity had substantially higher body weights at 45 days old, and were more likely to return to the breeding grounds the following year. We conclude that food abundance in brood rearing ponds has an immediate influence on duckling growth, which appears to affect post-fledging survival, making a substantial contribution to fitness differences among females. Predictable variation in pond productivity will strongly select for annual philopatry and territorial defense of more productive ponds by breeders, while birds breeding on less productive ponds would be expected to attempt to move to more productive sites from year to year. In this species, variation in duckling food, as well as nest site availability, are strong components of fitness variation.

Factors affecting nest abandonment by North American dabbling ducks.

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Nest abandonment by birds is of theoretical and practical interest. Studying nest abandonment provides insight into hypotheses about parental investment, and helps managers develop strategies to avoid disturbing vulnerable species. We evaluated the effects of species, nest age and nest initiation date on abandonment rates of dabbling ducks (*Anas* spp.). We also compared abandonment rates in areas with high and low predator activity. Nest abandonment decreased with increased nest age in all species. Abandonment was most pronounced during early laying (max. 5 eggs); mallards abandoned 30% of early laying nests, while abandonment was 15% for blue-winged teal, 16% for gadwall, and 20% for Northern pintail. Mallards abandoned at significantly higher rates than did other dabbling duck species. Abandonment increased with later nest initiation date for blue-winged teal, but not for any other species we tested. Nest abandonment rates did not differ between areas where mammalian predators were experimentally removed and untreated areas. Managers and researchers who wish to avoid causing nest abandonment should avoid disturbing early-laying females. Mallards appear to employ a strategy of readily abandoning nests and reneating, and make particularly poor research subjects if protocols require disturbing females early in laying.

Foraging ecology of common eiders wintering at polynyas in the Belcher Islands: constraints imposed by ice, darkness and tidal currents.

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Eiders wintering in the Belcher Islands are constrained by the availability of open water occurring at coastal floe edges and at recurring polynyas. Floe edge habitat varies almost daily due to changing wind and tidal currents, and polynyas act as refuges for eiders when no floe edge habitat exists. Here, we quantify how strong tidal currents, short day length, and variable ice conditions interact to constrain the number of foraging hours available to eiders even at polynyas. We monitored eider foraging behavior at the Ullutsatuq Polynya using scan and focal bird sampling. Eiders foraged almost entirely on Sea Urchins (*Sphaerechinus droebachiensis*), collected from the sea floor at 5-8 m depth. We deployed an Aquadop current flow meter at the margin of the polynya which quantified flow velocity, direction, and aspect every 5 min (placed equidistant from the sea floor to the bottom of the sea ice). When current velocities exceeded 0.8 m/sec eiders stopped diving for prey. When currents exceeded 1.0 m/sec, eiders left the water entirely to sit on the ice-edge. These behavioural changes reflected when eiders could no longer dive or maintain their position by swimming. By integrating data on tide cycles, foraging ecology, and day length in a model, we can now project when during the winter eiders have the shortest foraging time available to them. Inuit hunters can use this information to avoid hunting when eiders are most energetically constrained, thereby minimizing non-lethal effects of hunting disturbance.

Stable isotopic (δD , $\delta^{13}C$, $\delta^{15}N$) assessment of migration in waterfowl.

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Important to effective conservation and management of long-distance migratory organisms is the ability to associate geographic regions used by individuals throughout their life cycle. Conventional approaches to this question rely mainly on extrinsic markers (e.g., bands, tags) and the subsequent recovery of individuals. The use of intrinsic markers, such as stable isotopes in tissues, offers an alternative approach that does not rely on mark-recapture methods. Here, we present a new method using δD and $\delta^{13}C$ of selected tissues to 1) assess large-scale migration and 2) evaluate nutrient origins in waterfowl. Dietary isotopic ratios are reflected in consumer tissues, and may vary temporally depending on tissue turnover rate, or predictably over large geographic scales. Organisms that migrate between isotopically distinct biomes often carry in their tissues information related to the previous feeding location. Where isotopic differences exist over large geographic scales, this is especially useful. δD measurements of biochemically inert tissues in consumers can be used to provide quantitative information on geographic origins where tissues were grown. For metabolically active tissues, observed temporal changes in stable isotope values provide a novel alternative to deciphering origins and use of stored versus locally obtained nutrients.

A comparative study of incubation rhythms and nest microclimate of structure-nesting and ground-nesting mallards.

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Mallards (*Anas platyrhynchos*) that nest in artificial nesting tunnels consistently hatch fewer eggs per clutch than do ground-nesters. I hypothesized that lower egg hatchability in structure nests may be a result of tunnel microclimate and/or altered incubation behaviour of structure-nesting hens. I investigated hen incubation rhythms and nest site microclimate for both structure- and ground-nesting Mallards in Southwestern Manitoba's Prairie Pothole Region in 1999. Egg hatchability was 97% for ground-nesters but only 87% for structure-nesters. Eggs in structure nests lost more water during incubation than did eggs in ground nests ($P=0.0022$). A comparison of temperature and relative humidity between the two nest sites, and of female incubation behaviours such as incubation constancy, recess frequency and duration will be presented. Implications of my results to Mallard recruitment using artificial nesting tunnels will be discussed.

Breeding behavior of tree cavity-nesting wood ducks.

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Box-nesting populations of wood ducks have yielded a wealth of important information on the species' nesting biology, behavior, and habitat requirements. However, much of what we know about wood ducks is a product of how their breeding biology has been studied. Nest box studies suggest that hens are highly philopatric, nearly all hens attempt to nest, and they persistently re-nest. High rates of intra-specific nest parasitism are associated with limited availability of nest sites and dense aggregations of highly visible nest boxes. However, nest boxes do not represent the environment in which the species evolved, or where most wood ducks are produced. We studied breeding biology, nest site selection, and nesting productivity in a tree cavity-nesting population of wood ducks in southern Illinois during 1993-1998. Only 58% ($n = 179$) of resident radio-marked hens were tracked to nest sites over 5 years; none re-nested. Annual nesting effort (range 42-72%) was related to the timing and magnitude of flood pulses and varied inversely with nest parasitism rates (range 8-43%). We found a substantial level of nest parasitism (18%, $n = 67$) despite high densities of well-dispersed and unoccupied tree cavities suitable for nesting. Vulnerability to nest predation influenced nest distribution and tree cavity selection. Most hens nested in upland forest (66%, $n = 104$) up to 3 km from suitable brood habitat. Visibility and accessibility of nest sites may affect nesting behavior, although differences between box- and tree cavity-nesting wood ducks may be related to methodology. We discuss potential biases of methods used to study nesting wood ducks.

Can hiding nest boxes reduce brood parasitism and increase nesting efficiency of wood ducks?

GARY R. HEPP, School of For. Wildl. Sci., Auburn Univ., Auburn, AL.

Nest boxes are used extensively to supplement availability of natural cavities for breeding wood ducks (*Aix sponsa*) and often are effective in increasing local populations. Brood parasitism of females using nest boxes can be especially prevalent as size of the breeding population grows. Increased frequency of brood parasitism concerns managers, because it may reduce nesting efficiency (number of ducklings produced per egg laid). Recent studies, purportedly using Adaptive Resource Management (ARM), have concluded that conspicuousness of nest boxes influences frequency of brood parasitism and have recommended erecting boxes that are well-hidden to reduce brood parasitism and increase nesting efficiency. In this paper, I review these studies and find two fundamental problems with study design. First, visibility and density of nest boxes were confounded. Visible boxes were attached in pairs to wooden posts while hidden boxes were attached singly to trees; hence, density (boxes/ha) of visible boxes was greater than that of hidden boxes making inferences about the effect of visibility on brood parasitism impossible. Second, hidden and visible boxes were capable of being used by the same local population of females and hence were not independent. In essence, frequency of brood parasitism in hidden boxes may have been influenced by availability of visible boxes in the same area. Because of these problems, advocating use of hidden nest boxes to reduce brood parasitism in wood ducks is premature. I will outline an experimental design that provides a better test of the effect of nest box visibility on brood parasitism.

“TOP-DOWN” AND “BOTTOM-UP” PERSPECTIVES ON DUCK POPULATION LIMITATION AND REGULATION.

Adaptive harvest management and perspectives on learning.

*FRED A. JOHNSON, U.S. Fish Wild. Serv., Gainesville, FL.

Despite considerable investment in scientific investigation, the sustainable exploitation of North American duck populations remains an uncertain endeavor. Five years ago, the United States adopted a policy of adaptive harvest management (AHM), which is designed to reduce that uncertainty by testing competing hypotheses concerning the biological basis for sustainable yield. To date, the AHM process has focused principally on the midcontinent population of mallards (*Anas platyrhynchos*), whose dynamics are described by four alternative models. Collectively, these models express uncertainty (or disagreement) about whether harvest is an additive or compensatory form of mortality, and whether the reproductive process is weakly or strongly density dependent (i.e., the degree to which reproductive rates decline with increasing population size). Each model has an associated probability, which describes the relative ability of the model to predict changes in population size. These Bayesian probabilities are updated annually using a comparison of predicted and observed population sizes. The current AHM process is passively adaptive, in the sense that there is no *a priori* consideration of how regulatory choices might affect discrimination among models. I contrast this approach with an actively adaptive approach, in which regulatory "probes" might increase long-term management performance. My investigations suggest that the passive approach is expected to perform nearly as well as an optimal active approach, particularly when considering existing management constraints and the nature of the alternative models. I conclude my presentation with some general remarks about the nature of the biological hypotheses being tested, and the inherent limitations on learning in the AHM process.

Adaptive harvest management and mortality processes in ducks.

JAMES S. SEDINGER, Instit. Arctic Biol., Univ. Alaska - Fairbanks.

The Adaptive Harvest Management program has formalized the process of establishing hunting regulations. Implementation of AHM has two potential advantages: (1) the process of establishing regulations is objective and data-based, and depoliticized; (2) harvest regulations can be set to optimize long-term harvests. The current AHM program is passively adaptive, meaning that regulations are not necessarily designed to further understanding of the role of hunting regulations in the waterfowl mortality process. AHM settled quickly on a model of mortality in which harvest was additive to other mortality, and the current passively adaptive approach represents a risk that the AHM process will permanently "settle" on a model of mortality that is inconsistent with nature. Historically, population size, harvest regulations and mortality rates have been positively associated. The current direction of AHM appears to perpetuate these associations for mid-continent mallards, that is, regulations are more liberal when ducks are more abundant, resulting in a correlation between hunter kill and population size. So far, AHM does not explicitly consider forms of mortality other than hunting. Because population density is positively correlated with hunter kill, the potential exists for AHM to conclude that kill is additive to other sources of mortality, when mortality is density dependent and unrelated to kill. Recent analyses of mortality of mallards in the Pacific Flyway (Scheaffer and Malecki 1999) showed weak or nonexistent relationships between annual survival and hunter kill except at kill rates exceeding by about a factor of three those expected under current management. These analyses, indicate that the relationship between hunter kill and total annual mortality is much weaker (at least in the Pacific Flyway) than estimated under AHM for midcontinent mallards, and suggest the need for substantial research into the mortality process in ducks. An active AHM program, in which regulations are established with the intent of furthering our understanding of the mortality process, may be required to resolve these uncertainties.

Adaptive harvest management and modeling mallards.

*JEFFREY S. LAWRENCE, Wetland Wildl. Pop. Res. Group, Minnesota Dep. Natural Resour., Bemidji; DALE D. HUMBURG, Missouri Dept. Conservation, Columbia; FRED A. JOHNSON, Office of Migratory Bird Management, USFWS, Laurel, MD.

Adaptive Harvest Management (AHM) changed the approach to duck harvest management beginning in the mid-1990s. Waterfowl managers and administrators were faced with explicit specification of: 1) harvest-management objectives, 2) a set of regulations options; and 3) a set of alternative population models (with associated measures of credibility). One of the primary values of AHM has been a quantitative basis for decision-making, and a forum within which managers can consider harvest management objectives and alternative models. While wildlife managers generally have embraced this approach, the models of mallard populations dynamics developed by the U.S. Fish and Wildlife Service remain poorly understood by most, and their behaviors have not been thoroughly investigated. The U.S. Fish and Wildlife Service has continued efforts to improve the model set, but sensitivity of optimal harvest strategies to basic model parameters has not been tested. We will examine basic parameters in the models (e.g. sex ratio, crippling loss, predictions of recruitment), and conduct a sensitivity analysis to investigate how changes in parameter values influence the optimal harvest-management strategy and its expected performance. We believe it is important that waterfowl harvest managers understand the robustness of harvest-management decisions to variation in key model parameters.

Development of an adaptive harvest management protocol for American black ducks.

MICHAEL J. CONROY, USGS, Univ. Georgia, Athens; *NATHAN ZIMPFER & CHRISTOPHER FONNESBECK, Univ. Georgia, Athens.

Management of American black ducks (*Anas rubripes*) has been hampered by lack of understanding of factors affecting dynamics of black duck populations. This has led to a lack of agreement among managers as to the potential for arresting the decline of black duck stocks through management intervention, especially harvest regulations. Previous work has resulted in construction of an annual life cycle model based on four major, alternative factors potentially contributing to variations in populations of American black ducks : 1) breeding ground habitat; 2) wintering ground habitat; 3) harvest, and 4) interactions with mallards (*Anas platyrhynchos*). Our current work extends this approach to an optimal decision making framework, where the goal is long term maximum harvest, subject to constraints (e.g., population goals and parity of international harvest). We have developed an optimization model that can be used to explore harvest regulatory options, taking into account uncertainty with respect to population regulatory mechanisms, including harvest compensation. We propose to extend this model to a more realistic representation of black duck populations that incorporates spatial heterogeneity in population response, by defining subpopulations thought to vary with habitat conditions, impact of harvest, and mallard populations. Implications of this approach are discussed with respect to the spatial and temporal resolution of management, adequacy of current monitoring programs, and potential for reduction in uncertainty about population factors.

Harvest management models for mallards breeding in eastern North America.

*DIANE R. EGGEMAN, Fla. Fish Wildl. Conserv. Comm., FL; FRED A. JOHNSON, USFWS, Laurel, MD; JAMES A. DUBOVSKY, USFWS., Lakewood, CO.

We examined reproduction and mortality in eastern mallards and developed a set of 8 models describing the annual life cycle. We explored the implications of these competing models for predicting sustainable harvests. The models are based on differences in the functional form of the relationship between dependent and independent variables of interest. Two reproductive submodels express fall age ratios of males as either a negative-exponential or a logistic function of a Breeding Bird Survey (BBS) index. To enable managers to use current estimates of population size rather than the BBS index as the criterion for regulatory decisions, we expressed the BBS index as either a logarithmic or an exponential function of the population size estimated from recent aerial surveys. We developed 2 alternative submodels for survival, both of which include constant summer survival for males. However, 1 model allows random variation in summer survival of females, and the other expresses summer survival for females as a logistic function of the BBS index. We examined optimal harvest strategies and model behavior, relative to a management objective to maximize long-term cumulative harvest, using the 8 alternative life-cycle models (2 reproductive models x 2 BBS models x 2 survival models). Optimal harvest rates tended to increase with increasing population size, although the increase was not monotonic for all models. For recent population sizes, 7 of the 8 alternative life-cycle models prescribed optimal harvest

rates higher than those attained under current liberal regulations. We discuss implications of these results for management of other stocks of eastern ducks.

Energy limitation on the wintering grounds: what do we know and what do we assume?

*JOHN M. EADIE & EDWARD G. BURNS, Dept. Wildl. Fish. Cons. Biol., Univ. Calif. - Davis; MIKE EICHHOLZ, Central Valley Habitat JV, Rancho Cordova, CA; MARK PETRIE, Instit. Wetland Waterfowl Res., Memphis, TN

Much ink has been spilled on the issue of breeding ground vs. wintering ground limitation of waterfowl populations. It is surprising, then, that so few studies have attempted to directly test the hypothesis that food is limiting on the wintering grounds. This is even more remarkable given that several North American Joint Ventures have adopted, as their working model, a bioenergetic approach which assumes that energy is the rate-limiting variable and, hence, management efforts should focus on ensuring sufficient habitat to meet the energetic needs of wintering waterfowl. In this workshop presentation, we first summarize the existing evidence and logic that led to this position, focusing primarily but not exclusively on the Central Valley of California as a case study. We then describe preliminary results of an on-going field study designed to evaluate food depletion rates in key winter habitats, using experimental bird exclosures along a valley-wide gradient of waterfowl densities. Finally, we describe bioenergetic modeling efforts to evaluate alternative scenarios under which food may or may not be limiting. We argue that insights from these and similar studies elsewhere will prove essential, not only to understand the evolutionary forces structuring waterfowl communities, but also to develop landscape-level management plans with a sound biological basis.

Using large-scale field experiments to test for food limitation in migratory waterfowl during the breeding season.

*GLENN A. BENOY, Dept. Zool., Univ. Guelph, Guelph, ON.

When and where migratory waterfowl experience population bottlenecks remains a controversial issue in wetland management. Organismal studies have yielded insights regarding body condition and nutrient reserves in the breeding and wintering grounds but they provide for only limited inferences at broader spatial and temporal scales. There is sufficient evidence for and against food limitation during all phases of a bird's annual cycle to warrant a novel approach by investigating community-level patterns. By installing large (100 m²) exclosure structures in a series of prairie potholes (Minnedosa, Manitoba) the relationship between waterfowl and wetland macroinvertebrates can be isolated and evaluated. Trophodynamic theory predicts that if waterfowl compete for limited prey, then in the absence of waterfowl foraging, macroinvertebrates should be released from top-down predation pressure. This prediction was borne out as macroinvertebrates were found to be longer and more abundant (paired t-tests, $p < 0.05$) in exclosure areas. Further, tiger salamander abundance, converted to density, explained 44% of the difference between macroinvertebrate biomass inside and outside of the exclosures. These results are consistent with the hypothesis that waterfowl compete for food resources on the breeding grounds and that they strongly interact with other consumers. Additional results will be presented that consider the influence of primary productivity (water column chl-a) and habitat heterogeneity (open water:vegetation ratio) on observed patterns.

Positive association in nesting mallard and teal: resource limitation and interspecific competition in the light of census data and a depletion experiment.

*JOHAN ELMBERG & KJELL SJÖBERG, Dept. Animal Ecology, Swedish Univ. Agr. Sci., Umeå, Sweden; HANNU PÖYSÄ, Finnish Game & Fisheries Research Inst., Evo, Finland; and PETRI NUMMI, Dept. Applied Zool., Univ. Helsinki, Finland.

We address resource limitation and interspecific competition in dabbling ducks on boreal breeding lakes in Finland and Sweden with observational and experimental data. After initial vegetation mapping and yearly censuses of ducks in 1985-1990, we collected observational data in 1991-1994 from 28 lakes with natural populations of mallard *Anas platyrhynchos* and teal *Anas crecca*, species which co-occur over vast areas in the Holarctic and being the only breeding dabblers on many oligotrophic lakes. Log-linear model analysis of observational presence/absence data reveal a positive, not a negative, association between the species. This association is independent of habitat diversity as well as of lake size. Mallard-teal interaction was also studied in a cross-over introduction experiment on 32 other lakes in two years.

Wing-clipped mallards were introduced on breeding lakes before the arrival of teal to induce resource limitation and interspecific competition, hypothesized to reduce lake use by teal. Experimental lakes had 2.9-8.0 times higher pair density of mallards than controls, but there was no negative response by teal to the treatment. We believe this is the first combined observational-experimental demonstration of lack of interspecific competition in waterfowl. Our results indicate that heterospecific attraction may affect co-existence in dabbling ducks.

The impact of predators on duck production: what we know and what we wish we knew.

*FRANK C. ROHWER Delta Waterfowl Foundation, Portage, Manitoba, and Forestry, Wildlife & Fisheries, Louisiana St. Univ., Baton Rouge.

Most duck management on the prairies attempts to increase hatch by reducing the accessibility of nests to predators. A more controversial approach to improving nest success involves lethal reduction of predator abundance. Older literature suggests this approach is biologically feasible, but some recent experimental and comparative analyses suggest that predator reduction is only marginally successful at improving hatch. A cadre of Delta graduate students have done some large-scale field experiments looking at predator reduction and its impacts on ducks and other birds. Trapping 16 square mile blocks in North Dakota significantly elevated nest success of dabbling ducks to 45% compared to 17% Mayfield for the untrapped control blocks. Over water nests intrapped areas had 57% success compared to 29% for control areas. The impacts of trapping on duck broods and songbird nests was much less clear. In subsequent research, trapper effort was diluted by enlarging the trapped area to 36 square miles, yet upland nests had 36% success, which was significantly greater than the 15% success on neighboring untrapped areas in North Dakota. Operational management on a similarly large-sized block during the 1999 and 2000 breeding seasons produced 84% and 66% nest success, respectively, which was dramatically higher than for adjacent areas. In contrast, early results from a trapping study in Saskatchewan suggest modest gains in nest success and brood survival. It seems clear that an intensive trapping effort with effective and motivated trappers can substantially increase nest success. Unfortunately, we know nothing about long-term ecological effects of trapping and little about impacts on anything but duck nest success.

INVITED PLENARY LECTURE

Population limitation and regulation in ducks.

*JAMES D. NICHOLS, United States Geological Survey, Patuxent Wildl. Res. Center, Laurel, MD. Although there are still multiple concepts of population regulation, the idea of a stationary probability distribution of population size appears to capture the essential features of most such concepts. In this context, a factor can be defined as limiting if a change in the level of that factor moves the system from one stationary probability distribution to a different one. Time series of duck population size estimates represent some of the best such series available for any vertebrates in terms of both series length and use of approximately unbiased estimates. Nevertheless, commonly-used methods designed to test for regulation and density-dependence using such series are not recommended, as virtually all tend to provide misleading inferences in the face of sampling variation and covariation. If attention is moved away from long-term time series and focused on experimental manipulation of putative limiting factors, then abundance is a good response variable. Such studies can yield strong inferences about population limitation, although the mobility of ducks can sometimes obscure results. Time series of estimated abundances and vital rates (e.g., survival and reproductive rates) provide some opportunity to obtain inferences about the density-dependence of vital rates. Analyses of such data often focus on fitting relationships between abundance estimates and the vital rates. Although such analyses can be useful, they can also be criticized as being phenomenological. More mechanistic modeling frequently requires thought about the meaning of density, both in terms of spatial scale (perhaps the average "neighborhood density" throughout a population is more relevant than a density metric based on total population size) and in terms of critical resources that are potential limiting factors (number of ducks per unit resource will likely be more useful than the usual ducks-per-unit-area density metric). Previous studies relevant to duck population regulation will be reviewed, and some directions for future studies will be suggested.

WORKSHOP OUTLINES

Systematic Approaches to Management Decisions: Improving the Biological Foundations of NAWMP

Workshop leaders: MICHAEL ANDERSON, IWWR, DU, Oak Hammock Marsh, Manitoba
 FRED JOHNSON, USFWS, Laurel, Maryland
 KENNETH WILLIAMS, USGS

Workshop Objective: To help engage the waterfowl research community and waterfowl managers in strengthening the biological foundations of the North American Waterfowl Management Plan.

- 1) The Context -- NAWMP partners are recognizing the need to strengthen the scientific basis for conservation decisions (Mike Anderson, 10 minutes)

A brief introduction to the workshop, what motivated it, and an overview of the current NAWMP context for adaptive management

- 2) Progress and challenges in evaluating Joint Venture conservation actions: the example of the Central Valley Habitat JV. (Mike Eichholz et al., 10 minutes)

A summary of the challenges and frontiers in JV evaluation and monitoring, with a focus on the Central Valley of California.

- 3) Objective decision making in the face of uncertainty – Decision Theory 101 (Mike Runge, 15 minutes)

A short introduction to concepts of systematic approaches to decision making (both static and dynamic) for managers of natural resources.

- 4) A Case Study: Building a framework to help inform decisions for prairie grassland conservation (Workshop audience, Fred Johnson leader, 1 h+)

An interactive voyage, building on Johnson's rudimentary grassland easement decision models and including the development of:

- *A conceptual framework*
- *An objective function*
- *A set of alternative models*
- *A monitoring and assessment approach*

This exercise is intended to help the audience discover the basis for a more productive working relationship between researchers and managers.

- 5) Take-home messages – other contexts where systematic decision frameworks might help inform waterfowl management (Jim Ringelman, 10 minutes).

N Common Statistical Mistakes in Ecology

Workshop leader: DOUGLAS H. JOHNSON, USGS - Northern Prairie Wildlife Research Center

Wildlife biology has become much more quantitative in recent years, adopting tools such as modeling, simulation, and especially statistics. Journal editors, thesis advisors, and other authority figures are demanding greater use of statistics. Powerful computers and easy-to-use software allow virtually anyone to invoke very sophisticated methods. And many new statistical tools are being developed by and for individuals in the wildlife community.

While this "mathification" of our science is healthy, some caution is needed. This workshop will overview a number of statistical procedures and practices, and indicate how they may be misapplied. Among the mistakes to be discussed are:

1. Believing your model
2. Believing your results
3. Making management recommendations
4. Requiring randomness
5. Looking at lots of variables
6. Performing a meta-analysis
7. Proving the null hypothesis
8. Pooling data
9. Using nonparametric methods
10. Testing hypotheses
11. Worrying about multicollinearity
12. Being objective

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Waterfowl Community Ecology in Breeding and Nonbreeding Areas in the Holarctic

Workshop leaders: DR. TOM NUDDS, Department of Zoology, University of Guelph
DR. HANNU PÖYSÄ, Finnish Game & Fisheries Res. Instit., Evo, Finland

Over the years, large, cooperative management programs, protocols and international agreements have been initiated to conserve populations of migratory waterfowl and their wetland habitats. In North America, these efforts began with the Migratory Birds Convention Act of 1917 and continue with the North American Waterfowl Management Plan. Worldwide, efforts to conserve the habitats of migratory waterfowl are evident in the Ramsar Convention to conserve wetlands of international significance, and in the IUCN Bonn Convention on transboundary species. Still, in both the Nearctic and Palearctic, the fates of many populations of migratory waterfowl continue to be a concern and the list of proposed problems and solutions are, predictably, controversial.

Attempts to study the relative importance of events on breeding and nonbreeding areas, as they affect the abundance and distribution of migratory waterfowl, have been largely restricted to organismal and population biologists. For example, a tremendous amount of effort has been spent to understand the dynamics of energy and nutrient stores obtained on overwintering areas and the relative contribution of these nutrients to reproductive success and/or survival. Similar effort has been put into the study of population dynamics through extensive banding/ringing analyses to ascertain the relative importance of events on and off breeding areas to population dynamics. Despite this, there remains considerable uncertainty and controversy as to the relative contributions of events on and off breeding areas to the dynamics of waterfowl populations. In the Palearctic, for instance, a widely accepted idea is that overwinter hunting mortality is substantial – perhaps enough to lower population sizes to the point where resources are not limiting on breeding areas. In the Nearctic, there is presently considerable debate about the extent to which hunting affects population dynamics.

Community ecologists also are concerned with the question of the extent to which resources, like foods and habitats, influence distribution and abundance of wildlife, but their focus is explicitly on collections of species and their concern is principally about how interspecific interactions influence population dynamics of the constituent species in communities. However, considerably less work has been done about the issue of relative resource limitation on breeding and nonbreeding areas, in either the Palearctic or the Nearctic, from the perspective of community ecology.

To date, evidence from community-ecological studies of ducks, about the extent to which resources may be limiting in the breeding and nonbreeding seasons, is equivocal. In the Nearctic, patterns of species coexistence are consistent with an hypothesis that ducks compete for limited resources during the breeding season in the prairies, especially in stable habitats; that competition for limited invertebrate resources in the breeding season appears stronger than in winter; and that duck populations are more strongly regulated by “bottom-up” (food) than “top-down” (predators and, by extension, human harvest) factors. Further, populations appear to be largely driven by climatic events and land use on breeding areas; there seems, at this scale, little residual variation in the dynamics of populations that might be explained by events away from breeding areas. On the other hand, it has been postulated that dabbling ducks compete more strongly in the winter than during spring on the prairies and, in boreal forest, there is no evidence, from mensurative food addition experiments, of resource limitation in natural wetlands. In the Palearctic, there is some evidence consistent with the hypothesis that competition may structure dabbling duck communities; that distribution and abundance of ducks is related to food abundance; and that coexistence is morphology-mediated. However, other evidence from community-level analyses points to lack of competition; food addition experiments suggest facilitation rather than competition for limited resources; and that diving ducks compete more strongly for limited resources during nonbreeding than during breeding periods. Much of the ambiguity may result from either, or both, of (1) the use of different methods by different researchers, at

different scales of time and space and (2) real differences between the Palearctic and the Nearctic as to the extent of resource limitation on breeding and wintering areas.

There is much that might be learned about the extent to which breeding-ground or wintering-ground limitation may be more important for migratory waterfowl from studies of the responses of whole communities to variation in resource availability, in addition to the current heavy emphasis on organismal- and population-level approaches. However, such studies would require a coordinated, international approach by waterfowl community ecologists working simultaneously on breeding and nonbreeding areas, using consistent methods at similar scales of measurement in time and space. The working hypothesis, given the putative large effects of hunting in the Palearctic versus the Nearctic, as above, is that the extent of resource limitation of duck populations during the breeding season is greater in the Nearctic than in the Palearctic. We propose to test this hypothesis by conducting comparative analyses of the dynamics of waterfowl communities on selected, key breeding and nonbreeding areas in North America and in Europe by a group of waterfowl community ecologists using standardized methods.

There are four objectives for the Community Ecology Session and Workshop. The purpose of the **paper session on Friday evening** is (1) to provide an opportunity for an informal, international gathering of waterfowl ecologists to review and discuss the current state of our knowledge about the relative importance of “top-down” and “bottom-up” factors that affect waterfowl populations. The purposes of the **workshop on Sunday morning** (Salon Batoche, 08:00-12:00) are to (2) investigate the feasibility of a wide-scale, parallel and co-operative studies simultaneously in the Nearctic and the Palearctic; (3) draft a proposal framework, set detailed hypotheses and predictions; and agree upon standardized procedures to address them; and (4) draft a list of, and a timetable to approach, potential funding sources of funding.

IMPORTANT NOTE. ABSTRACTS PRESENTED DURING THIS FRIDAY EVENING WORKSHOP ARE SHOWN AFTER POSTER ABSTRACTS.

Recent Advances in Survival Analysis

Workshop leader: DR. GARY C. WHITE, Department of Fishery and Wildlife Biology,
Colorado State University, Fort Collins, CO 80523 USA

Objective: Provide information on extensions of the methodology of Brownie et al. (1985) on survival estimation from bands available from Program MARK. An array of examples, testing ecological ideas about variation in survival and other parameters from marked individuals, using waterfowl as examples whenever possible.

- I. Direct extensions of Brownie et al. (1985)
 - A. Recovery matrix versus encounter histories format
 - B. Reparameterization of $\{S, f\}$ to $\{S, r\}$ (Seber 1970).
 - C. Parameter Index Matrix (PIM)
 1. Age-specific model
 2. Time-specific model
 3. Age- and time-specific model
 4. Common parameters across attribute groups
 - D. Design matrix
 1. Identity design matrix
 2. Full design matrix
 3. Reduced design matrix
 - a. Duplication of PIM models with design matrix
 - b. Additive effect models
 - E. Time-specific covariates, e.g., weather, water levels, pond indices.
 - F. Group-specific covariates, e.g., spatial area, habitat variables, gender, type of mark. Comparison of survival rates for radio-marked versus regularly banded birds.
 - G. Individual-specific covariates, e.g., genetic heterozygosity, contaminant dose. Estimate effects of lead poisoning on survival by experimentally dosing individuals.
- II. Known fate models – radio telemetry – logistic regression
- III. Live resighting models
 - A. Cormack-Jolly-Seber model (Cormack 1964, Jolly 1965, Seber 1965, Lebreton et al. 1992)
 - B. Jolly-Seber model (Jolly 1965, Seber 1965)
 - C. Pradel (1996) model to estimate rate of change of the population on a study area
 1. f - recruitment
 2. γ - probability of previous existence
 3. λ - rate of change of population size
 - D. Robust design model (Kendall et al. 1995, 1997, Kendall and Nichols 1995)
 - E. Multi-strata model (Brownie et al. 1993, Hestbeck et al. 1991)
- IV. Combining live resightings with dead recoveries
 - A. Burnham (1993) model
 - B. Barker (1997) model
 - C. Lindberg et al. (2000) model
- V. Analysis of estimates
 - A. Model selection with information-theoretic methods (Burnham and Anderson 1998)
 1. AIC
 2. AICc
 3. QAICc

- 4. Akaike weights
- 5. Model likelihood
- B. Model averaging
- C. Variance components
 - 1. Process variance estimate
 - 2. Survival estimates
- VI. Availability of Program MARK
 - A. <http://www.cnr.colostate.edu/~gwhite/mark>
 - B. Primary citation: White and Burnham (1999)
 - C. Much additional documentation and literature available on the above web site.

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ABSTRACTS: POSTER PRESENTATIONS (Abstracts listed in alphabetical order; NAMES of graduate students eligible for poster presentation awards are underlined.)

The influence of partial clutch predation on parental investment decisions of nesting mallards (*Anas platyrhynchos*). *JOSHUA T. ACKERMAN & JOHN M. EADIE, Dept. Wildl., Fish, & Cons. Biol., Univ. Calif. - Davis.

Predators often partially depredate waterfowl nests. Consequently, hens must make parental investment decisions to stay with or abandon reduced clutches. We used observations of hen mallard responses (i.e., stay or abandon) to natural partial clutch predation events to demonstrate that: (1) substantial variation exists in the magnitude and timing (during incubation) of partial predation; and (2) a hen's likelihood of staying is inversely related to the magnitude, and positively related to the timing, of clutch loss. We then manipulated clutch size to determine the cause of these relationships. Specifically, we tested alternate hypotheses that females invest in a current clutch according to expected benefit (i.e., the number of eggs expected to hatch from a clutch after controlling for the probability of predation) or their past investment (i.e., costs associated with time, energy, and predation risk invested previously in incubation). Hens invested according to the expected benefit of a current clutch ($p < 0.05$) and not according to their past investment in the clutch ($p > 0.05$). Thus, hens were no more likely to abandon a partially reduced clutch with similar expected benefits earlier than later in incubation. Assuming that mallards make parental investment decisions which maximize lifetime reproductive success, results imply that for a clutch hens either: (1) cannot use past investment as a cue to make investment decisions; or (2) costs associated with incubation do not substantially diminish the value of future reproduction and therefore it is not advantageous to make parental investment decisions based on past investment.

Time-activity budgets of harlequin ducks molting in the Gannet Islands, Labrador. PETER A. ADAMS & IAN L. JONES, Dept. Biol., Memorial Univ., St. John's, Nfld.; *GREGORY J. ROBERTSON, Can. Wildl. Serv., Mount Pearl, Nfld.

We studied the time-activity budgets of Harlequin Ducks (*Histrionicus histrionicus*) molting at the Gannet Islands, Labrador in the summer of 1998. For the entire population, a large proportion of time was spent hauled out of the water (61.4%), and resting (53.5%). Only a small proportion of time was spent foraging (11.6%). Male Harlequin Ducks undergoing the pre-basic molt were hauled out of the water significantly more (92.2%) than males in basic plumage (8.1%). Males undergoing the pre-basic body feather molt also foraged significantly less (1.7%) than males in basic plumage (17.7%). Harlequin Ducks do not appear to increase their food intake to meet the nutritional requirements of molt. Instead they may try to reduce thermoregulatory and maintenance costs by engaging in activities that do not consume much energy, and by staying out of cold water while their plumage is not intact. They may deliberately lose body mass while molting to regain the ability to fly at an earlier stage of wing molt.

Habitat selection of duck broods on intensively-managed fishponds in the Czech Republic. *TOMAS ALBRECHT & PETR MUSIL, Dept. Zool., Charles Univ., Vinicna 7, CZ-128 44 Prague 2; JAROSLAV CEPAK, Inst. Applied Ecol., Kostelec n.Cernymi Lesy CZ-281 63; DAVID STORCH, Centr. Theoret. Studies, Charles Univ., Jilska 1, CZ-110 00 Prague 1, Czech Republic

In central Europe, artificial fishponds represent one of the most important inland wetland habitats for breeding waterfowl. An overabundance of nutrients due to fertilisation as well as high fish stock abundance (up to 1700 kg/ha), are among the main factors affecting the food web of these fishponds. The relationship between nutrient level (indicated by water transparency, zooplankton structure, fish-stock cohort and numbers), habitat structure (pond area, area of littoral zone, shore-line length, proportion of adjoining habitat types, isolation of pond) and number of duck broods was investigated on 70 fishponds in South Bohemia (Czech Republic) annually during 1993-99. Mallard, Gadwall, Common Pochard, Tufted Duck, Goldeneye were the most abundant duck species. Canonical Correspondence Analysis (CCA) revealed that the occurrence of diving duck broods on ponds was closely associated with younger fish-stock cohorts and higher water transparency, the most significant pattern occurring in the youngest ducklings (up to 2 weeks of age). On the other hand, pond habitat structure variables best explained the occurrence of dabbling duck broods. Both Mallard and Gadwall broods chose "safer" ponds with greater development of littoral stands and/or total water surface area. The majority of ponds are quite unsuitable due to management practices, particularly for diving ducks and their broods. Fish-farming intensification is probably among the key factors affecting the rapid decline in the breeding population numbers of Pochard and Tufted Duck recorded since the early 1980s in the Czech Republic.

Factors affecting the departure of common eider (*Somateria mollissima*) ducklings from a colony in the Canadian Arctic. *KAREL A. ALLARD, Atlantic Co-operative Wildl. Ecology Res. Network, Univ. New Brunswick, Fredericton; H. GRANT GILCHRIST, Can. Wildl. Serv., Yellowknife, NWT; ANTONY W. DIAMOND, Atlantic Co-operative Wildl. Ecology Res. Network, Univ. New Brunswick, Fredericton.

Few studies of common eider reproduction have focused on the nest-to-water portion of colony departure. In 1999, we observed departing broods from observation blinds on a small 36 ha, treeless island. The lack of tall vegetation allowed us to observe individual and group behaviours in detail. We quantified the influence of the following on the probability of successful departure: diurnal variation in departure rates of common eider broods, relative synchrony of departures, the time elapsed from nest departure to arrival at sea, variation of group size, the ratio of hens to ducklings, the effects of weather and ocean state, and attack by herring gulls (*Larus argentatus*). Unlike many other colonial waterbirds, there was no diurnal variation in brood departure. Departing broods did not follow the shortest path to water and often spent several hours covering distances of less than 100 m. Instead, hens often lead broods to a series of fresh water ponds on the island where brood amalgamation took place. These large groups would then move together to the next pond closer to the shoreline. Although increasing the time spent and distance travelled on the island, this behaviour apparently decreased vulnerability to herring gulls because ducklings could dive to avoid attack and hens were often more numerous on ponds.

Nutrient-reserve dynamics of lesser scaup (*Aythya affinis*) during spring migration in the Mississippi flyway: a test of the spring condition hypothesis. *MICHAEL J. ANTEAU, School of For., Wildl. and Fish., Louisiana St. Univ., Baton Rouge; ALAN D. AFTON, U. S. Geol. Surv., Louisiana Coop. Fish Wildl. Res. Unit, Louisiana St. Univ., Baton Rouge.

The continental scaup population has declined significantly during the past 20 years, and has been below the population goal of the North American Waterfowl Management Plan (NAWMP) since 1985. One hypothesis explaining the scaup decline is that reproductive success has declined because individuals are wintering, migrating, and arriving on breeding areas in poorer condition than historically ("spring condition" hypothesis). We are testing the "spring condition" hypothesis by collecting lesser scaup from 4 locations (Louisiana, Illinois, Minnesota, and Manitoba) in the Mississippi Flyway during spring of 2000 and comparing size-corrected body mass and nutrient reserve levels to that of lesser scaup collected from similar sites in the 1960s and 1980s.

Using stable carbon and hydrogen isotopes to examine nutrient allotment by breeding redhead ducks.

LISA ATWELL, Dept. Biol, Univ. Sask., Saskatoon; *KEITH A. HOBSON, Can. Wildl. Serv., Saskatoon, SK., LEN WASSENAAR, Env. Canada, Saskatoon, SK.; TINA YERKES, Ducks Unlimited, Memphis, TN. In cases where stable isotope signatures in macronutrients of female body tissues differ from those of local foods, it should be possible to trace relative importance of endogenous vs. exogenous nutrient inputs to reproduction. We hypothesized that body nutrients of female redhead ducks arriving on breeding grounds in Manitoba should differ from local foods since these birds winter at different latitudes and in different isotopic biomes than found on the breeding grounds. Specifically, we expected deuterium and carbon-13 signatures in body macronutrients to be enriched relative to local foods. Body nutrient isotopic values changed throughout the season as birds assimilated local nutrients. We measured female muscle and lipids isotopically and compared these with values in eggs. The lack of an overall correlation indicated little evidence for endogenous nutrient input to eggs at the population level. However, some females clearly showed this tendency suggesting scope for individual reproductive strategies.

Midwinter inventory versus Christmas Bird Counts for monitoring scaup populations. *JOHN S. BARCLAY, CHRISTOPHER M. RENSHAW & PATRICIA S. HOLLAY, Wildlife Conservation Res. Center, Dept. Natur. Resources Mgt. & Eng., Univ. Connecticut, Storrs.

Long-term declines in greater scaup (*Aythya marila*) and lesser scaup (*A. affinis*) populations in North America, particularly when most other major duck populations have been increasing, has heightened interest in the status of both species. Greater scaup harvest data indicate populations declining up to 90 percent in waters of the Long Island Sound region where 60 percent of the North American population has been known to winter. Inability to separate the two species in annual continental waterfowl surveys, i.e. breeding and state/federal midwinter waterfowl inventory (MWI), often leads to conflicting interpretations for greater scaup numbers. Results of analyses of scaup survey data at regional (sub-flyway) levels, and recent evidence of changes in regional winter populations, highlight needs for separation of the two species. We compared recent (1979-1999) Christmas Bird Count (CBC) data from five Northeastern states (MA, RI,

CT, NY, NJ) and adjoining regions to MWI data to better understand regional trends in greater scaup and lesser scaup populations. We also investigated the reliability and outcomes of these respective surveys. When the two species were separated in the Northeast CBC data, arguments for a pronounced and continuous decline in greater scaup, with a regional increase in lesser scaup, are reinforced. Advantages and limitations of CBC data versus MWI data encountered in this study are discussed as well.

Herbivory of native and exotic submersed aquatic plants by wintering ducks and American coots.

*JOSEPH R. BENEDICT JR., Fla. Fish and Wildl. Conserv. Comm, Tallahassee, FL; GARY R. HEPP, School of Forestry and Wildl. Sci., Auburn Univ., AL.

Reservoirs with abundant aquatic plants are used extensively by waterfowl, however, herbivory by waterfowl can significantly affect biomass of aquatic plants and subsequent use of these habitats. Gunterville Reservoir (27,479 ha) is an impoundment of the Tennessee River in Alabama which supports large areas of aquatic macrophytes (3,000-4,000 ha). In 1993-94, the exotic Eurasian watermilfoil (*Myriophyllum spicatum*) was the most abundant aquatic plant (approx. 90%). Milfoil is eaten by some species of waterfowl, but its food value has been questioned. We compared use-days of wintering ducks and American coots in milfoil and native plant (*Chara* sp.) habitats and examined the impact of waterfowl grazing on aquatic plants in fall and winter. Use-days in native plant and milfoil areas increased from October to November. Few birds used native areas after late November; but use of milfoil continued throughout the winter. Exclosures (1-m²) were used to prevent grazing of aquatic plants by waterfowl. Biomass of aquatic plants within exclosures and randomly located control samples (open plot) were sampled monthly and compared as a measure of herbivory. Biomass of milfoil did not differ between exclosed and open plots, but differed by month, declining over time. Waterfowl herbivory had a significant impact on native plants; biomass of exclosed samples (747 g/m²) was greater than that of open samples (449 g/m²). Native plant biomass also differed by month, declining over time. Many species of waterfowl used native plant areas first and switched to more stable milfoil habitats as native plants disappeared through grazing and natural senescence. Native aquatic macrophytes are an important habitat component during early fall, and milfoil remains available throughout the winter. Both Eurasian watermilfoil and native plant communities can provide important habitats for migrating and overwintering waterbirds at southern reservoirs.

A reliable, wireless device for continuously monitoring nest attendance in waterfowl. *GRACE E. BOTTITTA, Watershed Ecosystems Graduate Program, Trent Univ., Peterborough, Ont.; H. GRANT GILCHRIST, Can. Wildl. Serv., Yellowknife, NWT; ALLAN KIFT, Physics Dept., Trent Univ., Peterborough, Ont.

The incubation pattern of birds often reflects the physical condition of incubating individuals and the probability of nest success. Studies of avian incubation constancy have provided insights into how adults ensure future fecundity and survival as well as annual reproduction. Researchers have relied on electronic nest monitoring devices to minimize human disturbance at the nest and to obtain continuous behavioural observations. Existing devices were either sensitive to weather exposure, costly, or required repeated human visits near the nest to retrieve data. It was not possible to implement any existing devices to monitor nest attendance of Common Eiders (*Somateria mollissima*) nesting in high densities in a flat, open habitat. We developed a new device, Remote Incubation Monitoring System (RIMS), by modifying an existing home security system (NAPCO Security Systems). Camouflaged pressure sensitive switches placed in nests transmitted data wirelessly to receiver stations up to 50 m away. Data from receivers was then sent through a cable to a control panel outside the nesting habitat to be downloaded. RIMS detected the movement of hens on or off nests to within one second. Thirty-eight RIMS were placed in active Common Eider nests in 1999. Data generated from RIMS was compared with behavioural observations of the same hens monitored from observation blinds and was significantly correlated ($p < 0.05$, $r = 0.998$, $n = 29$). The wireless system was not affected by severe weather and provided instantaneous, continuous 24-hour monitoring and centralized data retrieval without disturbance to incubating hens.

Comparative ecology of common and Barrow's goldeneyes during the non-breeding season in the St. Lawrence estuary. DOMINIQUE BOURGET, Univ. Quebec - Rimouski, Que.; *JEAN-PIERRE L. SAVARD, Can. Wildl. Serv., Sainte-Foy, Que.; MAGELLA GUILLEMETTE, Univ. Quebec - Rimouski, Que.

We compared the distribution of common goldeneye (*Bucephala clangula*) and Barrow's goldeneye (*B. islandica*) along 100 km of shoreline on the south shore of the St. Lawrence estuary. Both species were usually segregated although they occurred together at a few sites. Barrow's goldeneyes tended to be more associated with rocky shorelines than common

goldeneyes. Spring and fall distributions differed for both species with Barrow's goldeneyes being more widespread in the spring. We analysed the oesophagus and gizzard contents of about 15 birds of each species. Both goldeneyes fed mostly on crustaceans with nereis being more frequent in common goldeneyes and gastropods in Barrow's goldeneyes. We also compared diving times of both species in different seasons and habitats. The results of our study will help understand the ecology of these two similar species during the non breeding season and thus help in their management.

Bufflehead and waterfowl moult in Riske Creek, B.C. *ANDRE BREAUULT, Can. Wildl. Serv., Delta B.C.; MATT EVANS, Simon Fraser Univ., Burnaby, B.C.

Approximately 100 moulting bufflehead, Barrow's goldeneye, lesser scaup and ruddy duck were captured with underwater monofilament nets in a late summer banding program conducted at Riske Creek, B.C. in 1998. More extensive efforts in 1999 resulted in the banding of an additional 300 moulting ducks of 9 different species in the same area. The most abundant moulting species was the bufflehead, with over 1000 birds distributed over ~30 wetlands. Based on tarsus measurements, female buffleheads accounted for 57% of all buffleheads captured, with males and females moulting on the same wetland. Of the 36 bufflehead banded during moult in 1998, 6 (3 males and 3 females) were recaptured in moult in 1999, indicating that both sexes are philopatric to their moult area. Riske Creek is also used by an estimated 100 breeding pairs of buffleheads, of which over 100 adults have been marked with nasal discs since 1997. None of the breeding birds were recaptured during moult. This indicates that local breeders do not moult on the wetlands where they breed and that breeding and moulting populations consist of different birds. There are therefore 2 moult migrations in Riske Creek: one out of the area (by local breeders) and one into the area (by birds of unknown origin). The recapture of a local hatch-year male banded in 1998 suggest that second-year unpaired males might return to their natal area for their first moult. This pattern of moult is quite different from what is known in other seaducks. Information on moult sites is kept in a GIS data set and will be used to characterise the use of different habitats and wetland types by various species. Tracking moulting birds might help generate information on different populations or segment of populations (i.e. breeding females or second-year birds) not covered by conventional surveys. These data might lead to the development of new monitoring programs and to a better understanding of moult sites in seaducks and waterfowl.

Breeding ecology of lesser scaup in the sub-arctic taiga. *RODNEY W. BROOK, Univ. Saskatchewan, Saskatoon SK; ROBERT G. CLARK, Can. Wildl. Serv., Saskatoon SK.

The lesser scaup (*Aythya affinis*) population has declined in the past decade and is currently below conservation goals. Evidence from age and sex ratios among harvested birds suggests that adult female survival and productivity may be decreasing. Information regarding breeding success and survival of lesser scaup, needed to evaluate population decline, is scant. The main objective of this study is to estimate scaup breeding propensity, breeding success, and adult and duckling survival rates on sub-arctic taiga near Yellowknife, NWT. In 1999, none of 12 females (most were yearlings) captured and outfitted with radio transmitters bred successfully. Nests were found during systematic searches of wetland margins. Mean clutch size was 8.6 (SE = 0.3, mode = 9, n = 22). Clutch size declined seasonally and egg size varied significantly among clutches. Nesting success (Mayfield-40%) for 24 active nests was 0.14 (95% CI = 0.05 - 0.37). Only 3.1% of eggs died as embryos in nests successfully hatching at least one egg (n = 65 eggs in 8 clutches); no infertile eggs were found. There was no indication of re-nesting among radio marked scaup. Duckling survival probability estimated for 47 days (minimum pre-fledging period) was 0.638 (95% CI = 0.462 - 0.880, n = 26), rates which may be over-estimated as total brood loss could not be reliably assessed. Adult female survival probability for 41 days from early June to late July was 0.802 (95% CI = 0.464 - 0.950, n=11). These results and other evidence indicate low lesser scaup productivity in 1999. Results of this study will be used to assist management decisions for scaup conservation.

Within-year breeding dispersal of female mallards in relation to habitat type and PHJV treatments.

*ROBERT B. BRUA, Dept. Biol., Univ. Sask., Saskatoon; ROBERT G. CLARK, Can. Wildl. Serv., Saskatoon, SK; DAVID W. HOWERTER, MICHAEL G. ANDERSON & JAMES H. DEVRIES, Instit. Wetland & Waterfowl Res., Stonewall, MB.

Several factors are known to affect avian breeding dispersal, including habitat quality. However, little information is available on dispersal among habitats for waterfowl, and knowledge of costs and benefits of dispersal among habitats, including those delivered by the Prairie Habitat Joint Venture (PHJV) is limited, primarily due to our inability to detect all nesting attempts. Thus, we used unique data collected from radio-marked female mallards (*Anas platyrhynchos*) to:

(1) quantify costs and benefits of within-year breeding dispersal among habitats and PHJV treatments and (2) elucidate factors promoting within-year breeding dispersal of females using managed and unmanaged habitats. Dispersal distance following nest failure did not vary among habitat types or PHJV treatments, or with female age, nest initiation date and previous nest duration. Subsequent nest fate was related to habitat type, with planted cover and wetlands having the highest probability of success, but female age, distance dispersed, nest initiation date, PHJV treatment and habitat change were unrelated to subsequent nest fate. Results of this investigation will provide new insights into dispersal of female mallards and assist managers responsible for delivering PHJV programs.

Causes and consequences of natal and breeding dispersal by gadwall and mallards. *ROBERT B. BRUA, Dept. Biol., Univ. Saskatchewan, Saskatoon, SK; ROBERT G. CLARK & STEPHEN W. LEACH, Can. Wildl. Serv., Saskatoon, SK.

Several hypotheses have been advanced to explain patterns of avian breeding dispersal. Many studies report that individuals typically disperse farther following an unsuccessful nesting attempt, while successful individuals tend to nest near their previous nest site. This dispersal response of unsuccessful individuals is considered adaptive since these individuals often are successful in a subsequent nesting attempt. However, a paucity of information exists on breeding and natal dispersal of waterfowl, and information regarding the consequences of either form of dispersal is limited. Thus, our objectives were to quantify costs, benefits, and mechanisms promoting natal and inter-annual breeding dispersal of gadwall (*Anas strepera*) and mallards (*A. platyrhynchos*) near St. Denis, SK. Median natal dispersal distance for mallards was 646 m and was unrelated to hatch date, nest initiation date or wetland abundance. Similarly, no measured variable was related to gadwall natal dispersal distance (528 m). For both species, fate of first nesting attempt was unrelated to distance dispersed. For mallards, median breeding dispersal distance differed between previously successful (211 m) and failed (381 m) individuals, while no difference was found for previously successful (350 m) and failed (485) gadwall. Subsequent nest fate of gadwall was not related to dispersal distance or change in nest habitat type, but nesting success tended to be negatively related to distance dispersed and change in nest habitat type for mallards. This result lends some support for the area familiarity hypothesis of dispersal. However, that most results were unrelated to any variable tested raises questions regarding the adaptive nature of dispersal.

Daily movement patterns of northern pintails wintering in diverse Central Valley landscapes. *MICHAEL L. CASAZZA, JOSEPH P. FLESKES & MICHAEL R. MILLER, U.S. Geol. Surv., Dixon Field Sta., Dixon, CA.

The Central Valley of California is comprised of several diverse landscapes, each providing critical wintering habitat for northern pintails (*Anas acuta*). As part of a study of wintering waterfowl ecology, we radio-tagged female pintails throughout the Central Valley and studied their daily movements during September through March, 1987-94 and 1998-2000. We obtained roosting and feeding locations for individual pintails on a daily basis. We examine local movements of radio-tagged pintails in relation to several factors including age class, season, hunting, year and weather in each of the major landscapes. These include the rice-agriculture landscape of the Sacramento Valley, the managed freshwater marsh complex of the Northern San Joaquin Valley and the managed estuarine Suisun Marsh. Our results will help managers improve Central Valley waterfowl habitat management.

Mallard duckling survival in the northern San Joaquin Valley, California. *MICHAEL P. CHOUINARD & TODD W. ARNOLD, Humboldt State Univ., Arcata, CA.

The two most important components of population growth in mallards (*Anas platyrhynchos*) are nest success and duckling survival. Previous studies have demonstrated that California mallards have adequate nest success, but duckling survival was less than 40% in two separate studies. We used radiomarked mallard hens and ducklings to study brood and duckling survival on two state wildlife areas and adjacent private duck clubs in the northern San Joaquin Valley. We followed 56 broods in 1996 and 1997. Total brood loss occurred in 27 of 53 broods (50.9%; 3 broods were censored before 30 days). We estimated survival from visual data on marked and unmarked ducklings in 16 broods and from this sub-sample, there was no evidence that survival rates differed between radiomarked (30-day survival = 0.287 ± 0.093 [1 SE]) and unmarked ducklings ($S = 0.225 \pm 0.047$). The best age-specific model of duckling survival recognized three age classes, breakpoints after days 1 and 12 (daily survival rates: age 1 = 0.795 ± 0.047 , age 2-12 = 0.919 ± 0.013 , age 13-30 = 0.987 ± 0.006). Estimated 30-day survival under this model was 0.248 (95% CI: 0.178 - 0.335). Overall, ducklings had higher survival rates (day 2-30) in reverse-cycle wetlands (0.755 ± 0.095) than in semi-permanent/permanent wetlands (0.189 ± 0.056) or moist-soil units (0.173 ± 0.067), but the latter two habitats did not differ. Avian and mammalian predators were the primary causes of death, comprising 39% (n = 31) and 22% (n = 18) of known mortalities. Our results indicate that mallard broods had poor survival in wetland habitats managed for wintering waterfowl (moist-soil units) or for year-round pair water, but respectable survival rates in habitats managed specifically for brood rearing (reverse-cycle wetlands).

Comparison of helicopter and ground counts for breeding ducks in Iowa's Prairie Pothole Region.

*STEVE D. CORDTS, Iowa Coop. Fish. Wild. Res. Unit, Iowa St. Univ., Ames; GUY G. ZENNER, Iowa Dept. Nat. Res., Clear Lake; ROLF R. KOFORD, Iowa Coop. Fish. Wild. Res. Unit, Iowa St. Univ., Ames. Ground and helicopter breeding-pair duck surveys were conducted in Iowa in 1996 and 1997 using four-square-mile breeding-pair waterfowl survey methods. Mallard, blue-winged teal, and wood duck were the most abundant species counted; gadwall, northern shoveler and redhead were uncommon and all other species were rare. Both surveys recorded similar numbers of breeding pairs of mallards and wood ducks but helicopter surveys produced higher counts of blue-winged teal and other late-nesting species each year. Visibility concerns for helicopter surveys were addressed using simultaneous air/ground counts and visibility biases were minimal for all species ($P > 0.05$). Costs to conduct each survey were similar. Differences in blue-winged teal counts and other species were most likely due to temporal differences in pair numbers during migration. Helicopter surveys seem to provide a viable alternative to traditional ground counts in the southern portions of the Prairie Pothole Region.

Responses of aquatic invertebrate, plant, and avian communities to experimental manipulations of moist-soil habitats at Humacao Wildlife Refuge, Puerto Rico. *JOSÉ A. CRUZ-BURGOS & FRANCISCO J. VILELLA, Dept. Wildl. Fish., Miss. Coop. Fish Wildl. Res. Unit, Mississippi St. Univ.; RICHARD M. KAMINSKI, Dept. Wildl. Fish., Mississippi St. Univ.; HENRY L. MURKIN, Inst. Wetland Waterfowl Research, Oak Hammock Marsh, MB; GUY A. BALDASSARRE, State Univ. - New York, NY; GOVINDA WEERAKKODY, Dept. Math. and Stat., Mississippi St. Univ.

Caribbean wetlands are characterized by lentic and lotic wetlands, absence of salt marshes, high species richness of plants and animals, and high rates of annual primary productivity. Area of wetlands in Puerto Rico has decreased by nearly 50% during the 20th century. The Humacao Wildlife Refuge is located in eastern Puerto Rico. The northwest region of the refuge (i.e., Mandri lagoon complex) contains emergent marsh and moist-soil habitats dominated by several species herbaceous plants. These habitats currently lack openings, which restrict wetland use by resident and migratory waterbirds. Reliable knowledge is lacking on responses by aquatic invertebrates, plants, and waterbirds to experimental manipulations of moist-soil habitats in Neotropical wetlands. Three impoundments (i.e., 8-12 ha each) were constructed in 1998 in the Mandri complex. In these impoundments, we will use a factorial randomized complete block design to test the effects of 3 percent ratios of vegetation-water interspersions (i.e., 30:70, 50:50, 70:30) and 2 basin manipulations (i.e., mowing and disking) on plants, invertebrates, and waterbirds. Plant and invertebrate biomass and diversity will be measured. Waterbird diversity and abundance also will be measured to test the hemi-marsh concept in this Neotropical wetland.

GPS/GIS techniques in aerial surveys. *D. ALAN DAVENPORT, USFWS, Laurel, MD.

The USFWS Office of Migratory Bird Management has been collecting GPS locations in conjunction with aerial waterfowl surveys for several years. A system has evolved using ArcView (by ESRI) to validate and tabulate survey data. It is primarily used during breeding population and production surveys but can be used with virtually any type of survey where GPS locations are collected. The system taps into the power of ArcView to overlay and extract data attributes from reference basemaps but is driven by a simple user interface, making it possible for users with no knowledge of ArcView to view, summarize and tabulate data.

Brood ecology of king eiders. *KATHERINE R. DRAKE, Dept. Biol., Univ. Saskatchewan, Saskatoon; RAY T. ALISAUSKAS & DANA K. KELLETT, Can. Wildl. Serv., Saskatoon, SK.

King eiders (*Somateria spectabilis*) breeding in North America may have declined by as much as 56% over the past 20 years. Reasons for declines are unknown, in part because our understanding of basic king eider ecology is lacking. Estimates of nesting and egg success exceed 50% in most years and apparent annual adult female survival is 76% for king eiders nesting at Karrak Lake, Nunavut. These high estimates suggest that king eider populations may be constrained by factors influencing the number of ducklings recruited into the breeding population. This may include changes in clutch size, prefledgling survival, and subadult mortality. Preliminary results suggest that king eider duckling survival at Karrak Lake is 61%; however this estimate of duckling survival is biased high, because it does not account for total brood loss. Additionally, extent of brood amalgamation in king eiders may be as high as 21%, with amalgamation occurring as early as 2 days after hatch. Lack of broods within the study area after ducklings attain 2-3 weeks of age suggests that broods may disperse from natal sites with increasing age. Although timing and extent of king eider brood movements are currently unknown, increased numbers of king eiders observed along the coast in early fall suggests that broods may move toward coastal areas before attaining flight. To obtain reliable estimates of duckling survival and movements, we will monitor radio-marked female king eiders throughout the brood-rearing period, 2000. Results will provide critical information on king eider vital rates that are currently unknown.

Differential survival of yearling and adult female mallards and its relation to breeding habitat conditions. *KEVIN W. DUFOUR, Dept. Biol., Univ. Saskatchewan, Saskatoon; ROBERT G. CLARK, Can. Wildl. Serv., Saskatoon, SK.

Information on age-specific survivorship is vital to understanding the dynamics of waterfowl populations, but few waterfowl studies have examined age-related variation in survival beyond the first year of life. We used capture-recapture data from a long-term (16 yr) field study of female mallards (*Anas platyrhynchos*) breeding in south-central Saskatchewan to evaluate potential survival rate differences between females marked in their second year (i.e., yearlings) and those marked as adults (>2 years old). Because the breeding season has been identified as a period of high mortality for female ducks, we further sought to determine whether age differences in annual survival might vary with wetland conditions on the breeding grounds. Capture-recapture analysis based on extensions of the Cormack-Jolly-Seber model suggested that survival was best modeled as a function of female age, with yearling females surviving at a higher annual rate (0.58 ± 0.05 SE) than adults (0.47 ± 0.03). However, an equally parsimonious model suggested that age differences in survival were most pronounced in years of low wetland abundance. Recapture rate (indicative perhaps of breeding propensity) was best modeled to include interactive effects of female age and wetland abundance, such that yearling females were recaptured at lower rates than adults in years of low wetland numbers. Collectively, our findings support the hypothesis that reduced breeding by yearling females may result in elevated probabilities of survival. Our results further suggest that this pattern is most likely to occur during years of poor breeding habitat conditions.

Using waterfowl to evaluate wetland ecosystem restoration projects. *BRUCE D. DUGGER, Coop. Wildl. Res. Lab. Southern Illinois Univ., Carbondale, IL, USA; STEFANI L. MELVIN, Ecosystem Restoration Dept., South Florida Water Management District, West Palm Beach, FL, USA.

We conducted aerial surveys to estimate pre-restoration, winter waterfowl population size in four reaches of the Kissimmee River floodplain and areas immediately adjacent to the floodplain. We compared our population estimates with historic estimates, discuss how waterfowl will respond to restoration, and conduct power analyses to determine the ability of our survey to detect relative changes (BACIP design) in population size between a reach that will be restored (treatment) vs. a reach that will not (control). Total population size for all reaches combined varied from 0 to 345, lower than estimates for the system prior to river channelization (4,000 - 5,000). Population estimates did not differ between control and treatment reaches for the floodplain portion of the survey area ($P = 0.93$), but were different when areas

outside the floodplain were included ($P = 0.008$). Separate power analyses for the floodplain and the floodplain plus surrounding areas indicated our survey could detect relative changes in population size between restored and non-restored sections of 60 and 326 birds, respectively. We argue such an increase is likely after restoration and conclude that BACIP-type designs may provide a less biased approach for using waterfowl abundance to evaluate wetland restoration. Detection of spatial variability between control and treatment sites indicates evaluation efforts that rely solely on post-restoration monitoring are inadequate.

A proposed mechanism for linking nutrient availability and the cessation of egg development in waterfowl. MIKE EICHHOLZ, Central Valley Habitat Joint Venture, Rancho Cordova, CA

David Lack first proposed that clutch size in altricial birds was limited by the amount of nutrients the adults could supply to the young. He later hypothesized that clutch size in precocial birds was limited by the amount of nutrients available to females for egg production. Since then numerous studies of waterfowl have attempted to test this hypothesis. Although the conclusions drawn from this work are still controversial, most ecologists agree that some nutrient is likely the proximate limiting factor of clutch size for waterfowl. However, the mechanism that would allow a female to determine when nutrients are becoming limited, thus egg formation should cease is still unclear and unintuitive. For example with most Arctic nesting geese there is a 10 to 15 day period from the time of ovulation until the egg is fully developed and laid, while the entire clutch of 4 – 6 eggs is laid over a 4 – 7 day period, indicating ovulation new follicles stopped and the clutch size was determined well before the first egg was laid. Understanding the mechanism that causes ovulation to cease will allow ecologists to better understand how and why clutch has evolved and what the limiting mechanisms are. In this presentation I will propose leptin, a hormone produced by fat cells in mammals, as the potential mechanism and provide a model that describes how leptin may interact with other hormones to cease egg production. I will also compare predictions of this model with observed trends in clutch size variation and suggest ideas for future research that would test this hypothesis.

Natural cavity use by Barrow's goldeneye and bufflehead in British Columbia, and a comparison to nest box usage. *MATTHEW R. EVANS, DAVID B. LANK, FRED COOKE, Ctr. for Wildlife Ecology, Simon Fraser Univ., Burnaby, B.C.; W. SEAN BOYD, Can. Wildl. Serv., Delta B.C.

Both Barrow's goldeneye (*Bucephala islandica*) and bufflehead (*B. albeole*) are secondary cavity nesters and rely heavily on nest sites created by primary cavity nesters such as pileated woodpeckers (*Dryocopus pileatus*) and northern flickers (*Colaptes auratus*), respectively. However, studies of natural cavity selection and success by these birds are lacking. Prior studies have predominantly made use of artificial nest boxes. This study examines the biophysical characteristics of cavity nest sites (tree species, decay class, dbh, distance from water, and distance from forest edge) and compares the nesting demographics of cavities to those of nest boxes. In 1997 and 1998 30 Barrow's goldeneye and 80 bufflehead natural cavities were examined. For both species nest sites were predominantly in aspen (74% and 85%, respectively) followed by Douglas fir (22% and 9%, respectively). Barrow's goldeneye cavities were typically 91.69m from water and 54.52m from forest edge. Bufflehead were found nesting 44.68 m from water and 2.89 m from forest edge. Nesting success for Barrow's goldeneye cavities was 86% in 1997 and 78% in 1998. This is compared to nest box nesting success of 52% and 48%, respectively. Bufflehead cavity nesting success was 88% in 1997 and 84% in 1998 and nest box success was 83% and 90%, respectively. Sources of nest failure and patterns of nest site philopatry for both cavities and nest boxes are also presented.

An investigation of which factors limit sago pondweed growth in Delta Marsh, Manitoba. *VINCENT D. EVELSIZER, Dept. Biol.-Clarion Univ. of Pennsylvania.

Sago pondweed is the most common submergent macrophyte in Delta Marsh. It is a key food plant to a variety of waterfowl, but in the past 20 years there has been a general reduction in sago beds and other submergent plants. Delta Marsh was once recognized as a premiere breeding and fall staging area for waterfowl due, perhaps in part, to these once extensive beds of sago pond weed. Recently, however, waterfowl usage of the marsh has declined. It's possible Delta Marsh no longer supports the necessary foodbase demanded by large numbers of breeding and migrating waterfowl. The purpose of this study is to test four possible limiting factors of sago pondweed growth: 1) carp activity, 2) forage fish activity, 3) water turbidity, and 4) waterfowl herbivory. This experiment is designed to test hypotheses individually by manipulating 3m x 3m exclosures. The response variables were late summer standing crop of sago vegetation and a number of limnological variables.

The role of grassland habitat in the settling patterns of prairie ducks. *STACEY A. FISCHER, Texas Parks and Wildlife Dept., Port Arthur; FRANK C. ROHWER, Delta Waterfowl Foundation, Portage-la-Prairie, MB.

We examined the influence of upland cover on selection of breeding habitat by prairie-nesting ducks by comparing breeding pair abundance on quarter section blocks that were covered with grassland or were annually-cropped farmland. Blue-winged teal (*Anas discors*) and northern shoveler (*A. clypeata*) were almost four times as abundant on grassland than on cropped habitats with similar wetland conditions. Mallard (*A. platyrhynchos*) were also significantly more abundant on grassland blocks than on cropped habitats. Abundance of dabbling ducks was positively related to shoreline length for all 7 species examined, with blue-winged teal showing the strongest relationship. The higher density of blue-winged teal pairs on grassland blocks is likely a reflection of active selection of grassland for nesting. The higher density of mallard and shoveler on grassland blocks may reflect active selection of grassland blocks or philopatry to sites with elevated nest success.

Waterfowl ecology relative to recent habitat changes in the Central Valley, California. *JOSEPH P. FLESKES, MICHAEL L. CASAZZA & DAVID S. GILMER U.S. Geol. Surv., Dixon, CA; J. GREG MENSİK, U.S. Fish and Wildl. Serv., Willows, CA; MICHAEL R. MILLER & DENNIS L. ORTHMEYER, U.S. Geol. Surv., Dixon, CA; JOHN Y. TAKEKAWA, U.S. Geol. Surv., Vallejo, CA; JULIE L. YEE, U.S. Geol. Surv., Dixon, CA; DANIEL R. YPARRAGUIRRE, Calif. Dept. Fish Game, Sacramento.

During the last decade, changing agricultural practices and conservation programs such as the Central Valley Habitat Joint Venture (CVHJV) have altered the landscape of the Central Valley of California, one of the most important waterfowl wintering areas in the world. To measure the response of wintering waterfowl to these habitat changes and aid CVHJV planning, we studied waterfowl distribution, movements, habitat use and survival throughout the Central Valley during September-April, 1998-2000, by conducting monthly aerial waterfowl surveys and tracking radio-tagged pintails, mallards and white-fronted geese. Data collected during the current study will be compared with similar data collected before recent habitat changes. Preliminary results indicate that the ecology of waterfowl wintering in the Central Valley has changed over the last decade and CVHJV habitat goals may require modification. This project is a cooperative effort of the California Department of Fish and Game, California Waterfowl Association, Central Valley Habitat Joint Venture, Ducks Unlimited, Inc., Grassland Water District, The Rice Foundation, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service and U.S. Geological Survey.

Food selection of young and adult diving ducks at Myvatn; Iceland. *ARNTHOR GARDARSSON, Inst. Biol., Univ. Iceland, Reykjavik, Iceland; ARNI EINARSSON, Myvatn Res. Stn., Reykjahlid, Iceland. Changes in numbers and production of five species of diving ducks (greater scaup, tufted duck, common scoter, oldsquaw and Barrow's goldeneye) at Myvatn, Iceland, are associated with variation in the availability of preferred foods, mainly benthic crustaceans, chironomid midges and their larvae, and blackflies (Simuliidae) and their larvae. We examined gut contents of a number of ducks collected over several years, mainly from fishing nets, and identified the chironomids to subfamily, tribe or genus, and sometimes to species. Adult greater scaup and Barrow's goldeneye fed on a variety of benthic foods, and both took relatively many larvae of the dominant chironomid species *Tanytarsus gracilentus* which was rarely eaten by other diving ducks. Adult tufted duck and common scoter showed a strong preference for *Chironomus* larvae. Young of all five duck species showed preferences for the benthic crustacean *Eurycerus lamellatus*, orthocladid chironomids and *Chironomus*. The difference in food selection between young and adult ducks seems to be explained mainly by the young selecting for protein-rich food, which they obtain by taking relatively large epifaunal invertebrates in preference to small infauna (such as *Tanytarsus*).

Effects of landscape features and predator removal on dabbling duck nest success. PAMELA R. GARRETTSON*, Delta Waterfowl Research Station, Portage, MB.

Proximity to landscape features has the potential to affect duck nesting success. In many eastern forest dwelling passerines, nest predation and parasitism increased with proximity to habitat ecotones but this relationship has not been well tested in grassland ecosystems. Proximity to wetlands might be associated with increased nest predation, as skunks and raccoons preferentially forage near wetlands. Abandoned buildings are used as denning sites by skunks and raccoons, so nearby nests might be more vulnerable to predation. I tested for a relationship between distance to nearest habitat edge, wetland edge, and abandoned building on sites where mammalian predators were experimentally removed and on untrapped control sites. Nest success did not vary with distance to habitat edge ($P = 0.51$) or wetland edge ($P =$

0.73), but did vary with distance to nearest abandoned building and predator removal treatment ($P < 0.001$). On untrapped sites, successful nests were located farther from abandoned buildings (2205 ± 97 m) while on trapped sites successful nests were located closer to abandoned buildings (1200 ± 41 m). Apparently, increased predator activity near abandoned buildings caused reduced nest success on untrapped sites. On trapped sites, the reverse was true, likely because trappers concentrated their efforts near abandoned buildings. My study is consistent with previous work in grassland ecosystems that found no effect of distance to edge or wetland on nest success, and is the first study to demonstrate reduced nest success near abandoned buildings. However, I did not test the effect of destroying abandoned buildings, so such management should be approached with caution.

Waterbird use during breeding and staging on the Peace-Athabasca Delta, northeastern Alberta, in 1999 and 2000. *MICHEL GENDRON, DUC, Edmonton, AB.; J. BRUCE POLLARD, IWWR, Stonewall, MB.; SEAN A. SMYTH, DUC, Edmonton, AB; AL J. RICHARD & GARY R. STEWART, DUC, Edmonton, AB.

The Peace-Athabasca Delta (PAD) is the largest boreal delta in the world and one of the largest inland freshwater deltas. The site has been designated an Alberta Wetland For Tomorrow and is recognized as a wetland of international importance under the Ramsar Convention. Early reports have long indicated that the PAD was very important to breeding and migrating birds but observations have been difficult to quantify. Ducks Unlimited's involvement with waterbird inventories on the PAD was initiated in 1998 with the objective to develop a scientifically defensible survey effort and to monitor the response by waterbirds to recent re-flood events on the PAD. Although pilot year surveys were flown in 1998 to test the methodologies employed and to derive an initial understanding of bird abundance, data presented will be from more comprehensive surveys completed in 1999 and 2000. In 1999, we conducted helicopter basin-specific breeding pair surveys in early and late May, fixed wing whole-Delta (10 % coverage) pair surveys in late May only, two sets of helicopter brood surveys on specific basins in early and mid-summer, and a series of three fixed wing staging surveys through late August and September. Preliminary results indicate pair and brood use is respectable, but the value of the PAD for production is dwarfed by the exceptional numbers of birds using the area during molting and staging. Peak abundance estimates were over 850 000 waterbirds at one point in time (mid-September) and we estimated over 21.5 million total waterfowl-use days between 30 August and 30 September. Surveys will continue in 2000 to determine annual variation in waterbird populations and distributions.

Survival rates, recovery rates and spatial patterns of recoveries for juvenile captive-reared Common Eiders released in Newfoundland. *SCOTT G. GILLILAND and GREGORY J. ROBERTSON. Can. Wildl. Serv., Mount Pearl, Nfld.

We describe recovery patterns and survival rates of hand-reared Common Eider ducklings released on the Northern Peninsula, Newfoundland. From 1988 to 1996, 3,413 ducklings were released. We obtained banding and recovery data for 266 hand-reared eiders from the Bird Banding Lab, Can. Wildl. Serv., that were shot up to January 2000. The sex ratio of released ducklings was 1:1. The direct recovery rate was $5.07\% \pm 2.25$ per year, and the sex ratio of direct recoveries deviated significantly from 1:1 (1:0.78 hatch-year males to females). Recoveries occurred from Table Bay, Labrador south to Massachusetts. The majority of recoveries (80.1%) were from Newfoundland and St. Pierre and Miquelon with smaller numbers occurring in Labrador (1.3%), Québec (4.9%), Nova Scotia (7.5%) and the New England States (4.9%). More indirect recoveries occurred in Nova Scotia and the New England States, and a larger than expected proportion of these recoveries were males. The majority of recoveries were of hatch-year (73%) and second-year birds (9.6%). Using a two-age model based on the alternative parameterization of recovery models (S and r), we obtained constant survival rate estimates of 0.300 (0.207-0.413; 95% CI) for juvenile and 0.725 (0.563-0.844) for adult males, and 0.438 (0.259-0.6352) for juvenile and 0.844 (0.603-0.950) for adult females. The oldest was an eight year-old male recovered in Maine. Overall, captive-reared Common Eiders showed migration patterns and survival rates comparable to wild populations.

Recovery rates, harvest distribution and harvest chronology of mallards banded at Sand Lake National Wildlife Refuge, South Dakota, 1960-95. *JEFFREY S. GLEASON, Univ. Western Ontario, London; WILLIAM A. SCHULTZE, US Fish Wildl. Serv., Sand Lake National Wildlife Refuge, Columbia, SD.

Recovery rates, harvest distribution, and harvest chronology were derived for normal, wild mallards (*Anas platyrhynchos*) banded at Sand Lake National Wildlife Refuge (SLNWR), South Dakota, 1960-95. Only data from

mallards banded pre-season (July-Sept.) and shot or found dead during the hunting season were analyzed. We tested 3 sources of variation in recovery rates: age, sex, and year periods (i.e., 1960-73 v. 1982-95). Recovery estimates were derived using Programs ESTIMATE and INTERVAL and were compared using Program CONTRAST. Akaike's Information Criterion was used to select the most appropriate model. Recovery rates declined ($P = 0.00001$) across periods for all age-sex cohorts except immature males. Male mallards had higher recovery rates than did female mallards ($P = 0.00001$) across periods, except for immature males versus immature females during the 1960-73 period ($P = 0.054$). Immatures had higher recovery rates than did adults ($P < 0.05$) except for immature versus adult males banded during the early period. Mississippi Flyway waterfowl hunters accounted for 38-73% of all mallard recoveries. Arkansas was in the top 3 harvest states for all age-sex cohort comparisons. More direct than indirect recoveries occurred in South Dakota for all age-sex cohorts as well as in other Central Flyway states. Proportionately, more mallard recoveries occurred during October. Overall, there was a decline in recovery rates across year periods and males and immatures had higher recovery rates than did females and adults, respectively. The Mississippi Flyway and to a lesser extent the Atlantic Flyway contributed substantially to the harvest of SLNWR banded mallards.

Trace element levels in eggs and blood of eiders nesting on the Yukon-Kuskokwim Delta, Alaska.

*JAMES B. GRAND, USGS., Alabama Coop. Fish Wildl. Res. Unit, Auburn Univ., AL; J. CHRISTIAN FRANSON, USGS, Nat. Wildl. Health Ctr., Madison, WI; PAUL L. FLINT & MARGARET R. PETERSEN, USGS, Alaska Biol. Sci. Ctr., Anchorage, AK.

Exposure to trace elements can cause mortality and reduced productivity in waterfowl. High mortality and low productivity may have contributed to declines in threatened populations of spectacled eiders. During 1996, we measured concentrations of arsenic (As), cadmium (Cd), lead (Pb), mercury (Hg), and selenium (Se) in blood and eggs of spectacled and common eiders on the Yukon-Kuskokwim Delta, Alaska and evaluated their effects on reproduction. Se concentrations in the blood of females were correlated with concentrations in their eggs. During brood rearing, blood Se levels were higher in adult females than in ducklings, but levels of As, Cd, Hg, and Pb were similar. Concentrations of Pb in the blood of spectacled eider females were higher in comparison to common eider females captured at hatch, but levels of the other four metals were similar. Concentrations of As, Cd, Hg, and Pb in blood and eggs were not correlated. Metal concentrations in blood were not different among females that abandoned their nests, those that nested successfully, and those that were unsuccessful, nor did metal concentrations in blood differ between females laying all viable eggs and those that laid at least one inviable egg. Metal concentrations did not differ in viable versus inviable eggs. Although concentrations of Se in blood samples taken from spectacled eider females early in the breeding season were higher than those reported to be associated with mortality in experimental studies with mallards, blood Se in eiders declined rapidly. We conclude that nest success and egg viability are not related to the concentrations of the five trace elements that we measured in the blood of females or their eggs.

Northern shovelers wintering in western France: foraging behavior, habitat choice and an artificial wetland. * MATTHIEU GUILLEMAIN, HERVE FRITZ & PATRICK DUNCAN, Centre d'Etudes Biologiques de Chizé, CNRS-UPR 1934, Beauvoir-sur-Niort, France.

The ecology of wintering northern shoveler has received little attention, especially in European wintering quarters. The marshes of Rochefort, Western France, are an important area for this species, with numbers of shovelers regularly exceeding the Ramsar criterion of international importance. We studied the distribution of shoveler at three levels: the whole wetland, pond and feeding depth. Within the 25 000ha wetland, shovelers concentrate in one of four reserves, a 100 ha sewage works where 90% of the birds are found during daylight hours in early winter. Nocturnal observations show that the site is also used as a foraging habitat by more than half of the individuals. They do not distribute at random over the eight ponds of the station, but seem to compromise between safety (i.e. pond size) and food abundance (i.e. density of zooplankton, their main prey). Invertebrate samples show that zooplankton populations crash during the winter at the sewage works, which is associated with a gradual abandon of the site by ducks. However, the duck population at the scale of the whole wetland remain fairly stable, due to a shift of birds to the three other areas. Food availability thus appears to be a main determinant of wintering site selection by this duck species. Diurnal and nocturnal behavioral observations show that shovelers switch their foraging methods across the 24-hour cycle, foraging close to the water surface at night and increasing their foraging depth around midday. These diel variations of foraging depth are consistent with the classical pattern of day-night vertical migrations of zooplankton, suggesting that food accessibility could also be a major factor affecting the selection of a search method by this duck species. These results shows the importance of artificial wetlands for the conservation of northern shoveler in this, as in other wetlands.

Feeding tactics of wintering granivorous ducks: exploring the role of competition in the selection of foraging depth. *MATTHIEU GUILLEMAIN, HERVE FRITZ & PATRICK DUNCAN, Centre d'Etudes Biologiques de Chizé, CNRS-UPR 1934, Beauvoir-sur-Niort, France.

Most animals use a range of feeding methods. Switching between search methods within a habitat is an important component of foraging strategies but has received little attention. We monitored search method selection by mallard, pintail and teal at two protected areas of western France, and completed the study with laboratory experiments. We distinguished shallow foraging (i.e., only the bill submerged) and deep foraging (i.e., head and neck underwater, or upending). All species at both sites selected shallow foraging at the beginning of winter, which was consistent with experimental results showing that this search method provided higher food intake rates. Shallow foraging may also allow ducks to monitor their environment and detect potential predators to some extent. Ducks subsequently changed their search methods, and at the end of the winter most of them were upending. This switch between methods did not appear to be linked to a lower predation risk, or to interference competition. Our field and experimental results suggest that food depletion is responsible for these behavioral adjustments. The selection of a search method by dabbling ducks seems to be the result of a trade-off between the cost of vigilance and feeding competition. The strong preference of dabbling ducks for shallow foraging has important implications for the management of wetlands, especially concerning shape and steepness of banks.

Predicting waterfowl breeding distribution using a GIS modelling method. *KARLA L. GUYN & BRIAN H. KAZMERIK, Ducks Unlimited Canada, Oak Hammock Marsh, MB; LLWELLYN M. ARMSTRONG, JAMES H. DEVRIES & DAVID W. HOWERTER, Instit. Wetland and Waterfowl Research, Ducks Unlimited Canada, Oak Hammock Marsh, MB.

In an effort to better focus Ducks Unlimited Canada's (DUC) resources, conservation initiatives will be directed to those landscapes and programs that are most likely to contribute to the recruitment of waterfowl populations in the prairie and parkland ecoregions of Western Canada. To aid in the strategic planning process, DUC is developing a GIS-based regional decision support system. As a first step in this process, we generated a Predicted Waterfowl Breeding Distribution Map for the Prairie Provinces. Using CWS/USFWS waterfowl survey data, wetland characteristics derived from Ducks Unlimited's Wetland Habitat Inventory, Canada Land Inventory for Waterfowl Capability (CLI), and latitude/longitude, waterfowl abundances were modelled as a function of temporally-dependent and time-invariant variables such as total wetlands, deep marsh acres, and CLI. Modelling challenges included information available at various spatial resolutions, large and small-scale spatial autocorrelations, and images obtained over multiple years with varying environmental conditions. We will discuss approaches we took to address these issues and will present the results for a seven species model. In the future, the decision support system also will include an upland habitat component. Digital land cover data will be used in combination with the Predicted Waterfowl Breeding Distribution to identify areas with both high waterfowl potential and landscape metrics that are indicative of high production.

A landscape and regional evaluation of the distribution of breeding American black ducks in the Maritimes. ALAN R HANSON & MYRTLE BATEMAN, Can. Wildl. Serv., Sackville, NB;

*C. DAVISON ANKNEY & ROBERT BAILEY, Univ. Western Ontario, London.

To address concerns over the decline of American Black Duck (*Anas rubripes*) populations, annual spring surveys of breeding Black Ducks were initiated in 1990 in New Brunswick and Nova Scotia. There is considerable variation in the number of Black Duck pairs observed among survey plots (e.g. 0 - 37 per 100 km² in 1990). Although much is known about habitat selection by breeding Black Ducks at a local level, the reasons for observed variation in Black Ducks among survey plots is unknown. Predictive models of Black Duck breeding pairs were developed using data from: 1052 water samples collected within the survey plots; Canadian Soil Information Survey; NTS topographic maps; Provincial Soil Surveys; Ecological Land Classifications; and the Maritime Wetlands Inventory. The Inventory includes information on wetland biophysical form, size, surrounding habitat, hydrologic connectivity, location in watershed, interspersed aquatic vegetation, and cover type for all wetlands over 0.25 ha in New Brunswick and Nova Scotia (ca. 67,000 wetlands). Models developed using different variables, different spatial scales and different survey years will be presented. Spurious correlations, predictive population models, and ecological relationships will be discussed.

Numbers and productivity of ducks in the subarctic taiga near Yellowknife, Northwest Territories, 1962-98. JAMES E. HINES and MICHAEL A. FOURNIER, Can. Wildl. Serv., Environment Canada, Yellowknife, NT.

The numbers and productivity of dabbling and diving ducks were monitored on a 38-km² study area near Yellowknife, Northwest Territories from 1962-65 and 1985-1999. We describe the significant long term and annual variations in the local numbers and reproductive success of the 4 most abundant species (lesser scaup, mallards, green-winged teal, and American wigeon) Factors which have likely limited the productivity of ducks on the study area are discussed as are the management implications of the long-term study.

Wetland seed dispersal potential of ducks. *MARGARET L. HOLT, USDA - Nat. Res. Cons. Serv., Hampton, Iowa; ARNOLD VAN DER VALK, Dept. Bot., Iowa St. Univ., Ames.

Though much is known about waterfowl feeding preferences, little is known about the ecological consequences of waterfowl feedings. This study consisted of feeding trial experiments where captive mallards were fed known quantities of either *Atriplex patula* L., *Chenopodium album* L., *Chenopodium rubrum* L., *Echinochloa crusgalli* L., *Polygonum* spp., *Scirpus acutus* Muhl., *Scirpus validus* Vahl., or *Sparganium eurycarpum* Engelm. Fecal samples were collected from these ducks for >24 hours post feeding. Seeds were sorted from the fecal material, counted and tested for viability. Seed size and a proxy for seed coat strength (percent acid detergent lignin) were measured on subsets of seeds used in feeding trials. Of seeds fed to ducks 23% were recovered, 36% of which were viable, at a mean time after force feeding of 7.6 hours. Differences in viability and passage rate were found between species. Seed size and seed coat strength were positively correlated with probability of successful passage. Seeds evacuated from ducks had lower viability than control seeds, on average.

Age and sex-specific distribution patterns of surf scoters (*Melanitta perspicillata*) wintering in the Strait of Georgia, British Columbia. SAM IVERSON & FRED COOKE, Ctr. Wildl. Ecol., Simon Fraser Univ.; SEAN BOYD, Can. Wildl. Serv., Delta, BC.

Seaduck life history strategies are generally characterized by high annual adult survival, delayed reproductive maturity, and variable annual production of young. Given these traits, recruitment, the process by which young birds are added to the breeding population, is a crucial demographic parameter for predicting population trends and dynamics within the tribe. I investigated age and sex-specific distribution patterns of surf scoters (*Melanitta perspicillata*) wintering in the Strait of Georgia, BC, to improve our understanding of the population biology and social foraging behavior of the species. Immature male surf scoters have a unique sub-adult plumage, which allows sex and age-specific counts to be made on winter flocks. However, flock distributions may be non-random with respect to sex or age-class, a factor which must be considered before winter counts can be used reliably to estimate recruitment. I present preliminary data on the winter sex and age composition of surf scoter flocks on a nested geographic scale: from single foraging sites, throughout the Strait of Georgia, and on a Pacific coast latitudinal cline. I also propose an approach for determining how behavioral interactions can regulate the size and degree of segregation present in foraging flocks.

Oldsquaw diet before and after ice formation in the Belcher Islands, Nunavut. *SARAH E.

JAMIESON, Memorial Univ. Nfld, St. John's, Nfld; GREGORY J. ROBERTSON, Can. Wildl. Serv., Mount Pearl, Nfld; H. GRANT GILCHRIST, Can. Wildl. Serv., Yellowknife, NWT.

Little is known about the diet of wintering oldsquaw (*Clangula hyemalis*), especially from the sites where they winter within ice leads and polynyas. In the fall and winter of 1998-1999, we collected oldsquaw in the Belcher Islands, Nunavut, to determine their diet. Collections were made in late October-early November before sea ice had formed, and in February and March, the time of maximum ice cover. Eight birds collected in the fall and 19 collected in the winter had food items in the proventriculus/esophagus. For birds collected in the fall, 88.8% (aggregate wet mass) of the diet consisted of the amphipod *Calliopius laeviusculus*, the rest of the diet consisted of other smaller amphipods (5.4%) and sandlance (*Ammodytes* spp.) (5.8%). In the winter, most of the diet consisted of the amphipod *Ischyrocerus anquipes* (69.2%), fish eggs (probably sandlance) (24.3%), sandlance (1.2%) and other amphipods (5.3%). Oldsquaw foraging at the landfast ice floe edge fed mostly on eggs and fish, while those in polynyas fed on amphipods. Compared to some other studies, oldsquaw wintering the Belcher Islands tend to consume more mobile prey and, at least in this sample, gastropods and mollusks were not major food items in the diet.

Exposure effects of mallards on a hypersaline playa. *CLINTON W. JESKE, National Wetlands Research Center, 700 Cajundome Boulevard, Lafayette, LA; MARY C. FINLEY, Johnson Controls Work Service, 700 Cajundome Boulevard, Lafayette, LA.

Many playa lakes in southeastern New Mexico provide important habitat for breeding, migrating, and wintering shorebirds, waterfowl, and raptors, and are used as terminal disposal basins for wastewaters generated from potash (brines) and oil and gas extraction (produced waters). To determine toxicity of the waters of Laguna Toston, five male and five female mallards were randomly assigned one of three treatments with water source being the variable of interest. Blood serum samples were analyzed for serum osmolality, and sodium levels, and total white cell counts, differential white cell counts, and Packed Cell Volumes (PCV) were determined at the start and conclusion of the trial. Six of the birds died within the 24-hour period and 5 others were *in extremis*. All birds exposed to the waters of Laguna Toston were heavily encrusted with salt. Ionic composition of the encrustation was principally sodium chloride which differed from the composition of the water and the precipitate around Laguna Toston. Encrustation was visible on the birds within 30 minutes of initial exposure. The main histopathologic change found was varying degrees of congestion in the brains. Serum potassium levels were similar and higher than controls for both treatments. Both serum sodium and osmolality increased throughout the trial and were significantly higher than controls. The hyper saline conditions in Laguna Toston resulted in birds rapidly encrusting with salt, limiting their ability to escape and compromising their plumage integrity. The increased salinity in Laguna Toston as a result of the brine pumped in from the potash processing has resulted in the mortality of migratory waterfowl.

Lead shot ingestion and lead concentration in mottled ducks. *WILLIAM P. JOHNSON, Texas Parks & Wildlife, Canyon; J. DALE ORTEGO, Dept. Chem., Lamar Univ., Beaumont, TX; DAVID S. LOBPRIES, Texas Parks & Wildlife, Wharton; and M. TODD MERENDINO, Texas Parks & Wildlife, Bay City.

Mottled duck gizzards were examined for evidence of ingested lead shot from 1987 through 1999. Gizzards were obtained from hunter-killed ducks at public hunting sites along the Texas coast. The mean ingestion rate of ducks from the Texas Central Coast was 7% and that of ducks from the Texas Upper Coast was 19%. Lead ingestion rates declined at a rate of -0.07 and -0.04 shots per year along the Central and Upper Coasts, respectively. During the 1998/1999 hunting season we also examined lead concentrations in wing-bones of mottled ducks collected from public hunting areas along the Texas Central and Upper Coasts, and Southwestern Louisiana. Lead concentrations averaged 18 ppm for after-hatching-year (AHY) ducks and 15 ppm for hatching-year (HY) ducks. In AHY birds, bone-lead levels differed among the three regions ($P = 0.046$), with the largest exposure area being the Texas Upper Coast where 65% ($N = 35$) of the ducks were exposed to lead (i.e., they had concentrations >10 ppm). Lead levels in HY birds did not differ among the three regions ($P = 0.271$). Evidence of lead in mottled ducks remains high despite a 20-year ban on use of lead shot. However, our use of hunter-killed birds might have contributed to the high evidence of lead. Studies evaluating the effects of lead levels on mottled duck survival are needed to determine the impact of lead contamination throughout the duck's range.

The roles of heterogeneity and scale in mallard nest site selection. *PETER E. JOYCE & R.K.

BAYDACK, Natural Resources Instit., Univ. Manitoba, Winnipeg; N. KENKEL, Dept. Botany, Univ.

Manitoba, Winnipeg; D.W. HOWERTER & T.W. ARNOLD, Instit. for Wetland Waterfowl Research, Oak Hammock Marsh, MB.

Waterfowl use of tall, relatively homogeneous upland nesting cover established as part of the North American Waterfowl Management Plan has often been lower than predicted by computer planning models. Little information exists regarding the influence of patchiness or the spatial scales at which mallards select nesting habitats. The present study addresses these questions at the level of the nest site, and should provide new information to managers concerned with improving the attractiveness and productivity of nesting habitat for prairie waterfowl. In 1998, a random sample of 64 mallard nests was chosen from all nests located on the 64 km² (25 mile²) Prairie Habitat Joint Venture Assessment (PHJV) site near Minnedosa, Manitoba. Vegetation characteristics were measured within 4x4 m, 16x16 m, and 32x32 m sample grids, centered at each nest and at paired random points. At all scales sampled, preliminary analysis indicates that average visual obstruction was greater at nest sites than at random sites. Mallards also appear to select "patchy" nest sites at some scales: cover was more diverse at the 4x4 m scale, and interspersions of cover types was greater in nest sites at 4x4, 16x16 and 32x32 m scales. Further analysis will examine and identify other spatial patterns in the data, and the scales at which mallards may perceive and select nesting habitat. The present study dovetails with broader scale research by PHJV partners. Management recommendations will be presented in view of the final study results and these findings.

Artificial nest box use by Orinoco geese (*Neochen jubata*) in the Venezuelan Llanos - an evaluation of a potential conservation tool in the Neotropics. *KENNETH KRIESE, Dept. Wildlife, Fish and Cons. Biol., Univ. Calif. - Davis, CA.

Orinoco geese (*Neochen jubata*) are tropical, non-migratory sheldgeese endemic to South America and partial to lowland rivers and wetlands in open grasslands with scattered trees. Once numerous, this species has experienced recent population declines and has been listed as near-threatened by the Threatened Waterfowl Species Group, IUCN, ICBP and Bird Life International. Unfortunately, Orinoco geese have also been very poorly researched. Therefore, I have initiated a study of the breeding biology of Orinoco geese and an assessment of the impact of artificial nest boxes as a management tool. This project will evaluate the suitability of nest boxes as a substitute for natural tree cavities by comparing nest data and reproductive success from both types of nest locations. We are also monitoring the response of local populations to artificial cavities to evaluate whether the availability of natural nest cavities is limiting Orinoco goose reproductive success. Finally, we are studying behavior, such as the presence or absence of territoriality and brood parasitism, factors found to impact nest box use and reproductive success. The results of this study will add a neotropical perspective to our understanding of Neararctic and Palearctic cavity nesting waterfowl, and will evaluate the potential for nest boxes as conservation tools in tropical habitats. It will also guide future research efforts, such as a determination of how the fragmentation of tropical forests will impact other cavity-nesting waterfowl. The data presented here are the initial results following one breeding season.

The influence of mammalian predators on dabbling duck nest-site selection. *VANCE G. LESTER, Dept. Biol., Univ. Saskatchewan, Saskatoon; ROBERT G. CLARK, Can. Wildl. Serv., Saskatoon, SK.

Nest predation is the primary cause of nest failure in many groups of birds, including ducks. There has been much controversy over the relative importance of nest-site characteristics with regard to how they influence reproductive success or survival. Thus, choice of nest site location has far-reaching implications for reproductive success and survival, and female attributes or tactics that reduce the probability of predators finding the nest should be favoured. We characterized nest-site characteristics at >1000 naturally occurring dabbling duck nests and >1000 random sites in south-eastern Saskatchewan to investigate whether the pattern of observed nest-site characteristics is influenced by nest predators. Nest predation pressure was experimentally manipulated through predator removal to address whether: (1) intra-specific differences exist in nest-site characteristics of successful and depredated nests; (2) differences occur in nest-site characteristics between areas of high predation pressure and low predation pressure; and (3) patterns of nest-site selection change throughout the nesting season in relation to predation pressure. This study is among the first to experimentally manipulate predation pressure to investigate effects of predators on nest site selection of ground-nesting birds.

Determining waterfowl exposure to inorganic environmental contaminants. *JEFFREY M. LEVENGOOD, Ctr. Wildl. Ecol., Illinois Nat. Hist. Surv.; LORETTA M. SKOWRON, Analytical Chem. Technol. Unit, Ill. St. Water Surv.; KRISTI D. CALDWELL, Ctr Wildl. Ecol., Ill. Nat. Hist. Surv.

We used a simulated gizzard environment to examine the exposure of wild and sentinel (released) mallards to elevated concentrations of Cd, Zn, and other elements present in a seasonally-flooded waterfowl impoundment. Exposure levels were compared to those of ducks using a reference site located 146 km distant and having a similar management regime. Extraction of elements from gizzard contents indicated that mallards experienced greater exposure to cadmium and zinc at the contaminated wetland than at the reference site, and ingesta cadmium and zinc concentrations were higher in sentinel ducks than in wild mallards using the former. Wild and/or sentinel mallards collected from the contaminated area also experienced greater exposure to Ba, B, Ca, Co, Fe, Mn, Ni, P, Pb, and Sr than wild mallards from the reference site or pre-release farm-raised ducks, respectively. Our results indicated that this technique is a sensitive method of determining exposure of waterfowl to environmental contaminants.

Using GIS to predict the attractiveness of wetlands and accessibility to uplands for breeding

waterfowl *CHARLES R. LOESCH & RONALD E. REYNOLDS, U.S. Fish Wildl. Serv., Bismarck, ND. The U.S. Fish and Wildlife Service has a long history of protecting wetland and grassland resources in the Prairie Pothole Region of the United States. Implementation of various easement, acquisition, and private lands programs has predominantly occurred based on opportunities provided by private landowners, with limited emphasis on targeting specific areas for protection. Declines in continental waterfowl populations coupled with reduced financial resources has resulted in a need to prioritize areas for protection and/or enhancement of upland and wetland habitats. We used 12 years of waterfowl pair count data (1987-98) from wetlands of known type and size, to develop pair-wetland relationship models. Predicted pairs were related to wetland size, type, and geographic location. These models were applied to U.S. Fish and Wildlife Service National Wetlands Inventory digital wetland data to predict the attractiveness of individual wetlands to mallards (*Anas platyrhynchos*), blue-winged teal (*A. discors*), gadwall (*A. strepera*), Northern pintail (*A. acuta*), and Northern shoveler (*A. clypeata*) pairs. Hen travel distances from core wetlands to upland nesting sites were used to develop an upland accessibility function to prioritize uplands for protection or management.

White-cheeked pintail (*Anas bahamensis*) hen and brood survival in Puerto Rico. *MARISEL LÓPEZ-FLORES & FRANCISCO J. VILELLA, Dept. Wildl. Fish., Mississippi St. Univ. and Mississippi Coop. Fish Wildl. Res. Unit; RICHARD M. KAMINSKI, LOREN W. BURGER & BRUCE D. LEOPOLD Dept. Wildl. and Fish., Mississippi St. Univ.

Coastal wetlands of Puerto Rico and the Virgin Islands have been significantly reduced in area and quality during the 20th century. The Humacao Wildlife Refuge (HWR) in eastern Puerto Rico contains estuarine lagoons used by migratory and resident species of waterfowl, including White-cheeked pintail. This island endemic species of Puerto Rico and the Virgin Islands has declined in abundance due to loss of suitable habitats and predation among other possible exogenous factors. Preliminary observations of radiomarked White-cheeked Pintail females indicate they nest successfully in emergent vegetation and atop artificial platforms and coconut palm stumps, but their ducklings disappear within two weeks after hatch. We will radiomark > 30 nesting female white-cheeked pintails and 3 randomly selected ducklings per brood in 2000-2002 to estimate survival and cause-specific mortality of ducklings and brood hens and relate probabilities of hen and duckling survival to wetland use, in order to identify suitable habitats for pintail brood rearing.

Effects of back-mounted radio transmitters with a subcutaneous anchor on mallard ducklings.

*KAREN L. MACHIN, Dept. Vet. Physiol. Sci., Univ. Saskatchewan, Saskatoon.

Waterfowl broods are difficult to monitor because of high mobility and low visibility. More accurate estimates of duckling survival may be obtained by radio-marking ducklings within the brood, however, transmitters may have deleterious effects. Most studies report few effects of transmitters but ducklings in these studies were raised in ideal conditions. Thus, I examined the effects of radio transmitters on mallard (*Anas platyrhynchos*) ducklings raised in outdoor pens, exposed to natural environmental conditions. Ducklings were hatched and raised by brood hens at St. Denis National Wildlife Area, Saskatchewan. In 1997, 36 day-old ducklings (5 broods) were divided randomly into 2 matched groups, with half the ducklings in each brood receiving transmitters and half the ducklings did not receive a transmitter but were handled for the same amount of time. In 1998, 154 day-old ducklings (21 broods) were divided randomly into 3 groups with one third of the brood receiving a transmitter, one third a sham surgery and one third control. In 1997, duckling mortality in the transmitter group (29%) was significantly greater than in the control group (5%). In 1998, 37% of transmitter ducklings died, whereas 8% sham ducklings and 4% control ducklings died. Duckling mortality in the transmitter group was significantly greater than in the control group but mortality did not differ between control and sham groups. Results also suggest that back-mounted radio transmitters have sublethal effects on

duckling growth and behaviour. Researchers should be cautious when interpreting duckling survival using radio transmitters.

Smart eagles and dead ducks: Bald eagle predation on an eider colony. *PAUL MATULONIS, American Mus. Natural Hist. and City College of NY, New York.

Natural catastrophic events can have severe effects on local populations. At the La Perouse Bay research station a colony of common eiders that we have monitored for nearly 30 years has recently been targeted by an influx of (immature) bald eagles. Although eagle predation on ducks is not uncommon, it was never noted en masse in this location prior to 1998. Eagle predation within this colony differs from mammalian or other avian predation in that the eagles seem to prefer hunting the adults whereas other predators generally take only eggs. Additionally, after each eagle attack many members of the eider colony temporarily vacate their nests allowing other avian predators undefended access to eggs. Continued harassment, predation, and total nest failure due to abandonment may result in the demise of this nesting colony. We present monitoring data that documents predation within this colony as well as the number of eagle sightings in the area. Eagle predation is compared to predation by other species and is shown to be more destructive than either fox, gull, or raven predation on the colony.

Molecular population genetics, phylogeography, and conservation biology of the mottled duck.

*KEVIN G. MCCRACKEN, LSU Mus. Natural Science, Baton Rouge, LA; WILLIAM P. JOHNSON, Texas Parks and Wildlife Dept., Canyon; FREDERICK H. SHELDON, LSU Mus. Natural Science, Baton Rouge, LA.

The mottled duck (*Anas fulvigula*) is a year-round endemic resident of the Gulf Coast and one of two non-migratory dabbling ducks that inhabit North America. To investigate population genetic structure of allopatric mottled duck populations, we collected 5' control region sequences (bp 78-774) from the mitochondria of 219 mottled ducks sampled at 11 broadly spaced geographic localities in Texas, Louisiana, and Florida and compared them to homologous sequences obtained from 4 Mexican ducks (*Anas diazi*), 13 American black ducks (*Anas rubripes*), and 10 mallards (*Anas platyrhynchos*). Haplotype relationships reveal a large terminal clade (52.5% of mottled ducks sampled in our study) composed of two reciprocally monophyletic clades of mottled duck haplotypes, one of which is endemic to Texas and Louisiana and the other endemic to Florida. No mottled ducks sampled in Florida appear in the clade composed of mottled ducks from Texas and Louisiana or vice versa, suggesting that (1) an enduring geographic split has existed for many years between east and west, and (2) gene flow currently is non-existent (or at least undetectable) across the central Gulf Coast. The remaining 47.5% of mottled ducks sampled in our study branch basally from this derived clade, show substantially less hierarchical structure, and fall into various lineage groups of mixed species composition with no clear geographic or species-specific pattern. Our findings are consistent with a pattern of partial lineage sorting from a polymorphic ancestral gene pool and yet undetermined levels of introgressive hybridization across New World mallard species boundaries.

Breeding waterfowl surveys in southern Ontario, 1971 - 2000. *GARY B. MCCULLOUGH, DARRELL G. DENNIS (retired), NORM R. NORTH & JAMES P. VANOS, Can. Wildl. Serv., London, Ont; R. K. ROSS & B. CAMPBELL, Can. Wildl. Serv., Nepean, Ont.

The Canadian Wildlife Service began operational surveys of breeding waterfowl in southern Ontario (132,000 km²) in 1971, as reported in Dennis (1974) and Dennis et al. (1989). These surveys of 349 (.8x.8 km) plots were designed to produce a breeding pair index for the common waterfowl species in southern Ontario and provide a benchmark against which to measure population trends. Data from 1971 to 1987 indicated increasing trends for mallards, wood ducks and Canada geese with populations doubling in 43, 17 and 13 years respectively. Decreasing trends were observed for black ducks and green-winged teal, with populations declining by one half every 11 and 19 years respectively. Preliminary analysis of trends from 1987 to 1998 indicate that the populations of mallards and wood ducks have remained stable, while the Canada goose population continues to grow exponentially. The trend in declining numbers of black ducks and green-winged teal continues. Density of indicated breeding pairs (IBP) in 1998 was 137 mallard and 51 wood duck per 100 km². Distribution of IBP density, illustrated using SPANS potential mapping, indicates the importance of wooded habitats, especially beaver ponds, for wood ducks, mallards and black ducks.

Waterfowl use of created wetlands in northeast Wyoming. *MARK C. MCKINSTRY & STANLEY H. ANDERSON, Wyoming Coop. Fish Wildl Res. Unit, Laramie, WY.

Over 1,500 wetlands have been created in northeast Wyoming as a result of bentonite mining. The potential for future creation is high and many groups are interested in impacting wetland creation during the construction/reclamation stage to improve habitat for waterfowl. We examined a sample of 92 bentonite wetlands for waterfowl use. Our main objective was to relate waterfowl use with physical habitat that could be modified during the construction phase. In general, waterfowl used wetlands that were >1.0 ha in size, with abundant emergent and submersed vegetation, and that were located within complexes of >5 wetlands within a 1 km radius. Wetlands created through bentonite mining tend to be small (<0.5 ha), shallow, and unvegetated, but no current guidelines exist for improving their design. Aquatic vegetation in these ponds is slow to establish due to a lack of natural wetlands that can provide a source for propagules and seeds, and poor growing conditions due to high salinity levels. Our current research is focusing on techniques to establish aquatic vegetation and henceforth improve habitat for waterfowl. Building on the concept of wetland complexes, biologists and engineers could improve this region's wetland resources dramatically if aspects of waterfowl ecology and management were incorporated into the design of future sites.

Population dynamics of oldsquaws breeding in Alaska: modeling for a small and dispersed population.

*JULIE A. MORSE & PAUL L. FLINT, Biol. Res. Div., USGS-Alaska Biological Science Center; J. BARRY GRAND, Alabama Coop. Fisheries Wildl. Res. Unit, Auburn Univ., Auburn, AL. Population estimates for oldsquaws (*Clangula hyemalis*) breeding in Alaska have declined drastically from mid-1970s estimates. This decline has resulted in a petition to list the oldsquaw under the Endangered Species Act. Due to the low density of breeding birds, very little is known of oldsquaw biology and potential explanations for this long-term decline are lacking. In conjunction with other studies, we typically find 20 to 30 nests every year along the outer coastal fringe of the Yukon-Kuskokwim Delta in Alaska. We found lead exposure rates similar to sympatric nesting Spectacled eiders and we believe lead poisoning may be contributing to the population decline. Mayfield estimates of nest success averaged 36% from 1991 - 1999 and mean clutch size was 7.0 ± 1.0 . Duckling survival estimates were quite low and averaged 7% over 2 years. Based on recaptures of marked females, annual survival was estimated at 73%. Using these estimates as input, we developed a simple model that suggests our study population is declining. While this model is oversimplified and relies on limited data, it provides the only framework available for developing a management strategy. We caution managers not to postpone important decisions for this small and declining population as detailed estimates of life history parameters may be unattainable.

Distribution and trends in duck breeding populations in the Czech Republic.

*PETR MUSIL Instit. Applied Ecology, Kostelec nad Ěrnými lesy, CZ - 281 63, Czech Republic. The nation-wide, "Monitoring of Water Bird Breeding Populations in the Czech Republic", started in 1988. Annually, 462-740 water bodies in various regions of the Czech Republic are investigated. Data sampled by this census programme were used for the analysis regional patterns of distribution and trends of selected waterfowl species. Significant decrease was found in 4 of 9 duck species analysed (mallard, shoveler, pochard and tufted duck). Fluctuations, and no significant trends in numbers, were found in the other species. Regional patterns in distribution and changes in numbers were found in several species. Gadwall seems to be the most abundant duck species in some regions of South Bohemia where it has been increasing. Numbers of red-crested pochard have increased in the south-eastern part of the country. Breeding populations of goldeneye are restricted to only two areas (Tøeboð Biosphere Reserve, Odra floodplain). Pochard prefer fishpond regions at lower altitudes while mallard are the most common duck species in fishpond systems consisting of smaller water bodies. Similarity of regional population trends was generally positively correlated with species abundance. The highest values of regional similarity in population trends were found in decreasing species, eg. tufted duck. Among causes affecting a decline of tufted duck, intensive management of fishponds (extremely-high fertilization levels and high grazing effect of fish stock) is most often suggested.

Plant dispersion and depletion by learning foragers.

*BART A. NOLET, Dept. Plant-Animal Interactions & WOLF M. MOOIJ, Dept. Food-Web Studies, Ctr for Limnol, Netherlands Instit. Ecol. We simulated canvasbacks (*Aythya valisineria*) diving for subterranean winter buds of wild celery (*Vallisneria americana*) in order to test the hypothesis that variations in bud dispersion (from clumped to uniform) had relatively minor effects on the foraging energetics of the ducks. In our model, the birds learnt about habitat quality using a linear operator rule and applied a patch leaving rule based on marginal value criteria. When the birds' expected gain rate fell below a minimum, the birds continued southward migration. We parameterized the model using data provided by Lovvorn & Gillingham (1996, Ecology) or experimental work on closely related *Aythya* ducks. We found strong effects

of bud dispersion on foraging energetics. Whether the degree of bud clumping positively or negatively affected the birds' gain depended on the parameter value of their memory updating process. Differences in cumulative gain were mainly due to differences in giving-up time and only to a minor extent attributable to differences in rate of gain. From a plant's point-of-view, clumping reduced the per capita mortality risk when the birds were forgetful and the overall habitat quality was low. This result contrasts with that of Cain (1985, Ecology), who suggested that if clumping is a plant strategy to avoid herbivory, it should occur at high rather than low densities. We conclude that ecological effects of plant clumping is highly dependent on the searching, learning and foraging behavior of the consumer.

Inventory and evaluation of waterbird use of seasonally flooded agricultural lands in the Gulf Coastal Plain. *WAYNE NORLING, USGS/NWRC, Lafayette, LA; WILLIAM L. HOHMAN, USDA/NRCS, Iowa St. Univ., Ames; PAUL C. CHADWICK & CLINTON W. JESKE, USGS/NWRC, Lafayette, LA.

The Gulf Coastal Plain (GCP) has traditionally provided habitat for millions of resident and migratory birds. Human activities and natural processes have altered habitat availability for wetland-dependent species. Rice, cultivated of the GCP since the late 19th century is a major component of the contemporary landscape. Similar to other freshwater habitats, rice fields and fields in rotation with rice (ricelands) have high potential value for wetland-dependent birds (waterbirds). To clarify relationships between farming practices and waterbird use we established 50 roadside survey routes randomly distributed on the GCP of TX and LA. Biweekly counts of waterbirds in fields within 200 m of roads were conducted from November through May, 1996-97 and 1997-98. A minimum of 70 species of waterbirds were recorded including 24 species of waterfowl. Density averaged 2,751 waterbirds/km. Expanded to GCP, ricelands in the region accommodate more than 10 million waterbirds annually. Density of all waterbirds was not associated with factors considered in our analysis. Waterfowl densities increased from dry fields to fields holding water, but were not influenced by low to medium height (0.25) vegetation or original cover (previous growing season). Geographic information system (GIS) is used to evaluate waterbird (and other waterbirds) use of ricelands in various management practices.

Individual foraging behaviour indicates resource limitation: an experiment with mallard ducklings.

*PETRI NUMMI, Dept. Appl. Zool. Univ. Helsinki, Finland; HANNU PÖYSÄ, Finnish Game & Fisheries Res. Inst., Evo, Finland; KJELL SJÖBERG & JOHAN ELMBERG, Dept. Anim. Ecol., Swedish Univ. Agric. Sci., Umeå, Sweden.

The effect of resource limitation on behavior of mallard ducklings was studied experimentally in boreal lakes. One group of human imprinted downy ducklings were taken to "rich" lakes to forage, another group to "poor" lakes. In the rich lakes, ducklings fed more and moved less than in the poor ones. In particular, ducklings on rich lakes fed more above water than ducklings on poor lakes. Variation in foraging behavior was associated with body mass change of the ducklings: the less ducklings moved and the more they used above water feeding, the more they gained weight. Our results indicate that at least some of the boreal wetlands lack duck broods because they do not provide enough food. Hence, during the breeding season there possibly occurs resource limitation at the brood stage.

Incubation recess behavior and habitat use of nesting spectacled eiders (*Somateria fischeri*) on the

Yukon Delta, Alaska. *WILLIAM T. O'CONNELL & JAMES S. SEDINGER, Instit. Arctic Biol., Univ. Alaska - Fairbanks, Fairbanks; PAUL L. FLINT, USGS - Alaska Science Center, Anchorage.

Incubation constancy is highly variable among female spectacled eiders, and it remains unclear what factors influence time spent off the nest, weight loss, and habitat use. We studied the behavior of 34 females on the Yukon Delta, Alaska in 1997 and 1998 to determine if differences in habitat use and forage availability influenced weight loss, recess frequency and duration, and activity budgets. Benthic samples were collected after hatch in both years. Recess length, behaviors, and distances traveled from nests varied among areas and years ($P < 0.05$) but not in relation to day of incubation. Females lost an average of 14.3g/day. Benthic samples consist mainly of chironomid larvae, oligochaetes, and seeds. Benthic sample data will be used to examine the relationship between female incubation patterns and food abundance.

Environmental variability and waterfowl community structure. *ERIK E. OSNAS, Indiana Univ., Dept. Biol., USA; C. D. ANKNEY, Univ. Western Ontario, Dept. Zool. London.

Ecologists have suggested that communities in stable environments should be more structured than those in variable environments (e.g., Wiens 1977, 1984, Nudds 1983, Weiher and Keddy 1995). To test this hypothesis, we studied local

community structure of dabbling and diving ducks using a null model that randomly allocated individual breeding pairs of ducks to wetlands. Deviations of observed patterns in species richness, average difference in morphology, and species coexistence from random communities were compared for each guild. These patterns were evaluated at multiple temporal scales, weekly and the entire breeding season. For all community statistics except morphology, diving duck communities deviated more from random expectation than did dabbling duck communities. Diving duck communities were more different in morphology than random over the entire breeding season but were random at any given week, suggesting strong breeding season chronology in community morphology. Dabbling duck communities were not different from random over the entire breeding season but, at the weekly time scale, were more similar than random for body length and not different than random for lamellar density. This suggests that similar types of ducks are tracking resources in a similar way at a fine temporal scale. In general, between-guild differences in community structure were consistent with predicted patterns of community structure along a gradient of environmental variability.

The size, composition, and quality of eggs and ducklings in ruddy ducks. *JEFFREY T. PELAYO,

Dept. Biol., Univ. Saskatchewan, Saskatoon; ROBERT G. CLARK, Can. Wildl. Serv., Saskatoon, SK.

Eggs of precocial birds are often characterized by greater energy densities and more functionally mature neonates than altricial species. We examined egg and neonatal composition of ruddy ducks (*Oxyura jamaicensis*), which have the largest eggs and one of the most highly developed offspring among anatidae. Fresh egg mass averaged 74.1 g and was comprised of 54% albumen, 36% yolk, and 10% shell. Dry egg components were 56% yolk, 26% shell, and 18% albumen. Lipids and lean dry mass (*LDM*) accounted for 64 and 36% of the dry yolk, respectively. Egg energy averaged 615.8 kJ/egg and 8.4 kJ/g. All egg components increased isometrically with fresh egg mass ($b = 1$). However, total egg energy showed positive allometry ($b > 1$). Wet yolk-free neonatal mass averaged 41.9 g with lipid comprising 4.9 g of the total mass. Dry neonatal mass contained 40% lipid and 60% *LDM*. Lipids and *LDM* increased in direct proportion with dry yolk-free body mass, but larger neonates had absolutely larger yolk sac reserves. Consequently, large eggs are more energy dense and produce larger ruddy duck neonates with greater yolk reserves. These factors may provide the duckling with an early survival advantage, especially during energetically stressful conditions.

Is zebra mussel consumption on the lower Great Lakes contributing to the continental scaup decline?

*SCOTT PETRIE, Long Point Waterfowl and Wetlands Research Fund, Long Point, Ont.

Since the mid-1980s continental populations of lesser (*Aythya affinis*) and possibly greater scaup (*Aythya marila*) (hereafter scaup) have declined. Several hypotheses for this decline have been advanced. One concern has been the substantial increase in the number of scaup staging on portions of the lower Great Lakes where these birds have switched to a diet dominated by zebra mussels (*Dreissena polymorpha*), a non-native bivalve introduced to nearby Lake St. Clair in 1986. Lesser (83% occurrence, $n = 57$) and greater (82% occurrence, $n = 27$) scaup consistently eat zebra mussels at Long Point, Lake Erie. Waterfowl days (an index of waterfowl use of an area) for scaup at Long Point rapidly increased from 58,000 in 1987, prior to zebra mussel colonization, to over 5 million in 1999. In the absence of natural predators and with limited competition, zebra mussels have increased; studies report densities in excess of 200,000 individuals/m² in Lake Erie and Lake St. Clair; native bivalves, which averaged 10 individuals/m² prior to zebra mussel colonization, have been almost completely displaced. This may be problematic because zebra mussels are filter feeders, and incorporate and accumulate contaminants [e.g., polychlorinated biphenyls (PCBs) and polynuclear aromatic hydrocarbons (PAHs)] into their tissue more readily than native bivalves; reproductive success in the closely related Tufted Duck (*A. Fuligula*) declines substantially when birds eat contaminated zebra mussels. Therefore, consumption of large quantities of zebra mussels may be contributing to continental scaup declines. Long Point Waterfowl and Wetlands Research Fund collected scaup on lakes Ontario, Erie and St. Clair during fall 1999 and spring 2000 ($n = 800$). Birds are being dissected and analysed for 1) types and levels of contaminants and heavy metals in liver, kidney, and breast mussel, 2) body condition (levels of fat, protein and calcium), and 3) diet. Zebra mussels will also be analysed for contaminants and heavy metals. Results may help answer questions about continental declines in scaup, and also enhance our understanding of the spring and fall staging ecology of scaup on the lower Great Lakes.

Ecology, hydrology and disturbance of western boreal wetlands: the development and delivery of a comprehensive research program to address current resource management issues in the boreal forest.

*J. BRUCE POLLARD, Instit. Wetland & Waterfowl Res., Stonewall, MB; IRENA F. CREED, Dept. Plant Sci., Univ. Western Ont., London; A. LEE FOOTE, Dept. Renew. Res., Univ. Alberta, Edmonton; GARY R.

STEWART, DU Can., Edmonton, AB; KEVIN J. DEVITO, Dept. Biol. Sci., Univ. Alberta, Edmonton; SUZANNE E. BAYLEY, Dept. Biol. Sci., Univ. Alberta, Edmonton.

Wetlands of the boreal and taiga plain of western North America are extremely important to continental waterbird populations. We initiated a research program in north-central Alberta in 1998 to further our understanding of the interaction between water source, nutrient status, vegetation structure and food web dynamics of these systems. Climate and geological setting clearly affects the linkages between uplands, wetlands and lakes. On seasonal to annual time frames, water level fluctuations are driven by basin morphology, wetland water budget, and biological factors (e.g., beaver). Although conventional wisdom suggests that boreal wetlands are stable systems relative to prairie wetlands, there is still substantial variation in water levels and pond availability. The biological productivity of wetlands and lakes is derived from nutrients carried into them by different water sources and, once in the basin, the way these nutrients are transformed and made available to organisms. Results from initial investigations suggest that waterfowl breeding in the region differentially use sites across this landscape. We present a conceptual model identifying interactions between land form, ecology, hydrology, nutrients and basic wetland properties. Resolution of the relative importance of these interactions should provide an indication of the key factors influencing use of boreal wetland systems by breeding, molting and staging waterfowl.

The Barrow's goldeneye in eastern North America: distribution, population size and threats.

*MICHEL ROBERT, JEAN-PIERRE L. SAVARD, and RÉJEAN BENOIT, Can. Wildl. Serv., Sainte-Foy, Que.

Last spring, a status report was sent to COSEWIC for an evaluation of the eastern North American population of the Barrow's goldeneye, in which we recommended classifying the population as either threatened or vulnerable. We review our state of knowledge on this small population, estimated to number 4,500 individuals or 1,400 breeding pairs (adult females comprise about 30% of the population). The first documented breeding records for eastern North America were obtained in 1998, in Quebec. Since then, using satellite telemetry, we have identified several breeding, moulting, and wintering sites. The core breeding area is located on the high plateaux north of the St. Lawrence Estuary and Gulf. Males migrate north to moult in Hudson, Ungava, and Frobisher Bays, and in a few coastal inlets of northern Labrador. Females probably moult close to the breeding areas. Nearly all of the Barrow's goldeneyes in eastern North America winter along the St. Lawrence corridor, mostly in Quebec and, to a lesser extent, in the Maritimes. A large part of the population congregates in a few areas of the St. Lawrence corridor, increasing its vulnerability. Although we do not have precise data to document a trend, we believe that the population has probably declined during the 20th Century. Current identified threats include oil spills, logging, fish introductions in breeding lakes, hunting, and contamination by toxic substances. Although a great deal of effort has been made during the past few years to document the status and ecology of the eastern population of the Barrow's goldeneye, much remains to be learned. Evidently, optimal allocation of monitoring, research and management efforts will be necessary to ensure this population's conservation.

A model for statistically discriminating gradual, catastrophic and correlated mortality from laying to fledging. *BARRY D. SMITH & W. SEAN BOYD, Can. Wildl. Ser., Delta, BC.

Recent interest in the effects of climate change on breeding success has prompted the need for a methodology to measure changes in breeding success over time. Such measurements are complicated by our knowledge that mortality of individual eggs and juveniles can occur both gradually and independently over time, or catastrophically. We introduce a multinomial likelihood model designed to measure egg and juvenile mortality rates continuously from laying to fledging using the Weibull mortality function to predict survival rates. Adjunct data series can be included as independent covariate series for evaluating their influence on the predicted survival rates. The model also statistically characterizes mortality into the extremes of gradual and catastrophic mortality, and can determine if the gradual (non-catastrophic) mortality of individual eggs or juvenile occurs as independent events or is correlated (i.e., over-dispersed). Catastrophe can be defined as extreme over-dispersion. Over-dispersion is estimated as a parameter of the beta-binomial distribution of expected mortalities, and thus differs from its treatment in Program MARK where over-dispersion is an *a posteriori* diagnostic.

Use of a maximum likelihood model of clutch and brood survivorship to describe inter-annual variation in breeding success of Barrow's goldeneye at Riske Creek, British Columbia. *BARRY D. SMITH & W. SEAN BOYD, Can. Wildl. Ser., Delta, BC; MATT EVANS, Simon Fraser Univ., Burnaby, BC.; SAUL SCHNEIDER, Can. Wildl. Ser., Delta, BC.

Since 1995, clutches and broods of Barrow's Goldeneye from hens of known identity have been tracked from laying and/or hatching through to fledging to document breeding success. The result is five years of data on number of eggs, number of ducklings, and adjunct data at frequent intervals of one to a few days for individual broods. Brood mortality, predators, and harsh weather events occurred but mortality events were rarely witnessed. Thus we used a maximum likelihood model of clutch and brood survivorship to investigate the statistical characteristics of our egg and juvenile mortality data to answer questions such as: (1) Are unwitnessed mortality events likely to have occurred independently or are they correlated? (2) When failed breeding attempts are not witnessed can we infer what proportion of failed attempts occurred as clutches or as broods? (3) Can egg or juvenile mortalities be characterized as gradual or catastrophic? The model we used was highly successful in discriminating among gradual, catastrophic and correlated mortality. In particular we show our characterizations of clutch and brood mortality varied markedly among years. We therefore advise that demographic analyses of Barrow's Goldeneye must incorporate, in a probabilistic sense, these inter-annual differences in the rates and characteristics of egg and brood mortality.

Potential effects of global warming on wetlands and waterfowl breeding in the Canadian Prairie

Pothole Region. *LISA G. SORENSON, Dept. Biol., Boston Univ., Boston, MA; RICHARD GOLDBERG, Cent. Clim. Sys. Res., Columbia Univ., NY, NY; MICHAEL G. ANDERSON, IWWR, DU Canada, Stonewall, MB; TERRY L. ROOT, SNRE, Univ. MI, Ann Arbor, MI.

The Prairie Pothole Region (PPR) of the Northern Great Plains is the most important breeding area for waterfowl in North America. All general circulation models (GCMs) predict warming of the mid-continent region under a doubling of atmospheric CO₂. Predictions of precipitation changes are less consistent, but increased moisture deficits are likely. Historically, the size of breeding duck populations in the PPR has been highly correlated with spring wetland conditions that are in turn determined by climate. We show that one indicator of climate conditions, the Palmer Drought Severity Index (PDSI), is strongly correlated with duck and pothole counts for both Prairie and Parkland ecozones within the region, indicating the utility of the PDSI as an index of climatic factors important to wetlands and ducks. Sensitivity tests show that the PDSI is highly sensitive to projected temperature increases in this region and that the Parkland region may be more sensitive and vulnerable than the Prairie to increasing temperatures. Using output from 4 GCMs, we develop projections of future moisture conditions across the PPR landscape (.5x.5 grid) for 3 time periods (2020s, 2050s, 2080s) and estimate effects on wetland and duck abundance. Three of 4 GCMs project increased drought in the coming decades with the most severe drying occurring in strata 26, 27, 35, 39, and 40 (mostly Parkland strata). We present contour maps of PDSI projections (3 time periods x 4 scenarios) for use in site-specific conservation planning. Our results suggest that significant reductions in wetland abundance and the numbers of ducks settling to breed in the Canadian PPR by the middle of the next century are highly likely.

Survival of mallard broods and ducklings produced on overwater nesting structures in eastern South Dakota. *JOSHUA D. STAFFORD & LESTER D. FLAKE, Dept. Wildl. Fish. Sci., South Dakota St. Univ., Brookings; PAUL W. MAMMENGA, South Dakota Dept. Game, Fish, and Parks, Aberdeen.

Overwater nesting structures have been shown to increase nesting success in mallards (*Anas platyrhynchos*). We evaluated survival of mallard broods produced from overwater nesting structures in eastern South Dakota during spring and summer 1998-99. Two study sites with overwater nesting structures were chosen in 1998, representing a large semipermanent marsh (Mickelson) and a complex of wetlands (Oakwood). A third site, representing a medium-sized semi-permanent marsh (Redetzke) was added in 1999. Eighty-six females and 58 day-old ducklings were radio-marked. Brood survival was high at Oakwood (71%), Mickelson (100%), and Redetzke (84.2%). Only broods with confirmed total loss or complete brood counts at ≥ 20 days post-hatch were included in duckling survival analyses. Duckling survival was 0.424 ± 0.057 to 38 ± 18 days at Oakwood (years pooled), 0.733 ± 0.035 after 40.5 ± 14.5 days at Mickelson (years pooled), and 0.467 ± 0.077 after 42 ± 22 days at Redetzke. Survival was significantly higher at Mickelson than at Oakwood ($c^2 = 21.341$, 1df, $P < 0.001$) or Redetzke ($c^2 = 9.890$, 1df, $P = 0.002$). Progressing date of nest exodus may adversely affect brood (Wald $c^2 = 7.065$, $P = 0.006$) and duckling ($F_{1,66} = 6.85$, $P = 0.011$) survival.

An experimental study of faunal communities in small wetlands on Prince Edward Island, Canada.

CAM STEVENS & ANTONY W. DIAMOND, Dept. For. & Wildl. Biol., Univ. New Brunswick, Fredricton.

We explored anuran and avian use of small, non-managed and managed (i.e., excavated) wetlands on Prince Edward Island. Pairs and broods of green-winged teal and American black ducks were significantly higher on managed wetlands

than on non-managed wetlands. American black duck brood occurrence was positively correlated with proximity to freshwater rivers and greater cattail cover in managed wetlands. The diversity of wetland obligate bird species was higher on managed wetlands than on non-managed wetlands. A community of tree swallows, American black ducks, blue-winged teal, and belted kingfishers was more frequent on managed sites. A community of swamp sparrows and sharp-tailed sparrows, and a community of common snipe, common yellowthroats, northern waterthrush, and palm warblers were associated with vegetative cover. Relative abundance of green frogs, northern leopard frogs, and spring peepers was significantly higher on managed wetlands. Small wetland excavation is a good conservation and management tool for anurans and avifauna associated with open water emergent wetlands.

Breeding ecology of white-winged scoters. *JOSHUA TRAYLOR, Dept. of Biol., Univ. Saskatchewan, Saskatoon; RAY T. ALISAUSKAS, Can. Wildl. Serv., Saskatoon, SK; F. PATRICK KEHOE, Ducks Unlimited, Regina, SK.

White-winged scoters (*Melanitta fusca deglandi*) breeding in North America have declined by 51% throughout their breeding range and by as much as 64% in core breeding areas of the prairie parklands and boreal forests of Canada since the 1980's. Recent declines and lack of knowledge regarding causes of decline underscore the need for research. Annual adult female survival is approximately 77% for white-winged scoters nesting at Redberry Lake, Saskatchewan. High adult survival and depressed age ratios (juveniles:adults) among harvested birds suggest population declines may have resulted from low recruitment of ducklings into the breeding population. Waterfowl recruitment has four constituent vital rates: nesting intensity, nest success, duckling survival, and survival from age 0 to breeding age. Our primary objectives are to investigate white-winged scoter nest success and duckling survival. We will examine nesting success and duckling and brood survival throughout the brood-rearing period, 2000, in a population nesting at Redberry Lake, Saskatchewan. Results will provide information about the sensitivity of the local growth rate of the population to various vital rates.

Parasites and declining populations of lesser scaup in the Mississippi flyway. *JOSH L. VEST and RICHARD M. KAMINSKI, Dept. Wildl. Fisheries, Mississippi St. Univ.; ALAN D. AFTON, Louisiana Coop. Fish Wildl. Res. Unit, Baton Rouge; LINDA M. POTE, Coll. Veterinary Medicine, Mississippi St. Univ.; FRANCISCO J. VILELLA, Mississippi Coop. Fish Wildl. Res. Unit, Mississippi St. Univ.

Population levels of greater scaup (*Aythya marila*) and lesser scaup (*A. affinis*) in North America have declined by >150,000 birds per year between 1978 and 1998. The 1998 estimate was the lowest since breeding waterfowl surveys began in 1955, and 45% below the North American Waterfowl Management Plan goal of 6.3 million birds. The recent downward trend in scaup populations suggests need for research to identify possible causes for the decline. Although emphasis has been focused on the possible effect of contaminants on scaup, there is growing evidence that parasites also may be impacting scaup populations. Thus, a methodical survey of parasites in lesser scaup is needed to begin understanding their potential negative effects on these diving ducks. In fall 1999 and winter 2000, a preliminary collection of hunter-harvested lesser scaup ($n \sim 150$) was made in Manitoba, Ontario, Minnesota, Wisconsin, Michigan, Illinois, Mississippi, and Louisiana to estimate (1) mean levels and variances of endoparasites in scaup and (2) adequate sample sizes for an expanded survey in fall-winter 2000-2001. The primary goals of the study are to test the effects of sex and age, geographic location and date of collection, and body condition on parasite burdens in scaup and compare current levels with available historical data.

Levels and effects of heavy metals in common and king eiders in the Canadian arctic. *MARK WAYLAND, Env. Canada, Can. Wildl. Serv., Saskatoon, SK; H. GRANT GILCHRIST, Can. Wildl. Serv., Yellowknife, NT; LYNNE DICKSON, Can. Wildl. Serv., Edmonton, AB; TRACY MARCHANT, Dept. Biol., Univ. Saskatchewan, Saskatoon; TRENT BOLLINGER, Can. Coop. Wildl. Health Centre, Univ. Saskatchewan, Saskatoon.

We examined trace element concentrations and physiological characteristics of king and common eiders at three locations in the Canadian arctic during 1997 and 1998. Cadmium levels were higher in king eiders than in common eiders, especially in the eastern arctic at East Bay (EB) where they were among the highest ever reported for eider species. Mercury concentrations were low at all locations. Selenium concentrations were higher at Holman in the western arctic than at other locations. Common eiders from Belcher Islands in southern Hudson's Bay had concentrations of these trace elements that were similar to those at EB. Body condition was unrelated to trace element concentrations. In king eiders, cadmium was negatively correlated with spleen mass. Counts of helminths were

generally unrelated to trace element concentrations. Thyroid hormones in common eiders were unrelated to these trace elements. The corticosterone stress response in common eiders was positively related to cadmium concentrations in 1998 but not in 1997. Overall, there was little evidence that these trace elements were adversely affecting these birds. Current studies are examining relationships between these trace elements and body condition, stress response and immune function.

Annual survival, recovery rates, and site fidelity of northern pintails banded on the Yukon-Kuskokwim delta, Alaska. MIKE L. WEGE, Yukon Delta NWR, Bethel, AK. *CHRIS A. NICOLAI, Univ. Alaska - Fairbanks; PAUL L. FLINT, USGS-BRD, Anchorage, AK.

We banded northern pintails at a single site on the Yukon Delta National Wildlife Refuge from 1990-1998. We used recaptures from our site in combination with hunter recoveries to model annual survival, recovery rates, and site fidelity to our capture location. Most recoveries (>90%) occurred in the Pacific Flyway with the largest number being reported from the Central Valley region in California (64%). Model selection suggests that survival varied among groups based on age and sex at initial capture. We estimated annual survival of birds originally banded as adults at 0.75 and 0.61 for males and females. Similarly, we estimated annual survival of birds originally banded as hatch year birds at 0.56 and 0.69 for males and females. Hunter recovery rates of adult males were more than three times higher than adult females and, within sexes, recovery rates of first year birds were higher than adults. Fidelity to our capture site varied among ages and sexes with estimates ranging from <31% for first year birds to 83% for adult females. The pattern of variation in survival among groups combined with fidelity estimates suggests that some level of sub-population structuring may exist for northern pintails.

Comparative analysis of incubation length in mallards, blue-winged teal, gadwalls, and northern shovelers. *ALICIA M. WELLS & HAROLD H. PRINCE, Michigan St. Univ., Lansing, MI.

Anas species should have similar embryonic growth rates that result in similar incubation period lengths. We collected fresh eggs in 1999 and 2000 from laying mallard, blue-winged teal, northern shoveler, and gadwall females nesting in dense cover near Minnedosa, Manitoba. We searched for laying females each week of the breeding season starting the first week of May through the second week of July. Mallards and northern shovelers nested from early May through June, while blue-winged teal began in mid-May and gadwalls in June. Fresh eggs were set within 4 days of collection and incubated at 37.5C and 70% relative humidity until pipped, and 85% until hatch. An allometric relationship between oxygen consumption and embryo wet weight for mallard, blue-winged teal, northern shoveler, and gadwall was developed as a non-invasive technique to analyze and compare embryonic growth rates of each species. Preliminary results showed that mallard, blue-winged teal and gadwall incubation lengths (604, 600 & 598 hr, respectively) were similar, whereas northern shoveler incubation length (562 hr) was shorter. Although incubation length declined for mallard and blue-winged teal throughout the breeding season, gadwall and northern shoveler incubation lengths were constant.

Stable carbon isotopic composition of redheads on their breeding and wintering ranges. *MARC C. WOODIN, U.S. Geol. Surv., Corpus Christi, TX; and BETH TRUST HAMMER, Univ. Texas Marine Sci. Inst., Port Aransas.

We investigated ^{13}C values of breast and leg muscle, liver, gizzard, abdominal fat, and subcutaneous fat from 276 redheads collected from the Texas winter range, South Dakota breeding grounds, and from a molting lake in Manitoba. We also measured ^{13}C values of known redhead foods from these areas. We tested the hypothesis that, as redheads change from a seagrass diet in winter, to a mixed diet while breeding, and then to a postbreeding diet of submerged aquatic vegetation, the isotopic composition of their tissues will change also. Tissue ^{13}C values, which were highest for winter birds (range = -10.0 to -13.1 %) and lowest for breeding birds (range = -22.4 to -28.7 %), changed seasonally to reflect altered isotopic composition of diets.

Aerial surveying of waterfowl in the California Central Valley. *JULIE L. YEE, JOSEPH P. FLESKES, & DAVID S. GILMER, U.S. Geol. Surv., Dixon, CA; J. GREG MENSİK, U.S. Fish and Wildl. Service, Willows, CA; DANIEL R. YPARRAGUIRRE, Calif. Dept. Fish and Game, Sacramento.

During the last decade, the California Central Valley landscape has been greatly altered by changing agricultural practices and conservation efforts such as the Central Valley Habitat Joint Venture. One of the largest changes has been an expansion of post-harvest flooding of rice fields in the Sacramento Valley. As part of a study to measure waterfowl response to habitat changes, we developed an aerial survey to observe monthly distribution of ducks, geese and swans from September to March. As in the 1970s, these periodic valley-wide counts surveyed State Wildlife Areas, National Wildlife Refuges, Suisun Marsh and San Joaquin Valley habitats. However, our survey was made more practical by the additional selection of transects across the large expanse of agricultural habitats in the Sacramento Valley and Delta. This region consists of six basins, contiguous in habitat, from which transects were selected by stratified sampling. The distribution of survey effort among the six transected basins, in terms of number of transects flown, was determined by 1996-1998 midwinter estimates of waterfowl abundance. Transects were separated by a minimum of two miles to reduce risk of double-counting birds disturbed by the airplane. The resulting sampling plan is akin to stratified systematic cluster sampling with the transect as the sampling unit. Estimates and standard errors of abundance are made accordingly on a monthly basis. Details of the aerial survey plan and preliminary results from 1998-2000 will be presented.

Recent changes in harvest derivation of mallards from the Great Lakes and prairie pothole region.

*DAVID A. ZUWERINK, & ROBERT J. GATES, School of Natural Resour., Ohio St. Univ., Columbus; MARK PETRIE, Instit. Wetland Waterfowl Res., Ducks Unlimited, Inc, Memphis, TN.

More comprehensive breeding population surveys and banding have increased our understanding of mallard populations. Eastern mallard populations have grown along with mallard populations in the U.S. prairies. Therefore, we re-analyzed harvest derivations in the United States to determine recent (1990-1997) changes associated with population changes of mallards and potential changes associated with variation in nesting productivity of mid-continental mallards. Harvest derivations for the Great Lakes/north Atlantic region show a gradual increase in the importance of eastern mallards. Mallards derived from the mid-Atlantic region increased by 12.1% in Ohio, 13.7% in New York and 52.8% in Pennsylvania. Arkansas, Illinois, Iowa, Kansas, Louisiana, Mississippi, Montana, Nebraska, North Dakota, Oklahoma, South Dakota and Texas all showed a decrease of 5% or more in mallards harvested from the Canadian prairies and a 5% or greater increase in mallards harvested from the U.S. prairies. Increases in mallards harvested from the U.S. prairies are probably related to habitat increases from the Conservation Reserve Program (CRP). Assuming migration patterns have remained relatively constant between 1961-1998, we developed a model to identify how changes in breeding populations and productivity affect harvest derivations. Recent changes in harvest derivations indicate eastern mallard populations have increased in importance to the Great Lakes region, while mallard populations in the U.S. prairies have increased in importance to the prairie pothole region. Results have application to management and allocation of habitat resources.

ABSTRACTS: Waterfowl Community Ecology in Breeding and Nonbreeding Areas in the Holarctic

[Abstracts listed in alphabetical order; NAMES of graduate students eligible for presentation awards are underlined.]

An experimental evaluation of competing hypotheses about ecomorphological relationships among breeding dabbling ducks. JOHN P. BALL, Dept. Anim. Ecol., Swed. Univ. Agric. Sci., Umeå, Sweden; *THOMAS D. NUDDS, Dept. Zool., Univ. Guelph, Guelph, ON; HENRY R. MURKIN, Instit. Wetlands Waterfowl Res., Ducks Unlimited, Stonewall, MB, Canada.

There exist competing views about the relative importance of bill morphology and neck length in facilitating coexistence among breeding dabbling ducks (*Anas* spp.). Evidence from North American and Baltic coastal wetlands indicates that species with few lamellae (but longer necks/bodies) tend to feed in shallow, vegetated microhabitats where invertebrate prey is large; species with dense lamellae (but shorter necks/bodies) tend to feed offshore where prey is smaller. In northern Europe, however, with virtually the same complement of species-types, the evidence is opposite, suggesting that differences in neck/body length instead facilitate coexistence. We exploited an existing data base from the Marsh Ecology Research Program to test the influence of morphology on microhabitat use. Between 1979-89, water depth was manipulated independently in 10 6-ha diked cells in the Delta Marsh, Manitoba, and duck abundance, habitat structure and invertebrates were monitored weekly from 1 May - 31 October each year. Regression was used to test whether the distribution and abundance of species with dense lamellae/small bodies was positively (consistent with the lamellar density hypothesis) or negatively (consistent with the neck/body length hypothesis) related to a multivariate microhabitat gradient of increasing water depth/decreasing vegetation. We underscore the need for manipulative experiments in community ecology and the role that waterfowl systems play.

Does morphology, foraging efficiency and water depth variation predict variation in local populations of dabbling ducks? * D. BRENT GURD, CWS/NSERC Centre for Wildlife Ecology, Dept. Biol. Sci., Simon Fraser Univ., Burnaby, BC.

Variation in local population size of breeding dabbling ducks (*Anas* spp.) is correlated with lamellar density and body size. Differences in these morphological features may allow partitioning of invertebrate prey between species, suggesting that species-specific foraging niches may be differentially affected by variation in wetland water depth. I tested whether species-specific foraging rates of dabbling ducks changed as a result of changing water depth using a combination of an optimal foraging model and experimental manipulations of water depth in 15 study ponds near Riske Creek, BC. The optimal foraging model was used to test for inter-specific differences in energy intake of ducks foraging for invertebrates in two dimensions: water depth and foraging depth. Energy intake was calculated as a function of filtering efficiency given prey density, prey size distributions, detritus density, and detritus size distribution. Water depth on five treatment ponds was increased between 1998 and 1999 by a minimum of 50 cm to their long-term average, greatly increasing cover of emergent vegetation. The distribution of foraging ducks and aquatic invertebrates were sampled in 1998 and 1999 on the treatment ponds and 10 control ponds to determine if increasing water depth altered the distribution of ducks and/or aquatic invertebrates.

Food habits of four diving duck species wintering in seagrass beds, Apalachee Bay, Florida.

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We studied food habits of greater scaup (*Aythya marila*), lesser scaup (*A. affinis*), redheads (*A. americana*), and buffleheads (*Bucephala albeola*) in Apalachee Bay, Florida, seagrass beds, 1990-92. Redheads (n=82) and greater scaup (n=46) consumed mostly plant matter (87% and 58% aggregate dry mass, respectively), predominately shoalgrass (*Halodule wrightii*), whereas lesser scaup (n=11) and buffleheads (n=39) consumed mostly animal matter (93% and 97%, respectively). Gastropods were the predominant animal food for redheads and both scaup species, although species composition of gastropod prey items differed among duck species. Buffleheads consumed a larger proportion of crustaceans and fishes than the other duck species. No year differences ($p > 0.05$) were found for redheads or greater scaup, the two species with adequate cell sizes for both years. Effect of species was highly significant ($p < 0.001$), but pairwise comparisons showed no differences between redheads and greater scaup, nor between buffleheads and lesser scaup. No effect of sex was found for any species, and only a weak seasonal effect ($p = 0.06$) was found for greater

scaup. Comparisons with food availability data (from core and sweep samples) indicate species differences in selectivity and preference, thus showing strong ecological separation where these four species are sympatric on the wintering grounds.

Ecomorphology and coexistence in breeding Holarctic dabbling ducks. *THOMAS D. NUDDS, Dept. Zool., Univ. Guelph, Guelph, ON; JOHAN ELMBERG, S. Swedish For. Res. Centre, Swed. Univ. Agric. Sci., Alnarp; HANNU PÖYSÄ, Finnish Game and Fish. Res. Instit. Evo; KJELL SJÖBERG, Dept. Anim. Ecol., Swedish Univ. Agric. Sci., Umeå; PETRI NUMMI, Dept. Appl. Zool., Univ. Helsinki, Finland. We have debated the effects of interspecific competition, especially in ecological time, on the distribution and abundance of dabbling ducks (*Anas* spp.), and the relative importance of bill morphology and body size in facilitating coexistence. Evidence from North American and Baltic coastal wetlands indicates that species with few lamellae (but longer bodies) tend to feed in shallow, vegetated microhabitats where invertebrate prey is large; species with dense lamellae (but shorter bodies) tend to feed offshore where prey is smaller. In northern Europe, however, the evidence is opposite, suggesting that differences in body length instead facilitate coexistence. Here, we present evidence that these views are compatible under a refined conceptual model. In both northern Europe and North America, microhabitat diversity within wetlands correlates with α -diversity (species per wetland). With increasing latitude, α -diversity decreases, coincident with changes in the shape of wetland basins from largely "saucer-" (prairie/steppe potholes) to "bowl-shaped" (nemoral/ boreal lakes and tarns). We propose that (1) there is less absolute microhabitat (water-depth/vegetation) gradient along which species can be accommodated in northern wetlands, owing to shoreline steepness, and (2) body length is more important in facilitating species co-existence among breeding dabbling ducks in "bowl-shaped" wetlands, whereas lamellar density is more important in "saucer-shaped" wetlands.

Null models of SW Manitoba dabbling duck communities: morphology, habitat, and time. *ERIK E. OSNAS, Dept. Bio., Indiana Univ., USA, C. D. ANKNEY, Dept. Zool., Univ. Western Ontario, London. Dabbling duck community structure differs between North America and Northern Europe even though many of the species are the same. Specifically, observed patterns of the relationship between habitat characteristics and morphology differs between the two regions. It is not known if this difference is due to real differences in community structure or due to methodological differences between researchers in each region. To resolve these differences and to answer basic questions about the structure of ecological communities, we studied community structure of dabbling ducks in Southwestern Manitoba using a null model approach. Observed patterns were compared to random patterns from the null model and deviations from the null model were correlated to habitat features of wetlands. These patterns were evaluated at multiple temporal scales, weekly and over the entire breeding season. Over the seasonal time scale, duck communities were slightly less species rich and not different in average morphology when compared to the null model. At the weekly time scale, however, communities were less different than average random communities. Deviations from random communities correlated to habitat variation for body length but not lamellar density, in agreement with European patterns. The scale-dependant results suggest important small-scale experiments. The null model technique allows hypotheses to be tested at spatial and temporal scales larger than that of manipulative field experiments.

Dabbling duck numbers and habitat use in relation to the availability of submerged macrophytes on an autumn staging site: a spatial model. *OLE R. THERKILDSEN, PREBEN CLAUSEN & JESPER MADSEN, National Envir. Res. Instit., Dept. Coastal Zone Ecol., Kalø, Grenaavej 12, Rønne, Denmark. A 3-D model to predict the distribution and abundance of autumn staging dabbling ducks in relation to wind induced water level changes affecting food availability in a non-tidal area in south east Denmark is presented. The model incorporates five dabbling ducks species and their main food supply (*Ruppia* spp. and *Potamogeton pectinatus*). Food biomass in relation to depth was modelled at differing water levels and the observed distributions of ducks were superimposed in a GIS-based analysis to estimate the relative importance of water level on the specific site use by the dabbling ducks. The model was expanded from a two years extensive study of species specific habitat use to a time series of ten years. The model was successful in predicting the observed distribution and abundance of dabbling ducks.