WEDNESDAY, 3 FEBRUARY 2016		
06:30 - 08:00	*Breakfast in Capital Ballroom*	
08:10 - 08:20	**Opening Remarks & Announcements**	
Capital Ballroom **08:20 - 09:40**	**E.1: Plenary**	
08:20	**E.1.1: Plenary Ken Williams** **Prospects for the Integration of Waterfowl Science and Management** (B. Ken Williams*)	
09:00	**E.1.2: Plenary Jim Nichols** **Adaptive Waterfowl Harvest Management: Where Are We and How Did We Get Here?** (Jim Nichols*, Fred Johnson, S. Boomer, B. Ken Williams)	
09:40 - 10:00	*Coffee break*	
Capital Ballroom **10:00 - 12:00**	**F.1: Strengthening the Links Between Waterfowl Research and Management** (Organizer: Tony Roberts)	
10:00 - 10:24	**F.1.1: Runge**	**Decision Analysis as a Framework to Link Waterfowl Research and Management** (Michael C. Runge*, G. Scott Boomer, Fred A. Johnson, and Byron K. Williams)
10:24 - 10:48	**F.1.2: Johnson**	**Waterfowl Conservation and the Value of Information** (Fred A. Johnson*, Byron K. Williams)
10:48 - 11:12	**F.1.3: Howerter**	**Using Science to Inform Waterfowl Habitat Acquisition and Management Decisions** (David Howerter*, Benjamin Rashford, Kathleen Fleming, Patrick K. Devers)
11:12 - 11:36	**F.1.4: Vrtiska**	**State and Flyway Perspectives on the Linkage between Research and Waterfowl Management and Conservation** (Mark P. Vrtiska*, Frank Baldwin, Greg Balkcom, Jeff Knetter)
11:36 - 12:00	**F.1.5: Eadie**	**Muddy Boots and Ivory Towers: Challenges and Opportunities of Applied Waterfowl Research in Academic Institutions** (John M. Eadie*, David N. Koons, Todd W. Arnold, Bart M. Ballard, Robert G. Clark, Scott R. McWilliams, Anthony Roberts, Chris Williams)
12:00 - 13:20	*Lunch break in Capital Ballroom*	
Capital ABC **13:20 - 15:20**	**G.1: Evolution, Ecology, and Conservation of Monochromatic Ducks** (Organizers: Ron Bielefeld, Bruce Dugger)	
13:20	**G.1.1: Dugger**	**Monochromatic Ducks - a Primer** (Bruce Dugger*, Ron Bielefeld)
13:40	**G.1.2: Lavretsky**	**Genomics of New World Mallard-Like Ducks** (Philip Lavretsky*, Jeffrey L. Peters, Kevin G. McCracken)
14:00	**G.1.3: Wells^**	**Why Are Some Ducks Brown?** (Caitlin Wells*)

*Speaker; ^Student

14:20	**G.1.4: Devers**	**Evolution, Ecology and Conservation of the American Black Duck** (Patrick K. Devers*)
14:40	**G.1.5: Wells^**	**Geographic Variation in Hybridization Between Mallards and Hawaii's Koloa Maoli** (Caitlin Wells*, Philip Lavretsky, Jeffrey Peters, Bruce Dugger, Christopher Malachowski, John Eadie, Andrew Engilis)
15:00	**G.1.6: Haukos**	**At What Scale Should Mottled Ducks Be Managed?** (David A. Haukos*, Jena A. Moon, Warren C. Conway)
Capital D **13:20 - 15:20**	**G.2: Incorporation of Hydrologic and Geomorphic Variability in the Restoration of Natural Processes: The Foundation for Producing Sustainable Wetland Resources for Wetland Dependent Wildlife** (Organizer: Leigh Fredrickson)	
13:20	**G.2.1: Fredrickson**	**Setting the Stage for Restoration and Management of Natural Processes** (Leigh H. Fredrickson*)
13:40	**G.2.2: Tashjian**	**Historic Landform Process Models: A Key to Successful Wetland and Riverine Restoration** (Paul L. Tashjian*, John Vradenburg)
14:00	**G.2.3: Henry**	**Incorporating Hydrologic and Geomorphic Variables into Wetland Management in the Intermountain West** (Adonia R. Henry*, William S. Smith, Leigh H. Fredrickson)
14:20	**G.2.4: Nelson**	**Missouri Public Waterfowl Hunting Area Wetland Renovation, Schell-Osage Conservation Area** (Frank Nelson*, Chris Daniel, Josh Cussimanio)
14:40	**G.2.5: Cordell**	**Trash the Cookie Cutter and Pick Up the Puzzle Pieces** (Keith Cordell*, Matt Bowyer, Frank Nelson)
15:00	**G.2.6: Vradenburg**	**Wetland Restoration and Management in Arid Floodplains with High Agricultural and Urban Water Needs** (John Vradenburg*)
Senate **13:20 - 15:20**	**G.3: Management** (Chair: Jim Anderson)	
13:20	**G.3.1: Hindman**	**Control of Mute Swans in the Upper Chesapeake Bay** (Larry J. Hindman*, William F. Harvey, IV, Hutchison R. Walbridge)
13:40	**G.3.2: Nichols, T.**	**Mute Swan Management in New Jersey: Lessons Learned** (Ted Nichols*)
14:00	**G.3.3: De La Cruz**	**Diving Duck Response to Mixed-Species Habitat Management in an Urban Pacific Flyway Estuary** (Susan E.W. De La Cruz*, Lacy Smith, Stacy Moskal, John Krause, Mason Hill, Ashley Smith, Kyle A. Spragens, John Y. Takekawa)

14:20	**G.3.4: Perry**	**Research and Management of Ducks on a Private Ranch in Argentina** (Don Pablo Research Team: Andrea Amaiden, Alicia Berlin, Josh Bueth, Enrique Bucher, Anibal Carbajo, Erio Curto, Marcelo Janik, Alan Jolicoeur, Scott McWilliams, Glenn Olsen, Christopher Perry, Matthew Perry*, Marcelo Prodel, Marcelo Romano, Sarah Sandoval-Mohapatra, Edward Soutiere)
14:40	**G.3.5: Elmberg**	**Success Factors Behind Multi-Stakeholder Multi-Species Management of Geese in an Agricultural Landscape** (Johan Elmberg*)
15:00	**G.3.6: Olson, A.^**	**Hot Ducks: Are Unshaded Nest Boxes an Ecological Trap for Wood Ducks?** (Ami C. Olson*^, John M. Eadie, Gary R. Hepp, Brian W. Olson)
Caucus **13:20 - 15:20**	**G.4: Techniques 1** (Chair: Don Kraege)	
13:20	**G.4.1: Evenson**	**Employing Digital Still Imaging and Observer Counts to Estimate Bias in Aerial Surveys of Wintering Sea Ducks** (Joseph R. Evenson*, Heather J. Tschaekofske, Jeffery B. Leirness, Emily D. Silverman, Tom A. Cyra, Bryan L. Murphie, Donald K. Kraege)
13:40	**G.4.2: Yetter**	**Comparison of Aerial Waterfowl Survey Methods during Fall and Spring Migration** (Aaron P. Yetter*, Heath M. Hagy, Michelle M. Horath, Joshua M. Osborn)
14:00	**G.4.3: Otto**	**Modeling Observer Detection Rates in Aerial Surveys** (Mark C. Otto*, John R. Sauer)
14:20	**G.4.4: Gilliland**	**Survey Design for Breeding Scoters: Helicopter vs. Fixed-wing** (Scott G. Gilliland*, Eric Reed, Christine Lepage, Jean-Pierre L. Savard, Daniel Bordage, Greg Robertson, Jean Rodrigue, John Bidwell, and Bill Harvey)
14:40	**G.4.5: Roche**	**What the Four-Square-Mile-Survey Can Tell Us About Long-term ChangesiIn Prairie Wetlands** (Erin Roche*, Terry Shaffer, Brian Wangle)
15:00	**G.4.6: Shaffer**	**Is the Waterfowl Breeding Population and Habitat Survey Conducted Too Early for Late-nesting Species?** (Terry Shaffe*, Brian Wangler, Terry Liddick)
15:20 - 15:40	*Coffee break*	
Capital ABC **15:40 - 17:40**	**H.1: Evolution, Ecology, and Conservation of Monochromatic Ducks** (Organizers: Ron Bielefeld, Bruce Dugger)	
15:40	**H.1.1: Krainyk^**	**Prioritizing Mottled Duck Habitat for Conservation along the Western Gulf Coast** (Anastasia Krainyk*, Bart M. Ballard, Michael G. Brasher, Barry C. Wilson, Mark W. Parr, Jena A. Moon, Cynthia Kallio Edwards)

*Speaker; ^Student

16:00	**H.1.2: Fedderson**	**Keeping the Florida Mottled Duck a Monochrome** (Jamie C. Feddersen*, Ronald R. Bielefeld)
16:20	**H.1.3: Varner**	**Movements and Seasonal Use of Habitats by Female Mottled Ducks in Southeast Florida** (Dana M. Varner*, Gary R. Hepp, Ronald R. Bielefeld)
16:40	**H.1.4: Pollander^**	**Timing and Movements of Mottled Ducks in Georgia and South Carolina** (Kaylee M. Pollander*, Greg D. Balkcom, and Michael J. Chamberlain)
17:00	**H.1.5: Kneece^**	**Survival and Recovery of Mottled Ducks in Coastal South Carolina 2008-2014** (Molly R. Kneece*, Joseph D. Lancaster, J. Brian Davis, J. Clay Shipes, Dean E. Harrigal)
17:20	**H.1.6: Shipes**	**Social Indices of Breeding Mottled Ducks in Coastal South Carolina** (J. Clay Shipes*, Molly R. Kneece, J. Brian Davis, Ernie P. Wiggers, Richard. M. Kaminski)
Capital D **15:40 - 17:40**	**H.2: Incorporation of Hydrologic and Geomorphic Variability in the Restoration of Natural Processes: The Foundation for Producing Sustainable Wetland Resources for Wetland Dependent Wildlife** (Organizer: Leigh Fredrickson)	
15:40	**H.2.1: Papon**	**Assessing the Value of Sediment Removal in Restoring Prairie Pothole Wetlands** (Shawn G. Papon*)
16:00	**H.2.2: Pagan**	**Private Land Initiatives in the Bottomland Hardwood Region of Bayou Meto Arkansas** (Jody Pagan*)
16:20	**H.2.3: Smith**	**Restoration of Native Hawaiian Plant Communities to Benefit Five Endangered Waterbirds: Recognition of Geomorphic Surfaces, Hydrologic Conditions, Native Seed Banks, and Bugs as a Path To Success** (Chadd Smith*)
16:40	**H.2.4: Vorland**	**Rehabilitation and Management of a Shallow Lake Complex in South Central Minnesota** (Jeanine Vorland*)
17:00	**H.2.5: Fredrickson**	**Tribute to Mike Wolder** (Leigh H. Fredrickson*)
17:20	**H.2.6: Discussion**	**Discussion** (Leigh H. Fredrickson*)
Senate **15:40 - 17:40**	**H.3: Human Dimensions** (Chair: Dean Smith)	
15:40	**H.3.1: Tapp**	**Evaluating the Migratory Bird Habitat Initiative after the Deep Water Horizon Oil Spill: Waterbird and Seed Abundance** (Jessica L. Tapp*, Matthew M. Weegman*, Richard M. Kaminski, J. Brian Davis, Elisabeth B. Webb, Kevin D. Nelms)
16:00	**H.3.2: Devers**	**Integrating Human Dimensions into Habitat Delivery: Relationships Among Landscape Characteristics and Recreation** (Patrick K. Devers*, Anthony Roberts, Paul Padding, Robert Raftovich, Scott Knoche)

16:20	**H.3.3: Lindstrom**	**Prairie Pothole Politics: Opportunities and Challenges to Conserving the Duck Factory** (Eric B. Lindstrom*)
16:40	**H.3.4: Slattery**	**Roads, Pipelines, and Seismic Lines…What Do They Mean for Boreal Ducks?** (Stuart Slattery, Susan Witherly, Glenn Mack, Llwellyn Armstrong, Howie Singer, Jared Knockaert, Dave Howerter)
17:00	**H.3.5: Dorak^**	**Urban Takeover: Canada Geese Shifting from City Parks to Industrial Rooftops** (Brett E. Dorak*, Heath M. Hagy, Mike P. Ward)
17:20	**H.3.6: Open**	
Caucus **15:40 - 17:40**	**H.4: Techniques 2** (Chair: Mike Buxton)	
15:40	**H.4.1: Hidden^**	**How Many Birds Are We Missing? Assessing Waterfowl Distribution and Abundance in Missouri Using an Aerial Strip-transect Survey** (Brian S. Hidden*, Elisabeth B. Webb, Andy H. Raedeke, Xiaoming Gao)
16:00	**H.4.2: Brown**	**Survey of Wetland Management Techniques in California – The 50 Buck Duck** (Michael Brown*, John M. Eadie, Mark Lubell, Robert H. Doster, Rob Holbrook, Chadd Santerre, Bruce Wickland, Dean Kwasny)
16:20	**H.4.3: Nicolai, C.**	**Geolocators: Breeding Probability and Movement of Three Species of Ducks** (Chris A. Nicolai*, Ben S. Sedinger)
16:40	**H.4.4: O'Connel^**	**Backscatter-brained: Using Radar Imagery to Determine Wetland Inundation Pattern** (John R. O'Connell*, Michael W. Eichholz, Heath M. Hagy)
17:00	**H.4.5: Webb**	**How Will Predicted Land Use Change Affect Mallard Spring Migration Stopover Ecology? Inferences from an Agent-based Model** (William S. Beatty, Dylan C. Kesler, Elisabeth B. Webb*, Luke W. Naylor, Andrew H. Raedeke, Dale D. Humburg, John M. Coluccy, Gregory J. Soulliere)
17:20	**H.4.6: Laborde**	**A Contrast of Alternative Survey Methodologies in the 2015 Survey of Louisiana Waterfowl Hunters** (Lucien P. Laborde, Jr*, Michael D. Kaller, Larry A. Reynolds)
17:40 - 19:00	*Dinner Break - on your own -* **NADS Board meeting** *- Senate*	
Annapolis Ballroom **19:00 - 22:00**	**Poster Session I**	
Parks Place **19:00 - 22:00**	**Hospitality** *hosted by* ***California Waterfowl Association***	

*Speaker; ^Student

E.1.1: Plenary Ken Williams

Prospects for the Integration of Waterfowl Science and Management

B. Ken Williams[1]*

[1] The Wildlife Society, Bethesda, MD, 20814, USA, kwilliams@wildlife.org

For at least 50 years waterfowl management has been one of the best expressions anywhere in the world of science-based wildlife management and conservation. Efforts to bridge the divide between science and management has led through the years to a good deal of creative thinking, resulting in new ways to bring science to management and new ways to engage management in scientific investigation. However, the pressures from a growing population with increasing demands on natural resources have created tensions in the linkages between waterfowl science and management. Habitat fragmentation, financial and budgetary limitations, changing social and demographic patterns and values, disconnects of people from the land, and a host of other issues necessitates our rethinking the roles and practices of waterfowl conservation in today's world. Though there is widespread agreement that science discovery will continue to have an important role as the future unfolds for waterfowl conservation, that role will develop in a context of changing relationships between the public and our waterfowl resources. Among other things, science discovery and its application to waterfowl management will play out in a rapidly changing socio-ecological framework, at local through international scales and at different levels of biological organization. It will be more important than ever to enhance partnerships among governmental and non-governmental organizations in the natural resources community, while including non-traditional interests in a broad coalition that will be needed to sustain our waterfowl heritage. It is only through such partnerships that large-scale investigations on critical waterfowl issues are likely to continue, that science-based conservation of waterfowl and their habitats can be sustained, and that public support for these activities can be maintained in the face of a growing number of competing needs for public resources.

E.1.2: Plenary Jim Nichols

Adaptive Waterfowl Harvest Management: Where Are We and How Did We Get Here?

James D. Nichols[1]*, Fred A Johnson[2], G. Scott Boomer[3], Byron K. Williams[4]

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[2] USGS Southeast Ecological Science Center, U.S. Geological Survey, Gainesville, FL, 32653, USA
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[4] The Wildlife Society, Bethesda, MD, 20814, USA

The adaptive harvest management (AHM) program for North American waterfowl represents an achievement of singular importance in modern wildlife management. The significance of this program is perhaps best appreciated by contrasting it with the approach to setting harvest regulations that it replaced. The traditional approach to harvest management is described, with emphasis on its shortcomings. The evolution of AHM is described, beginning with development of ideas within a small working group, moving to the formal adoption by the U.S. Fish and Wildlife Service, and to the subsequent full development and implementation of the approach. Lessons learned during the past 20 years of implementation of mallard AHM are discussed, as are current criticisms. Although current waterfowl AHM programs are not without problems, we know of no alternative approaches to management that deal as effectively with change and uncertainty.

F.1: Strengthening the Links between Waterfowl Research and Management (Organizer: Tony Roberts)

F.1.1: Runge

Decision Analysis as a Framework to Link Waterfowl Research and Management

Michael C. Runge[1]*, G. Scott Boomer[2], Fred A. Johnson[3], Byron K. Williams[4]

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Any aspect of waterfowl management is a decision, whether it is an annual decision regarding harvest regulations, a long-term decision about habitat protection and enhancement, or a collaborative decision about initiatives for hunter recruitment and retention. The formal application of decision analysis provides a way to structure those decisions, integrate existing scientific knowledge, embed stakeholder values, choose an optimal strategy, and identify valuable research questions. At the heart of a decision analysis are quantitative models that predict the performance of the management alternatives against the desired objectives. The development of these models requires an understanding of the decision context, as well as an understanding of the existing body of knowledge about the system in question. These predictive models serve as an expression of the assumptions and hypotheses about waterfowl population, habitat, and hunter dynamics, and as such, provide the raw material for monitoring and research. In a system of formal adaptive management, alternative hypotheses about those dynamics provide a method for internal learning, through the feedback generated by regular monitoring. The assumptions in the predictive models also provide the impetus for external learning, research outside of the management system to improve the predictions. Decision analytical methods can be used to identify topics for monitoring or research that have a high value of information, meaning they matter to the choice of management action. By way of example, we present the current set of models used to set northern pintail (*Anas acuta*) harvest regulations, and discuss how those models are used for internal learning, and how external research could be designed to enhance them. We also briefly discuss how predictive models of waterfowl habitat and hunter satisfaction could be used to link research and management.

F.1.2: Johnson

Waterfowl Conservation and the Value of Information

Fred A. Johnson[1]*, Byron K. Williams[2]

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[2] The Wildlife Society, Bethesda, MD, 20814, USA

Though the potential for information to measurably improve management has been highlighted for several decades, in recent years the "value of information" has surfaced with increasing frequency in natural resources. However, the use of this phrase belies the fact that many in natural resources have only a limited understanding about what it actually means, how to measure it, and what to do with it. We introduce and describe several forms of the value of information in a context of waterfowl management. The value of information is discussed in terms of a potential gain in value with the addition of new information, as well as a loss in value associated with the absence of information. Value metrics are developed for uncertainty about resource status as well as resource processes and responses to management. We provide a common notation for the metrics of value, and discuss linkages of the value of information to strategic approaches like adaptive resource management and partially observable decision processes. We demonstrate the value of information with examples from waterfowl management and discuss how it can help direct adaptive management programs, as well as research designed to support management.

F.1.3: Howerter

Using Science to Inform Waterfowl Habitat Acquisition and Management Decisions

David Howerter[1]*, Benjamin Rashford[2], Kathleen Fleming[3], and Patrick K. Devers[4]

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[2] University of Wyoming, Department of Agricultural and Applied Economics, Laramie, WY 82071 USA
[3] U.S. Fish and Wildlife Service, Branch of Population and Habitat Assessment, Patuxent Wildlife Research Center, Laurel MD 20708, USA
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Loss of habitat is a common cause of wildlife population declines. Accordingly, conservation outcomes commonly are achieved through the protection of intact or restoration of degraded habitats. Scarce resources, however, dictate that investments in habitat protection and restoration accomplish conservation objectives cost-efficiently. Thus, decision support tools that codify and integrate available data and assumptions of system dynamics can help inform these investment choices. On the breeding grounds, waterfowl scientists have invested heavily in understanding the relationships between demographic vital rates and landscape characteristics and the results form the foundation of decision support tools employed by several joint ventures. Similarly, scientists in wintering and migration areas have focused on understanding food energy demand and supply curves and use the results to determine how much, what type, and where habitat is needed most. Uncertainties in these relationships can result in suboptimal allocation of limited resources. Consequences of acquisition choices on waterfowl populations provides critical decision context, but other factors influence the return on investment for habitat management. For instance, when securing existing habitats (versus restoring degraded habitats), benefits accrue at the rate that habitat would be lost in the absence of management. Therefore, we used spatially explicit models of expected land-use change using a variety of geophysical and socioeconomic factors to inform where securing existing habitats may be most economically efficient. Similarly, heterogeneity in land acquisition costs and the method used to acquire land (e.g., fee simple vs conservation easement) affect programmatic efficiencies. Increasingly, land acquisitions are chosen to meet the requirements of waterfowl populations, and to engage conservation supporters. Thus, scientific investigations to quantify the ecological services habitat parcels confer to society or how habitat location affects hunter recruitment or retention are increasingly important. We reference several developing and implemented decision support tools to illustrate these principles.

F.1.4: Vrtiska

State and Flyway Perspectives on the Linkage Between Research and Waterfowl Management and Conservation

Mark P. Vrtiska[1]*, Frank Baldwin[2], Greg Balkcom[3], Jeff Knetter[4]

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[4] Idaho Department of Fish and Game, Boise, Idaho, USA

State/provincial wildlife agencies are involved in management and conservation of waterfowl and their habitats at multiple scales. Specific questions on management actions or monitoring programs may occur at state/provincial scales, but also may occur at regional, flyway or national scales. Resolving issues and efficient management and conservation of waterfowl and their habitats relies on knowledge and understanding of biological and ecological processes. Because limited resources are available, those responsible for management and conservation efforts must communicate and connect with those involved in research to improve efficiency and effectiveness in programs. Poor communication or understanding between waterfowl managers and researchers ultimately hampers management and conservation efforts. State/provincial wildlife agencies may support research or monitoring projects directly or through their respective flyways or joint ventures. Logistical constraints, funding requirements, and processes of state/provincial agencies and flyways differ, as well as the experiences of those agencies with researchers. Decades of good habitat conditions, strong duck populations, and growth of nearly every goose population may have decreased public advocacy and the apparent need for management-oriented research. The dramatic decline in waterfowl hunter numbers also may have contributed to diminished programs in Canada, but may have more positive effects for direct research in the U.S. Finally, the decline in waterfowl-specific programs at U.S. and Canadian universities and changes in programmatic or funding directives within some agencies also has and will continue to impede efforts for better linkages. Strengthening the relationship between waterfowl research and waterfowl management ultimately comes down to better communication and interaction between managers and researchers.

F.1.5: Eadie

Muddy Boots and Ivory Towers: Challenges and Opportunities of Applied Waterfowl Research in Academic Institutions

John M. Eadie[1]*, David N. Koons[2], Todd W. Arnold[3], Bart M. Ballard[4], Robert G. Clark[5], Scott R. McWilliams[6], Anthony Roberts[7], Chris Williams[8]

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The ability to conduct waterfowl research of direct management application has become increasingly difficult in academic institutions. Reasons for this include: (1) reduced funding is available for applied research, and most federal funding programs do not support purely management based research; (2) high overhead rates at academic institutions are prohibitive for state and NGO partners; (3) increased competition has developed for limited management dollars and support; (4) applied research is perceived by some academicians as being of lower scientific value relative to “basic” theoretical research; (5) merits and promotions of university academics are tied to the perceived prestige of publications and grant funding, and applied products are sometimes viewed as being less prestigious; (6) fewer academic programs and faculty teach and mentor research in basic and applied waterfowl research; (7) as a result, fewer undergraduates and graduate students are trained in the skills needed by the management community; all of which results in (8) fewer academics establishing partnerships with state and federal partners to pursue waterfowl research of management concern. Greater collaboration could be achieved in several ways. Academic researchers should be encouraged to be part of the technical and strategic teams of every joint venture and flyway council to ensure that the key management research needs are communicated. Conversely, state and NGO partners should be invited to participate on academic planning efforts to review, revise and update curriculum in wildlife sciences. Metrics of performance at academic institutions should be re-evaluated and the value of applied research should be better recognized. Cooperative agreements should be established with fixed, low, overhead rates to provide secure, reliable funding for applied research. Finally, collective efforts should be made with the private and public sector to ensure that there is a least one endowed waterfowl research and management program and professorship in every flyway.

G.1: Evolution, Ecology, and Conservation of Monochromatic Ducks (Organizers: Ron Bielefeld and Bruce Dugger)

G.1.1: Dugger - Bielefeld

Monochromatic Ducks – a Primer

Bruce Dugger[1]*, Ron Bielefeld[2]*

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Introduction to the session.

G.1.2: Lavretsky

Genomics of New World Mallard-Like Ducks

Philip Lavretsky[1]*, Jeffrey L. Peters[2], Kevin G. McCracken[1]

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The New World (NW) mallard group includes the dichromatic mallard (Anas platyrhynchos), and four monochromatic taxa; American black duck, (A. rubripes), Mexican duck (A [p.] diazi), and two subspecies of mottled ducks (Florida, A. fulvigula fulvigula; and West Gulf Coast. A. f. maculata). Although all NW taxa are phenotypically diagnosable, resolving their taxonomic relationships has been challenging due to genomic similarities attributable to their recent ancestry and/or hybridization. Using ddRAD-seq methods, we sequenced 3,029 autosomal and 198 Z-chromosome markers from a total of 166 samples (24–43 per taxon). For both marker-types, the monochromatic taxa each clustered into independent groups; however, American black ducks were largely indistinguishable from mallards. Under a neutral scenario in which genetic divergence is driven by genetic drift, the expected ratio for Z:autosomal differentiation is < 1.33, because Z loci have 0.75 the effective population size of autosomal loci. Comparing mallards to each monochromatic taxa recovered elevated Z divergence, with Z:autosomal ratios ranging between 4 and 6.5, and evidence of positive selection acting on 2-4% of Z-linked markers, but < 0.5% of autosomal markers. Furthermore, aligning markers along the Z chromosome revealed a region of elevated differentiation that was shared between all mallard-monochromatic comparisons; this region was less-differentiated or absent for pair-wise comparisons of monochromatic taxa. These results suggest that the Z-chromosome is at a later stage of divergence between mallards and monochromatic taxa and that this differentiation is likely driven by selection acting on traits that are Z-linked and derived in mallards. Overall, ddRAD-seq markers provided high resolution regarding the evolutionary history of the NW mallard clade. Furthermore, they revealed strong support for phylogenetic relationships within this group, suggesting that black ducks and mallards are sister species, this pair is sister to Mexican ducks, and the two mottled duck populations are a separate lineage.

G.1.3: Wells^

Why Are Some Ducks Brown?

Caitlin Wells[1]*^

[1] Department of Wildlife, Fish, and Conservation Biology, University of California, Davis, CA, 95616, USA

Sexual dichromatism is a striking characteristic of many waterfowl species. Yet in others, the buffy, brown plumage of males makes them hardly distinguishable from their female mates. There is general consensus that monochromatism in Anas ducks has been recently and repeatedly derived from dichromatic ancestors. However, the selective pressures that underlie these repeated transitions are not well understood, and may vary among monochromatic species. In this talk I will review hypotheses for the secondary evolution of monochromatism, with specific attention to the ecology of monochromatic ducks of North America and the Pacific Islands. I will present comparative evidence from other avian groups (galliforms, raptors, and sparrows) that exhibit similar evolutionary transitions to monochromatism, and address the proximate physiological mechanisms associated with the expression of brown plumage. Finally, I will present preliminary evidence linking seasonal monochromatism (i.e., eclipse plumage) of male mallards (*Anas platyrhynchos*) to persistent monochromatism in male Hawaiian ducks (*Anas wyvilliana*).

*Speaker; ^Student

G.1.4: Devers

Evolution, Ecology and Conservation of the American Black Duck

Patrick K. Devers[1]*

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The American black duck (*Anas rubripes*) is closely related to other monomorphic *Anas* species and the mallard (*A. platyrhynchos*) and was once considered a single species (*A. obsura*) with the mottle duck (*A. fulvigula*). Historically, the black duck was the most abundant dabbling duck in eastern North America with a breeding range stretching from Ontario to Newfoundland and south into the Great Lakes States and North Carolina. It is a partial short-distance migrant with a non-breeding range extending from the southern Canada to Mississippi and Alabama across to South Carolina. The population experienced a decline of >50% between the 1950s and 1990s, but the decline was not uniform across the species range. Several hypotheses have been proposed to explain the decline including over-harvest, competition and hybridization with mallards, decrease in the quantity and quality of wintering and breeding habitat, and environmental contaminants. To this day there is a no consensus as to the cause of the decline or current limiting factors. Black duck annual survival ranges from 0.47-0.67 and is lowest among juvenile females and highest among adult males; patterns similar to mallards. Similarly, reproductive rates appear similar among black ducks and mallards, though estimates of continental fall age ratios are slightly lower. Despite the similar demographic rates and lower harvest rates, the black duck breeding population has remained stable in eastern Canada whereas the mallard population continues to grow. Challenges facing black duck managers include lack of detailed information regarding productivity; resource extraction, agricultural, and climate change effects on the breeding grounds; and urban growth and sea-level rise effecting non-breeding habitat. Under the Coordination of the Black Duck Joint Venture and Black Duck Adaptive Harvest Management Working Group, researchers and managers are developing and implementing tools to address these challenges and ensure the future of the American black duck.

G.1.5: Wells^

Geographic Variation in Hybridization Between Mallards and Hawaii's Koloa Maoli

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Hybridization is common in birds, and particularly widespread among waterfowl. However, hybridization with feral mallards (*Anas platyrhynchos*) has emerged as a major threat to the genetic persistence of several monochromatic *Anas* species. In the Hawaiian Islands, hybridization with mallards, and resulting introgression, is the primary threat to the endemic koloa (Hawaiian duck, *Anas wyvilliana*). However, this threat may not affect all Hawaiian populations equally; knowledge of which populations are most impacted by hybridization will help target conservation efforts. Hence, we used multilocus genotypes and Baysian assignment of 288 individuals, sampled from 14 locations, to compare hybrid prevalence at two geographic scales: 1) among the main Hawaiian Islands, and 2) between urban and managed wetland habitats. Additionally, we used mitochondrial haplotypes, which are maternally inherited, to determine the direction of introgression among different populations. Putatively "pure" koloa were found on all islands except for Maui, but were more common in managed wetland than urban habitat. Hybrids were most numerous on Oahu and Maui, and hybrid prevalence on Kauai appears quite low. Though sample sizes were small, the direction of introgression varied by island and by habitat. On Oahu, 90% of hybrids in the urban habitats had mallard mitochondrial haplotypes compared to 10% with koloa haplotypes, indicating the majority of hybridizing pairs were female mallards and male koloa; in the managed wetland habitat these proportions were reversed, indicating the majority of hybridizing pairs were female koloa and male mallards. Higher prevalence of genetically "pure" koloa, and hybrids with koloa mothers, in managed wetland as opposed to urban habitat is consistent with previous work on koloa habitat preference. Species differences in habitat preference, coupled with female philopatry, may underlie geographic variation in the prevalence and direction of hybridization among populations.

G.1.6: Haukos

At What Scale Should Mottled Ducks be Managed?

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The mottled duck (*Anas fulvigula*) has a different life history strategy than other monochromatic North American waterfowl. By being non-migratory, the species must fulfill all of its life history needs in the same habitats. Further, limited mobility restricts individual and population response to extreme environmental events, habitat loss and degradation, and effects of climate change. For the Western Gulf Coast Population (WGC; Texas and Louisiana), mottled ducks persist as scattered populations primarily in fresh – brackish coastal marsh with the greatest densities on the Chenier Plain of Texas and Louisiana. Population fragmentation in the WGC has occurred as the result of urbanization, extensive conversation to agriculture, salt-water intrusion, industrial development, invasive species, and lack of management for the entire life cycle. The WGC population persists primarily as a metapopulation occupying isolated local and regional patches of habitat within an ever increasing matrix of landscapes resistant to movement. Band recovery data indicate little movement among regional populations limiting immigration, emigration, and genetic exchange. Population goals are available for the entire WGC population and Texas and Louisiana, but have yet to be stepped down to regional populations. Harvest management occurs independently between the Central and Mississippi Flyways with little consideration of movement patterns between Flyways. Regional habitat and population goals are currently nonexistent. Limiting factors, space use, and habitat selection are fairly well known for the Chenier Plain population, but inference to other populations may not be appropriate for estimating carrying capacity for mottled ducks. Population demography and relationships between vital rates and available habitat have not been developed, but are needed prior to setting regional management goals. Development of hierarchical habitat management objectives within a metapopulation framework with consideration of regional habitat constraints and impacts may have greater influence on species viability than top-down state or WGC level population goals.

H.1: Evolution, Ecology, and Conservation of Monochromatic Ducks (Organizers: Ron Bielefeld and Bruce Dugger)

H.1.1: Krainyk^

Prioritizing Mottled Duck Habitat for Conservation Along the Western Gulf Coast

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The mottled duck (*Anas fulvigula*) is a year-round resident of the Gulf of Mexico Coast. Because of its population decline in the western Gulf Coast, the mottled duck is a species of concern among state and federal agencies. The disappearance of suitable nesting and brood-rearing habitat is the primary factor believed to be responsible for the population decline. Therefore, a priority for increasing abundance of the mottled duck is to increase nest success and brood survival by preserving or creating landscapes with suitable nesting and brood-rearing habitat in appropriate spatial configurations. Our objective was to develop a decision support tool that will aide stakeholders in decision making processes by consolidating available biological and ecological knowledge and taking into account temporal and spatial variation at the landscape level. Our deliverable products use available biological knowledge of mottled duck nesting and brood rearing requirements to develop spatially explicit models that 1) identify currently suitable mottled duck nesting and brood-rearing habitat prioritized for protection, 2) identify and prioritize wetland basins for freshwater enhancement that can provide suitable brood-rearing habitat, and 3) identify and prioritize areas where grassland establishment can provide suitable nesting habitat. Results from our spatial models show that only 1,495 acres of currently suitable nesting habitat and 2,337 acres of currently suitable brood-rearing habitat fall within the top 10% of our priority ranking for conservation. This makes up approximately 0.05 % of the total currently suitable habitat identified by the model. The ratio of nesting to brood-rearing habitat area along the central and lower Texas Coasts is highly skewed towards nesting habitat (> 78% nesting habitat), suggesting that wetland enhancement or creation in these areas could provide large amounts of suitable habitat. Throughout the upper Texas Coast and coastal Louisiana, the ratio of nesting to brood-rearing habitat is nearly 1:1. Additionally, results from landscape level analyses indicate that approximately 400,000 acres of wetland habitat and 300,000 acres of grassland habitat could become suitable for breeding mottled ducks if appropriate wetland enhancement or grassland establishment measures were implemented. Our decision support tool, based on the best available biological information, will aid managers in identifying habitat patches where conservation efforts will have the largest impact on the mottled duck population.

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H.1.2: Feddersen

Keeping the Florida Mottled Duck a Monochrome

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The mottled duck (*Anas fulvigula*) in Florida has long been considered the same species as mottled ducks occurring in the western gulf coast areas of Texas and Louisiana. However, some authorities on the subject believe the birds in these two population are separate subspecies, *Anas fulvigula fulvigula* in Florida and *Anas fulvigula maculosa* in the western gulf coast. Recent genetic and phenotypic studies of the two birds may back up this assertion. Regardless, these two populations of birds have been and will continue to be managed separately. Over the past three decades, research investigating population trends, habitat use, movements, and survival of Florida mottled ducks has identified the biggest threat to the continued existence of this endemic monochromatic duck; genetic introgression from feral mallards (*Anas platyrhynchos*). Accordingly, the most recent research efforts have focused on developing the tools and techniques needed to identify 1) mottled ducks from non-mottled ducks, in real time, while in the field and 2) areas of high inter-species contact. Studies to take place over the next few years will assess the mottled duck versus non-mottled duck population, providing information necessary to develop and initiate protocols that will combat the introgression threat with the goal of conserving a Florida mottled duck population that Florida citizens can enjoy in perpetuity.

H.1.3: Varner

Movements and Seasonal Use of Habitats by Female Mottled Ducks in Southeast Florida

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Florida will continue to undergo high rates of habitat loss, primarily as a result of urbanization. In addition, invasive species are a major threat to Florida's biodiversity. The Florida mottled duck (*Anas fulvigula*), a bird unique to the state, is particularly vulnerable to loss of wetland habitats and hybridization with feral mallards. Because mottled ducks are more likely to encounter feral mallards in urban habitats, we trapped and radio-marked adult females in urban (n = 99) and rural (n = 146) areas to estimate home ranges and rates of movement into and out of urban areas. We also determined habitat use in urban and rural areas during the breeding (1 Feb–31 Jul), post-breeding (1 Aug–18 Nov), and hunting (19 Nov–31 Jan) periods and estimated seasonal habitat selection of rural female mottled ducks. Urban females used mostly aquatic habitats in low and high intensity human development year-round. Rural ducks used freshwater marshes throughout the year, but selection of other habitat types varied seasonally. Use of glades marsh and agricultural habitats by rural ducks peaked during the breeding season. Rural ducks selected artificial impoundments and reservoirs during the post-breeding and hunting periods. Median home range size of rural females was more than 65 times greater than that of urban females. Our results suggest the spread of mallard genetic introgression caused by females leaving urban areas may be slow because as few as 6% of the adult females moved between urban and rural areas. Focusing wetland conservation efforts on freshwater marshes and artificial impoundments in south Florida would likely benefit mottled ducks.

H.1.4: Pollander^

Timing and Movements of Mottled Ducks in Georgia and South Carolina

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Mottled ducks (*Anas fulvigula*) inhabit various coastal marsh habitats, ranging from freshwater prairies to saline coastal marshes in the southeastern United States. The species is considered non-migratory, but there is little information detailing individual movements within short or long temporal periods. Likewise, as residents mottled ducks are assumed to maintain home ranges, but band returns and coarse-scale telemetry data collected by previous studies suggests that movements away from maintained home ranges may occur. However, fine-scale data are also lacking in regards to the frequency and timing of movements outside of the home range. In August 2014, we captured and outfitted 9 mottled ducks (7 males and 2 females) with satellite GPS transmitters, which recorded 4 locations per day. Our objectives were to document daily distance traveled, document duration, timing, and distances traveled on excursions outside established home ranges, and document timing, duration, and distances traveled by mottled ducks to establish new home ranges. We determined distances between GPS locations using a Euclidean distance function. We found that average daily distances moved from capture through present varied from 72 m to 21,279 m (mean = 8,559 m, SE = 4,779 m). Three individuals left established home ranges and established new home ranges 46,232 m to 245,765 m (mean = 150,013 m SE = 83,518 m) away from their original home range. These new home ranges were established in ≤3 days. Four individuals made excursions outside their home range averaging 65,717 m (SE = 17,248 m); all returned to their previous home ranges in ≤4 days. These data suggest that mottled ducks in Georgia and South Carolina should be managed as one population rather than two separate populations.

H.1.5: Kneece^

Survival and Recovery of Mottled Ducks in Coastal South Carolina 2008-2014

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Mottled ducks (*Anas fulvigula*), comprising a genetically distinct subspecies (*A. fulvigula fulvigula*) are endemic to the western Gulf Coast (WGC) and peninsular Florida, respectively. Between 1975 and 1983, approximately 1,300 mottled ducks were introduced to coastal South Carolina from their endemic range. Fall banding was initiated in 2008 within the Santee Delta and Ashepoo, Combahee, Edisto Rivers Basin to estimate mottled duck survival and harvest. We acquired 3,471 banding and 442 harvest records of mottled ducks captured during remigial molt in 2008-2014. We used the dead recovery model with Brownie parametrization in Program MARK to estimate annual survival (S) and recovery probabilities (f) among combinations of age (juvenile [banded year of hatch] or adult [banded > 1 year after hatch]), sex, year, and band type/material (1-800 or web-address aluminum or web-address stainless steel). We ranked models using quasi-Akaike's Information Criterion (QAICc) adjusted for small sample size and a variance inflation factor ($\hat{c}$ = 1.4408) calculated from 1,000 bootstrap simulations of the global model. We averaged survival and recovery estimates among competing models (ΔQAICc $\leq$ 2). Survival varied by age and sex whereas, recovery probability varied by age, sex, and band type. We calculated harvest rates (K[c]) from recovery probabilities (f) using the equation $f / \lambda = K(c)$ where λ is the band reporting rate (0.73). Annual survival was greatest for adult males (0.60 ± 0.04 [SE]) and adult females (0.59 ± 0.05), followed by juvenile females (0.40 ± 0.12), and juvenile males (0.35 ± 0.08). Recovery and harvest rates were greatest for juvenile males (0.092 ± 0.01; 13% [harvest rate]), then adult males (0.08 ± 0.007; 11%), juvenile females (0.052 ± 0.01; 7%), and adult females (0.046 ± 0.006; 6%). Aluminum bands (1-800 and web-address) had slightly higher recovery rates than stainless steel (web-address) bands, however, 95% confidence intervals of beta included zero. Annual survival of adult mottled ducks was comparable to adult survival in other regions (0.47-0.58), except Georgia (0.35). Juvenile female survival was similar to estimates from the entire range (0.35-0.47), whereas, survival of juvenile males appears equivalent to those in Georgia (0.35), but lower than juvenile males elsewhere (0.48-0.91). Recovery rates of mottled ducks in South Carolina were lower than those from Georgia (0.19-0.22), likely because banding in Georgia occurred at an intensively hunted wildlife management area. Recovery rates of South Carolina mottled ducks were similar (0.06-0.13) to those in Florida and the WGC, with juvenile males and adult females having the greatest and least recovery rates, respectively. Harvest rates of South Carolina mottled ducks are similar to eastern mallards (*A. platyrhynchos*; 0.141), but unlike mallards, annual survival may affect mottled duck populations beyond those breeding season metrics (e.g., nest success) deemed critical for Midcontinent mallards. We found no evidence that recovery rates differed between band materials, which is consistent with herring gulls (*Larus argentatus*) marked with similar bands. Future research that estimates survival of females, ducklings, and broods will be needed to more fully understand population change in South Carolina mottled ducks.

H.1.6: Shipes

Social Indices of Breeding Mottled Ducks in Coastal South Carolina

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Mottled ducks (*Anas fulvigula*) are endemic to Gulf Coastal United States and Mexico. Birds from Florida, Louisiana, and Texas were released in coastal South Carolina from 1975-1983, but autecology of mottled ducks is little known there. To begin investigating nesting ecology of mottled ducks in coastal South Carolina, we conducted Indicated Breeding Pair surveys of mottled ducks in spring 2010-2011 in the Ashepoo, Combahee, and Edisto (ACE) Rivers Basin. We used lone and social groups of mottled ducks as indicators of breeding behavior to begin linking potentially important breeding habitats for these birds in the region. We conducted surveys from one-half hour before sunrise to 1 hour after sunrise once weekly in diverse but representative wetland types in the region. During each survey we collected salinity, water depth, size of the entire wetland surveyed, and numbers of mottled ducks seen and their corresponding social groupings, following standard survey protocol. We conducted a combined 330 surveys in 11 wetlands from March-June 2011-2012, and counted 4,472 individual mottled ducks in various social groups; these total observations included 1,497 (59%) pairs of mottled ducks, compared to all other birds in other social categories. The greatest proportion of pairs was observed in May across both years. We used occupancy modeling and found that the area of the entire wetland surveyed was positively associated (β=0.31, 95% CI=0.25-0.39) with breeding mottled ducks and was the only variable that was biologically meaningful. Our results corroborate those from Texas where breeding mottled duck pairs were positively correlated with wetland size. Larger wetland impoundments may provide a greater interspersion between vegetation and open water (e.g. hemi-marsh) and therefore more habitat complexity could attract breeding mottled ducks.

G.2: Incorporation of Hydrologic and Geomorphic Variability in the Restoration of Natural Processes: The Foundation for Producing Sustainable Wetland Resources for Wetland Dependent Wildlife (Organizer: Leigh H. Fredrickson)

G.2.1: Fredrickson

Setting the Stage for Restoration and Management of Natural Processes

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Wetland management has evolved extensively over the past century as more management areas have come under public ownership and more information has been generated on wetland-dependent wildlife and their habitats. In the early years of wetland management there was limited information on annual cycle requirements of wetland-dependent wildlife, wetland plants, wetland soils, and the dynamics of wetland processes. In fact the term wetland was not widely used until the 1970s. Early objectives were often based upon opinion, results from poorly designed studies, and likely were linked to animal populations but disconnected from factors that a land manager may be able to influence. This lack of understanding resulted in many widely held misperceptions about the placement and design of infrastructures in a diversity of geomorphic settings. Over time managers began to ask questions that clearly required an understanding of the hydrogeomorphic setting in which management actions occurred. The importance of geomorphic surfaces, soil type and textures, highly variable climatic factors, surface and subsurface hydrological conditions, as well as physical and chemical conditions, gradually emerged as important considerations upon which appropriate objectives must be developed. Furthermore, the skills required to implement land management were typically compromised as urbanization became more widespread and few individuals had the opportunity to be exposed to the challenges of implementing ecologically based decisions in highly modified environments where the constraints associated with desired economic benefits, politics, policy, and legislation must all be considered. To be effective requires a 10,000 hour development over about a decade to achieve the skills and confidence to deal with typical land management challenges. This presentation is an attempt to capture this evolution and set the stage for a series of examples about how talented managers in a diversity of systems have developed successful programs to meet the mission of agencies and the objectives of their management site.

*Speaker; ^Student

G.2.2: Tashjian

Historic Landform Process Models: A Key to Successful Wetland and Riverine Restoration

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Southwestern Riverine and Wetland Systems have witnessed an onslaught of engineering activities that have all but ruined historic processes and associated ecosystems in the name of flood safety, irrigation demand and efficient water delivery. As the awareness of the importance of our aquatic ecosystems has grown over the past decades, ecosystem needs have been placed alongside these conventional management purposes in an effort to more equitably manage our water resources. Our work demonstrates the critical importance of; 1) understanding "native" historic processes of a given aquatic system, 2) understanding the perturbations to these systems, 3) understanding the modern limitations on restoring key historic processes, and 4) formulating creative mechanisms for restoring key historic processes. In order to address these issues, the Southwest Region of the US Fish and Wildlife Service has modified the Missouri Wetland Review Process to incorporate data and exercises focusing on landforms and associated physical processes. An integral part of this approach to wetland management is the construction of a landform map and a landform directory that links landforms to conceptual models of how a given landform functioned in a native state and how native processes have been disrupted. Creating historic and modern landform maps requires expertise in geomorphology and photo interpretation. The mapper will interpret the historic and modern imagery classifying landforms based on landform nomenclature. Due to the variability in systems and available map products, the nomenclature for Southwestern US landforms has been loosely standardized based on seminal Middle Rio Grande mapping efforts of Lettis and Associates. Once a landform map has been compiled or created, the Landform Directory is created. This directory is a mechanism for hypothesizing how a given landform functioned historically and how these processes have been interrupted in the modern. Creating the Landform Directory is a starting point for constructing conceptual models and it needs to be emphasized that these models are iterative. The Landform Directory is best labeled as DRAFT and it helps to specifically state "The following directory is draft in perpetuity: these models are open to changes as more information becomes available". Through management experiences at applying this "lens" to wetland and river restoration at assorted wetland management areas in the Southwestern United States, we have witnessed successful restoration activities that have favored native species viability while maintaining or even improving conventional management purposes. A brief overview of products associated with wetland reviews in New Mexico is presented including Bosque del Apache NWR, Bitter Lake NWR, Brantley State Game Refuge, and the Armendaris Ranch.

G.2.3: Henry

Incorporating Hydrologic and Geomorphic Variables into Wetland Management in the Intermountain West

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Managed wetlands in semi-arid and montane wetlands in the Intermountain West range from highly modified and actively managed to more passively managed depending on the degree of anthropogenic alterations. Identifying the geomorphic, hydrologic, and climatic settings at a management site are critical because these factors have a profound influence on the contemporary ecological conditions and form the foundation for producing and making resources available for waterfowl and other wetland-dependent wildlife. Several National Wildlife Refuges in the Intermountain West have incorporated hydrologic and geomorphic information into planning efforts to improve management and restoration of wetland habitats. The landscape setting, spatially and temporally variable hydrologic patterns, topography, and diverse soil characteristics that historically resulted in highly dynamic surface and groundwater inputs are key features that should be identified and used to understand processes that drive wetland productivity. By assessing hydrologic and other abiotic parameters managers recognize that conditions are constantly changing from those that are generally considered “valuable” or “ideal” to dry conditions. Incorporating management strategies that mimic seasonally and annually variable ecological processes can support abundant waterfowl and wetland-dependent wildlife during both short and long-term wetland cycles. Thus, we would encourage any manager to focus their efforts on continually expanding their understanding of the habitat conditions that result from the geomorphic, climatic, and hydrologic setting for which they are responsible.

G.2.4: Nelson

Missouri Public Waterfowl Hunting Area Wetland Renovation, Schell-Osage Conservation Area

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Schell-Osage Conservation Area (CA) is over 60 years old and one of Missouri Department of Conservation's public waterfowl hunting areas. It is the fifth and last area to be part of the Golden Anniversary Wetland Renovation Initiative, which has focused on addressing aging wetland infrastructure issues. This area lies within the Osage River Basin and is in the Truman Lake Reservoir flood easement, in west central Missouri. Like many historic wetland areas in the United States, there have been a many modifications to the floodplain and adjacent streams which have altered the flow, frequency, depth and duration of flooding on Schell-Osage CA. Some of the initial engineering from the early 1960's has also added to some of the area's management challenges and limitations. The proposed rehabilitation of Schell-Osage CA applies our current understanding of wetland restoration, built off the concepts that have been successfully applied at Duck Creek CA, and has been recalibrated for the Osage Basin. Through the planning process, LIDAR was used to examine landscape features and juxtaposition of engineered infrastructure. We are proposing to reconfigure impoundments to coincide with the historic drainages, facilitate independent water control, and allow waterfowl hunter access to the blinds. This process has also provided the opportunity to think about redistributing the waterfowl refuge so that it provides better habitat and less disturbance. While this work will definitely benefit waterfowl, this approach also has broader ecological implications by incorporating blocks of higher and drier floodplain habitats along with the low lying ponded areas, and extending into the adjacent streams. The wetland renovation will reduce some of the chronic management challenges that have plagued Schell-Osage CA and help the area handle the seasonal variability that comes with being in Truman Lake's footprint.

G.2.5: Cordell

Trash the Cookie Cutter and Pick Up the Puzzle Pieces

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Research and today's industrial society often try to reduce the noise and streamline variability to find general trends and simple solutions. On the flipside, management deals with making decisions amidst the complexity and often messy interactions within larger systems. As an alternative to the cookie cutter approach to wetland management, the argument will be made for continual learning of wetland functions, embracing natural variability, and recalibrating management decisions. Piecing together these puzzle pieces are the tools to provide habitat for migratory water birds along with a range of other wetland dependent species in this complex, variable world.

Duck Creek Conservation Area is a Missouri Department of Conservation wetland management area in southeast Missouri on an old terrace of the Mississippi Alluvial Plain that is over 65 years old and has received a major renovation over the last 5 years. This work attempted to integrate ecological considerations into the engineering design to accommodate hydrologic connectivity and habitat diversity. As construction has been completed, management of the reconfigured pools and the reality of our planning decisions have begun to emerge. This presentation will examine the annual cycle of wetland ecology and rationale behind management decisions made to promote diverse wetland community interactions for this unique conservation area. While seasonally migratory waterfowl and the public emphasis on fall waterfowl hunting are positive elements of area management, they are taken within context of the broader wetland community and cross seasonal effects. This approach embraces the uncertainty and variability that occurs in wetland systems, is proactive towards risk, and allows for greater flexibility in potential outcomes. Instead of maximization, this approach is centered on ecological context and understanding community interactions. The benefits of communicating this strategy has garnered wider public support and understanding for wetland conservation on Duck Creek, which is often a big gap in today's society.

G.2.6: Vradenburg

Wetland Restoration and Management in Arid Floodplains with High Agricultural and Urban Water Needs

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Historically only two-percent of the land area of the arid southwest supported wetland or riparian habitat; modifications to hydrology and land surface removed one third of this wetted habitat from the landscape. Social and political pressures to capture and use water for agriculture, urban and energy demands functionally altered the remaining lands and compromised their value and contribution to wildlife management. In this modified setting limited lands have been set aside for the management and benefit of wildlife. Additionally, these managed lands are often overlaid within irrigation companies, reclamation projects or other jurisdictional constraints. Pressures and complexity with larger jurisdictional factors such as water rights, water deliveries or endangered species requirements often cloud the direction and objective of wetland restoration or management. Restoration must begin with an evaluation of abiotic conditions to answer questions such as “How is native vegetation successful,” “What opportunities have invasive species capitalized on,” “How does current management overlay historic conditions,” and “How do current conditions mesh with appropriate wildlife values?” Restoration success is a function of understanding abiotic conditions, evaluating the degree of perturbation, and implementing techniques to recreate or reactivate historic processes.

H.2: Incorporation of Hydrologic and Geomorphic Variability in the Restoration of Natural Processes: The Foundation for Producing Sustainable Wetland Resources for Wetland Dependent Wildlife (Organizer: Leigh H. Fredrickson)

H.2.1: Papon

Assessing the Value of Sediment Removal in Restoring Prairie Pothole Wetlands

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The typical prairie pothole wetland restoration project conducted on public or private lands usually involves plugging or filling drainage ditches and/or breaking tile lines to restore a more natural hydrological cycle to drained wetland basins. However, some managers have noticed that not only are these degraded basins drained by ditches or tile, the physical integrity of the basin has been further compromised by sediment accumulation from cropped or tilled uplands. The accumulation may vary from several inches to several feet. These sediments bury native seed banks, carry excess nutrients (N & P), and modify soil surface characteristics (organic matter, density, etc.). Thus, to fully restore these drained basins, some restoration projects have involved sediment removal in wetlands but these efforts have not always been well documented or monitored. Sediment removal is costly and there are considerable uncertainties about whether this approach to restore drained wetland basins is appropriate to use in combination with a typical ditch fill and tile removal. Typically ditch fill restorations commonly used for the past 5 decades to restore seasonal wetland basins with past cropping history tend to be dominated by hybrid cattail. Managers want to know whether or not removing the upland sediment will minimize or delay colonization by invasive plants such as reed canary grass and hybrid cattail and instead promote a native wetland community much more beneficial to breeding and migrating waterfowl. As of December 2014, 105 wetland basins are part of the Wetland Sediment Project, with study basins located near six FWS field stations in western Minnesota and Iowa. This presentation summarizes results of the project to date, provides several examples of extreme sedimentation and post-restoration plant response, and discusses challenges in restoring and managing prairie pothole wetlands given the suite of invasive species commonly encountered in the Prairie Pothole Region. Discussion will focus on ways to restore and manage a seasonal pothole to encourage the establishment of native emergent and submergent vegetation before hybrid cattail and other invasives become established and aggressively compete with desirable wetland plants.

H.2.2: Pagan

Private Land Initiatives in the Bottomland Hardwood Region of Bayou Meto Arkansas

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Green Tree reservoirs where originally developed in the bottomland hardwood forests of Arkansas to attract early arriving migrant dabbling ducks and especially mallards to feed in habitats early in the fall waterfowl hunting season before natural flooding typically occurred at this latitude. Migrant mallard response was exceptional in the early years after reservoir establishment but in the vast majority of cases the protocol established for management led to forest degradation or death and waterfowl use declined precipitously thereafter. Gradually over time the problems associated with the development and implementation of management were addressed and new strategies were formulated to address the complexities of managing wetland forests. This presentation will describe multiple forest management and flood regime practices used on degraded Greentree reservoirs over ten year period near Stuttgart AR. A seven step procedure has been formulated to assist landowners and managers when renovating degraded Greentree reservoirs. This planning process outlines all parameters critical to restore forest health and increase herbaceous vegetation in managed reservoirs. The presentation will describe the interconnectedness among geomorphic surfaces and vegetation communities because these factors dictate the type of flood regime most likely to lead to effective outcomes. This presentation is based on many years of field experience, multiple failed and successful attempts to renovate Greentree reservoirs across the Mississippi Alluvial Valley.

H.2.3: Smith

Restoration of Native Hawaiian Plant Communities to Benefit Five Endangered Waterbirds: Recognition of Geomorphic Surfaces, Hydrologic Conditions, Native Seed Banks, and Bugs as a Path To Success

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Over the last century as native Hawaiian wetland habitats were lost and degraded, five native wetland birds, the Hawaiian duck or Koloa maoli, Hawaiian stilt or Ae'o, Hawaiian moorhen or 'alae 'ula, Hawaiian coot or 'alae ke'oke'o and the nene or Hawaian goose were classified as endangered. As historic wetland processes were lost or compromised by agriculture and urbanization wetland habitats were besieged with invasive plants and animals and the five endangered waterbirds suffered steep population declines. Wetland agriculture was often embraced as successful management because such sites had open areas where waterbirds were visible but census numbers reflected decreasing population. Over the last two decades, much life history and habitat knowledge guided a path to provide more natural hydrological regimes and habitats dominated by native and naturalized plants. A management goal to restore native wetland plant communities tied to geomorphic surfaces associated with evolution of these species gradually evolved. Conversion to native plants was a daunting task because refuge lands were a sea of invasives after cultivation for rice, sugar cane, or taro production as well as cattle grazing. Little over a decade ago the present wetland units were completely dominated by invasive species, including thirty-foot tall hau bush and dense California grass. After years of intense management the invasives are now under control through precisely timed mowing, disking, tilling, and water manipulation strategies that have enhanced native seed banks and created conditions dominated by native plant communities. Currently an 18 to 24 month management regime has been developed for Hanalei and Huleia NWRs. Once native wetland plant communities were established, the avian response was immediate. At Hanalei NWR, Koloa increased from a long-term average of 125 birds across several decades to a 2013 total of 818 as measured by similar techniques. The other four endangered species experienced similar population increases on Hanalei NWR as wetland conditions improved in the last decade.

H.2.4: Vorland

Rehabilitation and Management of a Shallow Lake Complex in South Central Minnesota

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Conservationists and natural resource professionals have long recognized the value of Minnesota's shallow lakes to waterfowl and other wetland dependent wildlife. Despite their importance as natural resources, shallow lakes in south central Minnesota have been degraded by many factors and frequently devalued by society. In this agricultural landscape most wetlands including many shallow lakes have been lost to drainage. The surviving lakes are especially vulnerable to degradation from rough fishes, nutrient enrichment, altered hydrology and land use changes. While water is a public resource nearly all land is privately owned and the state has riparian rights on few basins. Effective management strategies to rehabilitate degraded lakes have been well known for decades; however, implementation can be fraught with difficulties. Public opposition to water level manipulations and restoration of macrophytes frequently stalls lake rehabilitation efforts. One must navigate the complexities of riparian and drainage rights, dams, the politics of multiple levels of government, diverse social expectations, environmental review and permitting. Public involvement including partnerships with area stakeholders, local governments and conservation organizations has reduced some of the acrimony that developed over lake management proposals. Adequate funding is helpful too. We use a combination of water level management and biomanipulation of fish communities to emulate natural processes to restore macrophytes and improve water clarity in a complex of shallow lakes. Waterfowl and other waterbirds have responded to management efforts, but without continued intervention these lakes quickly revert to turbid conditions. Examples of public involvement and management strategies adapted to the social, legal and ecological settings of individual basins will be presented.

H.2.5: Fredrickson

Discussion

Leigh H. Fredrickson[1]*

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G.3: Management (Chair: Jim Anderson)

G.3.1: Hindman

Control of Mute Swans in the Upper Chesapeake Bay

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During the 1980s and 1990s, non-native mute swans (*Cygnus olor*) increased dramatically in the Maryland portion of the Chesapeake Bay. This population increase led to interspecific competition with colonial waterbirds, conflicts between territorial swans and people, and loss of submerged aquatic vegetation. In 2001, the Maryland General Assembly directed the Maryland Department of Natural Resources (MDNR) to control the growing number of mute swans. The MDNR initiated a large scale, integrated control program aimed at reducing the mute swans in the upper Chesapeake Bay beginning in 2005. We used a combination of oiling swan eggs to reduce swan recruitment and the culling of swans by shooting and live capture and euthanasia. Between 2002 and 2015, we treated 1,672 mute swan nests containing 9,450 eggs and culled 5, 355 swans. Egg-oiling prevented an estimated 6,200 mute swans from entering the non-breeding population that would have required culling. Using this integrated approach we reduced the State's mute swan population from 3,995 in 1999 to 25 in 2015. The control program resulted in the complete removal of mute swans from most areas of the upper Chesapeake Bay. Annual control program costs ranged from about $128,906 in 2005 to about $4,300 in 2015. Although control continues, the serious impact of mute swans on the Bay's submerged aquatic vegetation beds and colonial waterbird nesting sites has been eliminated. The control program has also eliminated the conflicts between territorial swans and citizens' recreational use of riparian waters. Although successful at achieving a significant reduction in swan numbers, we will continue to prevent swan recruitment and cull the remaining breeding swan pairs and those that immigrate from Virginia. Our success provides a model to other state and provincial wildlife agencies in North America that are considering or undertaking the implementation of mute swan control programs.

G.3.2: Nichols, T.

Mute Swan Management in New Jersey: Lessons Learned

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Mute swans (*Cygnus olor*) are a non-native, invasive species, brought to North America from Eurasia during the late 1800s for ornamental purposes. Several studies have shown that mute swans cause a variety of conflicts, primarily destruction of submerged aquatic vegetation, displacement of native wildlife species, and aggressive behavior towards people, thus necessitating management in North America. The Migratory Bird Treaty Reform Act of 2004 affirmed that mute swans are a non-native species in North America and therefore not protected by federal regulation. Thus, it is up to the states to adopt policies, either individually or collectively (i.e. Flyway Councils), to implement measures to achieve management goals. However, given the perceived charisma of mute swans by some publics, enacting management strategies can be challenging for wildlife managers. Periodic surveys beginning in the 1980s indicated that the mute swan population in New Jersey was growing at about 7% per year and peaked at 1,890 birds during 2005. From 2007-14, New Jersey culled 1,662 mute swans in tandem with several disease surveillance research projects. Annual cull rates ranged from 13-18%. From 2007-14, the mute swan population declined at 10% per year to a 2014 estimate of 850 birds. Without management, the 2014 population could presumably have been 3,515 birds based on growth rates observed during the 1990s. Past, present and future issues concerning mute swan management in New Jersey and the Atlantic Flyway will be discussed.

G.3.3: De La Cruz

Diving Duck Response to Mixed-Species Habitat Management in an Urban Pacific Flyway Estuary

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San Francisco Bay is a critical wintering site for waterfowl and shorebirds of the Pacific Flyway. Waterbirds in this highly urbanized estuary rely on mudflat and managed salt pond habitats for roosting and foraging. The San Francisco South Bay Salt Pond Restoration Project is the largest tidal marsh restoration project on the Pacific coast, with an objective of maintaining current bird numbers on salt ponds while converting 50 to 90% of them to tidal marsh. Habitat managers are working to achieve this goal through multiple methods, including mixed-species management on a subset of ponds that are partially drained to create western snowy plover (*Charadrius alexandrinus nivosus*) nesting habitat in summer, and filled to create diving duck foraging habitat in winter. Our objective was to evaluate the response of diving ducks and their invertebrate prey to these management actions. During winter (Oct – April) 2013 - 2015 we measured duck abundance, behavior, and diets, benthic invertebrate density and community composition, and water quality in three mixed-species treatment ponds and in three reference ponds that were filled throughout the year. The most abundant divers in treatment ponds were scaup (*Aythya affinis* and *A. marila*) and ruddy ducks (*Oxyura jamaicensis*). Treatment ponds were used mainly for roosting, while foraging occurred more frequently in reference ponds. Benthic invertebrate species diversity and density increased from fall to spring and was greatest in deep areas of treatment ponds; however, diversity, density and spatial extent were greater in reference ponds. Scaup and ruddy duck diets consisted predominantly of ostracods and seeds in treatment ponds, versus amphipods and seeds in reference ponds. Preliminary results suggest that treatment ponds provide mainly roosting habitat for wintering waterfowl; however, foraging may be enhanced by increasing water circulation in deep borrow ditches during summer to maintain invertebrate populations.

G.3.4: Perry

Research and Management of Ducks on a Private Ranch in Argentina

Don Pablo Research Team: Andrea Amaiden[1], Alicia Berlin[1], Josh Bueth, Enrique Bucher[1], Anibal Carbajo[1], Erio Curto[1], Marcelo Janik[1], Alan Jolicoeur[1], Scott McWilliams[1], Glenn Olsen[1], Christopher Perry[1], Matthew Perry[1]*, Marcelo Prodel[1], Marcelo Romano[1], Sarah Sandoval-Mohapatra[1], Edward Soutiere[1]

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A private 6300 hectare cattle ranch in Argentina (lat. -29.5) was converted to a duck hunting management area in 2007. Rice cultivation on large impoundments created in 2007-10 attracted up to 50 thousand ducks of 11 species. Objectives of research were to learn about movements of ducks, both local and long-distant, and habitat preferences to better manage their populations. Satellite telemetry with implanted 26-gram PTT-100 transmitters in rosy-billed pochard (*Netta peposaca*; n=16), white-faced whistling duck (*Dendrocygna viduata*; n=34), black-bellied whistling duck (*D. autumnalis*; n=14), and fulvous whistling duck (D. bicolor; n=29) in 2008-10, revealed random movements within an 850 km distance from the ranch, but an average of only 66 km. Although there was a tendency for the ducks to move south, there were no clear north/south movements as seen with ducks in the northern hemisphere. The distribution of ducks in the spring (Oct-Dec) in South America may reflect less dependency on specific habitats for breeding or because South America was less affected by recent ice age periods. Instrumentation of 3 Brazilian ducks (*Amazonetta brasiliensis*) in 2012 and 15 ringed teal (*Callonetta leucophrys*) in 2014-15 with 12-gram PTT-100 solar-powered satellite transmitters with loop harnesses, showed more local movements, 82% within 160 km of the ranch, for both species, but one ringed teal moved 400 km from ranch. Satellite-determined locations of all six species indicated strong selection of cultivated rice habitat by the ducks. Predation by fish and reptiles maybe an important factor in habitat use by ducks. Over 360 artificial nest boxes have been established on the ranch and provide nesting habitat for ringed teal and black-bellied whistling ducks. The ranch management has been a model for good wildlife management that is benefiting numerous species, including some species that have not been recorded in the area in many decades.

G.3.5: Elmberg

Success Factors Behind Multi-Stakeholder Multi-Species Management of Geese in an Agricultural Landscape

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On both sides of the Atlantic, geese are a major management challenge, not least because of shifting distributions, increased availability of nutritious agricultural forage, and unprecedented growth of some populations. In northwest Europe, managers face the task of devising management strategies for areas with up to 10 co-occurring goose species. These taxa range from being globally threatened to over-abundant, usually present in mixed-species assemblages whose composition change seasonally. I present a case study from a densely populated agricultural region in south Sweden where goose numbers and damage by geese on crops have increased dramatically during recent decades. A goose management group (GMG) was founded in 2002 comprising landowners, farmers, hunters, ornithologists, conservation NGOs, and local and county level administration. The GMG has autonomy to self-organize and a key point is that it has neither legal jurisdiction nor authority to make formal decisions. This makes the GMG adaptive, free to react quickly to signals from the socio-ecological system. In essence, the GMG provides a collaborative arena for sharing experiences and discussing conflicts. With time this has built trust between stakeholders so that there is no longer any disagreement over input variables such as goose numbers, bag size, and magnitude of crop damage. Further GMG success factors are its continuity over time, that it is embedded in the local community, and that some of its members also represent authorities that do have jurisdiction over hunting permits and crop damage reimbursement. This is an example of how human-wildlife conflicts can be reduced and defused by simple means. Interestingly, GMG members as well as people outside the group consider it a success even though it has not led to reduced goose numbers locally, illustrating that understanding the sociology of management conflicts is often just as important as understanding biological details of the system.

G.3.6: Olson, A.^

Hot Ducks: Are Unshaded Nest Boxes an Ecological Trap for Wood Ducks?

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In California's Central Valley, availability of natural nest cavities appears to be limited and Wood Ducks (*Aix sponsa*) rely heavily on nest box programs. Current nest box management strategies commonly place nest boxes on poles away from trees to reduce access by nest predators. However, placing nest boxes in direct sun, where summer temperatures can reach around 45° C in the Central Valley, strongly influence the internal ambient temperature, and in turn, the incubation temperature in the nest. Current research has shown that slight changes in lab-controlled incubation temperatures can have adverse effects on duckling development and survival. In this study, we examined whether placing nest boxes in full sun versus shade can have similar detrimental impacts on duckling hatch success, development, and survival. We investigated the effect of nest box placement in 2014 and 2015 by randomly assigning nest boxes to a shade or no-shade treatment. Artificial shade structures were installed on approximately half of all active nests, while the other half remained unshaded. Shades were installed shortly before or after the onset of incubation; therefore, hens were unable to choose a shaded or unshaded box prior to egg-laying. Both incubation temperature and ambient temperature inside the nest box were recorded using iButtons. Each iButton recorded one temperature reading every ten minutes throughout the entire incubation period. Within 12-hours of hatch, ducklings were weighed, measured, assessed for neuromuscular development, and injected with a Passive Integrated Transponder (PIT) tag to uniquely mark each duckling. The PIT tags also enable long-term tracking, without the need of recapture, of all females returning to the breeding population in subsequent years. This is accomplished by installing Radio Frequency Identification (RFID) readers on each box within the study site. The RFID reader records the time, date, and unique PIT tag number each time a hen passes through the entrance of a nest box. Several results have emerged from our 2014 data: (1) Internal ambient nest box temperature in shaded nest boxes can be up to 6° C lower than that of unshaded boxes. (2) Hens are more easily able to regulate the incubation temperatures in cooler boxes. (3) Hatch rate and nest box exodus are higher in cooler boxes. (4) Cooler boxes produce more ducklings that are both structurally larger (have longer tarsus measurements) and weigh more. (5) Finally, neuromuscular reaction times are quicker for ducklings hatching from cooler boxes. Our results in 2014 suggest that unshaded boxes within California's Central Valley produce fewer and lower quality ducklings than boxes provided with shade. We are currently analyzing data from 2015, including assessment of return rates and survival of PIT-tagged ducklings from 2014.

G.4: Techniques 1 (Chair: Don Kraege)

G.4.1: Evenson

Employing Digital Still Imaging and Observer Counts to Estimate Bias in Aerial Surveys of Wintering Sea Ducks

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To better understand the bias in aerial survey abundance estimation that results from aircraft and observer effects, we conducted a study to estimate availability bias, detection, and misidentification by collecting images and observer counts of wintering sea ducks. We employed a fixed-wing aircraft with two digital still-image cameras and two observers to survey multiple 50m-wide strip-transects. A forward-facing (FF) camera attached to the wing strut captured images of the transect 250-300m ahead of the aircraft, while a point-of-view (POV) camera mounted to the rear window captured images of the transect abeam of the aircraft. Comparing the FF to POV camera counts allowed estimation of availability bias, or aircraft effect (the proportion of birds that flew out of the transect or dove due to the aircraft). Analyses suggested that 5-30% of sea ducks dove or flew off-transect as the aircraft approached: 5% for goldeneye, 20% for long-tailed duck and surf scoter, 25% for white-winged scoter, and 30% for bufflehead. Comparing the POV camera to observer counts allowed estimation of detection (the percentage of birds within the transect that were detected by observers) and misidentification. Estimates of birds detected on transects ranged from 50% to 95%, varying by species and observer, with long-tailed duck detection being slightly higher than other species. Misidentification of surf and white-winged scoters was about 1% and 4-6%, respectively. Our results suggest that, due to a combination of aircraft and observer effects, current survey estimates could be increased by a factor of 1.3 to 2.2 depending on species. We are developing methods for additional studies to address these biases, as well as effects of transect width and aircraft type.

G.4.2: Yetter

Comparison of Aerial Waterfowl Survey Methods during Fall and Spring Migration

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Illinois provides important stopover habitat for migratory waterfowl. Consequently, the Illinois Natural History Survey has aerially inventoried waterfowl since 1948. However, inventory-style monitoring does not yield detection probabilities or variance estimates and locations are not random making population estimation difficult. We evaluated aerial line transect surveys of diving ducks (*Aythyini*) on Pool 19 of the Mississippi River during springs 2013–2015 and assessed aerial quadrat (1-mi2) surveys of waterfowl along the Illinois River during falls 2014–2015. For comparison, we estimated waterfowl abundance along both rivers using inventory methods. We used Program DISTANCE to generate detection probabilities and populations sizes. Spring transect surveys in 2013 were oriented perpendicular to the river and tended to underestimate populations of diving ducks on Pool 19. Detection probabilities exceeded 50% with coefficients of variation <9%, but encounter rate was extremely low (≤0.005) and variable (CV = 5.2–28.5%). We oriented transects parallel to the river during spring 2014, and estimated duck densities were greater from transect surveys than inventories ($\bar{x}$ = 43%, CV = 117%) and densities ranged from 0.06–10.7 ducks/ha. We noted inventory and transect surveys produced similar population estimates for most species when abundances were 10,000–150,000, but differences were common and pronounced when inventory abundances were outside this range. Preliminary analyses indicated detection probability exceeded 50% during surveys with coefficients of variation <13%. Duck abundance extrapolated from density estimates from a quadrat survey conducted during peak fall migration indicated quadrats were 17% less than the traditional inventory (538,960 ducks) on refuges. Our results suggest transect surveys oriented parallel to the river were logistically feasible and produced reasonable population estimates. Overall, parallel transect surveys appear to be a viable option for further evaluation along rivers, and we suggest comparison to statistically valid quadrat surveys for estimating waterfowl abundance along river systems.

G.4.3: Otto

Modeling Observer Detection Rates in Aerial Surveys

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Detection rates are estimated as part of wildlife surveys to correct for animals missed. Usually the detection is the function of the crew, all the observers together. The counts in aerial surveys are usually corrected by counts from a more reliable platform or the ground. While there are differences among crews there are often also strong differences among observers in the same craft. These differences have often been modeled by multiple observer sampling; here we describe double sampling approaches using the side-by-side transect counts with a random effect for observers. These model-based approaches to estimation are increasingly used in survey analyses due to the increasing availability of statistical software such as WinBUGS. Accommodation of these differences are especially important when experienced observers or pilot have consistent counts year after year in annual survey are paired with different, much less experienced observer that change each year. We describe models appropriate for waterfowl survey designs using paired transects (i.e., counts from different sides of aircraft) associated with ground counts that may or may not be associated with the aircraft observer data. Examples presented include the California Waterfowl survey and the Western Gulf Breeding Waterfowl Survey. Careful consideration of pairing of sample units from ground and aerial counts in waterfowl surveys is needed to ensure that sufficient information exists for estimation using these model-based approaches.

G.4.4: Gilliland

Survey Design for Breeding Scoters: Helicopter vs. Fixed-wing

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Obtaining accurate estimates of population size from surveys is critical for effective management of populations. Current breeding ground surveys do not allow Scoter species identification and may suffer from biases related to detection. In this study, we assessed the effectiveness of helicopter surveys on 25 km^2 plots and fixed-wing surveys on 100 km long transects on a 22,000 km^2 study area in Labrador. We used a dependent double-observer approach to estimate detection probabilities from helicopters and distance sampling for the fixed-wing. Detection probabilities were high for the helicopter (0.99; 95% CI: 0.98-1.0), while detection probability for the fixed-wing was low (0.31; 95% CI: 0.27-0.36). Pair density estimates corrected for incomplete detection were similar between the two platforms for Black Scoters (~0.8 pr/km^2); however, the density for Surf Scoters estimated from the fixed-wing (0.05 pr/km^2; 95% CI: 0.03-0.10) was less than half that estimated from the helicopter (0.11± pr/km^2; 95% CI: 0.02-0.21). The species composition within the first 100 m distance band from the fixed-wing (46% Surf Scoter; 42% Black Scoters and 12% unknown scoters) was different with that recorded from the helicopter (69% Surf Scoters, 23% Black Scoters and 7% White-winged Scoters). These results suggest that Surf Scoters were often miss-classified as Black Scoters from the fixed-wing. Overall density estimates for scoters corrected for detection for scoters were 1.4 times greater when measured from the helicopter (0.23 pr/km^2; 95% CI: 0.22-0.24) than from the fixed-wing (0.16 pr/km^2; 95% CI: 0.11-0.22) suggesting that a larger proportion of the population was detectable from the helicopter than from the fixed-wing. Our results indicate that species identification from fixed-wing aircraft are not accurate and that detection probabilities are low. We suggest that procedures to estimate detection probabilities and unbiased assessments of species composition are necessary for Scoter species-specific population indices from aerial breeding-ground survey programs.

G.4.5: Roche

What the Four-Square-Mile-Survey Can Tell Us About Long-term Changes in Prairie Wetlands

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Many duck species breeding in the US Prairie Pothole Region (PPR) have demonstrated a preference to settle on partially vegetated wetlands (i.e. ‘hemi-marshes’). However, wetlands in the PPR are sensitive to temperature and precipitation, making it likely the availability of the hemi-marshes preferred by breeding waterfowl will fluctuate over time. Since 1987, the ground-based Four-Square-Mile Survey (FSMS) has been used to produce estimates of breeding duck populations. While collecting duck counts, observers also were instructed to assign the vegetative cover type of surveyed ponds to one of four categories varying from nearly completely vegetated to no emergent cover. We used time-series data collected in South Dakota, North Dakota, and Eastern Montana (1987-2012) from ponds (n = 1,228) surveyed for at least 25 years (n = 31,758 pond-years) to describe how prairie wetlands had changed over time as measured by vegetative cover type. We then employed regression analysis to assess the relationship between wetland class and annual water level fluctuations and vegetative cover type. Except for temporary wetlands, prairie wetlands have generally become less vegetated and more open since surveys began in 1987. These changes have been the most pronounced for semi-permanent wetlands. Annual water level fluctuation partially explained vegetative cover type, but we suspect this relationship interacts with as of yet unexamined factors including wetland use, seasonal water level change, and wetland hydrology. For example, less vegetated wetlands may represent a shift toward deeper wetlands with implications for food availability and accessibility for breeding and staging waterfowl. Furthermore, less vegetated wetlands may reduce vegetative cover for overwater nesting and brood rearing ducks in the PPR.

G.4.6: Shaffer

Is the Waterfowl Breeding Population and Habitat Survey Conducted Too Early for Late-nesting Species?

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Since 1955, the internationally coordinated Waterfowl Breeding Population and Habitat Survey (WBPHS) has provided annual estimates of North American breeding duck numbers by species. The survey consists of a single aerial count accompanied by a count from the ground that provides a correction factor for birds not seen from the air. In the Eastern Dakotas (strata 25–49), timing of the survey (typically early to mid-May) coincides with onset of nesting for early nesting species, such as mallard (*Anas platyrhynchos*) and pintail (*A. acuta*) but precedes that of late-nesting species like lesser scaup (*Aythya affinis*) and gadwall (*Anas strepera*). The Four-Square-Mile Survey (FSMS) is a ground-based survey of breeding ducks that has been in existence since 1987. FSMS is a pond-based survey that utilizes both early (early to mid-May) and late (late May to early June) counts to arrive at estimates of breeding duck numbers. In an effort to understand if timing of the WBPHS introduces bias in estimates of late-nesting species, we compared population size estimates for the Eastern Dakotas from the FSMS between early and late counts for 10 duck species. We then relied on a database of duck nests (N=89,364) from the last 50 years to quantify the onset of nest initiation for the same species. We used results of that analysis to classify each of the 10 species as an "early" or "late" nester. We then correlated abundance estimates from the WBPHS with abundance estimates from either the early or late count from the FSMS, depending on whether the species was an early or late nester. A weak correlation for a late-nesting species may provide evidence that the WBPHS may be conducted too early to adequately determine settling patterns and breeding population size of that species.

H.4: Techniques 2 (Chair: Mike Buxton)

H.4.1: Hidden

How Many Birds Are We Missing? Assessing Waterfowl Distribution and Abundance in Missouri Using an Aerial Strip-transect Survey

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Wetlands at the confluence of the Missouri and Grand Rivers (GMR) in central Missouri can provide the necessary nutrients and refuge that migratory waterfowl require during autumn migration and wintering. The region contains four public wetland areas providing high quality wetland habitat for migratory waterfowl as well as a substantial number of recently restored wetlands on private lands. Although aerial surveys have been used to document fall and winter waterfowl use of public wetland areas for over 50 years, and have well documented waterfowl estimates, minimal effort has been dedicated to estimating waterfowl abundance and distribution beyond the boundaries of the intensively managed wetland areas. The goal of this study was to assess waterfowl abundance and distribution outside of public wetland areas in the GMR ecoregion in northern Missouri. We divided the ecoregion into four strata based on land cover variance and expected waterfowl density. Stratum 1 included area outside the GMR floodplain and beyond 30km of any public wetland area, Stratum 2 included area outside the GMR floodplain and within 30km of a public wetland area, Stratum 3 included the GMR floodplain within 30km of a public wetland area, and stratum 4 included the GMR floodplain beyond 30km of a public wetland area. We used a Geographic Information System to create a database of strip-transects oriented to avoid directly following land features such as rivers and valleys. To identify survey transects within each stratum we used a weighted random selection process, in which transects with greater wetland density had a greater selection probability. Three surveys were conducted using a fixed wing aircraft during fall/winter 2014 using a double-observer removal method where both observers kept observations separate until the survey was completed. We used window markers calibrated for 250-m transect width at 150-m height above ground level while maintaining a flight speed of approximately 150-km/hour to ensure consistency in detection probability. We estimated population indices ($\hat{I}$) and used Petersen estimates with a mark-recapture framework to correct population indices and estimate population abundance (N) for each stratum. Estimated waterfowl density was relatively low (0.01-0.27 birds/ha) and mean estimates of variance for both ($\hat{I}$) and (N) were relatively high (CV= 0.76 and 0.77 respectively). Stratum 3 had the greatest mean density of dabbling ducks (0.27 birds/ha). Mallards (*Anas platyrhynchos*) were the most abundant duck species observed among surveys with a mean density of 0.1 birds/ha among strata. Low density estimates and high variance among transect observations indicate that autumn and winter waterfowl distributions in northern Missouri are highly aggregated and spatially heterogeneous. Our findings suggest that wetlands outside public wetland areas can provide habitat for approximately 250,000 waterfowl during peak migration, representing up to 27% of the waterfowl population in the ecoregion. Our results emphasize the potential importance of wetlands outside intensively managed wetland areas in providing wetland habitat for migratory waterfowl, however based on our low density estimates and high variance we are exploring additional methods to reduce variance among and within survey strata.

H.4.2: Brown

Survey of Wetland Management Techniques in California – The 50 Buck Duck

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Migrating and wintering waterbirds of the Pacific Flyway depend on the wetlands of the Central Valley of California every fall, winter and spring. Of the remaining 120,000 hectares of wetlands, two thirds are privately owned, yet considerable uncertainty exits as to how these wetlands are managed. This information represents a critical need for conservation planning by the Central Valley Joint Venture given that the quality of wetland habitat is a direct result of the management actions implemented each year. To date, a systematic evaluation of the management practices implemented on private wetlands in California has not been completed. To address this need, we conducted the first comprehensive survey of wetland management techniques in use on 168 properties in California. The properties surveyed by our study comprise 26,716 hectares of California wetlands and $2,836,500 in annual management expenditures, ranging <$1,000 to >$50,000 with an average $18,910. Funds are used to perform manipulations such as summer irrigations (56.9% of participants), disking (86.6% of participants), and maintaining brood rearing habitat (80.5% of participants). Those managers performing the needed soil and water manipulations also experience increases in the average number of waterfowl harvested each year ($X2 = 53.36$, $P < .0001$). Our results indicate not only that private landowners are performing the needed management practices to produce quality wetland habitat and increase moist-soil seed production, but they are performing these actions at great personal cost averaging $50 per bird harvested.

H.4.3: Nicolai, C.

Geolocators: Breeding Probability and Movement of Three Species of Ducks

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Geolocators have had limited use in waterfowl even though they are commonly used on non-game birds. In western Nevada, we attached 16 and 48 geolocators on mallards and female wood ducks, respectively in 2013. We attached 50 additional geolocators on each of the following species in 2014/15: mallards, canvasbacks, and female wood ducks. For mallards and canvasbacks, we were interested in assessing what proportion of the annual cycle is spent in large scale habitats (i.e., joint ventures) and assumed that hunter recoveries would facilitate downloads of the geolocators. Based on band recoveries, we knew that the intensively monitored wood duck population in western Nevada did not disperse much from the study site (<17% of recoveries were away from study area), but we were interested in using geolocators to assess breeding propensity. Both annual releases of mallards were immediately before hunting seasons and 4 individuals were shot and reported as direct recoveries each year; no indirect recoveries have been obtained yet. Canvasbacks were fitted in February 2015 and have not yet been exposed to hunting. We have retrieved and downloaded 29 of the geolocators from the first cohort of wood ducks. Of those, 25 had year round data and showed 100% breeding probability. One of these individuals moved to breed in western Montana and returned to western Nevada and was recaptured. However, we were concerned as geolocatored wood ducks had to survive and be recaptured to provide breeding data.

H.4.4: O'Connell^

Backscatter-brained: Using Radar Imagery to Determine Wetland Inundation Patterns

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Monitoring wetland inundation is critical to the management and conservation of waterfowl. Different inundation regimes impact the biogeochemical processes and thus productivity of wetlands. Inundation, or lack thereof, can have an even more direct impact on waterfowl, waterbirds and shorebirds; if a wetland is not inundated during the period when one of those functional groups are in the area, then it is not available to that group. Relying on the National Wetlands Inventory (NWI) alone and lacking the data necessary to consider wetland availability during biologically important periods, managers may substantially underestimate the amount of wetlands needed to support waterfowl, waterbirds and shorebirds. Determining the timing and extent of Illinois wetland inundation is an important step towards making informed decisions in wetland management in the state. Ground surveys are labor intensive and optical remote sensing techniques struggle to accurately resolve wetland inundation where there is heavy vegetative cover. Synthetic aperture radar (SAR) has been used to detect inundation in multiple wetland cover types and may be an efficient method of recording inundation patterns in Illinois. A pilot study testing the use of SAR imagery to these ends was conducted on imagery of the Cache River watershed prior to the commencement of a state-wide survey in order to assess feasibility and identify potential pitfalls. Archival PALSAR L-band imagery was attained for four seasons over a one year period and was classified without ground survey to determine inundated wetlands. The results were compared to NWI and were compared among seasons. Inundated wetlands were detected to cover a much smaller area than the total NWI polygon area (46%), but seasonally matched the hydrologic record of the Cache River during the same time frame (R2 = 0.83). Only a small portion of detected inundation persisted throughout spring, summer and fall (17%), highlighting the ephemeral nature of inundation in the watershed during the period evaluated. Further analysis of SAR imagery with in situ validation is necessary to determine the accuracy of the technique. Beginning in spring of 2015, ground surveys crews have been mapping the extent of wetland inundation in ~90 wetland plots throughout Illinois. The ~50ha plots cover multiple cover types including forested, scrub/shrub, emergent and open water wetlands. Surveys are timed to coincide with the spring waterfowl migration, the summer waterbird nesting season and the autumn shorebird migration. The resulting thematic maps will be used to train and validate a random forest classification model of inundation from newly-acquired PALSAR-2 L-band imagery. Several image resolutions will be compared to determine the most cost-efficient method before the model is expanded to cover the entire state. Successful implementation of the model will allow managers to monitor inundation in the state's wetland at a level that was previously unattainable.

H.4.5: Webb

How Will Predicted Land Use Change Affect Mallard Spring Migration Stopover Ecology? Inferences from an Agent-based Model

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Habitat loss, habitat fragmentation, overexploitation and climate change pose familiar and new challenges to conserving natural populations throughout the world. One approach conservation planners may use to evaluate the effects of these challenges on wildlife populations is scenario planning. We developed an agent-based model to evaluate the effects of future land use and land cover changes on spring migrating dabbling ducks in North America. Our model was based on theoretical and empirical research for the mallard within a major stopover area in the Mississippi Flyway. We assessed the effects of three future climate scenarios (Intergovernmental Panel on Climate Change scenarios A1B, A2, B1) on mallard stopover duration, movement distances and mortality. We specifically focused on migration stopover duration because previous research has demonstrated that individuals arriving earlier on the nesting grounds exhibit increased reproductive fitness. Compared to present conditions, all three modeled scenarios predicted increased stopover duration and movement distances of agent mallards. Although all three scenarios presented migrating mallards with increased amounts of wetland area, scenarios also contained substantially less cropland, which decreased overall energetic carrying capacity of the study area. Furthermore, future climate patterns may alter spatial distribution of croplands in North America, increasing uncertainty regarding availability of waste grain as a food source to mallards. Predicted increases of wetland area within the study area may provide other dabbling ducks species with food resources of greater nutritional value compared to cropland. However, increased yearly variability in precipitation patterns due to climate change will pose new challenges to wetland managers and conservation planners within the next 50 years.

H.4.6: Laborde, Jr.

A Contrast of Alternative Survey Methodologies in the 2015 Survey of Louisiana Waterfowl Hunters

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We surveyed 2 random samples of 2,500 Louisiana waterfowl hunters each (random mail and mixed-mode methods), 24,842 waterfowl hunters for which we had e-mail addresses after drawing our random samples (e-mail method), and 1 convenience sample (open web method) following the 2014-2015 hunting season. We asked identical questions about waterfowl hunting effort, success, satisfaction, attitudes toward proposed regulations, and demographics. We hypothesized no statistically significant differences (≤ 0.05) between responses to the random mail and mixed-mode methods, but significant differences between the randomly selected methods and the e-mail and open web methods. We further hypothesized no difference between any of the methods in attitudinal responses. After elimination of duplicate responses, we received 603 usable responses to the random mail survey, 426 usable responses to the mixed-mode survey, 4,873 usable responses to the e-mail survey, and 1,480 usable responses to the open web survey. We randomly subsampled 426 responses from each survey method and compared results by methods using generalized linear models (GLMs) with Tukey-Kramer *post hoc* tests. In tests of 3 variables measuring effort and success, 6 variables measuring hunter satisfaction, 6 variables measuring attitudes towards proposed regulations, and 7 demographic variables, we identified no significant differences between the random mail and mixed-mode methods. We identified no significant differences between any of the 4 methods in responses to 6 attitudinal variables. Compared to the random mail and mixed-mode survey respondents, e-mail survey respondents were not significantly different in demographic variables, satisfaction, or regulatory preferences, but differed in days hunted and years of participation. Respondents to the open web survey were more avid, harvested more waterfowl, and were less satisfied with season dates. The cost per usable response for the random mail, mixed-mode, e-mail, and open web surveys were $85.41, $70.42, $0.36, and $1.18, respectively. Analysis of attitudes towards proposed regulations would lead to identical managerial conclusions irrespective of survey method.

H.3: Human Dimensions (Chair: Dean Smith)

H.3.1: Tapp

Evaluating the Migratory Bird Habitat Initiative after the Deep Water Horizon Oil Spill: Waterbird and Seed Abundances

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The USDA Natural Resources Conservation Service (NRCS) implemented the Migratory Bird Habitat Initiative (MBHI) in summer 2010 after the Deepwater Horizon Oil Spill to provide habitat inland from potential oil impacted wetlands. We studied waterfowl and other waterbird use and seed resources in NRCS Wetland Reserve Program (WRP) easements enrolled in MBHI and non-managed WRP easements in the Mississippi Alluvial Valley of Arkansas, Louisiana, Mississippi, and Missouri. We conducted waterfowl and other waterbird surveys from August 2011–April 2012 in Mississippi and from October 2011–April 2012 in Louisiana. In Arkansas and Missouri, we conducted waterfowl surveys from November 2011 through February 2012. In Louisiana and Mississippi, nearly 3 times more dabbling ducks and all ducks combined were observed on MBHI than non-managed wetlands. Additionally, waterbirds other than waterfowl and shorebirds were nearly twice more abundant on MBHI than non-managed wetlands. In Arkansas and Missouri, MBHI wetlands attracted over 2 times more dabbling ducks and 1.7 times more waterbird species than non-managed wetlands. Wetlands enrolled in MBHI in Mississippi and Louisiana contained ≥1.3 times more seeds (mass) known to be consumed by waterfowl than non-managed wetlands. In Arkansas and Missouri, seed mass estimates did not differ among MBHI, non-managed, and publicly managed wetlands. Additionally, seed mass did not differ among management practices of mowing, disking, or fall-winter inundation in these states. While other studies have documented greater waterbird densities on actively than non-managed or passively managed wetlands, our results highlighted the potential for MBHI and similar initiatives to increase waterbird use and energetic carrying capacity of privately owned wetlands for waterbirds. Our results complement other NRCS-supported research in the MAV and elsewhere in the USA that actively managed WRP wetlands received significantly greater use by waterbirds than passively or non-managed WRP wetlands.

H.3.2: Devers

Integrating Human Dimensions into Habitat Delivery: Relationships Among Landscape Characteristics and Recreation

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In 2012, the North American Waterfowl Management Plan (NAWMP) explicitly included a human dimension objective to grow the number of active supporters of waterfowl and wetland conservation. The inclusion of this objective has challenged the habitat management community, particularly the Joint Ventures, to consider how habitat delivery influences the recruitment and retention of active supporters. Habitat managers and science coordinators in the NAWMP community have hypothesized participation in waterfowl hunting and bird watching are limited by availability of lands that support wetland bird species and provide recreational opportunity. Specifically, availability is hypothesized to be a function of travel distance, quality of lands open to recreation, land ownership, presence of supporting infrastructure (i.e., boat ramps and signage), and the presence of birds that provide an opportunity for harvest or viewing. Our objective was to use data from the U.S. Fish and Wildlife Service Harvest Information Program, U.S. Geological Survey Bird Banding Laboratory, and the Cornell Lab of Ornithology E-bird Program with random utility models to investigate the hypothesized relationship between landscape characteristics and recreational site choice of Atlantic Flyway birdwatchers and waterfowl hunters. Using >150,000 trips for both hunters and bird watchers we found active participants take on average 6 trips a year, with>50% of the trips in their county of residence and >90% in their state of residence. In addition, the amount of wetlands and public lands available to users has a positive effect on the number of trips and the distance traveled to recreational sites. Using site choice models we are exploring how changes in the amount and location of public lands changes overall site use. These results can be incorporated into the Atlantic Coast Joint Venture waterfowl implementation plan to assist managers in identifying and managing areas that provide maximum benefit to waterfowl populations, waterfowl hunters, and birdwatchers.

H.3.3: Lindstrom

Prairie Pothole Politics: Opportunities and Challenges to Conserving the Duck Factory

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The Prairie Pothole Region (PPR) is one of the most important landscapes for continental waterfowl populations. However, intensive land-use pressures, economic drivers and public policies are fueling large-scale conversion of this region's important waterfowl breeding habitat (Wright and Wimberly 2013, Lark et al. 2015, Wright 2015). Functional and abundant small wetlands are the cornerstone of this region's ability to produce and sustain record waterfowl populations. However, current PPR conservation planning goals will not be met without significant increases in funding and policy reforms (Doherty et al. 2013). Public policy plays an important role in PPR habitat conservation through various incentives and disincentives. For example, as part of the 2014 Farm Bill, Congress recoupled conservation compliance ("Swampbuster") to federal crop insurance and enacted a new six state (North Dakota, South Dakota, Montana, Minnesota, Iowa and Nebraska) "Sodsaver" provision that discourages conversion of native grasslands through reduced crop insurance subsidies. Other federal habitat funding programs like the North American Wetlands Conservation Act (NAWCA) and federal duck stamp provide significant funding for voluntary incentive-based habitat conservation programs. During the past 80 years, the federal duck stamp program has raised over $800 million to protect more than 6 million acres of migratory bird habitat across the U.S. This effort has largely been funded by waterfowl hunters. Despite past and current political challenges, interest among private landowners for voluntary habitat conservation programs (both short- and long-term) remains strong. In this presentation, I will highlight some of the policy drivers, political challenges and urgent conservation funding needs in the U.S. PPR.

H.3.4: Slattery

Roads, Pipelines, and Seismic Lines…What Do They Mean for Boreal Ducks?

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The Western Boreal Forest (WBF) is changing rapidly due to industrial development. Implications of these changes for waterfowl are unknown though landscape changes are thought to alter food availability and predation with subsequent negative impacts on demography. Linear features (roads, seismic lines, and pipelines) have the second largest anthropogenic footprint in the WBF and our objective was to assess relationships between these features and waterfowl settling and productivity. Waterfowl surveys were conducted using helicopters to count pairs and broods on grids (2.5km x 2.5km, n = 100 per year, 2013 and 2014) distributed across gradients of linear feature densities in north-central Alberta. We employed a double observer and repeated visit methodology then used hierarchical models to examine relationships with linear features while correcting for detection probability and habitat biases. Analyses were conducted at both the wetland and grid levels. Preliminary results indicate both negative and positive relationships with pair and brood abundance depending on the survey period (pair, brood), nesting guild (cavity, overwater, upland) and spatial scale (wetland, grid). Overall, relationships with distance to or density of linear features for both pair and brood abundance were 31% positive, 15% mixed (±), and 17% negative, while 37% had no detectable relationship. However, not all relationships were robust. Our index of breeding success (brood:pair ratios, hereafter productivity) was positively correlated with individual and cumulative linear feature density for cavity nesters and generally negative for the upland nesting guild. We also observed a weak positive correlation between productivity and roads for the overwater nesting guild. Collectively, these preliminary results provide limited support for a priori predictions that settling or productivity decline at either higher densities of or closer to linear features. Additional fieldwork is underway to further assess spatial and temporal variation in patterns.

H.3.5: Dorak^

Urban Takeover: Canada Geese Shifting from City Parks to Industrial Rooftops

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In the past several decades, temperate-breeding Canada geese (*Branta canadensis*) have increased throughout the midwestern United States. Moreover, subarctic-breeding populations of Canada geese appear to be shifting their wintering range northward from the south and central portions of the Mississippi Flyway to more northern latitudes. We investigated Canada geese wintering in the Greater Chicago Metropolitan Area (GCMA), including determining genetic composition of birds using locations nearby Midway International Airport, home range sizes, spatial and temporal use of thermal refugia, and response to harassment.

During summers 2014–2015, we captured 690 Canada geese within the GCMA during their annual molt. We obtained morphological measurements (i.e., culmen length, skull length, tarsus length, mass) and DNA samples to determine a baseline for temperate-breeding Canada geese. We also affixed an aluminum leg band and a plastic waterfowl neck collar with unique alpha/numeric codes on all birds for use in re-sighting efforts.

During the autumn and winters of 2014–2016, we captured 152 Canada geese using a combination of rocket nets, net guns, and cast nets within the urban area. We attached solar-powered global positioning system (GPS) CTT-1040a transmitters (Cellular Tracking Technologies, Somerset, PA) to neck collars of 39 geese spread throughout the two winter field seasons to collect detailed information on their movements and habitat use. DNA analysis from the first field season shows that the population of captured birds consisted of ~58% from subarctic-breeding populations and ~42% from the temperate-breeding population. The transmitters acquire a GPS location once per hour and relay data through global system for mobile communication (GSM) towers, also used by cell phones. By using GSM technology, we are able to receive data in near real time and have the ability to change transmission rates for finer scale resolution when needed.

Multiple thermal refugia within close proximity to food sources were used by geese staying within the GCMA. During extreme cold periods, geese moved from parks and cemeteries to rooftops and warm water discharge areas along the canal to aid in thermal regulation. Geese sought thermal refuge on black rooftops, with as many as 450 individuals occupying a rooftop at one time. Temperature recorders and anemometers were deployed in these thermal refugia locations to compare weather variables between sites used during harsh weather and sites used during warmer periods of the winter to identify shifts in spatial use in relation to climactic variables.
Operative temperature models were created for areas with and without roosting geese in order to determine if the thermal environment differs, and if so whether there is a "threshold" thermal environment needed for Canada geese to winter in the GCMA. We then took the weather data collected from each sight used and created an agent-based model to identify future goose movements in response to shifts in weather variables and assessed those movements with our transmitter data. The data gathered from this research will help evaluate current management practices and help design future management practices of Canada geese that winter in the GCMA area.

*Speaker; ^Student