U.S. Geological Survey
Minnesota Cooperative Fish and Wildlife Research Unit
University of Minnesota
Department of Fisheries, Wildlife, and Conservation Biology
200 Hodson Hall
1980 Folwell Avenue
St. Paul, Minnesota 55108
Phone: (612) 624-3421
Fax: (612) 625-5299

mncoopunit.cfans.umn.edu
www.coopunits.org/Minnesota

MINNESOTA COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT

Biennial Report

January 2017—December 2018

U.S. Geological Survey

University of Minnesota

Minnesota Department of Natural Resources

The Wildlife Management Institute

U.S. Fish and Wildlife Service

The Minnesota Cooperative Fish and Wildlife Research Unit was established in 1987 on the St. Paul Campus of the University of Minnesota as part of the Cooperative Research Units Program and is hosted by the Department of Fisheries, Wildlife, and Conservation Biology. The Cooperative Research Units program was established over sixty years ago to facilitate cooperation among the U.S. Department of the Interior (currently through the U.S. Geological Survey), universities, state fish and wildlife agencies, and private organizations, by developing and conducting programs of research and education related to fish and wildlife resources conservation. That mission continues today, with support from both long-standing and new partners. At the Minnesota Cooperative Fish and Wildlife Research Unit, we emphasize research on impacts of human activities on aquatic and terrestrial ecosystems that are of state, regional, and national significance. Our research program addresses both the biological and social aspects of both game and nongame fisheries and wildlife management in the context of maintenance of biological diversity, and integrity and sustainability of ecosystems.

This is the fifteenth biennial report produced by the Minnesota Coop Unit and summarizes Unit activities during 2017 and 2018. Over the past two years, support for the Unit program has remained strong, even in light of difficult economic conditions and budget pressures at the federal, state, and University levels. We currently have a vacancy in that Assistant Leader-Fisheries scientist Dr. Bruce Vondracek retired in May 2015, and that position has not been refilled. We continue to enjoy support from our Minnesota Department of Natural Resources, University of Minnesota, Wildlife Management Institute, and U.S. Fish and Wildlife Service partners. We are also fortunate to work with a wide range of cooperators, outstanding graduate students, and university, federal, state, and non-governmental scientists and resource managers to further our research and teaching missions, and to provide technical assistance to partners and clients. Please view our University of Minnesota website (http://mncoopunit.cfans.umn.edu/) or Cooperative Units Program website (http://www.coopunits.org/Minnesota/) for more information about our activities and to download copies of reports and publications. We invite you to review the summary of our Unit's accomplishments in this biennial report and to contact us with comments or to request additional information. Finally, thanks to our many partners and collaborators for their continued support, and we look forward to continuing a productive relationship to further our mission and shared interests.

Sincerely,

Dr. David E. Andersen
Leader

Dr. David C. Fulton
Assistant Leader - Wildlife

Table of Contents

Personnel and Cooperators

Unit Personnel

Unit Staff – U. S. Geological Survey – Cooperative Research Units

Dr. David E. Andersen, Unit Leader

Dr. David C. Fulton, Assistant Leader – Wildlife

Unit Staff – University of Minnesota

Jason Bruggeman, Postdoctoral Research Fellow

Shalesa Johnson, Student Office Worker

Holly Miller, Research Associate

Hattie Saloka, Program/Project Specialist

Susan A. Schroeder, PhD, Research Associate

Kristina Slagle, Postdoctoral Scientist (Fulton)

UNIT STUDENTS

Kaly Adkins, M.S. (Andersen, graduated 2017)

Katelin Goebel, M.S. (Andersen)

Nina Hill, M.S. (Andersen)

Gunnar Kramer , M.S. (Andersen, graduated 2017)

Kelsie LaSharr, M.S. (Fulton, graduated 2017)

Leslie McInenly, Ph.D. (Fulton)

Evan Salcido, M.S. (Fulton)

Jason Spaeth, Ph.D. (Fulton)

Eric Walberg, M.S. (Fulton, graduated 2016), Ph.D. (Fulton)

David Wolfson, M.S. (Andersen and Fieberg, graduated 2018)

Unit Affiliated Staff and Students

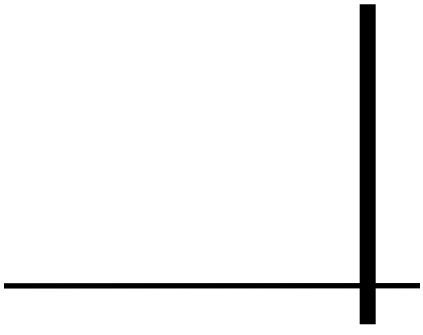
Briana Burke, Undergraduate Student (Hove)

Aaron Claus, B.S. and M.S. (Sorensen, graduated 2015)

Alex Franzen, Undergraduate Student (Hove)

McKenna Rodine, Undergraduate Student (Hove)

Sarah Saunders, Postdoctoral Scientist (Arnold)



Unit Coordinating Committee

University of Minnesota

Head, Department of Fisheries, Wildlife, and Conservation Biology
Dr. Susan Galatowitsch
135D Skok Hall, 2003 Upper Buford Circle
St. Paul, MN 55108
(612) 624-3242

Dean, College of Food, Agricultural and Natural Resource Sciences
Dr. Brian Buhr
277 Coffey Hall
1420 Eckles Ave.
St. Paul, MN 55108
(612) 624-1234

MN Department of Natural Resources
500 Lafayette Road,
St. Paul, MN 55155

Fisheries Chief
Don Pereira (retired 2018)
Brad Parsons
(651) 259-5229

Wildlife Research and Policy Manager
Lou Cornicelli
(651) 259-5202

Deputy Director for Fish and Wildlife
Pat Rivers
(651) 259-5224

Director for Fish and Wildlife
Jim Leach
(651) 259-5180

Fisheries Research and Policy Manager
Melissa Treml
(651) 259-5231

Ecological Resources
Monitoring and Control Unit Supervisor
David I. Wright (retired)
(651) 259-5155

Wildlife Management Institute

President
Steven A. Williams
1440 Upper Bermudian Road
Gardners, PA 17324-9766
(717) 677-4480

Midwest Field Representative
Bill Moritz
1608 Packwood Road
Fairfield, IA 52556
(989) 413-3115

U.S. Geological Survey

Eastern Region Supervisor, Cooperative Research Units
Dr. Michael W. Tome
Leetown Science Center
1700 Leetown Road
Kearneysville, WV 25430
(301) 834-8054

Division Chief, Cooperative Research Units
Dr. John Organ, (703) 648-4261
12201 Sunrise Valley Drive, MS 303
Reston, VA 20192

U.S. Fish and Wildlife Service (non-voting)
Midwest Region
5600 American Blvd. West
Suite 990
Bloomington, MN 55437-1458

Assistant Chief, Migratory Birds
Sean Kelly (retired 2018)
(612) 713-5470

Chief, Migratory Birds
Tom Cooper
(612) 713-5338

Unit Cooperators

Cooperating Investigators in Unit Research

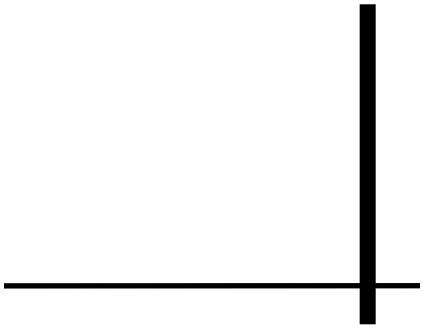
Todd Arnold (University of Minnesota)
David Buehler (University of Tennessee)
Tom Cooper (U.S. Fish and Wildlife Service)
Lou Cornicelli (Minnesota Department of Natural Resources)
Gino D'Angelo (University of Georgia)
Nicole Davros (Minnesota Department of Natural Resources)
John Fieberg (University of Minnesota)
James Forester III (University of Minnesota)
Dave Fronczak (U.S. Fish and Wildlife Service)
Susan Galatowitsch (University of Minnesota)
Howie Harshaw (University of Alberta)
Christine Herwig (Minnesota Department of Natural Resources)
Greg Hoch (Minnesota Department of Natural Resources)
Mark Hove (University of Minnesota)
Douglas H. Johnson (University of Minnesota / U.S. Geological Survey)
Patricia L. Kennedy (Oregon State University)
Jeff Lawrence (Minnesota Department of Natural Resources)
Dan Licht (National Park Service)
James A. Perry (University of Minnesota)
Andrew Raedeke (Missouri Department of Conservation)
Charlotte Roy (Minnesota Department of Natural Resources)
Mike Schrage (Fond du Lac Tribe)
Rudy Schuster (U.S. Geological Survey)
Peter W. Sorensen (University of Minnesota)
Henry Streby (University of Toledo)
Sara Vacek (U.S. Fish and Wildlife Service)
Petra B. Wood (West Virginia Cooperative Fish and Wildlife Research Unit)

Cooperating University of Minnesota Academic Units

College of Food, Agricultural and Natural Resource Sciences
Conservation Biology Graduate Program
Department of Fisheries, Wildlife, and Conservation Biology
Fisheries and Aquatic Biology Graduate Program
Natural Resources Science and Management Graduate Program
University of Minnesota Graduate School

Cooperating Organizations

Ducks Unlimited
Fond du Lac Tribe
Legislative-Citizen Committee on Minnesota Resources
Minnesota Department of Natural Resources
Missouri Department of Conservation
    Human Dimensions Working Group
National Flyway Council
Ohio State University
Oregon State University
University of Alberta
University of Georgia
University of Tennessee
University of Toledo
U.S. Bureau of Land Management
U.S. Fish and Wildlife Service
    Bird Habitat Conservation, Upper Mississippi River - Great Lakes Joint Venture
    Division of Migratory Birds, Region 3
    Webless Migratory Gamebird Research Program
U.S. Geological Survey
    Columbia Environmental Research Center
    Geosciences & Environmental Change Science Center
    Science Support Partnership
    Upper Midwest Environmental Sciences Center
    West Virginia Cooperative Fish and Wildlife Research Unit
U.S. National Park Service
    Midwest Region



Completed Research

Applied Ecology

Delineating Sandhill Crane Populations in Minnesota

Investigators:	David E. Andersen and John Fieberg (Cooperating Faculty)
Collaborators:	Tom Cooper (U.S. Fish and Wildlife Service), Jeff Lawrence (Minnesota Department of Natural Resources), Dave Fronczak (U.S. Fish and Wildlife Service)
Students:	David Wolfson, M.S. (Natural Resources Science and Management)
Duration:	May 2014 to June 2017
Funding source:	U.S. Fish and Wildlife Service, Minnesota Cooperative Fish and Wildlife Research Unit, Minnesota Department of Natural Resources, and the State of Minnesota's Environment and Natural Resources Trust Fund as recommended by the Legislative-Citizen Committee on Minnesota Resources
Project Location:	Central and northern Minnesota Minnesota Cooperative Fish and Wildlife Research Unit

Minnesota is one of few states that supports portions of two distinct breeding populations of sandhill cranes (*Antigone canadensis*)—the Mid-continent Population (MCP) that breeds and migrates through northwestern Minnesota, and the Eastern Population (EP) that breeds throughout much of the rest of the state. Although there is a small amount of gene flow between the two populations, genetic analyses in the early 2000s concluded that the two populations were genetically distinct enough to be managed separately. Sandhill cranes are long-lived birds with relatively low recruitment rates, making accurate knowledge of abundance and distribution critical for well-informed harvest management. Whereas the MCP of sandhill cranes has exhibited stable population estimates over time, the EP is currently experiencing a significant increase in population size, and also appears to be experiencing a concurrent expansion in breeding range.

Sandhill crane numbers sharply declined following widespread European settlement during the late 19th century. Unregulated harvest and wide-

spread habitat alteration led to a historic low of 25 breeding pairs of EP cranes in the 1930s. Since then, sandhill crane numbers increased following passage of the Migratory Bird Treaty Act of 1918, which banned all hunting of cranes. Cranes have also benefitted from widespread public land acquisitions and wildlife habitat preservation.

Historically, the breeding range of MCP cranes in Minnesota was restricted to the extreme northwestern portion of the state, especially Kittson and Roseau counties, whereas the breeding range of EP cranes was limited to the east-central part of the state, with a large area separating the two populations. The breeding ranges of these two populations have expanded and come into closer proximity as numbers of cranes have increased, particularly for the EP. However, the current distribution of these two populations, and the resulting implications for their management, is unknown.

To better understand the relationship between MCP and EP cranes along the boundaries of their breeding distributions in Minnesota, we captured breeding cranes in the zone between the two historic range boundaries and equipped them with Global System for Mobile Communication/Global Positioning System (GPS/GSM) transmitters to monitor their movement over multiple years. Specifically, we addressed the following objectives:

1. Delineate the current boundary between breeding MCP and EP sandhill cranes in Minnesota
2. Test *a priori* spatial hypotheses regarding sandhill crane habitat use and selection in agricultural, upland, and wetland environments.
3. Evaluate year-round movement patterns (e.g., migration) and survival of Minnesota sandhill cranes.

Our results indicate that EP sandhill cranes have extended their breeding distribution to the northwest and the current boundary between these two populations is in northwestern Minnesota. We documented some mixing of MCP and EP cranes in the early fall, with the potential for some harvest of EP cranes during the MCP hunting season in northwestern Minnesota, although the harvest risk to EP cranes appears low. We also demonstrated that during the period when crop depredation is most likely (during planting and the early growing season), juvenile cranes are much more likely to make movements consistent with foraging on crops than adults, suggesting that harvest of adults in the fall is likely not an effective strategy to mitigate crop damage. Finally, we described and compared movement patterns of juvenile vs. adult sandhilll cranes, and our results suggest that juvenile cranes both move greater distances and exhibit lower fidelity to use areas, compared with adults. We have published the results of the boundary delineation portion of this project, and are currently revising a manuscript related to movement patterns of juveniles and adults.

Determining the Behavioral and Physiological Chemosensory Sensitivity of Asian Carp to Chemical Attractants

Investigator: Peter W. Sorensen (Cooperating Faculty)

Students: Aaron Claus, M.S. (Conservation Biology, Fisheries & Aquatic Biology)

Duration: July 2013 to June 2017

Funding Source: U.S. Geological Survey—Columbia Environmental Research Center

Project Location: University of Minnesota

Although it is well established that the bigheaded carps (*Hypophthalichthys* spp.) are microphagous filter-feeders, how they locate and then identify their food is unknown. If understood, chemical feeding stimuli could be used to target these invasive species. This study, which commenced in the summer of 2013, is exploring the roles of olfaction (smell) and gustation (taste) in food finding and the possibility that these senses detect chemicals unique to plankton preferred by these fishes. We are especially interested in the possibility that feeding stimuli could be used as species-specific attractants for trapping or to permit easier population assessment using environmental DNA (eDNA) or as gustatory stimulants to evoke swallowing, and thus ingestion of poisoned microparticles for carp control. Behavioral studies have characterized ingestion behavior in both the silver (*H. molitrix*) and bighead (*H. nobilis*) carps and shown it to be largely mediated by the olfactory sense with the epibranchial organ, an internal taste organ playing a role in ingestion. We have also tested a dozen food items on both bighead and silver carp and whereas species differences are evident, Spirulina, a cyanobaterium, is especially active in both species (Claus and Sorensen 2017). Studies of the L-amino acids released show that they can account for some, but not all feeding activity. Recent work identified novel fatty acids as additional cues that show mixture synergism that can drive attraction; however, the presence of unknowns with significant biological activity is now implicated. Future work should focus on these because it is highly likely they are novel and taxon-specific.

An Integrated Population Model for American Woodcock

Investigator: Todd Arnold (Cooperating Faculty)

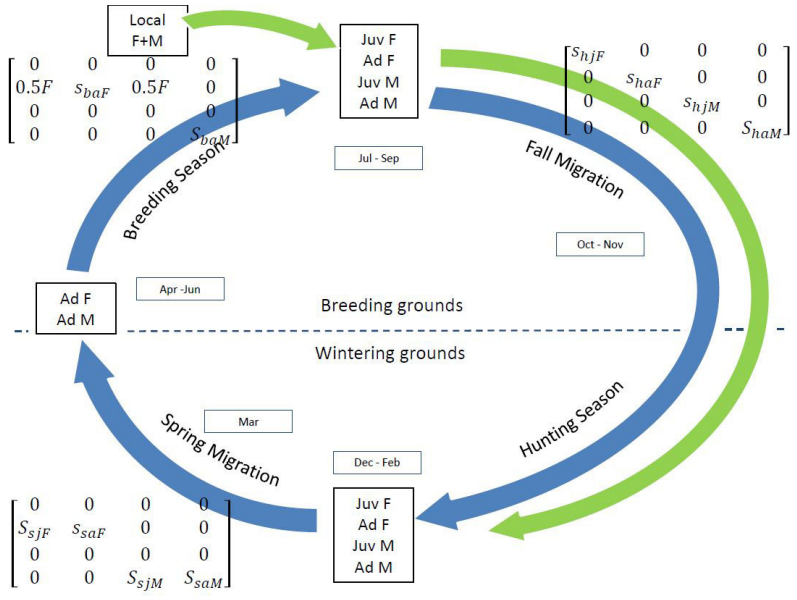
Staff: Sarah Saunders, Post-doctoral Research Fellow

Duration: August 2015 to December 2017

Funding Source: U.S. Fish and Wildlife Service - Webless Migratory Gamebird Research Program

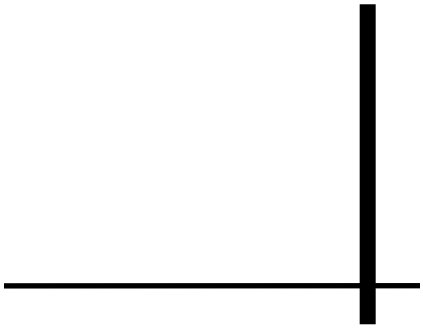
Project Location: University of Minnesota, Twin Cities Campus

Estimates of total harvest help inform harvest management decisions, but such data are also useful for estimating population size and composition in demographic models. Historical estimates for U.S. harvest of American woodcock (*Scolopax minor*) are available from two separate surveys: the 1964 to 2001 duck stamp survey (DSS) that sampled woodcock hunters who also hunted waterfowl, and the 1999 to 2016 Harvest Information Program (HIP) that sampled all licensed woodcock hunters. During overlap years (1999 to 2001), HIP estimates of total woodcock harvest were approximately twice as large as DSS estimates, but with only three years of overlap there was little potential to develop robust correction factors for historical DSS data. I developed a model of historical woodcock harvest that posited three groups of woodcock hunters, including those who always, sometimes, or never hunted waterfowl. During the HIP survey all three groups were included in harvest surveys; however, during the DSS years only woodcock hunter who always hunted waterfowl were reliably sampled during all years, but I used annual duck stamp sales as a covariate to help predict harvest by woodcock hunters who hunted waterfowl irregularly. Using a reverse-time (2016 to 1964) model that assumed these three proportions of harvest remained constant through time, I was able to estimate total harvest in all years by estimating the latent component of harvest by non-waterfowl hunters. Averaged over all harvest jurisdictions, this model estimated that hunters who always, sometimes, or never hunted waterfowl contributed 43%, 32%, and 25% of the total woodcock harvest, using these relationships, I estimated total harvest during all years (1964 to



Conceptual model

2016) using data from both harvest surveys, although estimates based only on DSS data had greater uncertainty. In combination with band recovery data and harvest composition from the Parts Collection Survey, analysts could use estimates of historical harvest to estimate population size, composition, fecundity, and survival dating back to the initiation of harvest surveys in 1964.



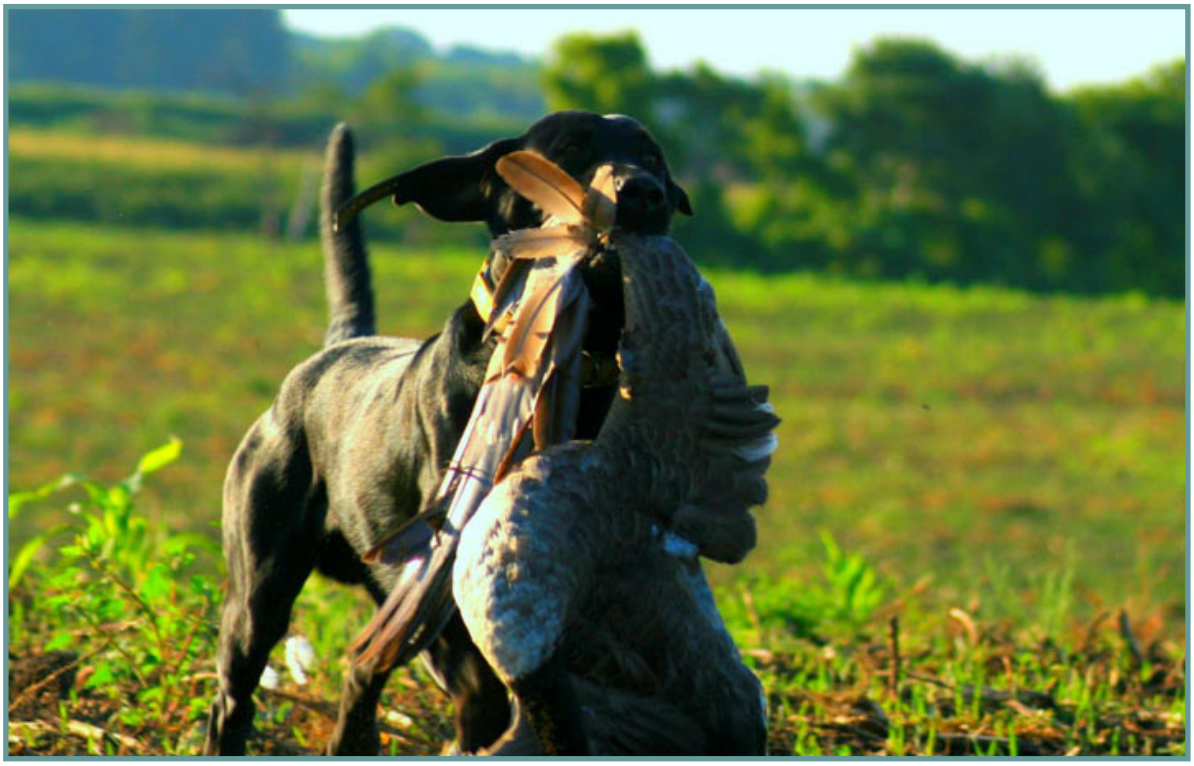
Quantifying the Relationship between Grasslands, Conservation Reserve Program (CRP) Enrollments, and Greater Prairie-chicken Populations in Minnesota

Investigator:	David E. Andersen
Collaborator:	Charlotte Roy (Minnesota Department of Natural Resources)
Student:	Kaly Adkins, M.S. (Natural Resources Science and Management)
Duration:	September 2015 to June 2017
Funding source:	Minnesota Department of Natural Resources
Project Location:	Northwestern Minnesota
	Minnesota Cooperative Fish and Wildlife Research Unit

*Both the abundance of greater prairie-chickens (*Tympanuchus cupido pinnatus)* and the area in grassland Conservation Reserve Program (CRP) in northwestern Minnesota have undergone recent declines. Although wildlife conservation is a stated objective of the CRP, the impact of CRP grassland on greater prairie-chicken populations has not been quantified. To address that information need, we evaluated the association between greater-prairie chicken lek density (leks/km^2) and the number of males at leks (males/lek) and CRP enrollments in the context of landscape structure and composition in northwestern Minnesota using data from standardized prairie-chicken surveys and land-cover in 17 42-km^2 survey blocks during the period 2004-2016. We used a mixed-effect model and a layered approach in an information-theoretic framework at multiple spatial scales to identify covariates related to prairie-chicken abundance. At the landscape scale, the amount of CRP grassland; state-, federal-, and The Nature Conservancy (TNC)-managed grasslands; CRP wetland; state-, federal-, and TNC-managed wetlands, "other" wetlands; the contiguity of grasslands; and the number of patches of grasslands and wetlands in each survey block in each year best explained lek density (leks/km^2). At the lek scale, the amount of CRP grassland; state-, federal-, and TNC-managed grasslands; CRP wetland; state-, federal-, and TNC-managed wetlands; "other" wetlands; forests; developed areas; shrubs; and the contiguity of CRP grassland best explained the number of males at leks. These results suggest that increasing the quantity of grassland and wetland CRP contracts throughout the existing range of greater prairie-chickens in northwestern Minnesota and aggregating CRP grassland contracts in areas of known lek sites may increase greater prairie-chicken abundance.

*Project description from Adkins, K.I.S. 2017. The relationship between grasslands, Conservation Reserve Program (CRP) enrollments, and greater prairie-chicken (*Tympanuchus cupido pinnatus*) populations in Minnesota. M.S. Thesis, University of Minnesota, St. Paul, Minnesota, U.S.A.

Completed Research



Human Dimensions, Management, and Conservation

Assessing the Preferences of Stakeholders and Waterfowl Management Professionals to Inform the Implementation of the NAWMP Action Plan

Investigator: David C. Fulton

Collaborators: Howie Harshaw (University of Alberta), Andy Raedeke (Human Dimensions Working Group / Missouri Department of Conservation), Rudy Schuster (U.S. Geological Survey)

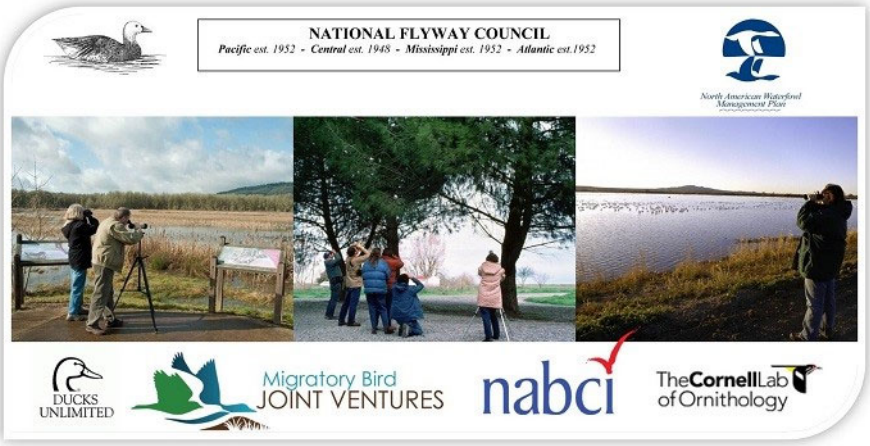
Staff: Kristina Slagle, Postdoctoral Scientist (Ohio State University)

Student: Jason Spaeth, Ph.D. (Natural Resources Science and Management)

Duration: June 2015 to September 2018

Funding sources: National Flyway Council, Ducks Unlimited

Project Location: Minnesota Cooperative Fish and Wildlife Research Unit



This project addresses three key research activities associated with a broader proposal by the National Flyway Council's Human Dimensions Working Group (HDWG) to conduct research involving key stakeholders and the general public in the U.S. and Canada that will inform implementation of the North American Waterfowl Management Plan (NAWMP).

The broader objectives of the study were to:

1. Assess what hunters and other waterfowl conservationists (i.e., members of organizations supporting migratory bird conservation including viewers) most desire from their natural resource based management and social settings to inform NAWMP objectives and select habitat and population management alternatives.
2. Establish baseline measures that can be repeated to inform the development of a Public Engagement Strategy and monitor trends in achieving the NAWMP goal of "growing numbers of waterfowl hunters, other conservationists, and citizens who enjoy and actively support waterfowl and wetlands conservation."
3. Assess waterfowl hunters' knowledge, preferences, levels of use, and support for waterfowl and wetlands conservation.
4. Assess other waterfowl conservationists' knowledge, preferences, levels of use and support for waterfowl and wetlands conservation.
5. Assess the general public's awareness and their perceptions regarding the importance of the benefits and values (i.e., Ecological Goods

and Services - EGS) provided by waterfowl and wetlands conservation.

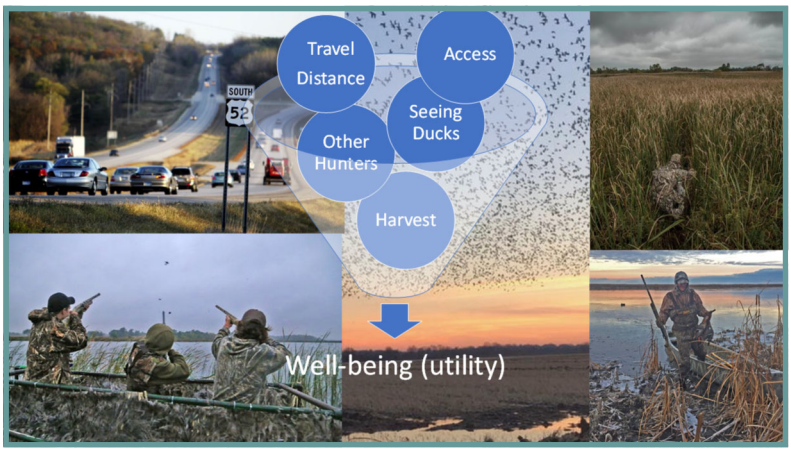
6. Assess the general public's participation in waterfowl-associated recreation and how much they support waterfowl and wetlands conservation.
7. Assess waterfowl professionals' perspectives on the levels of waterfowl populations and habitats needed to support hunter and viewer use opportunities.

At the University of Minnesota, two surveys across the continental United States were conducted with waterfowl hunters and birdwatchers. We used records from the 2015 migratory bird Harvest Information Program (HIP) maintained by the U.S. Fish and Wildlife Service to contact a total of 39,601 waterfowl hunters in 49 U.S. states (excluding Hawaii) between November 2016 and May 2017. A total of 8,123 waterfowl hunters in 49 states completed an online survey (20.5% response) after being contacted through an invitation letter in the mail (up to 4 contacts through the mail were made). We used membership information from Cornell's Lab of Ornithology web-based eBird checklist program to contact 133,956 individuals in 49 U.S. states (excluding Hawaii) who were active on eBird between 1 January 2012 and 26 October 2016. Contact was made using e-mail and potential participants could link the the web-based survey directly from the e-mail invitation. A total of 33,071 completed some portion of the survey (24.7% response).

Kristina Slagle, postdoc on the project, completed summary reports for hunters and birdwatchers for each of the four continental migratory bird flyways. These summaries are available at the North American Waterfowl Management Plan website (hunters: https://nawmp.org/nawmp-udpate/national-survey-waterfowl-hunters ; birdwatchers: https://nawmp.org/nawmp-udpate/national-survey-birdwatchers).

For both the waterfowl hunter and birdwatcher studies a discrete choice experiment (DCE) was conducted to identify the key attributes important to choosing hunting and birdwatching experiences. For birdwatchers, seven key attributes were included in the DCE: 1) diversity of bird species you see; 2) rarity—whether there is a chance to see a rare or unusual species; 3) number of birds; 4) ease of access at the area you visit; 5) wetlands—whether there are wetlands and wetland species present; 6) naturalness—degree to which the area is a natural condition or has been developed; and 7) travel distance from home. For waterfowl hunters, five key attributes were included in the DCE: 1) havest—number of waterfowl you are likely to harvest in a day; 2) ease of access at the area you hunt; 3) travel distance measured in time; 4) quantity of waterfowl you see when hunting even if outside shooting range; 5) potential for interference / competition from other hunters.

Results on the DCE were very similar across all four flyways for both birdwatchers and waterfowl hunters.

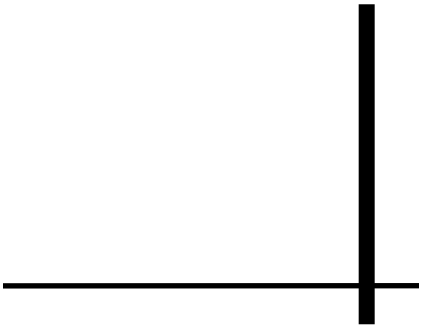


For birdwatchers travel distance was most important, followed by rarity of species, naturalness of the areas, diversity of species, presence of wetlands and wetland species, ease of access, and number of birds.

For waterfowl hunters potential for competition

from other hunters followed closely by length of travel at potential harvest were the most import attributes in choosing where to hunt. Quantity of waterfowl seen and ease of access were less important to choosing where to hunt.

Several publications are being developed with research partners on the project.



Deer Goal Setting Surveys and Deer Hunter Attitude Research

Investigator:	David C. Fulton and Lou Cornicelli (Minnesota Department of Natural Resources)
Students:	Eric Walberg, M.S. (Natural Resources Science and Management)
	Leslie McInenly, Ph.D. (Natural Resources Science and Management)
Duration:	May 2014 to August 2017
Funding source:	Minnesota Department of Natural Resources
Project Location:	Minnesota Cooperative Fish and Wildlife Research Unit

As Minnesota moved from a more conservative deer (*Odocoileus* spp.) management toward a more liberal framework based on harvesting antlerless deer, there has been an increased need to gather accurate hunter survey information. Regulations that impose restrictions by requiring antlerless harvest (e.g., earn-a-buck) or protect a segment of the antlered male population (e.g., antler point restriction) likely cannot be implemented without broad public support and a thorough examination of the policy trade-offs.

Policy is politics and the acceptance of a management policy occurs when solutions and problems are sufficiently credible. This speaks to the concept of wildlife governance, which can be broadly interpreted as what governments do with respect to wildlife policy and management. Within that governance structure, the instruments and mechanisms are available to steer an organization and allow that organization to be effective and responsive to stakeholders. The Minnesota Department of Natural Resources (MNDNR) has been engaging stakeholders for decades through a formalized roundtable meeting and formalized random surveys/public meetings/stakeholder engagement processes. As MNDNR enters a 'next phase' of inquiry that includes re-defining deer populations goals and assessing hunter attitudes statewide, there is continued interest from organized groups and individuals to make the process transparent and inclusive. To complete this work, we used a mixed-mode approach to survey a random sample of deer hunters in five strata throughout the state over a three-year period. For each survey, the first two mailings were comprised of an invitation to complete a survey online, and the third mailing was a traditional self-administered mail-back questionnaire.

The 2015-2017 Minnesota deer hunting survey were conducted to assess hunters':

- participation and activities,
- deer population perceptions and preferences,
- satisfaction,
- attitudes about deer management,
- regulatory preferences,
- relationship with MNDNR, and
- involvement in agency decision-making.

Surveys were distributed to 25,319 deer hunters in five regions of the state (11,417 after the 2014 deer season, 10,403 after the 2015 season, and 3,499 after the 2016 season); 10,894 completed surveys were used for this analysis. After adjusting for undeliverable surveys and invalid respondents, the response rate was 44.8%.

Survey timing after the 2014 and 2015 seasons was coincident with the two lowest annual harvests in over a decade, a management response to population declines following two consecutive years (2013 and 2014) of moderate-to-severe winter conditions. During this time, MNDNR was also coordinating a public process to revisit deer population goals for most of the deer permit areas (DPAs) in the state.

Stated Choice Experiment: Regulatory combinations

This study also included a stated choice experiment examining the preferences of deer hunters concerning different potential combinations of deer seasons and regulations in Minnesota. Stated choice models present hypothetical scenarios to respondents to derive individuals' preferences for alternatives composed of multiple resource and management attributes (Adamowicz et al. 1994; Oh et al. 2005). Survey respondents were presented with eight deer season choice scenarios and asked to choose one option. Each scenario included two season structure choices plus a "none" (i.e., I would not hunt deer in Minnesota with these options).

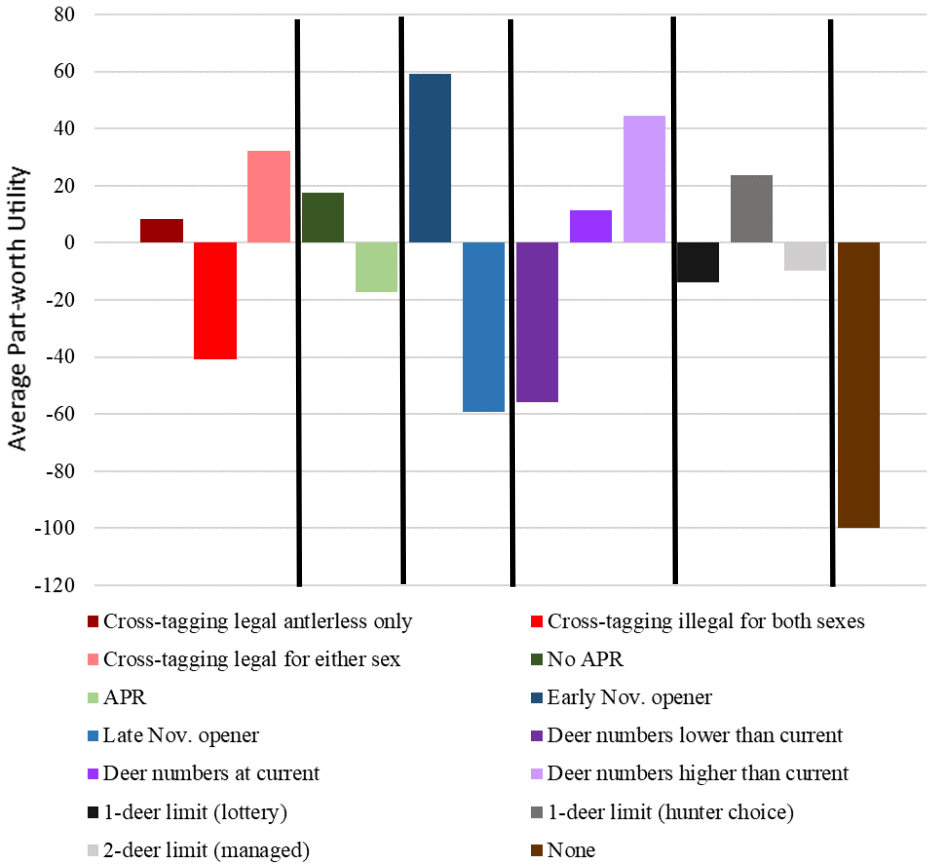
Alternatives presented in this season choice experiment consisted of five attributes: (a) cross-tagging of harvested deer, (b) whether or not antler point restrictions are in place, (c) timing of the firearm opener during or out of the rut, (d) the population level or number of deer, and (e) deer harvest limit. By using an experimental design, scenarios selected by respondents can be used to identify the relative importance, or influence, of each attribute on regulatory and season combinations. In addition, by analyzing individuals' preferences for different levels of each attribute, we can estimate the utility, or relative desirability, of each level among respondents.

Across all survey areas, timing of the opener - either in early or in late November (in or out of the rut) - had the most influence on scenario choice followed closely by deer numbers in all but north-central Minnesota. The third most important attribute was cross-tagging in the majority of survey areas. Implementation of antler point restrictions had the least influence on scenario choice in northwestern and east-central Minnesota whereas harvest limit was least important in northeastern, south-central, and north-central Minnesota.

Across all survey areas, and statewide,

- a hunting opener in early November had the highest utility and was preferred over a late-November opener,
- legal cross-tagging for either sex was preferred over antlerless-only cross-tagging or no cross-tagging,
- no antler point restriction was preferred over an antler point restriction regulation,
- deer numbers higher than 2014-2016 levels were preferred over levels experienced during that period or lower population levels, and
- the preferred seasonal harvest (bag) limit was a one-deer, either sex regulation (Hunter Choice) rather than a one-deer limit with an antlerless lottery (Lottery) or a two-deer limit (Managed).

Results of the stated choice experiment allow comparison of various regulatory packages via market simulation to estimate the proportion of respondents that would be expected to choose a particular scenario. For example, market simulation comparing regulatory packages representing existing regu-



latory structures with 2014-2016 population levels compared to similar packages with a higher deer population suggest that hunters would prefer scenarios with higher deer populations (67.7%) and, of those, most would prefer regulations requiring a one-deer limit (40.1%). This suggests bag limit preferences are somewhat insensitive to population levels, i.e., the preference for a higher population is not driven by a desire to harvest more deer based on current statewide hunter preferences.

A second choice simulation was conducted to examine preferences related to regulatory packages that could increase the proportion of antlered bucks in the population. In this simulation, the option describing existing regulations was preferred. Notably, not hunting was predicted to be preferred over a package including a late-November hunt at 2014-2016 population levels. If the same package were offered but with higher deer population levels, the existing regulations were predicted to receive an even greater share of hunter preference and a smaller percentage of hunters were predicted to indicate they would not hunt given the options provided. Results from these simulations suggest that, statewide, commonly proposed MNDNR regulatory packages that could increase the proportion of antlered bucks in the population are currently less attractive than existing MNDNR regulations even at higher population levels.

Results of these studies have been used by staff and decision-makes at the MNDNR to develop regional and statewide deer management strategies.

McInenly, L. E., L. Cornicelli, and E. Walberg. 2017. Minnesota deer management: a study of deer hunter opinions about deer populations and management: Blocks H1 -H5 Final Report. University of Minnesota, Minnesota Cooperative Fish and Wildlife Research Unit, Department of Fisheries, Wildlife, and Conservation Biology, St. Paul, Minnesota, U.S.A.

Fishing in Minnesota: A Study of Statewide Angler Participation and Activities

Investigator: David C. Fulton
Staff: Holly Miller, Research Associate
Duration: November 2017 to December 2018
Funding source: Minnesota Department of Natural Resources
Project Location: Minnesota Cooperative Fish and Wildlife Research Unit

The purpose of this study was to follow up on previous statewide surveys of anglers and provide longitudinal data on Minnesota residents' fishing participation and experiences. To do this, we examined fishing involvement, motivations for fishing, satisfaction with fishing, and opinions about fisheries management. We also queried

fishing information gathering, fishing for individual species, interest in muskellunge fishing, and fishing activities in 2017, including participation in fishing tournaments.

Surveys were sent in late spring and summer of 2018 to 1,000 anglers in each of five regions (northwest, northeast, southern, central, and metro) and to an additional sample of 1,000 female anglers, for a total of 6,000. We received 1,731 completed surveys for a response rate of 32%. Data were weighted by regional population and gender. Comparisons were conducted for selected demographics and regions but those results are not included in this executive summary.

Fishing in Minnesota

More than 70% of respondents had purchased a Minnesota fishing license every year for the past 10 years. The majority of respondents had either fished the same number of days per year over the past five years (53%) or had increased the number of days they fished (21%), but a quarter said the number of days had decreased (26%). On average, respondents had fished the most days during the 2017 season on open water from a boat on lakes (17 days), followed by ice fishing on lakes (eight days) and open water from a pier or shore on lakes (seven days). More than half of respondents fished at least one day during the 2017 season for walleye (70%), crappie (59%), whatever is biting (56%), and sunfish (54%). Respondents fished the most days for whatever is biting (21 days), walleye (18 days), crappie (16 days), and sunfish (16 days). When respondents were asked to rank their top three species, walleye (39%) and crappie (30%) were ranked most often. Walleye was also the species with the most number one rankings

(32%), followed by whatever is biting (12%). Few respondents had participated in fishing tournaments in the 12 months prior to the survey (13%). More respondents (10%) had participated in ice fishing tournaments than in open water tournaments (6%). The majority of respondents participated in one to three tournaments (77% for open water and 97% for ice fishing). Half of respondents who participated in open water tournaments had participated in one to three tournaments with more than 25 boats (50%). The most common species targeted in tournaments were walleye (52% of respondents) and bass (48%).

Most respondents thought that the quality of fishing in Minnesota had stayed the same (43%) or declined (47%) over the past 10 years. Similar percentages thought quality of fishing would stay the same (44%) or decline (39%) over the next 10 years. Most respondents were satisfied with their overall fishing experience in Minnesota during the 2017 season (72%). Over half of respondents were satisfied with the size of fish they caught (59%), the number of fish they caught (54%), access at lakes and streams (70%), and facilities at lakes and streams (59%). Less than half of the respondents were satisfied with the behavior of other anglers (45%) and non-anglers (32%), but that was due to relatively large percentages of neutral respondents and not respondents who were actually dissatisfied. (Throughout the report it is important to note that neutral responses should not be interpreted as disagreement or dissatisfaction but rather that respondents might not care or do not know enough to have formed an opinion.) Most respondents believed they were receiving a good (48%) or fair (43%) value from their Minnesota fishing license.

Minnesota Fisheries Management

When asked about a variety of lake management issues, half or more of respondents agreed that human activities on land can impact water quality and fish (90%), aquatic plants should be managed like other resources (75%), habitat restoration is an acceptable use of fishing license revenue (64%), heavy fishing pressure is reducing the numbers of fish (53%), and the Minnesota Department of Natural Resources (MNDNR) should use beneficial practices even if the public does not believe they are beneficial (50%). More than half of respondents disagreed that aquatic plants are weeds and have no value to the lake (74%) and lakeshore owners should have the right to alter the shoreline any way they want (66%).

Respondents were asked about a variety of management actions for individual species, including walleye, sunfish, tulibee/cisco/whitefish, and burbot. For walleye and sunfish, respondents were in the most agreement with maintaining current bag limits, with around half of respondents agreeing for walleye (47%) and sunfish (48%). There was the least agreement with reducing the bag limits significantly (e.g., 52% disagreed with reducing the walleye bag limit from six to three fish) or putting size limits on the fish that are caught (e.g., 40% disagreed with reducing the sunfish bag limit from 20 to 10 with no more than five greater than eight inches). Respondents were also not in favor of continuing to stock walleye in lakes where stocking had not increased walleye populations (44% disagreed) or of reducing the number of lakes with protected slots for walleye (41% disagreed). Respondents were mostly neutral about implementing bag limits for tulibee/cisco/whitefish (48%) and burbot (46%), though more respondents agreed with these ideas than disagreed.

Whereas only 11% of respondents reported fishing for muskellunge for at least one day during the 2017 season, a total of 29% were moderately (18%), strongly (6%), or very strongly (5%) interested in fishing for muskie in Minnesota, and 29% reported they were moderately (15%), strongly (8%), or very strongly (6%) likely to fish for muskie in Minnesota in the future. About four out of 10 indicated they were not at all interested or likely to fish for muskie, with about one in three indicating they were slightly interested in and slightly likely to fish for muskie in Minnesota in the future. Whereas 68% of respondents indicated they did not at all consider themselves to be muskie anglers, 32% identified slightly (19%), moderately (8%), strongly (2%) or very strongly (2%) as muskie anglers. Among those who reported fishing for muskie, the majority (65%) identified moderately (29%), strongly (17%), or very strongly (19%) as muskie anglers. The minimum muskie size limit that respondents preferred and that they thought was biologically

best was 51 inches, somewhat smaller than the current minimum size limit of 54 inches.

A MaxDiff choice model was developed to help the MNDNR decide what management activities to prioritize when face with limited funds. Eight general management activities were selected and respondents were asked to select the most and least important activities for each of eight questions (each question contained four of the eight activities). When the responses to all the different questions were combined, relative importance could be determined. Managing and protecting fish habitat, raising fish for stocking in public waters, and monitoring fish populations were the most important management activities, whereas recruiting and retaining anglers and providing aquatic education opportunities were the least important.

Miller, H.M. 2018. Fishing in Minnesota: a study of angler participation and activities-2018 Final Report. University of Minnesota, Minnesota Cooperative Fish and Wildlife Research Unit, Department of Fisheries, Wildlife, and Conservation Biology, St. Paul, Minnesota, U.S.A.

Fishing for Panfish in Minnesota: A Study of Angler Participation and Activities

Investigator: David C. Fulton

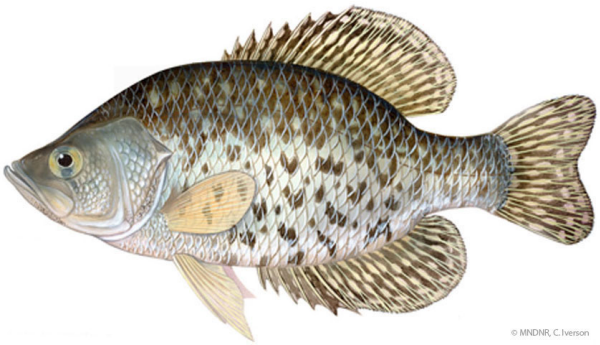
Staff: Susan A. Schroeder, Ph.D. Research Associate

Duration: July 2016 to March 2017

Funding source: Minnesota Department of Natural Resources

Project Location: Minnesota Cooperative Fish and Wildlife Research Unit

This study was conducted to characterize the preferred experiences, level of involvement, catch orientations, satisfaction, use histories, management and regulatory preferences, and sociodemographics of Minnesota resident panfish anglers. The population of interest in this study included Minnesota resident anglers who had targeted panfish (i.e., sunfish, crappie, or yellow perch) in the state during the previous 12 months. Data were collected using a mail-back survey. A postcard was used to prescreen anglers for participation in panfish angling in Minnesota. The sample was stratified by region of residence in (a) the seven-county metropolitan area near Minneapolis/St. Paul and (b) Minnesota counties outside the seven-county metropolitan area. For metropolitan counties, we had an adjusted response rate of 55% for full-length surveys, and a total response rate of 68% including nonresponse surveys. For non-metropolitan counties, we had an adjusted response rate of 58% for full-length surveys, and a total response rate of 71% including nonresponse surveys.



Survey recipients were asked to indicate their preference level for sunfish, crappie, and yellow perch. Crappie was most preferred over sunfish and yellow perch. Over 70% of respondents preferred or strongly preferred sunfish, compared to over 80% for crappie and 33% for yellow perch. Over 60% of respondents used live bait to target panfish, compared to just over 30% who used live bait and artificial lures equally, and less than 10% who fished only with artificial lures. Over 60% of anglers kept most or all crappies they caught, compared to about 42% of sunfish, and 38% of yellow perch. Panfish anglers in Minnesota are fairly satisfied with the overall panfish angling experience and the number of panfish they catch, but they are less satisfied with the size of panfish they catch. The size of fish that are caught are relatively important to anglers, perhaps because the comparatively small size of panfish compared to other game species that are kept for consumption. Although a majority of respondents rate current bag limits for panfish “about right,” the preferred bag limits for sunfish and yellow perch are about 15 fish/day compared to the current bag limits of 20/day for each, and the preferred bag limit for crappie is 11 fish/day compared to the current bag limit of 10/day. Of regulation options presented in the survey, respondents were most supportive of reduced bag limits and minimum size limits to improve the quality and quantity of panfish in a lake. Respondents were not supportive of restrictions on the use of live bait, which was found to be commonly used for panfish

angling. Respondents, however, felt that there had been a decline in quality panfish angling opportunities in the state, and generally agreed that regulations could improve the quality and quantity of panfish.

Schroeder, S. A. 2017. Fishing for panfish in Minnesota: a study of angler participation and activities. University of Minnesota, Minnesota Cooperative Fish and Wildlife Research Unit, Department of Fisheries, Wildlife, and Conservation Biology, St. Paul, Minnesota, U.S.A.

Landowner Attitudes Toward Elk in Northwest Minnesota

Investigator: David C. Fulton and Gino D'Angelo (University of Georgia)
Student: Eric Walberg, M.S. (Natural Resources Science and Management)
Duration: July 2015 to August 2017
Funding Source: Minnesota Department of Natural Resources
Project Location: Minnesota Cooperative Fish and Wildlife Research Unit

Managing the elk (*Cervus canadensis*) population in northwestern Minnesota provides a multitude of challenges ranging from whether or not they should be present at all to how both private and public lands should be managed to benefit elk. This divisiveness has led to strong opinions about both elk and their management. Historically, there has been a lack of information about public attitudes toward elk in northwestern Minnesota, which further complicates the issue. Long-term viability of elk in northwestern Minnesota is largely dependent on public support and the tolerance of private landowners. Minnesota's natural resources provide many benefits to the state's residents, including outdoor recreational activities such as hunting, fishing, and wildlife viewing. Elk are valued for aesthetic and intrinsic reasons, recreation including hunting and viewing, and for revenues derived from recreation associated with elk. Prior to the 1900s, elk ranged over most of the state but were functionally extirpated due to overharvest and habitat loss. Restoration efforts near Grygla, Minnesota in the early 20th century and natural immigration from Manitoba and North Dakota into Kittson County have allowed the northwestern elk population to increase to approximately 150 elk; however, this estimate fluctuates due to population movement across the International Border. Elk currently exist in four localized herds in two areas of northwestern Minnesota, but the population is managed at low levels to reduce human-wildlife conflict. The long-term vision is to increase the population size and range of the elk population in Minnesota.

We surveyed 3,000 private landowners in northwestern Minnesota within the current elk range and the surrounding area to describe landowner attitudes toward elk and preferences for future elk population management. The population of interest was private landowners in parts of Beltrami, Kittson, Marshall, Pennington, and Roseau counties. The sample was stratified by landowners who resided, (a) within the current elk range (n = 768), and (b) outside the elk range (n = 2,232). Within the elk range, we had an adjusted response rate of 53% for full-length surveys, and a total response rate of 66% including nonresponse surveys. Outside of the elk range, we had an adjusted response

rate of 37% for full-length surveys, and a total response rate of 50% including nonresponse surveys. The mean age of respondents was 59 years. Overall, 49% had income from farming, 86% were male and 33% of respondents had a four-year college degree or higher level of education.

Landowner Experiences with Elk

A majority of respondents within elk range indicated that elk live near their property (75%) and they have seen elk or elk sign on their property (72%), although almost half (45%) only saw elk or elk sign a few times per year. As expected, a limited number of respondents outside of elk range reported elk living near their property (14%). A majority of respondents outside of elk range (85%) have never seen elk or elk sign on their property. Some landowners outside of elk range reported seeing elk or elk sign on their property a few times per year (15%), though few saw elk more frequently (0.4%). Landowners within elk range were asked about whether they have experienced elk-caused damage to their property and, if so, the severity of damage experienced during the last year and/or while they have owned their property. Respondents reported damage most frequently to small grains (24%), row crops (21%), and fences (18%). Reported damage experienced by respondents was typically negligible or minor, although some reported severe damage. Few landowners (2%) reported experiencing an elk-vehicle collision.

Landowner Attitudes Toward Elk

A majority of landowners both within (64%) and outside (67%) elk range had favorable attitudes toward elk (Figure S-1 in report). Landowners with larger properties had less favorable attitudes toward elk, on average, compared to landowners with smaller property sizes ($r = -0.15$). Landowners who hunted had more favorable attitudes toward elk in northwestern Minnesota than non-hunting landowners (72% vs 48%, respectively). Landowners with a household income from farming had less favorable attitudes toward elk in northwestern Minnesota than non-farming landowners (58% vs. 74%, respectively).

A majority of respondents were supportive of having elk on their property (56%), within five miles of their property (65%), and in northwest Minnesota in general (71%). Respondents both outside and within elk range were supportive of having elk present on their property (72% vs 69%, respectively). A majority of all landowners were supportive of elk regardless of property size, though landowners with large properties (>150 acres) were less supportive of elk (64%) than landowners with medium-size (76%) or small parcels (76%).

Elk Population Size

A majority of respondents outside of elk range believed that the elk population in northwestern Minnesota was too low (58%). Nearly half of respondents within elk range believed the elk population was too low (46%) and about one-third believed the elk population was about right (31%). Respondents with larger properties within elk range and outside of elk range were more likely to believe the elk population was too high. About half of respondents within elk range (58%) and outside of elk range (49%) preferred increasing the elk population in northwestern Minnesota. Respondents outside of elk range preferred increasing the elk population more than respondents within elk range. A smaller portion of respondents (within: 22%, outside: 11%) preferred decreasing the elk population. Respondents with large properties were more likely to desire fewer elk in the future. Respondents indicated that increasing the elk population by approximately 25% (35 elk) over the next 10 years would be most acceptable . Increasing the elk population by 50% (65 elk) or 100% (130 elk) were also acceptable scenarios. Respondents within elk range and outside of elk range preferred increasing the elk population and indicated that any decrease to the elk population was unacceptable. Respondents outside of elk range indicated that an increase to the elk population was more acceptable than respondents within elk range.

Walberg, E., G.J. D'Angelo, and L. Cornicelli, 2017. Northwest Minnesota elk: a study of landowners' attitudes toward elk and elk management. University of Minnesota, Minnesota Cooperative Fish and Wildlife Research Unit, Department of Fisheries, Wildlife, and Conservation Biology, St. Paul, Minnesota, U.S.A.

Minnesota DNR Walk-In Access Study: Landowners' Perceptions

Investigator: David C. Fulton

Student: Evan Salcido, M.S. (Natural Resources Science and Management)

Duration: July 2017 to October 2018

Funding Source: Minnesota Department of Natural Resources

Project Location: Minnesota Cooperative Fish and Wildlife Research Unit

We collected information from Minnesota landowners who own land that is considered eligible for enrollment in the Walk-In Access (WIA) program, as well as from Minnesota landowners who own land that is currently enrolled in WIA. The purpose of this study was to help understand drivers of landowner participation in WIA, beliefs about WIA, and support for the WIA program. Survey questionnaires were sent to 2,885 adult (18+) Minnesota landowners with valid addresses who owned at least 40 acres of natural property. A total of 1,059 completed questionnaires were returned, resulting in an overall response rate of 38.2%. This sample size provides estimates within ± 3% at the 95% confidence level. The study questionnaire included the following topic areas:

- Land usage and place attachment;
- Knowledge, attitudes, and beliefs about the Walk-In Access program;
- Land use priorities and perceived responsibilities;
- Landowner trust; importance of hunting activities; personal identification.

Knowledge, Attitudes, and Beliefs about the Walk-In Access Program

We were interested in understanding what Minnesota landowners know and believe about WIA, as well as their overall disposition towards the program. Pre-existing knowledge of WIA was significantly higher among Enrolled respondents, who were also more confident in their ability to maximize program participation and work through any challenges. Enrolled respondents' attitudes towards WIA were primarily positive, and most were likely to re-enroll their land. Eligible respondents' attitudes towards WIA were primarily negative, with most being unlikely to enroll their land. Eligible respondents were largely skeptical about potentially beneficial outcomes of WIA enrollment, and were more strongly convinced of potentially negative outcomes; these beliefs were reversed among enrolled landowners. Eligible landowners were also more concerned than enrolled landowners about liability issues and other complications that could arise from participation in WIA.

Evan Salcido produced a study report for the Minnesota Department of Natural Resources and two manuscripts used for his MS thesis .

Salcido, E. 2018. Landowner perceptions and opinions of the Minnesota DNR's Walk-In Access program. University of Minnesota, Minnesota Cooperative Fish and Wildlife Research Unit, Department of Fisheries, Wildlife, and Conservation Biology, St. Paul, Minnesota, U.S.A.

Minnesota Waterfowl Hunter Study

Investigator: David C. Fulton
Staff: Susan Schroeder, PhD, Research Associate
Duration: November 2017 to September 2018
Funding Source: Minnesota Department of Natural Resources
Project Location: Minnesota Cooperative Fish and Wildlife Research Unit

This study of the 2017 Minnesota waterfowl-hunting season was conducted to assess waterfowl hunters':

- participation and activities,
- satisfaction,
- motivations,
- involvement with the activity, and
- attitudes about waterfowl management.

The survey was distributed to 3,600 waterfowl hunters in a statewide sample stratified by region, along with 900 pictorial stamp buyers, and 900 crane permit buyers. The number of full-length survey respondents for the three samples were: 1,661 for the statewide sample, 425 for the pictorial sample, and 415 for the crane sample. Total response numbers including shortened, nonresponse surveys were: 1,842 for the statewide sample, 486 for the pictorial sample, and 457 for the crane sample. After adjusting for undeliverable surveys and invalid respondents, the response rate for the full-length survey was 49% for all three samples, and the response rates including respondents to the shortened, nonresponse survey was 53% for the crane sample, 54% for the statewide sample, and 55% for the pictorial sample.

Over two-thirds of hunters (69%) reported being satisfied with their general waterfowl-hunting experience. Younger hunters and hunters who had been hunting for fewer years reported higher levels of satisfaction. Nearly three-fourths (71%) of respondents were satisfied with their 2017 duck-hunting experience. Nearly half of respondents (49%) were satisfied with their duck-hunting harvest. Satisfaction with duck-hunting regulations was between satisfaction levels for experience and harvest. A larger proportion of hunters were dissatisfied with their harvest compared to the proportion dissatisfied with the experience or regulations. There was a significant positive relationship between the number of ducks bagged and satisfaction with duck-hunting harvest.

Respondents reported significantly higher satisfaction levels for the 2017 season than for the 2000, 2005, 2007, 2010, 2011, and 2014 seasons. Satisfaction was not significantly different from the 2002 season. Support for Youth Waterfowl Hunting Day in 2017 was significantly higher than for previous survey years. Reported memberships in Ducks Unlimited, Delta Waterfowl, the Minnesota Waterfowl Association, and local sportsmen's clubs were lower in 2017 than in 2014, but similar to levels seen in previous study years.

Schroeder, S. A. and S.D. Cordts. 2018. The 2017 waterfowl hunting season in Minnesota: a study of hunters' opinions and activities. University of Minnesota, Minnesota Cooperative Fish and Wildlife Research Unit, Department of Fisheries, Wildlife, and Conservation Biology, St. Paul, Minnesota, U.S.A.

Understanding User Preferences and Visitor Numbers at Minnesota Wildlife Management Areas

Investigator: David C. Fulton and Lou Cornicelli (Minnesota Department of Natural Resources)

Student: Kelsie LaSharr, M.S. (Natural Resources Science and Management)

Duration: July 2015 to August 2017

Funding source: Minnesota Department of Natural Resources

Project Location: Minnesota Cooperative Fish and Wildlife Research Unit

Wildlife Management Areas (WMAs) were established by the Minnesota Department of Natural Resources (MNDNR) to provide quality wildlife habitat and publicly accessible land for hunting and wildlife viewing opportunities. MNDNR staff were interested in understanding how people use the WMA system, which activities they enjoy pursuing, and the number of people recreating during peak seasons. WMAs are historically used most frequently during fall hunting seasons for hunting both big and small game. To achieve our research goals, we intercepted hunters in the field during the 2015-2016 fall hunting season. Publicly accessible properties provide a crucial resource for protecting wildlife resources and providing recreational opportunities. Hunting opportunities on publicly-owned state land are especially important in the eastern United States for continued hunting participation. Publicly restricted hunting, such as opportunities on private lands, continues to decline as these properties are parceled, sold, and otherwise fragmented. Land that is owned in a checkerboard pattern becomes problematic for hunters when barriers to quality habitat are formed by unpassable private property. As such, it is important to maintain public land for hunters to use, especially when private land is otherwise not available. Wildlife management agencies can ensure the public obtains benefits from publicly managed, wildlife-producing lands by better understanding desired outcomes and motivations of hunters. In turn, these agencies can help ensure hunters are recruited, retained, and reactivated for generations to come.

The overall goal of this project is to improve the understanding of visitor use at MNDNR WMAs. Specifically, our objectives were to:

1. Characterize WMA users through an increased understanding of beliefs, values, and satisfactions they associate with using WMAs
2. Determine participation levels by estimating visitor usage during fall hunting seasons (September through December)

The study area covered 43 counties located in the Prairie Pothole Region of western Minnesota and contained 1,061 WMAs. We divided the

study area into two regions (northwestern and southwestern) based on the abundance of WMAs found in these areas. The northern study area is best characterized by larger counties, and fewer but larger WMAs. Conversely, the southern study area has smaller counties and more, albeit smaller WMAs. We created a sampling grid for each region, with grid size being a function of average county size within each region. Within each of the 21 grid blocks we randomly selected one WMA and the nine nearest neighbors to create a cluster of WMAs for sampling visitor usage. Cluster size was modified in some cases because of access issues and to ensure equal sampling effort. The final sample consisted of 228 WMAs organized into 21 driving routes (clusters of WMAs).

We used methods that were previously applied to understand visitation levels at U.S. Fish and Wildlife Service Waterfowl Production Areas in Minnesota that had been modified from techniques recommended the U.S. Forest Service to measure visitor use. Sampling occurred on weekend days (Saturday and Sunday) over an 11-week period from 26 September 2015 (waterfowl opener) to 6 December 2015. Observers drove a specified route over a set period of four hours, with each sample WMA being surveyed once per weekend day. This resulted in a point-in-time sample of observed WMA user groups. We also surveyed a subset of WMAs intensively (repeated visits from sunrise to sunset) to estimate probability of intercept, which we defined as the average proportion of total user groups per site-day that we intercepted at a random point in time. We then used the probability of intercept to convert observed counts (point-in-time) to expected total user groups per site-day.

Visitor Estimate Analyses. For each of the 1,061 WMAs within our study area, we determined a series of site attributes using GIS data layers obtained from MN Geospatial Commons, https://gisdata.mn.gov/dataset, with data processing accomplished using ArcGIS 10.3. We obtained information on WMA name, county locality, area, nearest town, species present (including deer, small game, forest upland birds, sharp-tailed grouse, pheasants, waterfowl, wild turkey, and mourning doves), managed parking areas, dominant cover types, perimeter length, and easting/northing vectors. We also determined how far each WMA was from various points of interest via Euclidian distance: U.S. Fish and Wildlife Service Wildlife Production Areas (WPAs), other WMAs, major roads, and towns of various densities. We used a linear mixed-effects model to explore the relationship between average car counts/WMA/day and WMA attributes, with the goal of predicting expected mean user groups per weekend day for all WMAs in our sampling frame.

Mail Surveys. Data were collected using mail-back surveys. Respondents were sent questionnaire-booklets with personalized cover letters, and included a business-reply envelope to return their responses. Potential respondents were sent multiple contacts four times between March 2016 and July 2016. Complete results are available in:

LaSharr, K. and L. Cornicelli. 2017. Survey of Minnesota Wildlife Management Area users participating in the 2015-2016 seasons. University of Minnesota, Minnesota Cooperative Fish and Wildlife Research Unit, Department of Fisheries, Wildlife and Conservation Biology, St. Paul, Minnesota, U.S.A.

Ongoing Research

Applied Ecology

Evaluating Nest-site Selection of Arctic Peregrine Falcons in the Colville River Special Area

Investigators: David E. Andersen

Collaborator: Patricia L. Kennedy, Oregon State University

Postdoc: Jason Bruggeman

Duration: August 2016 to July 2019

Funding Source: U.S. Geological Bureau of Land Management

Project Location: Colville River Special Area, Alaska

Minnesota Cooperative Fish and Wildlife Research Unit

Arctic peregrine falcon (*Falco peregrinus tundrius*) and other peregrine falcon populations suffered drastic declines during the 1950s-1970s owing, in part, to DDT-related reproductive failures. Arctic peregrines were listed in 1973 under the U.S. Endangered Species Act (ESA) and recovered sufficiently enough to be removed from the ESA in 1994. A key part of Arctic peregrine recovery in the U.S. was establishment of BLMs Colville River Special Area (CRSA) in 1977, which was formed to conserve Arctic peregrine nesting and foraging habitat. The CRSA is located within the National Petroleum Reserve-Alaska (NPR-A), which allows for oil and gas mining and exploration. To afford additional protections to the arctic peregrine falcon, the Record of Decision (ROD) from the 2004 Integrated Activity Plan/Environmental Impact Statement (IAP/EIS) for the Northwest planning unit of the NPR-A and the final ROD for the Northeast planning unit required a management plan for the arctic peregrine falcon in the CRSA to be developed and put into effect prior to any lease sales. The Colville River Special Area Management Plan (CRSAMP) was completed in July 2008 (Bureau of Land Management 2008 Colville River Special Area Management Plan) and fulfills the requirement for a management plan for the area. In accordance with its designation in 1977 and the CRSAMP, the Colville River Special Area will be managed to provide maximum protection to the Arctic peregrine falcon while allowing other activities including oil and gas development, recreation, subsistence, and scientific research. Protective regulations for Arctic peregrines exist under the CRSA Management Plan to minimize disturbance and preserve nesting and foraging habitat. However, additional information needs were identified in the CRSA Management Plan to improve knowledge of Arctic peregrine ecology in the CRSA, better inform management decisions, and evaluate possible changes to protective regulations.

Arctic peregrine occupancy of nest sites and nesting cliffs and abundance on cliffs in the CRSA. We will use information from that work to help select covariates of nest-site attributes (e.g., habitat; topography; surrounding prey habitat availability) to evaluate productivity and RSF models for this study. We will use the RSF model and map to identify areas along the Colville River predicted to have higher intensity of use for Arctic peregrine nesting and examine characteristics of these areas relevant to Arctic peregrine nesting ecology.

Secondary objectives of the study may include: (1) providing additional support for interpretation of the model and maps beyond what is provided in the project final report; (2) evaluation of possible disturbances (e.g., habitat loss) on predicted Arctic peregrine nesting intensity; and (3) incorporating climate covariates (e.g., snow pack) into an updated version of the model.

The primary objective of this study is to develop a Resource Selection Function (RSF) model using 24 years of Arctic peregrine nest-site location data along the Colville River to predict and map the intensity of nest-site use throughout the portion of the Colville River that has been repeatedly surveyed for Arctic peregrines since 1981. The RSF model will incorporate modeled productivity data from nest sites. Previous work helped identify some of the abiotic and biotic covariates related to

Improving Survival of Juvenile Winged Mapleleaf Mussels (*Quadrula fragosa*) through Identification of Host Fish Over-wintering Areas

Investigators: Mark Hove, Susan Galatowitsch (Cooperating Faculty)

Student: Alex Franzen, Briana Burke, and McKenna Rodine, undergraduate students (Department of Fisheries, Wildlife and Conservation Biology)

Duration: May 2016 to May 2019

Funding Source: U.S. Geological Survey - Upper Midwest Environmental Sciences Center

Project Location: University of Minnesota, Twin Cities Campus

The winged mapleleaf (*Quadrula fragosa*) is a federally endangered freshwater mussel with some unusual life history characteristics, which, if better understood, could improve conservation efforts. Most North American freshwater mussels must attach to host fish as larvae to metamorphose to the juvenile life stage. The winged mapleleaf is limited to the St. Croix River in Minnesota where the channel catfish (*Ictalurus punctatus*) is its only known host.

Research at the University of Minnesota is part of a larger U.S. Geological Survey project to identify host fish over-wintering areas, specifically, to: (1) use telemetry to describe movements of St. Croix River channel catfish living with winged mapleleaf before, during, and after the glochidia release period, and (2) monitor winged mapleleaf larvae release behavior. This project addresses the second research objective, specifically, to (1) monitor winged mapleleaf display period, and (2) video display-ing winged mapleleaf behavior and host interactions in the St. Croix River.

We followed standard methods to study winged mapleleaf brooding period, and utilized recent developments in underwater video and computer recording systems to video interactions between brooding winged mapleleaf and fishes. We worked with Upper Mississippi River Conservation Committee's Mussel Conservation Team divers to check mussels two to three times per week from late August through early October at Interstate State Park, and we checked mussels twice a week during the same period at Lakeland, Minnesota. During each check the presence of displaying winged mapleleaf was recorded. To observe interactions between brooding winged mapleleaf and fishes we used underwater video. We used an underwater video system (Aqua-Vu AV Multi-Vu HD [720p] system) to record three to 12 hours of video per field session from dusk into the night or the next morning throughout the

Mark Hove (left) Alex Franzen (middle) and Briana Burke (right) at Lakeland study site

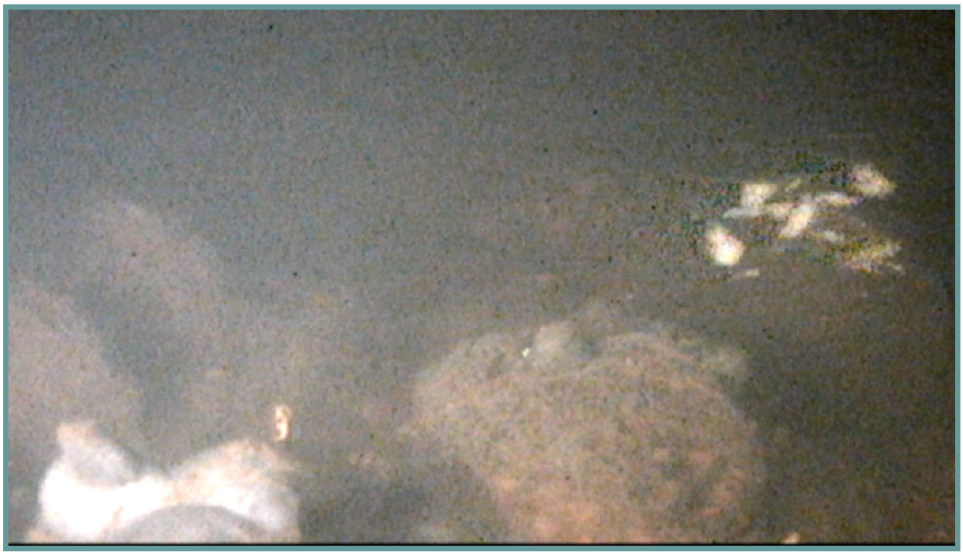
winged mapleleaf display period.

During the fall of 2017 we documented winged mapleleaf brooding period at Interstate State Park and collected video data from Lakeland, Minnesota. During this period we observed what appeared to be a cessation of brooding behavior during a brief high water event as well as the first channel catfish interacting with a brooding winged mapleleaf. These events are described in an article published in Ellipsaria, the newsletter of the Freshwater Mollusk Conservation Society (Hove et al., 2018).

Alex Franzen (left) and Mark Hove at Lakeland, MN

During fall 2018 we observed winged mapleleaf brood glochidia primarily from late August through mid-September at Interstate State Park. Water temperature generally rose through the spring, varied between 22-26 °C during the summer, and began dropping in August with a warm spell in September. Displaying winged mapleleaf were observed at Interstate State Park when they were first checked on 28 August through 7 September with one interesting individual displaying on 21 September. State, federal, and academic biologists working together on winged mapleleaf propagation efforts at Interstate agreed that the winged mapleleaf brooding period was over by 24 September.

Also during fall 2018 we videoed brooding winged mapleleaf and co-occurring fishes in the St. Croix River at Lakeland, Minnesota. Displaying winged mapleleaf were observed for a short period at Lakeland between 7 September and 14 September. However, we expended extra effort to make long video recordings by sleeping overnight with the cameras at the study site. With this extra effort we observed several interesting interactions. The placement of chicken livers upstream of the displaying winged mapleleaf appeared to draw channel catfish, redhorse, freshwater drum, and buffalo as these fishes seemed to aggregate in the area just upstream of the cameras near the chum containers and would circle around to this location repeatedly. Channel catfish were observed once during the first video recording (7-8 September), four times during the second (11-12 September), and many times on the third shooting (14-15 September). Channel catfish were observed passing by brooding winged mapleleaf nearly 90 times during this period. Although the barbels of individual catfish appeared to brush brooding winged mapleleaf and possibly the mantle magazine at least 11 times we never observed a channel catfish bite down on a magazine. During one evening we observed two partially displaying winged mapleleaf release small numbers of broken conglutinates and possibly individual glochidia numerous times over several hours. Although we never saw any fishes eat freshly released conglutinate fragments, we observed two occasions where fishes inhaled what appeared to be aggregations of winged mapleleaf conglutinates. The first instance involved a channel catfish change the direction it was swimming to use its barbels to touch a small clump of conglutinates drifting downstream. The catfish briefly returned to its original swimming direction but then turned back to the conglutinates, moved in to strike the conglutinate mass, and then drew the mass into its mouth. As the channel catfish swam away we did not see it spit out the conglutinates although the fish was



Winged Mapleleaf releasing conglutinates

difficult to observe in the faded background and it didn't stay in view for long. The other occasion involved what appeared to be a large aggregation of conglutinates presumably released by a nearby winged mapleleaf. The conglutinates came to rest on a partially displaying winged mapleleaf. In near-dark conditions a bluegill looked at the conglutinates, drew them in its mouth, and then spit them out. Occasionally we observed channel catfish, buffalo, and a logperch apparently feed on something on the shells of partially displaying winged mapleleaf. This activity did not touch the magazine and the mussel did not release glochidia or conglutinates in response; rather, it usually drew its mantle magazine in between its valves. As observed in previous years, winged mapleleaf with full displays were not disturbed by changes in light intensity, shadows, or being bumped by a fish, as compared to winged mapleleaf with minor or partially inflated mantles, which would briefly draw in their magazines in response to changes in camera light intensity, passing shadows, or when channel catfish barbels, other fish, or softshell turtles would brush them.

Insecticide Exposure Risk for Grassland Wildlife on Public Lands

Investigator: David E. Andersen

Collaborator: Nicole Davros (Minnesota Department of Natural Resources)

Student: Katelin Goebel, M.S. (Natural Resources Science and Management)

Duration: September 2016 to September 2019

Funding source: Minnesota Department of Natural Resources

Project Location: Southwestern Minnesota

Minnesota Cooperative Fish and Wildlife Research Unit

*Increasing evidence suggests that pesticides may be an important factor explaining declines in grassland-dependent wildlife in agricultural landscapes. Minnesota Department of Natural Resource (MNDNR) wildlife managers and members of the public have reported concerns about foliar-application insecticides in particular. Such insecticides are used on a variety of crops but their use has been especially important for controlling soybean aphid outbreaks in Minnesota. Concerns have been raised about the impacts of chlorpyrifos, a broad-spectrum organophosphate, and other foliar-application insecticides on water quality and human health, prompting the Minnesota Department of Agriculture (MDA) to release guidelines for voluntary best management practices for their use. Although lab studies have shown chlorpyrifos and other insecticides used to target aphids are highly toxic to non-target organisms, including economically important game species and pollinators, few studies have investigated the environmentally-relevant exposure of free-ranging wildlife to these chemicals. Our objective is to assess the direct and indirect exposure of grassland wildlife to the three most common soybean aphid insecticides (i.e., chlorpyrifos, lambda-cyhalothrin, and bifenthrin) along a gradient from soybean field edge to grassland interior. During summer 2017 and 2018, we sampled five treatment and four control sites across southern Minnesota. We detected chlorpyrifos at all distances examined (0-400 m) at both treatment and control sites, suggesting that some background level of chlorpyrifos exposure is occurring in the environment regardless of landowner activities in the adjacent row crop field. Our preliminary analyses of filter paper samples (used to quantify direct exposure) showed that insecticide deposition tended to be greater at the field edge than the grassland interior at treatment sites. Furthermore, we detected chlorpyrifos deposition amounts above levels known to cause mortality or morbidity in lab tests for some bird and pollinator species. Our future analyses will use a model-selection approach to determine the effects of vegetation, distance from field edge, and spray application method (i.e., airplane or ground boom) on direct and indirect exposure of wildlife and their invertebrate food resources to these insecticides. Our results will be used to help natural resource managers and private landowners better design habitats set aside for grassland wildlife in Minnesota's farmland region.

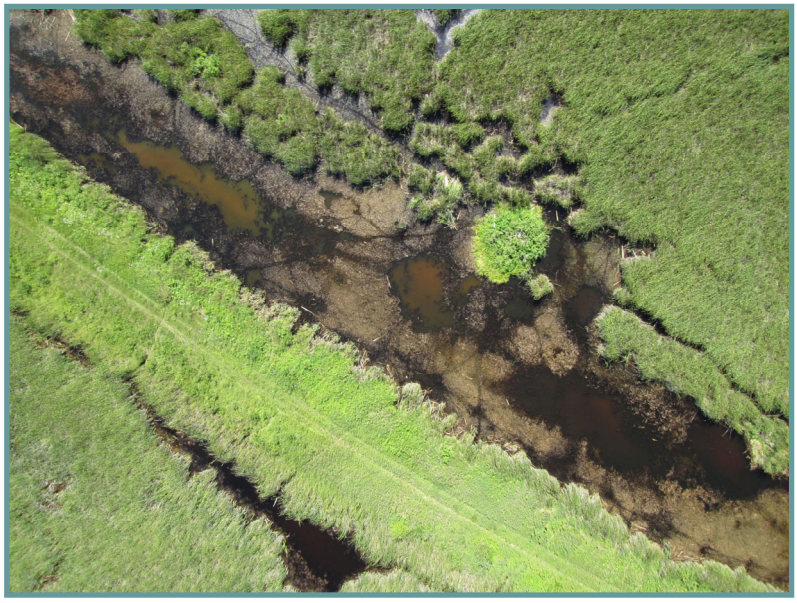
*Project description from Geobel, K. and N. Davros. 2019 Minnesota Department of Natural Resources Research Summaries, with permission.

Marshbird Response to Invasive Cattail Control Using Grazing, Mowing, and Herbicide Application in the Prairie Pothole Region of Minnesota

Investigator:	David E. Andersen
Collaborators:	Tom Cooper (U.S. Fish and Wildlife Service), Greg Hoch (Minnesota Department of Natural Resources), Doug Johnson (U.S. Geological Survey – retired), Christine Herwig (Minnesota Department of Natural Resources), Sara Vacek (U.S. Fish and Wildlife Service)
Student:	Nina Hill, M.S. (Natural Resources Science and Management)
Duration:	August 2014 to December 2017
Funding source:	U.S. Fish and Wildlife Service—Region 3 and Webless Migratory Game Bird Research Program
Project Location:	Western and northwestern Minnesota Minnesota Cooperative Fish and Wildlife Research Unit

Secretive marshbirds, including rails, bitterns, and snipe, are arguably the least monitored group of North American birds due to their cryptic behavior and low detectability. Over the past 15 years, stakeholders have made considerable progress in better monitoring marshbirds; however, many of these efforts have not focused on estimating marshbird response to wetland management. In 2011, participants at a national marshbird monitoring workshop recommended that future monitoring efforts be directed toward assessing marshbird response to management. Our research is focused on assessing the response by marshbirds to invasive wetland vegetation management techniques in the Prairie Pothole Region and impoundments in northwestern Minnesota.

The Prairie Pothole Region, an important breeding area for many marshbird species, is facing serious threats, including wetland loss through drainage and declining habitat quality of remaining wetlands primarily caused by invasive vegetation. Narrow-leaf (*Typha angustifolia*) and hybrid (*Typha x glauca*) cattail and reed canary grass (*Phalaris arundinacaea*) have dramatically changed the character of many western Minnesota wetlands. These invasive species often form dense monotypic stands that



reduce plant diversity and change the vegetative structure in both the emergent and wet meadow zones of prairie pothole wetlands. Wetlands with invasive vegetation are often characterized as having low plant diversity, structural homogeneity, low edge-to-area ratios, limited interspersion of vegetation and water, and no mudflats. Due to the concern about the effects of invasive wetland vegetation on marshbirds, the *Midwest Marshbird Monitoring Working Group* has hypothesized that the alteration of wetland vegetation and structure due to invasive species may reduce the attractiveness of wetlands to breeding marshbirds in the Midwest.

Our research had two primary goals. First, we examined the effect of different management treatments (fire, grazing, grazing and fire, and no treatment) on wetland use by secretive marshbirds in west-central Minnesota. Second, we assessed marshbird response to herbicide application to control invasive cattails in northwestern Minnesota. To examine the effect of management treatments on secretive marshbirds in west-central Minnesota, we first needed to develop an estimation approach that accounted for both declining probability of detection as a function of distance from an observer, and variable amounts of wetland cover across survey locations. We then evaluated associations between marsbhird abundance and vegetation treatments. We further evaluated landscape-scale factors (e.g., basin size, surrounding land cover) and basin-level factors (e.g., vegetation composition) to assess what factors were associated with marshbird abundance.

In our northwestern Minnesota study, our results suggested no immediate response of marshbirds to chemical control of invasive cattails, likely because the conditions present when marshbirds return and occupy breeding areas are similar whether or not cattail control has occurred the previous fall. For both our west-central and northwestern Minnesota studies, there appear to be different responses by different marshbird species to vegetation management, confounded efforts to affect marshbird communities in these landscapes.

Modeling with Long-term Datasets to Inform Management of National Park Grasslands

Investigator: David E. Andersen

Postdoc: Jason Bruggeman

Duration: October 2017 to December 2019

Funding source: National Park Service and U.S. Geological Survey

Project Location: Great Plains National Parks

Minnesota Cooperative Fish and Wildlife Research Unit

*Black-tailed prairie dog (*Cynomys ludovicianus*) populations have been dramatically reduced in size and distribution since European settlement. Many remnant populations face human-related threats including poisoning, shooting, and habitat destruction. However, black-tailed prairie dogs and other wildlife are protected in national parks, thereby allowing examination of abiotic and biotic factors influencing populations. Badlands National Park and Wind Cave National Park in South Dakota, and Scotts Bluff National Monument in Nebraska, have monitored their black-tailed prairie dog populations for close to twenty years by mapping colony boundaries. Surveyors mapped a total of 983 colonies from 1996 through 2017 consisting of 142 unique colonies with 114 colonies located in Badlands, three in Scotts Bluff, and 25 in Wind Cave. We used colony maps to estimate individual colony areas and total colonized area per park over time. We developed mixed-effects regression models to relate individual colony areas and total colonized area to covariates describing bison (*Bos bison*) grazing presence, precipitation, the Palmer Drought Severity Index (PDSI), and the outbreak of plague epizootics. Both individual colony areas and total colonized area were negatively correlated with the average of monthly PDSI values during the growing season (July-June) with a lag of two years, suggesting drought conditions were favorable for colony establishment and expansion in the future. Individual colony areas and total colonized area were also negatively correlated with plague epizootic events, which occurred in Badlands beginning in 2008. Precipitation and bison grazing covariates were not included in the best-approximating models. Our results provide new insights into the role of climate and drought on prairie dog populations and demonstrate the value of collecting long-term ecological data in the Northern Great Plains.

*Project description from Bruggeman, J.E., D. Licht, D.H. Johnson, and D.E. Andersen. 2018. Modeling with long-term datasets for inform management of National Park grasslands: 2017 annual report. University of Minnesota, Minnesota Cooperative Fish and Wildlife Research Unit, St. Paul, Minnesota, U.S.A.

Range-wide Migratory Connectivity for Full-cycle Conservation of the Golden-winged Warbler, Climate-sensitive Songbird of the Highest Conservation Concern

Investigator:	David E. Andersen and Henry M. Streby (National Science Foundation Post-doctoral Fellow at University of Toledo)
Collaborators:	David A. Buehler (University of Tennessee) and Petra B. Wood (West Virginia Cooperative Fish and Wildlife Research Unit)
Students:	Gunnar R. Kramer, M.S. (Natural Resources Science and Management)
Duration:	July 2013 to December 2017
Funding source:	U.S. Geological Survey, Science Support Partnership
Project Location:	Eastern North America Minnesota Cooperative Fish and Wildlife Research Unit

Compared to migration routes and Central and South American wintering grounds, extensive information is available on distributions, survival, and productivity for many species of migrant songbirds on their North American breeding grounds. However, most Neotropical-Nearctic migrant birds spend only four or five months on their breeding grounds, with the rest of the year spent on wintering grounds and migration routes. Recent demographic models suggest that songbird population growth is more sensitive to annual survival than to reproductive parameters. As a result, tracking songbirds during migration and linking breeding populations to their wintering grounds is a critical research need in songbird conservation and population dynamics. Furthermore, identifying population-specific wintering grounds is critical to allow state and regional North American stakeholders to justify targeted spending on wintering-ground conservation efforts.

It is particularly important to identify population-specific wintering grounds for species experiencing dramatic population declines and breeding-range shifts despite apparent high reproductive success. Golden-winged warblers (*Vermivora chrysoptera*; hereafter GWWA) have experienced dramatic population declines in a portion of their breeding range, and the GWWA Working Group has identified the non-breeding season as a primary research need for the conservation of this species. Despite apparent high reproductive success across much of their breeding range and

availability of abundant breeding habitat in many areas, GWWA populations appear stationary in a few areas, are declining precipitously in some areas, and expanding their range to the north and west in Canada. Declines in some populations of GWWA are reportedly linked to hybridization with closely related Blue-winged warblers (*V. cyanoptera*; hereafter BWWA) although the dynamic relationship between these two species is still poorly understood. Nest success estimates from GWWA populations in Michigan, New York, North Carolina, Tennessee , and West Virginia suggest that those populations may have high productivity (although post-fledging survival rates are unknown), but are all declining at concerning rates. An intensive study of fledging success and fledgling survival in Minnesota found that those apparently stationary populations are reproducing at levels that should support very strong population growth. That same study found that GWWA in southeastern Manitoba are reproducing at levels too low to explain the observed population growth and range expansion in that province. This mismatch between productivity and population growth suggests that differences in population trends may be associated with differential survival along population-specific migratory routes, or on wintering grounds, and that low-productivity populations may be supplemented by high-productivity populations.

The winter range of GWWA includes tropical forests from central Honduras to central Colombia and Venezuela, a range across which anthropogenic land-use patterns have changed dramatically over the past few decades and within which new agricultural lands are developed primarily by clearing tropical forest. It is also possible that climate change is driving GWWA to expand their breeding range to higher latitudes and wintering range to higher altitudes into lower-quality habitat that supports lower reproductive success and lower winter survival.

We studied migratory connectivity using geolocators because (1) GWWA have high nesting territory fidelity (i.e., surviving adults usually return to nest in the same territory in successive years), thereby ensuring retrieval of a high proportion of geolocators, (2) adult males are relatively easy to capture with call broadcast and mist nets, allowing for tissue collection and geolocator attachment and retrieval, (3) there were >10 ongoing collaborative studies of GWWA across their North American breeding range when we began this study, which greatly reduces logistical costs compared to initiating a large-scale study independently, (4) hundreds of GWWA have been monitored with radio telemetry and at least 18 successfully carried geolocators for a full year, confirming the species' ability to carry devices weighing up to 5.5% of their body mass without significant effects, and (5) BWWA breed with, and alongside GWWA at many sites offering a rare opportunity to gather detailed information about the migratory behaviors and wintering locations of two closely related, declining species.

From 2012 - 2017 we and our collaborators (hereafter; we) concluded the data-gathering component of our research investigating the range-wide migratory connectivity of *Vermivora* warblers. We deployed light-level geolocators on GWWA,

BWWA, and *Vermivora* hybrids throughout their breeding distributions in eastern North America. We searched for returning marked birds and used mist-nets and song and call broadcasts to recapture individuals and retrieve geolocators. From 2013-2017, we recovered useable data from 76 geolocators representing 70 individual warblers. We recovered data from 24 sites across the species-complex breeding distribution, which also resulted in apparent complete coverage of the wintering distribution. We analyzed light-level data using the template-fit method with modifications G. Kramer developed and published as part of this project. In addition, we collected and are currently analyzing claw, blood, and feather samples and recorded songs for several-hundred individuals across our study area.

Our results indicate that GWWA exhibit strong migratory connectivity, with birds from the Appalachian Mountains breeding distribution segment wintering predominantly in northern South America and birds from the western Great Lakes breeding distribution segment wintering in Central America. The dramatic decline in population size of the Appalachian Mountains breeding distribution segment is coincident with deforestation in northern South America, suggesting that factors outside the breeding season were the dominant factor responsible for population decline. Current conservation efforts for *Vermivora* warblers are focused on habitat abundance and quality on the breeding grounds. It is not clear from our work that such efforts are addressing the primary factors influencing population size, especially of GWWA in the Appalachian Mountains breeding distribution segment.

Results of this research have been published in peer-reviewed journals (*Condor* and *Proceedings of the National Academy of Sciences*), and we continue to work with the data derived from this project to address additional research questions.

Ongoing Research

Human Dimensions, Management, and Conservation

Airspace as Habitat: Methods for Assessing Use by Animals

Investigator:	James Perry (Cooperating faculty)
Collaborator:	Douglas H. Johnson (U.S. Geological Survey - retired)
Duration:	March 2014 to March 2019
Funding source:	U.S. Geological Survey —Geosciences and Environmental Change Science Center
Project Location:	University of Minnesota, Twin Cities Campus Upper Midwest

"Habitat" is a fundamental unifying concept in ecology and evolutionary biology. Scientists in these fields seek to understand how species' survival and reproductive strategies are shaped in relationship to the habitats on which they depend. The habitat concept is also foundational to conservation and policy strategies that address human impacts on species' survival. Currently, the role of environmental factors in shaping species' life history strategies is viewed almost entirely in terms of terrestrial and aquatic habitat. For many of the 1,000 bat, 9,000 bird, and 900,000 insect species on Earth, the focus on land and water environments considers only part of the full suite of habitat requirements. Technological and methodological innovations are enabling scientists to better observe how these animals use four-dimensional airspace to perform many critical life tasks. These considerations are advancing the notion that airspace is in fact habitat and should be treated similarly to terrestrial and aquatic habitats. Concurrent is a growing urgency to understand animal use of the aerial environment as human use and development of this same airspace is rapidly increasing, especially its use for wind energy development.

Wind energy development is occurring at a rapid pace and is expected to increase dramatically under the U.S. objective of producing 20% of the Nation's energy from wind by 2030. Although wind provides a renewable source of energy, concerns exist about the effects on wildlife, particularly migratory birds and bats. Migratory birds and any endangered bats are trust species of the Federal government, and any "take" of such animals is of concern. The federal government has also made extensive investments in national wildlife refuges, waterfowl productions areas, and wetland and grassland easements, primarily for the protection and production of migratory birds. It is important to understand the extent to which wildlife values associated with these investments may be compromised by wind energy development.

The focus of this research is on assessing the intensity of flight activity by animals, spatially and temporally. Historically, locations used by animals were determined from visual detections, actually seeing where animals were. The use of markers, such as leg bands on birds, sometimes allowed animals to be recorded at two or more locations and facilitated speculation about the route taken between subsequent locations. In recent decades, the use of telemetry tracking/transmission devices and other data loggers has become widely used for studying animals that use airspace during migration and other movements. The information they can provide is dependent on (1) the type and amount of raw data they collect, (2) the kinds of animals suitable to carry them, and (3) the ability to recover the data. The usefulness of this equipment varies widely, and depends on the physical

dimensions, the attachment mechanisms, and the data collection, storage, and recovery technology. Most recently, satellite receivers have unleashed a flood of information about animal movements and locations, which often led to major surprises about how animals actually move. Fixed-site radar facilities, such as NEXRAD Doppler radar weather monitors, provide information about mass movements of birds and bats, insects, and other flying animals. Mobile radar units can be located wherever desired to assess movements at particular sites.

We are on the threshold of another wave of new technologies that could greatly inform an assessment of wind development effects on wildlife. Acoustic monitors provide information on airspace use by bats and migrating birds, stable isotope analysis sheds light on migration pathways of many species, and photo-sensitive geolocators can record information on approximate latitude and longitude traversed by animals. Other potential tools include genetic markers and thermal cameras. Furthermore, Internet tools such as eBird (ebird.org) and cooperative monitoring projects such as Oldbird (Oldbird.org) bring citizen science to the task of recording dates and locations of bird observations, with the potential to record movements of birds on a nearly real-time basis.

Specific objectives of this project include:

1. Evaluate the potential of the tools mentioned above, and others deemed relevant, for determining the intensity of low-elevation flight of birds, bats, and other flying animals
2. Identify if and how currently available tools can be used, most likely in combination, to determine the intensity of flight activity by animals, and how it varies spatially and temporally
3. If feasible, propose new tools or extensions of existing tools to address the objective.

Long-term Research Focused on Human Dimensions Information Addressing Wildlife Management Issues in Minnesota

Investigator: David C. Fulton
Staff: Susan A. Schroeder, Ph.D. Research Associate
Duration: July 2018 to June 2020
Funding Source: Minnesota Department of Natural Resources
Project Location: Minnesota Cooperative Fish and Wildlife Research Unit

This project is the continuation of a long-term research effort established in 2002 that provides funding for a full-time Research Fellow to work closely with Minnesota Department of Natural Resources (MNDNR) wildlife researchers and managers to collect timely information to assist in the evaluation of management programs. The primary focus of this position is on developing social science information for fisheries and wildlife management in Minnesota and to use this information to support MNDNR management, planning, and decision-making processes. The current project provides funding to support a Ph.D. research associate and operating funds to conduct up to four studies during the two-year period.

The two primary topics currently being addressed include: 1) understanding hunter and land-owner issues related to the management of Chronic Wasting Disease (CWD) in Minnesota; and 2) developing social science information to support the development on a MNDNR statewide management plan for wolves.

Chronic Wasting Disease

A study of 2018 southeastern Minnesota firearm deer hunters was conducted to assess:

- participation, involvement, and satisfaction with deer hunting in southeastern Minnesota,
- opinions and preferences for deer populations and management in southeastern Minnesota,
- knowledge and information sources related to CWD,
- feelings and concerns about CWD,
- opinions and preferences related to CWD management, and
- trust in the MNDNR generally, and specifically related to CWD management.

A questionnaire was distributed to 4,995 deer hunters in southeastern Minnesota. This sample included all firearms deer hunters who identified the CWD management zone (permit area 603) as their primary deer hunting area (n = 2,195), and a random sample of hunters who identified one of the 300-series permit areas surrounding the CWD management zone (n = 2,800) as their primary deer hunting area at the time of license purchase. The number of full-length survey respondents for the two samples were: 880 for the CWD management zone, and 1,206 for the surrounding permit areas. Total response numbers including shortened, nonresponse surveys were: 993 for the CWD management zone, and 1,346 for the surrounding permit areas. After adjusting for undeliverable surveys and invalid respondents, the response rate for the full-length survey was 42% for the CWD management zone and 45% for the surrounding permit areas.

A summary report has is currently in draft form.

Schroeder, S. A, A.C. Landon, L. Cornicelli, T. Forberg, and L. McInenly. DRAFT. A study of hunters' activities and opinions about deer populations and chronic wasting disease. University of Minnesota, Minnesota Cooperative Fish and Wildlife Research Unit, Department of Fisheries, Wildlife, and Conservation Biology.

Social Science Data to Support a Wolf Plan

The Division of Fish and Wildlife is engaged in an update to the Minnesota Wolf Management Plan. Public input and engagement are at the forefront of these efforts. Understanding the values, beliefs, attitudes, and behaviors of stakeholders can enhance the legitimacy and efficacy of agency decisions with respect to wolf management, while helping to minimize conflict. This is particularly important in a context like wolf management where diverse publics hold divergent preferences and values, and the public discourse surrounding wolves is dominated by stakeholders at the extremities of beliefs. Therefore, collecting statistically representative data is of critical importance. To better understand the potential impacts of wolf management decisions and to assess public preferences, we propose conducting a comprehensive study of stakeholder attitudes early in the management plan revision process. These data will inform technical and stakeholder committee review, the tenability of proposed actions in the social arena, and avenues for further communication with stakeholders on the topic of wolf management.

We propose to assess stakeholder attitudes toward wolves in Minnesota in general, their preferences for potential management priorities, their values toward wildlife, preferred options for funding wolf management, and tolerance of wolves on the landscape. We will also assess preferences for tradeoffs between alternative management goals associated with wolves, white-tailed deer, and moose where the species coexist. The study will target four strata including: 1) tribal and band members, 2) adult firearm deer hunters (license holders in 2018) that indicated a wolf range deer permit area as their primary hunt area, 3) the general public (statewide) including Minnesota residents 18 years and older, and 4) livestock producers in wolf range.

The study is being designed and will be implemented in Fall 2019, with a summary report available by March 2020.

Restoration of Elk to Northeastern Minnesota

Investigators:	David C. Fulton, James Forester III (Cooperating Faculty)
Collaborator:	Mike Schrage (Fond du Lac Tribe)
Student:	Eric Walberg, Ph.D. (Natural Resources Science and Management)
Duration:	July 2016 to July 2019
Funding source:	Legislative-Citizen Commission on Minnesota Resources
Project Location:	Minnesota Cooperative Fish and Wildlife Research Unit

Elk (*Cervus canadensis*) have historically ranged over most of the state of Minnesota but were functionally extirpated in the early 1900s due to overharvest and habitat loss (Hazard 1982). Although two small populations have been restored to northwestern Minnesota, they are currently managed at low levels to reduce human-wildlife conflict (Minnesota Department of Natural Resources [MNDNR], 2016). Forested areas of the state, however, might avoid some of these conflicts and see significant ecological and economic benefits from returning elk to the landscape. Reestablishing this keystone herbivore could help restore the state's traditional wildlife heritage, diversify the large mammal community, increase tourism from wildlife viewers, and eventually provide additional hunting opportunities. Additional benefits include adapting to future climate change through assisted dispersal of a climate hardy species like elk and protecting against unforseen events which could lead to the extirpation of Minnesota's current small and isolated elk populations. Finally, a landscape actively managed for elk will benefit other species adapted to young forests and brushlands. Evidence from other eastern states indicates elk restoration can be successful, but success is dependent on active forest management and public support for elk by local communities.

Understanding the public's attitudes and acceptance of elk and their potential impacts are key components of assessing the viability of elk restoration. Long-term management of elk will require an adaptive impact approach in which management objectives and strategies are guided by the preferences of the impacted public. The University of Minnesota, in collaboration with the Fond du Lac Band of Lake Superior Chippewa, conducted a self-administered mail-back questionnaire of landowners and local residents in northeastern Minnesota to determine their attitudes toward restoring an elk population.

Study Purpose and Objectives

The goal of this study was to understand the attitudes of private landowners and local residents toward potentially restoring elk to northeastern Minnesota.

Specific objectives were to:

- understanding citizens' attitudes toward elk and elk restoration;

- acceptance and tolerance of potential elk impacts;
- preference for management objectives concerning elk restoration including elk population size and geographic distribution; and
- preferences for management strategies to address potential conflicts with elk.

We surveyed 4,500 private landowners and 4,000 local residents in northeastern Minnesota to describe landowner and local resident attitudes toward potentially restoring an elk population to northeastern Minnesota. The population of interest in this study was private landowners and local residents within the study area that covered portions of Carlton, Pine, and St. Louis counties. Three potential restoration areas for elk were identified based on recommendations from local natural resource professionals. These areas were selected due to abundant public land, while minimizing potential conflict from other land uses (e.g., agriculture). A random sample was used for: (1) private landowners (≥10 acres) within five miles of the restoration areas, and (2) local residents matched to census blocks within four areas that correspond to county boundaries and major landmarks (e.g., roads, river). Among landowners, we had an adjusted response rate of 60% for full-length surveys, and a total response rate of 67% including nonresponse surveys. Among local residents, we had an adjusted response rate of 46% for full-length surveys, and a total response rate of 49% including nonresponse surveys.

Support for Elk Restoration

Overall landowners and local residents within the study areas strongly supported restoring wild, free-ranging elk to the study areas in northeastern Minnesota (80% and 81%; Figure S-1 in report) and Minnesota in general (78% and 78%). About 12% of landowners and 9% of local residents were unlikely to support elk restoration. Landowner support for restoration in northeastern Minnesota was highest in the Cloquet Valley Study Area (82%) and lowest in the Fond du Lac Study Area (75%). Support from landowners in the Nemadji Study Area was 81%. Among local residents support was highest in southern St. Louis County (83%) followed by Duluth (82%), northern Pine County (78%), and Carlton County (75%). Overall, a majority of landowners were supportive of restoring elk on their own property (70%) and within five miles of their property (76%). Landowners and local residents within each study area and group strongly supported restoring elk, although landowners were slightly less supportive of restoring elk within close proximity to their own property.

Landowners and local residents were presented with a series of 14 potential outcomes from restoring a wild, free-ranging elk population within the study areas in Minnesota and asked the likelihood of each outcome. Respondents believed that the most likely outcomes from restoring an elk population were: (1) providing opportunities to view elk, (2) restoration of a native wildlife species, and (3) providing opportunities to hunt elk. Respondents believed that the least likely outcomes from restoring an elk population were: (1) negatively impact other wildlife populations, (2) increase risk of disease transmission to livestock and wildlife, and (3) increase damage to trees and forest vegetation. The beliefs that had the largest positive influence on landowner and local resident support for elk restoration included: (1) restoration of a native wildlife species; (2) providing economic opportunities; (3) increase youth involvement and interest in the outdoors; (4) providing hunting opportunities for elk; and (5) providing opportunities to view elk. Beliefs that had the largest negative influence on support included: (1) negatively impact other wildlife populations, (2) increase risk of disease transmission to livestock and wildlife, and (3) increase damage to trees and forest vegetation.

The project is nearing completion and a summary report has been produced:

Walberg, E., J. Forester, and M. Schrage. 2019. Northeastern Minnesota elk: a study of landowner and public attitudes toward potential elk restoration in Minnesota. University of Minnesota, Minnesota Cooperative Fish and Wildlife Research Unit, Department of Fisheries, Wildlife, and Conservation Biology, St. Paul, Minnesota, U.S.A.

Activities

Publications

Peer-Reviewed

2017

French, W.E., **B. Vondracek**, L.C. Ferrington, Jr., J.C. Finlay, and D.J. Dieterman. 2017. Brown trout (*Salmo trutta*) growth and condition along a winter thermal gradient in temperate streams. *Canadian Journal of Fisheries and Aquatic Sciences* 74:56-64. DOI:10.1139/cjfas-2016-0005.

Fronczak, D.L., **D.E. Andersen**, E.E. Hanna, and T.R. Cooper. 2017. Distribution and migration chronology of Eastern Population sandhill cranes. *Journal of Wildlife Management* 81:1021-1032. DOI:10.1002/jwmg.21272.

Kramer, G.R., H.M. Streby, S.M. Peterson, J.A. Lehman, D.A. Buehler, B.P. Wood, D.J. McNeil, J.L. Larkin, and **D.E. Andersen**. 2017. Nonbreeding isolation and population-specific migration patterns among three populations of golden-winged warblers. *The Condor: Ornithological Applications* 119:108-121. DOI: 10.1650/condor-16-143.1.

Manfredo, M.J., J.T. Bruskotter, T.L. Teel, **D.C. Fulton**, S.H. Schwartz, R. Arlinghaus, S. Oishi, A.K. Uskul, K. Redford, S. Kitayama, and L. Sullivan. 2017. Why social values cannot be changed for the sake of conservation. *Conservation Biology* 31:772-780. DOI:10.1111/cobi.12855.

Pradhananga, A., M. Davenport, **D.C. Fulton**, G. Maruyama, and D. Current. 2017. An integrated moral obligation model for landowner conservation norms. *Society & Natural Resources* 30:2 212-227. DOI:10.1080/08941920.2016.1239289.

Schroeder, S.A. and **D.C. Fulton**. 2017. Voice, perceived fairness, agency trust and acceptance of management decisions among Minnesota anglers. *Society & Natural Resources* 30:569-584. DOI:10.1080/08941920.2016.1238987.

Schroeder, S.A., **D.C. Fulton**, J.S. Lawrence and S.D. Cordts. 2017. How hunter perceptions of wildlife regulations, agency trust, and satisfaction affect attitudes about duck bag limits. *Human Dimensions of Wildlife* 22:454-475. DOI:10.1080/10871209.2017.1345021.

Wolfson, D., J. Fieberg, J. Lawrence, T. Cooper, and **D.E. Andersen**. 2017. Range overlap between Mid-Continent and Eastern sandhill cranes revealed by GPS-tracking. *Wildlife Society Bulletin* 41:489-498. DOI: 10.1002/wsb.799.

2018

Bruggeman, J.E., T. Swem, **D.E. Andersen**, P.L. Kennedy, and D. Nigro. 2018. Incorporating productivity as a measure of fitness into models of breeding area quality of Arctic peregrine falcons. *Wildlife Biology* 2018:wlb.00475. DOI:10.2981/wlb.00475.

Cross, M., A. Heeren, L.J. Cornicelli, and **D.C. Fulton**. 2018. Bovine tuberculosis management in northwest Minnesota and implications of the risk information seeking and processing (RISP) model for wildlife disease management. *Frontiers in Veterinary Science* 5:190. DOI:10.3389/fvets.2018.00190.

Humburg, D. D., M.G. Anderson, M.G. Brasher, M. F Carter, J.M. Eadie, **D.C. Fulton**, F.A., Johnson, M.C. Runge, and M.P. Vrtiska. 2018. Implementing the 2012 North American Waterfowl Management Plan revision: populations, habitat, and people. *Journal of Wildlife Management* 82:275-286. DOI:10.1002/jwmg.21391.

Kramer, G.R., **D.E. Andersen**, D.A. Buehler, P.B. Wood, S.M. Peterson, J.A. Lehman, K.R. Aldinger, L.P. Bulluck, S. Harding, J.A. Jones, J.P Loegering, C. Smalling, R. Vallender, and H.M. Streby. 2018. Population trends in *Vermivora* warblers are linked to strong migratory connectivity. *Proceedings of the National Academy of Sciences* 115:E3192–E3200. DOI: 10.1073/pnas.1718985115.

Schroeder, S.A., L.J. Cornicelli, **D.C. Fulton**, and S.S. Merchant. 2018. Explicit versus implicit motivations: clarifying how experiences affect turkey hunter satisfaction using revised importance-performance, importance grid, and penalty-reward-contrast analyses. *Human Dimensions of Wildlife* 23:1-20. DOI:10.1080/10871209.2018.1385112.

Schroeder, S.A., **D.C. Fulton**, E. Altena, H. Baird, D. Dieterman, M. Jennings. 2018. The influence of angler values, involvement, catch orientation, satisfaction, agency trust, and demographics on support for habitat protection and restoration versus stocking in publicly managed waters. *Environmental Management* 62:665. DOI:10.1007/s00267-018-1067-9.

Schroeder, S.A., **D.C. Fulton**, L.J. Cornicelli and J.T. Bruskotter. 2018. How Minnesota wolf hunter and trapper attitudes and risk- and benefit-based beliefs predict wolf management preferences. *Human Dimensions of Wildlife* 23:552-568. DOI:10.1080/10871209.2018.1511876.

Schroeder, S. A., **D.C. Fulton**, L.J. Cornicelli, and S.S. Merchant. 2018. Discrete choice modeling of season choice for Minnesota turkey hunters. *Journal of Wildlife Management* 82:457-465. DOI:10.1002/jwmg.21382.

Streby, H.M, G.R. Krammer, S.M. Peterson, and **D.E. Andersen**. 2018. Evaluating outcomes of management targeting the recovery of a migratory songbird of conservation concern. *PeerJ* 6:e4319. DOI:10.7717/peerj.4319.

Streby, H.M, G.R. Kramer, S.M. Peterson, J.A. Lehman, D.A. Buehler, and **D.E. Andersen**. 2018. Response to Lisovski et al.: carefully interpreted light-level geolocator data can lead to the discovery of interesting animal behavior. *Current Biology* 28:R101-R102. DOI:10.1016/j.cub.2017.12.025

Walberg, E. L.J. Cornicelli and **D.C. Fulton**. 2018. Factors impacting hunter access to private lands in southeast Minnesota. *Human Dimensions of Wildlife* 23:101-114. DOI:10.1080/10871209.2018.1396510

In Press, Review, or Revision

Adkins, K., C. Roy, **D.E. Andersen**, and R.G. Wright. *In Revision*. Landscape-scale greater prairie-chicken – habitat relations and the Conservation Reserve Program. *Journal of Wildlife Management*.

Bergh, S.M. and **D.E. Andersen**. *In Press.* Estimating density and effective area surveyed for American woodcock. *Proceedings of the 11th American Woodcock Symposium*.

Bergh, S.M. and **D.E. Andersen**. *In Press*. Occupancy and detection probability of American woodcock during Singing-ground Surveys. *Proceedings of the 11th American Woodcock Symposium*.

Daly, K.O., **D.E. Andersen**, W.L. Brininger, and T.R. Cooper. *In Press*. Breeding season survival of American woodcock at a Habitat Demonstration Area in Minnesota. *Proceedings of the 11th American Woodcock Symposium*.

Daly, K.O., **D.E. Andersen**, W.L. Brininger, and T.R. Cooper. *In Press*. Evaluating techniques for estimating post-breeding season age ratios for American woodcock. *Proceedings of the 11th American Woodcock Symposium*.

Danehy, R.J., K. Nislow, C.A. Dolloff, **Vondracek, B.**, R.M. Newman, C. Blinn, R. Mackereth, M. Young, J. Walter, D. Martin, and M. Wilzbach. *In Review*. Regional specific interactions of forests and fish: Great Lakes Region. Reflections on forest management, can fish and fiber coexist? Editors R. Danehy and A. Dolloff. American Fisheries Society, Bethesda, Maryland, U.S.A.

Gigliotti, L.L. Sweikert, L.J. Cornicelli, and **D.C. Fulton**. *In Revision*. Minnesota landowners' trust in their Department of Natural Resources, salient values similarity and wildlife value orientations. *Human Dimensions of Wildlife*.

Kramer, G.R., K.O. Daly, H.M. Streby, and **D.E. Andersen**. *In Press*. Landscape composition and configuration, and full-season productivity of American woodcock in Minnesota. *Proceedings of the 11th American Woodcock Symposium*.

Kramer. G.R., R. K. Pagel, K. Maley, C. Ziegler, S. M. Peterson, **D. E. Andersen**, D. A. Buehler, and H. M. Streby. 2019. *In Press*. Say what? Bivalent singing in *Vermivora* warblers. *Scientific Naturalist*.

Kramer, G.R., S.M. Peterson, K.O. Daly, H.M. Streby, and **D.E. Andersen**. *In Press*. Left out in the rain: comparing productivity of two associated species exposes a leak in the umbrella species concept. *Biological Conservation*.

Lasharr, K., **D.C. Fulton**, and L.J. Cornicelli. *In Revision*. Experience preferences and place attachment of Minnesota Wildlife Management Area users. *Human Dimensions of Wildlife.*

Manfredo, MJ., T.L. Teel, A. DonCarlos, L. Sullivan, A. Bright, A. Dietsch, J. Bruskotter, and **D.C. Fulton**. *In Review*. The changing socio-cultural context of wildlife conservation. *Conservation Biology*.

Moore, J.D., T.R. Cooper, R. Rau, **D.E. Andersen**, J.P. Duguay, C.A. Stewart, and D.G. Krementz. Assessment of the American Woodcock Singing-Ground Survey zone timing and coverage. *Proceedings of the 11th American Woodcock Symposium*.

Moore, J., **D.E. Andersen**, T.R. Cooper, J. Duguay, S. Oldenburger, C.A. Stewart, and D.G. Krementz. *In Press*. 2019. Migratory connectivity of American woodcock derived using satellite telemetry. *Journal of Wildlife Management*.

Peterson, S.M., H.M Streby, G.R. Kramer, and **D.E. Andersen**. *In Revision*. Ecology of brood division in golden-winged warblers. *Condor*.

Reiter, M. E. and **D.E. Andersen**. *In Review*. Impacts of lesser snow goose-mediated habitat alteration on Canada goose nest density. *Avian Conservation and Ecology*.

Schroeder, S.A., L.J. Cornicelli, **D.C. Fulton** and S.S. Merchant. *In Press*. The influence of motivation versus experience on recreation satisfaction: how appreciative- versus achievement-oriented recreation experience preferences relate to hunter satisfaction. *Journal of Leisure Research.*

Schroeder, S.A., **D.C. Fulton**, L.J. Cornicelli, S. Cordts, and J. Lawrence. *In Press*. Clarifying how hunt-specific experiences affect satisfaction, among avid and less avid waterfowl hunters. *Wildlife Society Bulletin.*

Schroeder, S.A., **D.C. Fulton**, L.J. Cornicelli, L. McInenly. *In Review*. How beliefs about regulations, institutional trust, and personal motivations predict attitudes about hunting regulations. *Human Dimensions of Wildlife.*

Schroeder,S.A., **D.C. Fulton**, L. Cornicelli, L. McInenly. *In Review*. Recreation conflict, coping, and satisfaction: interference and coping response among Minnesota grouse hunters. *Leisure Science.*

Tingley, R.W., J.F. Hansen, D.A. Isermann, **D.C. Fulton**, A Musch, A. and C.P. Paukert. *In Press*. Characterizing angler preferences for largemouth bass, bluegill, and walleye fisheries in Wisconsin. *North American Journal of Fisheries Management.*

Wilkins, E., N. Cole, H. Miller, R. Schuster, A. Dayer, J. Duberstein, **D.C. Fulton**, H. Harshaw, A. Raedeke. *In Review.* Perceived constraints to participating in wildlife-based recreation. *Wildlife Society Bulletin*.

Wilkins, E., N. Cole, H. Miller, R. Schuster, A. Dayer, J. Duberstein, **D.C. Fulton**, H. Harshaw, A. Raedeke. *In Review.* Rural-Urban differences in hunting and birdwatching. *Human Dimensions of Wildlife*.

Wolfson, D.W., J.R. Fieberg, and **D.E. Andersen**. *In Review*. Movement strategies of adult and juvenile sandhill cranes (*Antigone canadensis*) during the breeding season. *Ibis*.

Awards and Honors

2017. Edited Book Award, The Wildlife Society (David E. Andersen, Henry M. Streby, and David A. Buehler)

2017. Fellow, The Wildlife Society (David E. Andersen)

2018. Professional Award of Merit, North Central Section of The Wildlife Society (David E. Andersen)

Cooperating Faculty Publications

Hove, M, M. Bartsch, B. Burke, A. Franzen, D. Waller, N. Eckert, M. Bradley, T. Smith, M. Davis, B. Sietman, B. Karns, R. Whaley, and A. Holdhusen. 2018. Brooding *Quadrula fragosa* behaviors and interactions with fishes. *Ellipsaria* 20:22-25.

Claus, A, and P.W. Sorensen, 2017. Chemically-mediated control of the feeding behavior of filter-feeding bigheaded carps. *Journal of Chemical Ecology* 43:374-384.

Completed Theses and Dissertations of Minnesota Coop Unit Students

2017

Adkins, K.I.S. 2017. The relationship between grasslands, Conservation Reserve Program (CRP) enrollments, and greater prairie-chickens (*Tympanuchus cupido pinnatus*) populations in Minnesota. M.S. Thesis, University of Minnesota, Saint Paul, Minnesota, U.S.A. 114 pages. (David E. Andersen)

Both the abundance of greater prairie-chickens (*Tympanuchus cupido pinnatus)* and the area in grassland Conservation Reserve Program (CRP) in northwestern Minnesota have undergone recent declines. Although wildlife conservation is a stated objective of the CRP, the impact of CRP grassland on greater prairie-chicken populations has not been quantified. To address that information need, I evaluated the association between greater-prairie chicken lek density (leks/km^2) and the number of males at leks (males/lek) and CRP enrollments in the context of landscape structure and composition in northwestern Minnesota using data from standardized prairie-chicken surveys and land-cover in 17 42-km2 survey blocks during the period 2004-2016. I used a mixed-effect model and a layered approach in an information-theoretic framework at multiple spatial scales to identify covariates related to prairie-chicken abundance. At the landscape scale, the amount of CRP grassland; state-, federal-, and The Nature Conservancy (TNC)-managed grasslands; CRP wetland; state-, federal-, and TNC-managed wetlands, "other" wetlands; the contiguity of grasslands; and the number of patches of grasslands and wetlands in each survey block in each year best explained lek density (leks/km^2). At the lek scale, the amount of CRP grassland; state-, federal-, and TNC-managed grasslands; CRP wetland; state-, federal-, and TNC-managed wetlands; "other" wetlands; forests; developed areas; shrubs; and the contiguity of CRP grassland best explained the number of males at leks. These results suggest that increasing the quantity of grassland and wetland CRP contracts throughout the existing range of greater prairie-chickens in northwestern Minnesota and aggregating CRP grassland contracts in areas of known lek sites may increase greater prairie-chicken abundance.

The Conservation Reserve Program (CRP) has the potential to influence the abundance of greater prairie-chickens (*Tympanuchus cupido pinnatus),* a species of special concern in Minnesota, by altering the amount and configuration of grassland and wetland in agriculturally dominated landscapes. However, the CRP has experienced recent declines in enrollments in northwestern Minnesota, and these declines are expected to continue following the reduced enrollment cap in the 2014 Farm Bill. These declines increase the need to prioritize CRP reenrollments or new enrollments that are likely to have the most positive impact on greater prairie-chicken populations. To predict changes in greater prairie-chicken abundance caused by expirations of CRP contracts and target CRP enrollments at both the landscape and lek scale, I used models relating lek density and the number of males at leks to CRP enrollments and the resulting landscape structure. I simulated different land-cover scenarios of CRP contract expirations, and results in-

dicated that the abundance of greater prairie-chickens would be reduced. Simulations of targeted CRP contract enrollment suggested mixed effects on greater prairie-chicken abundance if adding grassland cover did not increase existing grassland contiguity. Landscapes with a large proportion of existing CRP grasslands and wetlands were most likely to continue to support high prairie-chicken abundance through reenrollment and enrollment of new contracts that are large and contiguous with existing grassland- and wetland-cover types. These findings highlight the importance of maintaining existing CRP grasslands and wetlands in landscapes that currently have low levels of grassland and wetland cover.

Although greater prairie-chickens (*Tympanuchus cupido pinnatus)* are identified as grassland obligate birds, not all grassland-cover types meet their habitat requirements of a diverse mosaic of vegetation composition and structural components. The Conservation Reserve Program (CRP) has the potential to make millions of ha of grassland in CRP enrollments available nationwide, but many are not high-quality habitat for greater prairie-chickens because the seeding mix planted or subsequent management plan for the planting does not result in high-quality habitat conditions for greater prairie- chickens. Because the CRP has experienced recent declines in northwestern Minnesota that are expected to continue, the ability to understand which CRP programs provide high-quality habitat conditions for greater prairie-chickens can allow for prioritization of these programs. To understand the program types and conditions that create optimal greater prairie-chicken habitat conditions, I modeled the relationships between remotely measured characteristics of CRP enrollments and vegetation characteristics associated with high-quality greater prairie-chicken breeding habitat. I then used models based on these relationships to predict existing extent and distribution of CRP enrollments that provide high-quality greater prairie-chicken breeding habitat across their northwestern Minnesota distribution. My results suggest that there are many combinations of CRP contract type, age of planting, and soil type that can provide appropriate vegetation structure and composition for greater prairie-chickens, and that high-quality greater prairie-chicken breeding habitat is not restricted to high diversity native-seed plantings. Additionally, my results suggest that a higher amount of high-quality breeding habitat in northwestern Minnesota is positively associated with greater prairie-chicken abundance (leks/km^2) although there are many other landscape factors that also contribute to greater prairie-chicken abundance.

Kramer, Gunnar R. 2017. Nonbreeding and migratory ecology of golden-winged warblers and effects of landscape composition and configuration on American woodcock productivity. M.S. thesis, Univeristy of Minnesota, St. Paul, Minnesota, U.S.A. 88 pages. (David E. Andersen).

Golden-winged Warblers (*Vermivora chrysoptera*) are Nearctic-Neotropical migrants experiencing varied regional population trends not fully explained by breeding-grounds factors (e.g., nest success). No detailed information exists on the nonbreeding distributions, migration routes, or timing of migration among populations of this species, and factors outside the breeding period may influence population trends. I tracked annual movements of 21 Golden-winged Warblers from three North American breeding locations experiencing varying population trends using geolocators from 2013-2015 to investigate the potential for nonbreeding site factors to influence breeding populations. I used the template-fit method to analyze light data collected with geolocators and estimate locations of individual warblers throughout the year. Geolocator-marked warblers exhibited significant isolation among populations during migration and the nonbreeding period. During the nonbreeding period, Golden-winged Warblers from Minnesota, USA (*n* = 12) occurred in Central America from southern Mexico to central Nicaragua; warblers from Tennessee, USA (*n* = 7) occurred along the border of northern Colombia and Venezuela; and warblers from Pennsylvania, USA (*n* = 2) occurred in north-central Venezuela. Golden-winged Warblers I monitored from these three breeding populations exhibited essentially no effective overlap (<0.001%) outside the breeding period. Warblers travelled at slower rates over more days in fall migration than spring migration. Fall migra-

tion routes at the Gulf of Mexico were population-specific, whereas spring routes were more varied and overlapped among populations. Geolocator-marked Golden-winged Warblers from Pennsylvania migrated 4,000 and 5,000 km yr-1 farther than Tennessee and Minnesota warblers and spent almost twice as long migrating in the fall compared to Minnesota warblers. My results reveal nearly complete temporal and geographic isolation among three populations of Golden-winged Warblers throughout the annual cycle resulting in opportunities for population- and site-specific factors to differentially influence populations outside the breeding period. My findings highlight the need for monitoring multiple populations of migratory species to understand and better inform conservation strategies.

The effects of landscape composition and configuration on the full-season productivity (i.e., juveniles raised to independence from adult care) of most bird species, including American Woodcock (*Scolopax minor*), is largely unknown. Understanding landscape components and cover-type configurations associated with high full-season productivity can be useful in developing more effective management strategies that increase recruitment. I used data on nest and juvenile survival rates of American Woodcock in northern Minnesota from 2011 to 2012 to inform logistic exposure models of survival and predict full-season productivity. I used those models to link landscape features with nest survival rate and juvenile survival rate; predict spatially explicit, full-season productivity across my study area; and identify areas of high productivity within my study landscape. Finally, I used simulations to explore the impact of potential management actions aimed at improving productivity and the effects of long-term succession of young-forest cover types. I found that associations between land-cover composition and different components of productivity (i.e., nest and juvenile survival rates) were scale-specific. Generally, my models suggested stand-level composition (i.e., the amount of cover types within 500 m of the nest) influenced nest survival rate with mature forest having a small, but mostly positive association with nest survival rate in most landscape contexts. Conversely, my models predicted lower nest survival rates in landscapes with greater amounts of grassland and upland shrubland. The amount of wetland shrubland and upland shrubland at stand (i.e., <500 m) and landscape-level (i.e., 1,000 m) scales was positively associated with juvenile survival rate. My methods demonstrate that the effects of management actions depend on the context of the surrounding landscape mosaic and may be useful for informing local management strategies. Finally, my results suggest that relationships between survival and specific land-cover types may change throughout the reproductive cycle in American Woodcock.

LaSharr, K. 2017. Understanding visitors to Wildlife Management Areas in Minnesota. M.S. Thesis, University of Minnesota, St. Paul, Minnesota, U.S.A. 73 pages. (David C. Fulton)

Previous research has shown that hunters are motivated to participate in recreational activities in order to achieve a specific set of desired experiences. Using data obtained from a self-administered mail survey conducted in 2016, we examined the different recreational experiences hunters were pursuing. We used k -means cluster analysis to define unique clusters of users who recreated on Minnesota Department of Natural Resources' publically-owned Wildlife Management Area (WMAs) during the fall 2015-2016 hunting season. We identified six clusters based on recreation experience preferences at WMAs. The clusters differed on demographic characteristics, as well as level of satisfaction with various experiences during their hunting trips to WMAs. The cluster of hunters with the highest overall satisfaction for WMAs also had the highest place and emotional attachment to these publically accessible areas. In addition, the cluster that showed the lowest satisfaction with WMA experiences was also the least supportive of management actions. This information will help wildlife managers understand their constituents, manage public lands, and help recruit, retain, and reactivate hunters into the activity.

In Minnesota, the Wildlife Management Area (WMA) system encompasses more than 0.52 million hectares across 1,400 units. In order to better understand their visitors to these areas of high-quality habitat, wildlife managers want to know how many individuals use the WMA system and ultimately, the recreational experiences they are hoping to achieve. From September to December 2015, we counted vehicles using a randomized sample of WMA units in order to estimate total visitation during the fall 2015 hunting season. Our field observations were conducted during single point-in-time driving surveys that occurred over 10 weekends. We used a linear mixed-effects model to estimate visitation based on mean vehicle counts per site (averaged over the hunting season) and WMA site attributes (e.g., unit size, presence of popular game species, and distance to points of interest). We refined our point-estimate using intensive observations conducted on a subsample of study WMAs and self-reported hunting trip data from a companion study of WMA users. We determined the average probability of intercepting a vehicle and a unique visitor during a normal sampling day was PI = 0.229 and PU = 0.467 respectively. We used these adjustment factors, along with self-reported hunting party information, to obtain a final estimate of 32,374 user groups, 61,122 individual visitors, and 130,942 total visits to WMAs in our study area during the 2015-2016 hunting season.

2018

Wolfson, D.W. 2018. Migratory ecology and movement patterns of Mid-Continent and Eastern sandhill cranes. M.S. thesis, University of Minnesota, St. Paul, Minnesota, U.S.A. 62 pages. (David E. Andersen and John Fieberg)

Sandhill cranes (*Antigone canadensis*) are long-lived birds with relatively low recruitment rates, making accurate knowledge of abundance and distribution critical for well-informed harvest management. Minnesota is one of few states containing portions of 2 distinct breeding populations of greater sandhill cranes (*A. c. tabida*)—the Mid-continent Population (MCP) and the Eastern Population (EP). Historically, the breeding range of MCP cranes in Minnesota was restricted to the extreme northwestern portion of the state, whereas the breeding range of EP cranes was limited to the east-central part of the state with a large area of separation between the 2 populations. Whereas MCP cranes have exhibited stable population estimates over time, EP cranes are currently experiencing a significant increase in population size and a concurrent expansion of breeding range. Our objectives were to evaluate the current range boundaries of the 2 populations in Minnesota and to determine whether the populations overlap on their breeding areas and fall staging grounds. We captured and attached Global Positioning System-Global System for Mobile Communications (GPS-GSM) transmitters to 50 cranes in the zone between the historical breeding range boundaries of the 2 populations. Movements of captured cranes revealed that EP cranes have greatly expanded their breeding range in Minnesota while MCP cranes have experienced more moderate range expansion in the state. Results of this study provide the first documentation of overlap between the breeding ranges of EP and MCP sandhill cranes. Our results also suggest that staging areas in northwestern Minnesota, where recreational harvest targeted at MCP cranes was allowed beginning in 2010, are being used by both populations and there is overlap in migration corridors, as evidenced by 4 cranes that used both the Mississippi and Central flyways.

The movement patterns of juveniles, which are influenced by a combination of both internal and external factors unique to their age class, affect both range expansion of populations and patterns of spatiotemporal overlap, yet are not well-studied in birds and other vertebrates. Recent technological advances in animal biotelemetry have made it possible to quantify movements of juvenile birds prior to settlement on breeding areas. We used fine-scale GPS telemetry data to characterize movements of adult and juvenile

sandhill cranes (*Antigone canadensis*) in and near the transition zone between breeding Eastern and Mid-Continent Populations from arrival on natal areas until staging prior to fall migration. We segmented the movement trajectory of each crane into a series of behavioral states indicative of either roaming or settled movement patterns. Juvenile and adult sandhill cranes utilized different movement strategies throughout the breeding season. Juveniles were more likely than adults to display long-distance roaming movements and also traversed much larger areas than adults when roaming. Roaming was most common during spring (i.e., April-May), early in the breeding season and soon after juvenile cranes returned to natal areas. Adult cranes revisited areas at higher rates than juveniles regardless of behavioral state. Adults visited areas for longer durations than juveniles during roaming periods but for shorter durations during settled periods. We hypothesize that the differences in frequency and intensity of space-use between juvenile and adult cranes may be attributed to differences in both biological requirements and familiarity with the landscape. Adult cranes are constrained by association with breeding areas during spring and early summer, but also likely have prior experience with foraging and roosting sites within their home ranges. In contrast, juvenile cranes are not associated with a nest during this period, and they are learning where and how to independently secure resources.

Student Awards

2017

Nina Hill. Minnesota Chapter of The Wildlife Society, Bob Fedeler Award.
Evan Salcido. University of Minnesota CFANS Graduate Student Fellowship.
Eric Walberg. Minnesota Chapter of The Wildlife Society, Bob Fedeler Award.

2018

Kaly Adkins. Minnesota Chapter of The Wildlife Society, Bob Fedeler Award.
Kaly Adkins. Minnesota Chapter of The Wildlife Society, Student Conservationist Award.

Presentations

Invited Presentations

2017

Andersen, D.E. 2017. American woodcock breeding range habitat management. 11th American Woodcock Symposium. Rosscommon, Michigan, U.S.A.

Buehler, D.A., G.R. Kramer, S.M. Peterson, J.A. Lehman, D.J. McNeil, J.L. Larkin, **D.E. Andersen**, P. Wood, and H.M. Streby. 2017. New insights into the migration ecology and full life cycle conservation of golden-winged warblers. Annual Meeting of the Tennessee Ornithological Society, Knoxville, Tennessee, U.S.A.

Fulton, D.C., J. T. Bruskotter, and S.A. Schroeder. 2017. Using the cognitive hierarchy to understand and predict angler behavior: its promise and limitations. World Recreation Fishing Conference. Victoria, British Columbia, Canada.

Fulton, D.C. and L.J. Cornicelli. 2017. The dynamic nature of values and wildlife value orientations. International Symposium on Society and Resource Management (ISSRM). Umeå, Sweden.

Fulton, D.C. and H. Harshaw. 2017. NAWMP stakeholders study findings summary for waterfowl hunters in the United States and Canada. Future of Waterfowl Workshop II. National Conservation Training Center, West Virginia, U.S.A.

Harshaw, H. and **Fulton, D.C.** 2017. NAWMP stakeholders study findings summary for birdwatchers in the United States and Canada. Future of Waterfowl Workshop II. National Conservation Training Center, West Virginia, U.S.A.

Kramer, G.R., **D.E. Andersen**, H.M. Streby, S.M. Peterson, and K.O. Daly. 2017. Golden-winged warbler and American woodcock full life-cycle biology and management. U.S. Fish and Wildlife Service - Region 3 Headquarters, Bloomington, Minnesota, U.S.A.

2018

Buehler, D.A., G.R. Kramer, S.M. Peterson, J.A. Lehman, D.J. McNeil, J.L. Larkin, **D.E. Andersen**, P. Wood, and H.M. Streby. 2016. New insights into the migration ecology and full life cycle conservation of golden-winged warblers. Chattanooga Chapter of the Tennessee Ornithological Society, Chattanooga, Tennessee, U.S.A.

Cornicelli, L.J., **D.C. Fulton**, L. McInenly, and S. Schroeder. 2018. Applying the North American Model of Wildlife Management to hunter behavior: it's not as simple as it sounds. Human Dimensions Pathways. Goslar, Germany.

Fulton, D.C. and L.J. Cornicelli. 2018. Management implications of the enduring wildlife value orientations concept. Human Dimensions Pathways. Goslar, Germany.

Fulton, D.C., H.W. Harshaw, H. Miller, A. Raedeke, R. Schuster, A. Dayer, and J.N. Duberstein 2018. Using discrete choice experiments to understand trip preferences of birdwatchers and waterfowl hunters in the United States and Canada. International Symposium on Society and Resource Management. Snowbird, Utah, U.S.A.

Fulton, D.C., H. Harshaw, R. Schuster, H. Miller, A. Raedeke. A. Dayer., J. Duberstein, D. Humberg, 2018. NAWMP stakeholder studies: findings highlights from the United State and Canada. North American Wildlife and Natural Resources Conference. Norfolk, Virginia, U.S.A.

Harshaw, H., J.N. Duberstein, **D.C. Fulton,** H. Miller, A. Dayer, A. Raedeke, and R. Schuster. Influence of social networks and identity diversity on the conservation involvement of North American bird watchers. 2018 International Symposium on Society and Resource Management. Snowbird, Utah, U.S.A.

Raedeke, A., **D.C. Fulton,** H.W. Harshaw, H. Miller, R. Schuster, J.N. Duberstein, A. Dayer, and E. Wilkins 2018. A coordinated, adaptive framework for birdwatcher and waterfowl hunter public engagement. International Symposium on Society and Resource Management. Snowbird, Utah, U.S.A.

Schuster, R., E. Wilkins, H. Miller, H.W. Harshaw, J.N. Duberstein, **D.C. Fulton**, A. Dayer, A. Raedeke. 2018. Communicating information on nature-related topics: information channels and trust in sources preferred by the American public. International Symposium on Society and Resource Management. Snowbird, Utah, U.S.A.

Contributed Presentations

2017

Adkins, K., C. Roy, **D.E. Andersen**, and R.G. Wright. 2017. Quantifying the relationship between grasslands, Conservation Reserve Program (CRP) enrollments and greater prairie chicken (*Tympanuchus cupido pinnatus*) in Minnesota. 2017 Annual Meeting of the Minnesota Chapter of The Wildlife Society, Callaway, Minnesota, U.S.A.

Adkins, K., C. Roy, **D.E. Andersen**, and R.G. Wright. 2017. Quantifying the relationship between grasslands, Conservation Research Program (CRP) enrollments and greater prairie-chicken populations (*Tympanuchus cupido pinnatus*) in Minnesota. 77th Midwest Fish and Wildlife Conference, Lincoln, Nebraska, U.S.A.

Bergh, S.M. and **D.E. Andersen**. 2017. Estimating density and effective area surveyed for American woodcock. 11th American Woodcock Symposium, Rosscommon, Michigan, U.S.A.

Bergh, S.M. and **D.E. Andersen**. 2017. Occupancy and detection probability of American woodcock during Singing-ground Surveys. 11th American Woodcock Symposium, Rosscommon, Michigan, U.S.A.

Daly, K.O., **D.E. Andersen**, W.L. Brininger, and T.R. Cooper. 2017. Breeding season survival of American woodcock at a habitat demonstration area in Minnesota. 11th American Woodcock Symposium, Rosscommon, Michigan, U.S.A.

Daly, K.O., **D.E. Andersen**, W.L. Brininger, and T.R. Cooper. 2017. Evaluating indices of recruitment for American woodcock. 11th American Woodcock Symposium, Rosscommon, Michigan, U.S.A.

Goebel, K., N. Davros, and **D.E. Andersen**. 2017. Evaluating insecticide exposure risk for grassland wildlife on public lands. 2017 Annual Meeting of the Minnesota Chapter of The Wildlife Society, Callaway, Minnesota, U.S.A.

Goebel, K., N. Davros, and **D.E. Andersen**. 2017. Evaluating insecticide exposure risk for grassland wildlife on public lands. 77th Midwest Fish and Wildlife Conference, Lincoln, Nebraska, U.S.A.

Hill, N., T. Cooper, D.H. Johnson, and **D.E. Andersen**. 2017. Secretive marshbird response to wetland management in western Minnesota. 2017 Annual Meeting of the Minnesota Chapter of The Wildlife Society, Callaway, Minnesota, U.S.A.

Hill, N., T. Cooper, D.H. Johnson, and **D.E. Andersen**. 2017. Secretive marshbird response to wetland management in western Minnesota. 77th Midwest Fish and Wildlife Conference, Lincoln, Nebraska, U.S.A.

Hill, N., T. Cooper, D.H. Johnson, and **D.E. Andersen**. 2017. Secretive marshbird response to wetland management in western Minnesota. Minnesota Waterfowl Symposium, Bloomington, Minnesota, U.S.A.

Kramer, G.R., **D.E. Andersen**, D.A. Buehler, P.B. Wood, S.M. Peterson, J.A. Lehman, K.R. Aldinger, L.P. Bulluck, B. Gray, S. Harding, J.A. Jones, D.I. King, J.L. Larkin, J.P. Ooegering, D.J. McNeil, D.B. Miles, C. Smalling, R. Vallender, and H.M. Streby. 2017. Range-wide migration patterns and distribution of *Vermivora* warblers during the nonbreeding period. Joint Meeting of the American Ornithological Society and the Society of Canadian Ornithologists, East Lansing, Michigan, U.S.A.

Kramer, G.R., **D.E. Andersen**, D.A. Buehler, P.B. Wood, S.M. Peterson, J.A. Lehman, K.R. Aldinger, L.P. Bulluck, S. Harding, J.A. Jones, J.P. Loegering, D. Miles, C. Smalling, R. Vallender, H.M. Streby. 2017. Range-wide migration patterns and distribution of *Vermivora* warblers during the nonbreeding period. Ohio Avian Research Conference. Granville, Ohio, U.S.A.

Kramer, G.R., K.O. Daly, H.M. Streby, and **D.E. Andersen**. 2017. A spatially explicit method for estimating the effects of landscape composition and configuration on full-season productivity of American woodcock

in Minnesota. 11th American Woodcock Symposium, Rosscommon, Michigan, U.S.A.

Moore, J.D., T.R. Cooper, R. Rau, **D.E. Andersen**, J.P. Duguay, C.A. Stewart, and D.G. Krementz. 2017. Assessment of the American Woodcock Singing-Ground Survey zone timing and coverage. 11th American Woodcock Symposium, Roscommon, Michigan, U.S.A.

Walberg, E., **D.C. Fulton**, L. Cornicelli. and G. D'Angelo. 2017. Attitudes toward and management preferences for elk in northwestern Minnesota. Pathways in Human Dimensions Conference. Estes Park, Colorado, U.S.A.

Wolfson, D., J. Fieberg., T. Cooper, J.S. Lawrence, and **D.E. Andersen**. 2017. Range overlap between Mid-Continent and Eastern sandhill cranes revealed by GPS-tracking. 77th Midwest Fish and Wildlife Conference, Lincoln, Nebraska, U.S.A.

Wolfson, D., J. Fieberg., T. Cooper, J.S. Lawrence, and **D.E. Andersen**. 2017. Range overlap between Mid-Continent and Eastern sandhill cranes revealed by GPS-tracking. Minnesota Waterfowl Symposium, Bloomington, Minnesota, U.S.A.

Wolfson, D., J. Fieberg, J. Lawrence, T. Cooper, and **D.E. Andersen**. 2017. A comparison of movements between adults and juvenile sandhill cranes during spring and summer: evidence for prospecting? 14th North American Crane Working Group Workshop, Chattanooga, Tennessee, U.S.A.

Wolfson, D., J. Fieberg, J. Lawrence, T. Cooper, and **D.E. Andersen**. 2017. When worlds collide: a current assessment of two formerly distinct sandhill crane populations in Minnesota. 2017 Annual Meeting of the Minnesota Chapter of The Wildlife Society, Callaway, Minnesota, U.S.A.

2018

Adkins, K.I., **D.E. Andersen**, C. Roy, and R. Wright. 2018. "Flushing Out" the relationship between grasslands, Conservation Reserve Program (CRP) Enrollments, and greater prairie-chicken (*Tympanchus cupido pinnatus*) populations in Minnesota. 2018 Annual Meeting of the Minnesota Chapter of The Wildlife Society. St. Cloud, Minnesota, U.S.A.

Adkins, K.I., **D.E. Andersen**, C. Roy, and R. Wright. 2018. "Flushing Out" the relationship between grasslands, Conservation Reserve Program (CRP) Enrollments, and greater prairie-chicken (*Tympanchus cupido pinnatus*) populations in Minnesota. Minnesota Prairie Chicken Society Annual Meeting, Glyndon, Minnesota, U.S.A.

Adkins, K., C. Roy, **D.E. Andersen**, and R.G. Wright. 2018. Predicting the effects of grassland Conservation Reserve Program enrollments and expirations on greater prairie-chickens in northwestern Minnesota. 78th Midwest Fish and Wildlife Conference. Milwaukee, Wisconsin, U.S.A.

Buehler, D., T. Boves, L. Bulluck, J. Larkin, A. Rodewald, P. Wood, S. Stoleson, H Streby, S. Peterson, and **D.E. Andersen**. 2018. Status and conservation of golden-winged and cerulean warblers: lessons learned from long-term research in Tennessee and from across the range. Tennessee Bird Summit, Tennessee, U.S.A.

Daly, K.O., **D.E. Andersen**, W.I. Brininger, and T.R. Cooper. 2018. Evaluating indices of full-season productivity for American woodcock. 78th Midwest Fish and Wildlife Conference. Milwaukee, Wisconsin, U.S.A.

Goebel, K., N. Davros, and **D.E. Andersen**. 2018. Insecticide exposure risk for grassland wildlife on public land in southwestern Minnesota. 78th Midwest Fish and Wildlife Conference. Milwaukee, Wisconsin, U.S.A.

Goebel, K., N. Davros, and **D.E. Andersen**. 2018. Insecticide exposure risk for grassland wildlife on public land in southwestern Minnesota. 2018 Annual Meeting of the Minnesota Chapter of The Wildlife Society. St. Cloud, Minnesota, U.S.A.

Goebel, K., N. Davros, **D.E. Andersen**, and P. Rice. 2018. Evaluating insecticide exposure risk for grassland wildlife on public lands. 2018 LCCMR Pollinator Project Meeting, St. Paul, Minnesota U.S.A.

Goebel, K., N. Davros, **D.E. Andersen**, and P.J Rice. 2018. Insecticide exposure risk for grassland wildlife on public land in southwestern Minnesota. 2018 Annual Conference of The Wildlife Society. Cleveland, Ohio U.S.A.

Hill, N., **D.E. Andersen**, D.H. Johnson, and T. Cooper. 2018. Converting marshbird counts to density: adjusting for distance and variable amounts of potential cover at survey points. 2018 Annual Conference of The Wildlife Society. Cleveland, Ohio U.S.A.

Hill, N., **D.E. Andersen**, D.H. Johnson, and T. Cooper. 2018. Secretive marshbird response to long-term vegetation management in west-central Minnesota. 2018 Annual Meeting of the Minnesota Chapter of The Wildlife Society. St. Cloud, Minnesota, U.S.A.

Hill, N., **D.E. Andersen**, D.H. Johnson, and T. Cooper. 2018. Secretive marshbird response to herbicide control of invasive cattail (*Typha* spp.) in northwestern Minnesota. 2018 Annual Meeting of the Minnesota Chapter of The Wildlife Society. St. Cloud, Minnesota, U.S.A.

Hill, N., **D.E. Andersen**, D.H. Johnson, and T. Cooper. 2018 Secretive marshbird response to fire and grazing in wetlands of western Minnesota. 78th Midwest Fish and Wildlife Conference. Milwaukee, Wisconsin, U.S.A.

Kramer, G.R., **D.E. Andersen**, D.A. Buehler, P.B. Wood, S.M. Peterson, J.A. Lehman, K.R. Aldinger, L.P. Bulluck, B. Gray, S. Harding, J.A. Jones, D.I. King, J.P. Loegering, D.B. Miles, C. Smalling, R. Vallender, and H.M. Streby. 2018. Range-wide patterns of migratory connectivity and nonbreeding distribution of *Vermivora* warblers. 78th Midwest Fish and Wildlife Conference. Milwaukee, Wisconsin, U.S.A.

Kramer, G.R., H.M. Streby, S.M. Peterson, K.O. Daly, and **D.E. Andersen**. 2018. Of woodcock and warblers: two species trying to thrive in the same landscape. The Wildlife Society Annual Conference, Cleveland, Ohio, U.S.A.

Kramer, G.R., H.M. Streby, S.M. Peterson, K.O. Daly, and **D.E. Andersen**. 2018. What's good for the woodcock is good for the warbler? Productivity of two young-forest species on a shared landscape. 136th Stated Meeting of the American Ornithological Society. Tucson, Arizona, U.S.A.

Kramer, G.R., **D.E. Andersen**, D.A. Buehler, P.B. Wood, S.M. Peterson, J.A. Lehman, K.R. Aldinger, L.P. Bulluck, S. Harding, J.A. Jones, J.P. Loegering, C. Smalling, R. Vallender, and H.M. Streby. 2018. Population trends of *Vermivora* warblers are linked to strong migratory connectivity. The Wildlife Society Annual Conference, Cleveland, Ohio, U.S.A.

Kramer, G.R., **D.E. Andersen**, D.A. Buehler, P.B. Wood, S.M. Peterson, J.A. Lehman, K.R. Aldinger, L.P. Bulluck, S. Harding, J.A. Jones, J.P Loegering, C. Smalling, R. Vallender, and H.M. Streby. 2018. Range-wide migration patterns in *Vermivora* warblers. 136th Stated Meeting of the American Ornithological Society. Tucson, Arizona, U.S.A.

Walberg, E., **D.C. Fulton**, L. Cornicelli. and G. D'Angelo. 2018. Attitudes toward and management preferences for elk in northwestern Minnesota. The Wildlife Society Annual Conference, Cleveland, Ohio U.S.A.

Cooperating Faculty Presentations

2017

Burke, B. and M. Hove. 2017. Studying winged mapleleaf life history to improve conservation. Minnesota Chapter of the American Fisheries Society, St. Cloud, Minnesota, U.S.A.

Unit News

During the last two years (2017-2018), the Minnesota Cooperative Fish and Wildlife Research Unit has continued to operate at a reduced capacity, in that we have not been able to fill the vacancy left when Dr. Bruce Vondracek (Assistant Leader – Fisheries) retired in May 2015. Funding for the Cooperative Research Units Program has been such that only Leader positions and positions at Coop Units where there is only one federal scientist have been filled, and both fortunately and unfortunately, the Minnesota Coop Unit hasn't made that list. Federal funding to support Coop Unit activities has remained scarce, and we have relied more and more on our Minnesota Department of Natural Resources base contributions to support day-to-day operations. The University of Minnesota has reduced the space allocated to the Coop Unit, in part as result of the vacancy resulting from Bruce's retirement, and in part because space was allocated to higher departmental priorities. The University of Minnesota also requested that our Cooperative Agreement be renegotiated, in part, to retain the indirect cost recovery from Coop Unit projects—funds that previously went to support Coop Unit activities. So, as seems to be the case in many places, the Minnesota Cooperative Fish and Wildlife Research Unit is operating in an environment where we are being asked to function with reduced resources and increasing costs; for example, the ever-increasing cost of supporting graduate students on externally funded grants.

In spite of those challenges, and with the continued support of our cooperators, both David Fulton (Assistant Leader- Wildlife) and David Andersen (Leader) continue to have active research programs that support M.S. and Ph.D. graduate students and postdoctoral research associates. We completed a number of research projects during 2017-2018, and initiated several new projects. As you can see in this report, our students continue to present their research results at professional conferences and in the peer-reviewed literature at an impressive rate. During the last two-year period, we are also happy to report that we have continued to have a strong relationship and work collaboratively with the Minnesota Department of Natural Resources and our federal partners.

There are some challenges ahead, however. As I write this summary in spring 2019, the future of federal funding for natural resources research is

anything but clear. Internal Department of Interior policies have extended the time needed to implement federal funding agreements, and deadlines have moved earlier into the federal fiscal year, making it difficult for agencies to commit funds in time for agreements to be completed prior to contracting deadlines. The extended partial government shutdown in late 2018 and early 2019 caused considerable disruption in our operations, and resulted in even more complications for working with other federal agencies to address research needs. In addition, without increases to the Cooperative Research Units Program budget, it is likely that the program, including the Minnesota Coop Unit, will continue to carry vacancies for the foreseeable future. On the state side, budgets in both fisheries and wildlife have shrunk, and the Minnesota Department of Natural Resources is facing significant financial challenges in the absence of increases in revenue, which makes research collaboration more challenging. Finally, the University of Minnesota, like many institutions of higher education, faces ongoing financial challenges that affect availability of resources to support departmental and graduate program operations. Over the more than 25 years the Minnesota Coop Unit has been in existence, the last 10 or more years have seen constant downward pressure of department budgets, which influences institutional support for our program. So, perhaps as much as ever, we need support from our cooperators, collaborators, former students, colleagues, and friends to champion what we do and the contributions we have made. If you have the opportunity, please put in a good word on our behalf! Throughout all the changes and pressures, however, we continue to "make it work," which I think is a hallmark of the Cooperative Research Units Program, and an indication of how our cooperators and collaborators value Coop Units.

Finally, a quick update on some of the activities of Minnesota Coop Unit scientists and staff. David Fulton continues to work closely with the Minnesota Department of Natural Resources to address their information needs, and Sue Schroeder continues to assist him in these efforts in her position as a Research Fellow. David is currently working on a variety of projects within the State of Minnesota, and also is working with collaborators across the country on issues of national and international importance. Summaries of those activities are provided in this report. David Andersen has wound down field portions of projects focused on golden-winged warblers, sandhill cranes, peregrines, American woodcock, secretive marshbirds, and greater prairie-chickens, and has recently initiated a project on movement ecology of Interior Population trumpeter swans, and collaborating with others on a continuing project on red-headed woodpeckers in the Upper Midwest. Finally, Hattie Saloka, who as everyone familiar with the Minnesota Coop Unit knows, continues to keep everything humming along. As a busy mother of two growing boys, she's got her hands full at home in addition to keeping all of us in line.