U.S. Geological Survey

Minnesota Cooperative Fish and Wildlife Research Unit

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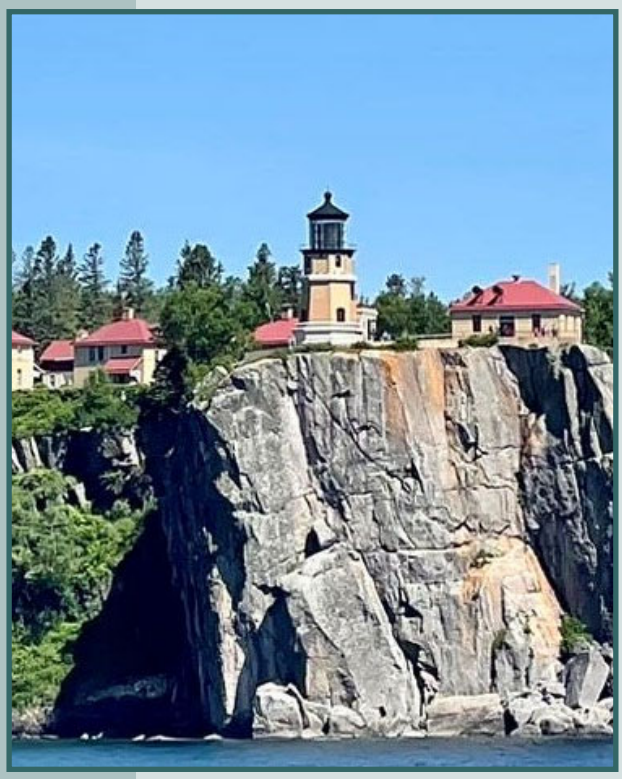
MINNESOTA COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT

Biennial Report

January 2021—December 2022



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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 80 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 aquatic and terrestrial ecosystems that are of state, regional, and national significance, including issues related to human activity. 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 17th biennial report produced by the Minnesota Coop Unit and summarizes Unit activities during 2021 and 2022. During that period, we and our partners operated in an environment influenced dramatically by Covid-19 policy, with significant changes in how we engaged with students and interacted internally and with collaborators, limitations on field work and other activities, and work-from-home directives from both the U.S. Geological Survey and the University of Minnesota. We are now all much more adept at using virtual tools to interact, including how to hold an annual Coordinating Committee meeting remotely. In spite of those constraints, we have continued to work with our partners to conduct research, advise and train graduate students, teach graduate level courses, and otherwise continue to operate as best as possible. Federal funding for the Cooperative Research Units Program remains strong, and the Minnesota Cooperative Fish and Wildlife Research Unit gained a scientist with the addition of Dr. Lynn Waterhouse, Assistant Leader – Fisheries, who joined our Unit in July 2021. Dr. Waterhouse has worked under the constraints of a Covid pandemic to get her research and teaching programs up and running, and to develop working relationships with our partners—a difficult accomplishment under normal conditions.

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 postdoctoral researchers; 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 collaborate to address issues of mutual interest.

Dr. David E. Andersen
Leader

Dr. David C. Fulton
Assistant Leader - Wildlife

Dr. Lynn Waterhouse
Assistant Leader – Fisheries

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Dr. Lynn Waterhouse, Assistant Leader – Fisheries

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Maddie Stevens, M.S. (Fulton)

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Unit Affiliated Staff and Students

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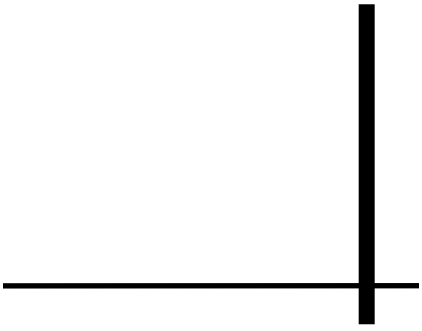
Toni Sleugh, Scripps Institution of Oceanography

Max Titcomb, Scripps Institution of Oceanography



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Dr. Gretchen Hansen (University of Minnesota)
Dr. Scott Heppell (Oregon State University)
Dr. John M. Hoenig (Virginia Institute of Marine Sciences)
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Dr. Rachel Walls (Reef Environmental Education Foundation)
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Cooperating University of Minnesota Academic Units

Cedar Creek Ecosystem Science Reserve
College of Food, Agricultural and Natural Resource Sciences
College of Veterinary Medicine
Conservation Sciences Graduate Program
Department of Fisheries, Wildlife, and Conservation Biology
Minnesota Aquatic Invasive Research Center
University of Minnesota Graduate School
Water Resource Science Program

Cooperating Organizations

Beartooth Wildlife Research, LLC
Cayman Islands Department of the Environment
Environmental and Natural Resources Trust Fund as recommended by the
    Legislative-Citizen Commission on Minnesota Resources
Fisheries and Oceans Canada
Minnesota Department of Natural Resources
Minnesota Sea Grant
Institute of Marine Research, Norway
International Commission for the Conservation of Atlantic Tunas
John G. Shedd Aquarium
Kansas State University
Oregon State University
Reef Environmental Education Foundation
University of California San Diego
    Scripps Institution of Oceanography
U.S. Fish and Wildlife Service
U.S. Geological Survey
    Fort Collins Science Center
    Midwest/Midcontinent Climate Adaptation Science Center
    Water Resources Research Act Program FY 22 104g Aquatic Invasive Species Grant (AIS)
U.S. National Park Service
    Midwest Region
Virginia Institute of Marine Sciences at the College of William and Mary

Completed Research

Applied Ecology

Red-headed Woodpeckers: Indicators of Oak Savanna Health

Investigator: David E. Andersen

Postdoc: Elena West

Duration: July 2019 to June 2021

Funding Source: Environmental and Natural Resources Trust Fund as recommended by the Legislative-Citizen Commission on Minnesota Resources

Project Location: Minnesota Cooperative Fish and Wildlife Research Unit

Red-headed woodpeckers (*Melanerpes erythrocephalus*) are a flagship species of oak savanna ecosystems and play a crucial role in maintaining healthy oak savanna by creating habitat for other species in live and dead trees. Red-headed woodpeckers are considered ecosystem engineers and a keystone species, and their presence may have far-reaching effects on species richness and ecosystem health. Historically, red-headed woodpeckers were common across the Midwest, but populations have experienced dramatic regional declines estimated at 67% since 1970. The situation in Minnesota is even grimmer: since 1967, this species has experienced an average annual decline of 6%, representing a cumulative loss of nearly 95% of the population. Although the rate at which red-headed woodpeckers are declining has slowed since 1990, populations in Minnesota do not appear to have stabilized.

Fragmented patches of oak savanna exist across Minnesota, and there is considerable interest and effort from public and private land managers to preserve and restore this rare ecosystem. Efforts to support red-headed woodpeckers and other oak savanna specialists through habitat restoration are ongoing at a number of sites, but these initiatives have been challenged by a general lack of information on the factors that make savannas desirable for red-headed woodpeckers. Fortunately, red-headed woodpeckers occur in relatively stable numbers (>100 breeding adults annually) at the Cedar Creek Ecosystem Science Reserve (hereafter “Cedar Creek”) despite dramatic declines in surrounding areas. Since 2008, a citizen-driven initiative of the Audubon Chapter of Minneapolis has been monitoring this species at Cedar Creek, and has generated some basic information on population size and nest cavity use. In 2017, a formal research collaboration was established with partners at the University of Minnesota and the University of Toledo in Ohio to address key information gaps about red-headed woodpecker ecology, with a particular

emphasis on identifying the aspects of oak savannas that support nest success, survival, and migration patterns. Our goals are to address population declines in a charismatic species of great conservation concern, to assess the outcomes of ongoing management and conservation efforts in an endangered ecosystem, and to develop a unified management plan for restoring oak savanna for red-headed woodpeckers and other oak habitat specialist species in Minnesota and throughout the Midwest.

Our specific goals are to:

1. Identify oak savanna characteristics and adult condition and behaviors associated with successful production of young, the factors related to whether and where individuals migrate, and the consequences of migratory status on productivity and survival.
2. Develop a long-term management plan for restoring oak savanna to support red-headed woodpeckers and other oak-savanna specialists in Minnesota and the Midwest.

Summary of findings

Our results indicate that red-headed woodpecker productivity is higher in landscapes with both open and closed-canopy forest and that even in large stands of oak savanna, productivity near the center of those stands is predicted to be lower than in savanna closer to other forest types. GPS tracking data show detailed information on the migratory and overwintering locations and behaviors of adult red-headed woodpeckers, which, to our knowledge is the first reported data of its kind for this species in Minnesota. Our results provide information on snag density around nest trees, the importance of nest tree wood hardness, and habitat use by adult and fledgling woodpeckers. We also gained considerable information on the community of predators that may affect red-headed woodpecker nest survival through our trail camera project, now hosted on Zooniverse. We have engaged with thousands of volunteers from around the world to share more about our research through our cavity camera project. Our best management practices are based on current results and we intend to update our recommendations in consultation with collaborators and other experts.

Results Summary:

Migratory movements and winter habitat use

Following recapture of GPS-tagged individuals during each subsequent breeding season from 2018 – 2021, we downloaded and analyzed GPS data using the software provided from the manufacturer. We recaptured 41 adult woodpeckers marked with GPS tags during each subsequent breeding season (n = 9 marked in 2017, n = 8 marked in 2018, n = 15 marked in 2019, n = 9 marked in 2020). Of this total, 12 birds were missing their devices and two devices were damaged such that data could not be extracted from them. Due to substantially shorter battery life than expected in these newly developed tags, only 3 tags lasted through the full programmed schedule and 11 tags stopped collecting data between October and March after deployment.

Of the 25 GPS tags recovered with enough data to estimate non-breeding season movement patterns, nine included data indicating that migration had occurred during the prior year (n = 1 in 2018, n = 8 in 2020). GPS data for the remaining 16 individuals (n = 3 in 2017, n = 2 in 2018, n = 11 in 2019) indicated that these birds remained on the study site for the duration of the breeding season and wintering season. Locations from the nine birds that migrated indicated that those individuals departed the breeding site (Cedar Creek) during the first three weeks of September and arrived at their respective wintering sites nine to 29 days after departure. Location data for birds that migrated indicated that all individuals departed from the breeding site to the southeast, towards the Mississippi River. One bird moved approximately 51 km to the northwest after an initial movement away from the breeding site to the southeast. From there, this individual traveled approximately 101 km north before making migratory movements to the southeast again, ultimately overwintering in Indiana. The distance traveled between 3-day locations varied by individual, with the longest averaging 288 km and the shortest averaging 166 km between locations. The distance between locations ranged from 5 km to

720 km. Woodpecker locations during migration spanned five states (Iowa, Kansas, Missouri, Wisconsin, and Illinois). Sites occupied during migration were primarily hardwood forest patches within landscapes dominated by agricultural fields (*n* = 53 locations, 98%) with the single remaining location in oak barrens (*n* = 1, 2%). Sites occupied during winter were small (mean = 2.1 ha, range = 0.08 – 12 ha) and were located primarily in hardwood forest patches surrounded by agriculture. Data from two birds indicated that spring migration movements took place over approximately 3 and 7 days (small sample size of spring migration data was due to battery failure on the majority of the GPS tags on birds that migrated), with both birds arriving at Cedar Creek by 3 May. The average distance traveled between 3-day locations by these birds during spring migration was 313 and 664 km.

GPS data indicated that sedentary (non-migratory) birds were located primarily in oak savanna that overlapped the areas used during the breeding season. Sedentary individuals remained near their previous year's nest tree (mean = 44 m, range = 21 – 109 m; males = 31 m, females = 57 m) and close to nest trees used the following year if they differed from the previous year's nest tree (mean = 45 m; males = 35 m, females = 48 m). Sites used by sedentary individuals were small (mean = 0.67 ha; males = 0.43 ha, females = 0.92 ha). Six individuals made one-time movements (i.e., a single location recorded away from the winter site with locations prior to and after these movements on the wintering site). These movements often occurred in September – October or March – April. One individual made five one-time movements ranging from 0.3 km – 2.2 km to oak savanna or hardwood forest patches.

Breeding season home-range size and habitat use

We obtained an average of 40 tracking locations per individual adult woodpecker (range: 19–57). Adult woodpecker home-range size during the breeding season was small, with individuals generally occupying the area around their nest trees (mean = 0.02 km^2 based on the 95% UD, range: = 0.0031 – 0.05 km^2), primarily in oak savanna and hardwood forest. Nests located in hardwood forests were generally near forest edges and open grasslands. To explore patterns in adult home-range size, we tested nine model combinations that included live- and dead-tree density within each bird's home range, sex, age, and total years an individual spent on the same territory. Our top-performing model indicated that snag density was an important predictor of home-range size in red-headed woodpeckers. Our results also show a strong positive relationship between home-range size and distance to individual bird's nearest neighbor.

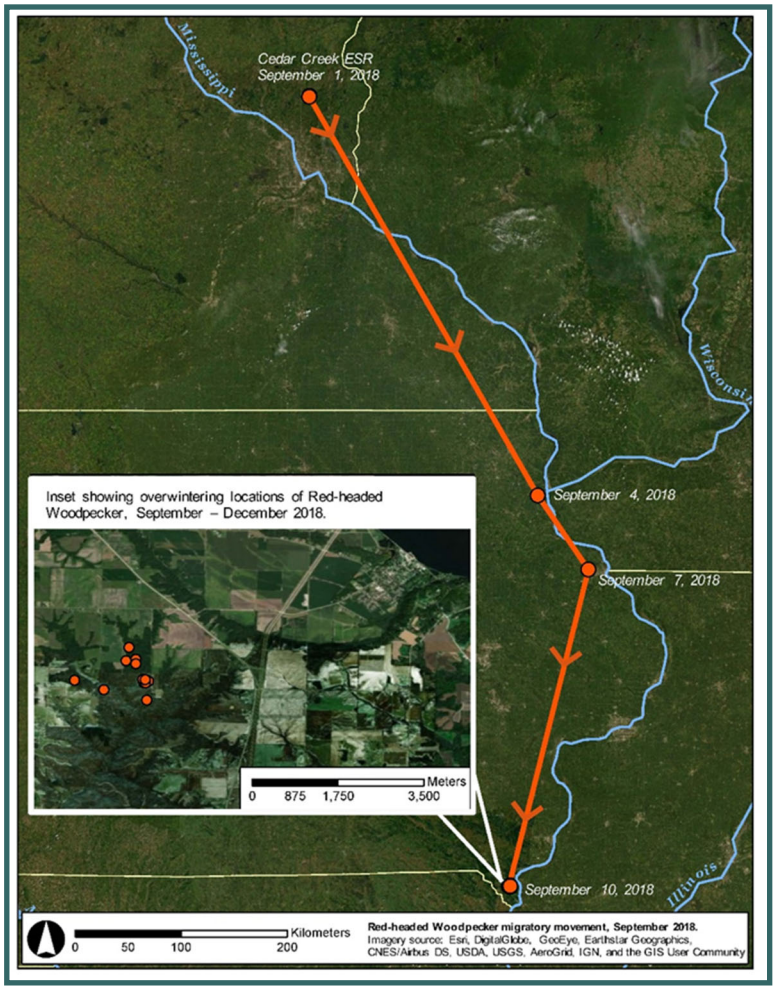
Nest and fledgling survival

We observed nest failure at 37 of 135 nests with known fates, yielding an apparent nest success rate of 0.72 (*n* = 98 nests that fledged ≥ 1 young). Although we were not able to confidently determine the cause of failure for most nests, we documented probable occurrences of nest predation by small mammals, including raccoons (*Procyon lotor*), flying squirrels (*Glaucomys sabrinus*), and bull snakes (*Pituophis catenifer*), and multiple occasions of nest eviction by flying squirrels. Mean clutch size was 4.4 eggs (SD = 1.06, SEM = 0.1). Of the 98 nests that fledged young, the average age from nest initiation to the first fledge event was 44.7 days (SD = 3.49, SEM = 0.35). The median nest initiation date was 21 May, and 75% of nests were initiated between 1 May and 27 June. Our top model of nest survival included live tree count within 10 m of nest trees, canopy closure, maximum temperature anomalies, and year. Tree count and year showed a strong effect on nest survival whereas canopy closure and temperature anomalies showed a weak positive relationship with nest survival.

We estimated a mean of 2.1 fledglings produced per successful nest, and 70% of those fledglings survived to independence from adult care. Overall, mortality of fledglings was due to predation (86%) and exposure (14%). Daily survival rates were lowest in the first five days post-fledging at ~0.98 and increased to >0.99 at 12 days after fledging, well within the parental dependent phase, with no mortalities observed past 50 days.

Nest site selection

The majority of red-headed woodpecker nests (81%) occurred in northern pin oak (*Quercus ellipsoidalis*) trees and 77% of nests were located in dead trees. Woodpeckers nested at sites with a mean of 2 ± 1 snags within 10 m of the nest tree (range = 0 – 8 snags), and the average nest tree had a DBH of 35 cm (range = 25 – 76 cm). Mean nest cavity orientation was 83.4 degrees, and a Rayleigh test of uniformity indicated cavity orientation was randomly distributed (R = 0.05, p = 0.75). Our resource selection model showed significant positive selection for habitat patches with more dead trees and no effect of live trees (within a 10-m radius of each nest tree) on the relative probability of nest site selection. Finally, torque measurements (wood density measures) were much lower in nest trees (mean = 5.37) compared to available trees (mean = 19.31), indicating that woodpeckers used nest trees with softer interior wood (effect of nest tree = -13.89; 95% CI = -16.60, -11.33).



Autumn 2018 migration trajectory of a red-headed woodpecker captured at the Cedar Creek Ecosystem Science Reserve (Anoka and Isanti counties), in Minnesota.

Landscape productivity

In general, full-season productivity in red-headed woodpeckers was positively associated with areas that contained both savanna and closed canopy forest types adjacent to one another but was negatively associated with larger areas (>50 ha) of only savanna. Even in large stands of oak savanna, with which woodpecker abundance was positively associated, productivity near the center of those stands was predicted to be lower than in savanna closer to other forest types. There was a positive association between full-season productivity and the area of the landscape that was water, which included shrubby and grassy wetlands, ephemeral wetlands, and open water. This relationship was apparently driven by the tendency for high productivity from nests near or in shallow or ephemeral wetlands and should not be misinterpreted as high productivity within areas of open water, where woodpeckers generally do not nest. There was a complicated relationship between full-season productivity and area of grassland, wherein small areas of grassland (i.e., narrow strips or patches of only 1–2 ha) had a positive effect, whereas larger areas of grassland had an increasingly negative effect on productivity. This relationship is likely driven by reduced fledgling survival from nests in snags that were not near live trees, as is the case in lone snags in grasslands away from forest or savanna edges. There was a slightly positive association between full-season productivity and roads, but that relationship should be viewed in the context of the negative effect of roads on abundance and adult survival, indicating that roads likely have an overall negative effect on red-headed woodpecker populations.

Completed Research

Human Dimensions, Management, and Conservation

Assessing Attitudes towards Chronic Wasting Disease

Investigator: David C. Fulton
Student: Kyle Smith, Ph.D. (Conservation Sciences)
Duration: August 2019 to June 2021
Funding Source: Minnesota Department of Natural Resources
Project Location: Minnesota Cooperative Fish and Wildlife Research Unit

The emergence of chronic wasting disease (CWD) in wild deer in Minnesota, and declining deer hunter participation, are topics of concern for the Minnesota Department of Natural Resources (MN DNR). Consequently, greater capacity to conduct studies that support decision making associated with white-tailed deer (*Odocoileus virginianus*) management has been identified as an area of need. This project supported a Ph.D. student position at the University of Minnesota, housed in the Minnesota Cooperative Fish and Wildlife Research Unit to conduct human dimensions studies on CWD, deer hunters, and white-tailed deer management.

Chronic wasting disease is an infectious disease of animals belonging to the family cervidae including deer, elk (*Cervus canadensis*), moose (*Alces alces*) and caribou (*Rangifer tandarus*). Since 2002, CWD has been found in wild deer populations and captive deer farm facilities throughout the Midwestern United States, including Minnesota. The disease is always fatal and represents a significant threat to the long-term health of wild deer populations and the future of deer hunting opportunity where it is found. Identifying effective avenues for disease management is a concern for the MN DNR. Many of the identified solutions for CWD containment, risk management, and elimination require the voluntary participation of statewide deer stakeholders including hunters, landowners, and the general public (Minnesota Chronic Wasting Disease Response Plan, 2019). Consequently, understanding the concerns of these stakeholders and the factors that influence the likelihood of participation in behaviors that support disease management will better equip the MN DNR with the knowledge needed to succeed in containing the threat of CWD. Moreover, providing avenues for diverse stakeholders to voice their concerns about the disease and proposed management activities in a scientifically rigorous way will help to foster dialogue and build trust between the MN DNR and the public; priorities identified in the 2018 Minnesota White-tailed Deer Management Plan.

Over half a million Minnesotans participate in deer hunting annually and generate an estimated $800 million in primary economic impact. Receipts from hunting license sales also support a broad range of wildlife-related activities, including habitat restoration and threatened and endangered species management on state-owned properties. A large proportion of hunting license sales are tied to participation in deer hunting. Therefore, the influence of CWD on hunting license sales and hunting participation is a topic of particular concern, with implications beyond white-tailed deer and deer hunting specifically.

This project supported two specific study efforts including:

1. Statewide Hunter Survey and Survey of the General Public – Conduct a two-strata survey of Minnesota deer hunters' (strata 1) and the general publics' (strata 2) values, beliefs, knowledge, and attitudes toward CWD and CWD management.
2. Lapsed Hunter Survey – Conduct a survey of lapsed deer hunters to determine constraints to participation and effective avenues for hunter reengagement and the potential of CWD to serve as a constraint.

In addition, Kyle Smith successfully defended his PhD thesis in December 2022 using data from this study. He also has developed the following peer-review publications:

Smith, K., S.A. Schroeder, A. C. Landon, L. Cornicelli, L. E. McInenly, D. C. Fulton. 2021. A replication of proximity to chronic wasting disease, perceived risk, and social trust in managing agency between hunters in Minnesota and Illinois, *Human Dimensions of Wildlife,* 26:503-506. DOI: 10.1080/10871209.2020.1860270

Smith, K., A.C. Landon, S.A. Schroeder, and L.E. McInenly. *In Press.* Application of the heuristic-systematic model to chronic wasting disease risk perceptions. *Society & Natural Resources.*

Smith, Kyle, A.C. Landon, **D.C. Fulton**. *In Revision*. The variable influence of autonomous and controlled motivation on identity salience among Minnesota deer hunters. *Leisure Science*.

Smith, K., A. Landon, D.C. Fulton, and G. Kyle. *n Review.* Self-determination theory as an alternate conceptual foundation for motivation in natural resource recreation. *Human Dimensions of Wildlife.*

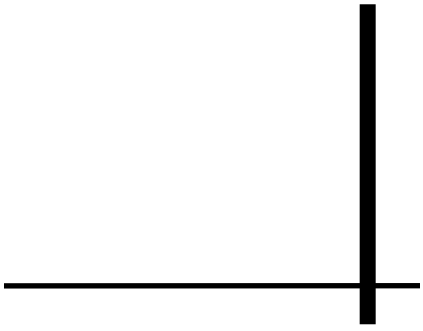
Assessing the Motivations and Constraints of Lapsed Small Game Hunters

Investigator: David C. Fulton
Student: Maddie Stevens, M.S. (Conservation Sciences)
Duration: July 2021 to September 2022
Funding Source: Minnesota Department of Natural Resources
Project Location: Minnesota Cooperative Fish and Wildlife Research Unit

Rates of hunting participation are declining across the United States. This decline has implications for the long-term financial health of state wildlife agencies that principally rely on hunting license revenues to support both game and non-game management activities. Consequently, understanding the factors that shape citizens' patterns of participation in hunting, preferences and interest in hunting, and constraints to long-term engagement is critical for ensuring the current funding model employed by the agencies, fostering citizens' connection to outdoor heritage, and wildlife conservation moreover.

Growing emphasis has been placed on activities to recruit, retain, and re-engage hunters and anglers. However, limited scientific scrutiny has been directed toward these activities. Hunter recruitment and retention activities are enhanced with an understanding of the needs, preferences, and differences of a diverse target population. For instance, constraints to participation in outdoor recreation have been shown to vary as a function of a variety of life- course attributes and socio-demographics including having children, household income, health, age, access to transport and social supports. Understanding the role of these factors, and others, in shaping citizens' patterns of participation in hunting is critical for effective program design and outreach. Lapsed hunters, defined as individuals that have hunted in the past but have since ceased participation, are a demographic of particular interest for outreach efforts given their apparent existing interest in hunting generally. Enticing these individuals to return to hunting by facilitating the needed social, institutional, and economic supports could be an effective strategy for bolstering participation. However, limited scientifically valid knowledge exists regarding the factors that cause hunters to otherwise cease participation, or strategies for alleviating these causes. The objective of this project is to conduct a survey to assess the factors that cause hunters to cease participation in small game hunting including social, economic, and institutional constraints, and their likelihood to return to hunting.

This study was completed in September 2022. Maddie Stevens collected data with direction from Adam Landon (MN DNR) during spring of 2022 and completed analysis and a draft report during the summer of 2022. She will use these data to write one manuscript as part of her MS thesis expected Summer 2023.



Ongoing Research

Applied Ecology

Assessing Size Composition, Biodiversity, and Abundance of Elasmobranchs and Reef Fish in The Bahamas from Stereo Baited Remote Underwater Video Surveys (Stereo BRUVS)

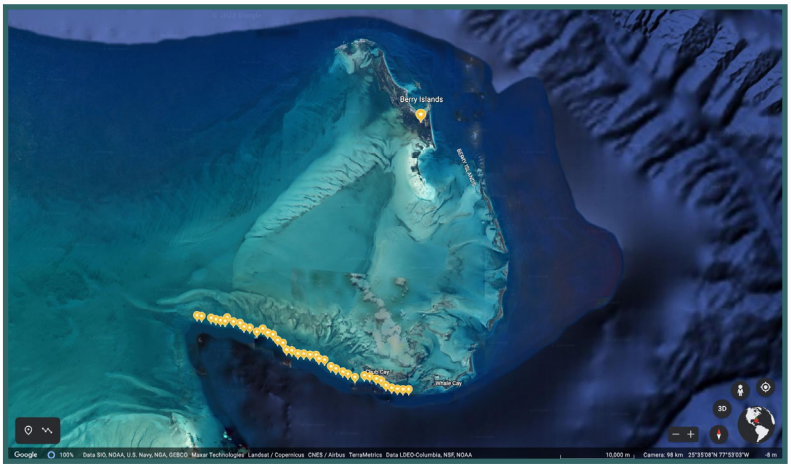
Investigator: Lynn Waterhouse, Steve Kessel (John G. Shedd Aquarium)

Student: Briana Davis, M.S. (Conservation Sciences)

Duration: January 2019 to ongoing

Funding Source: John G. Shedd Aquarium

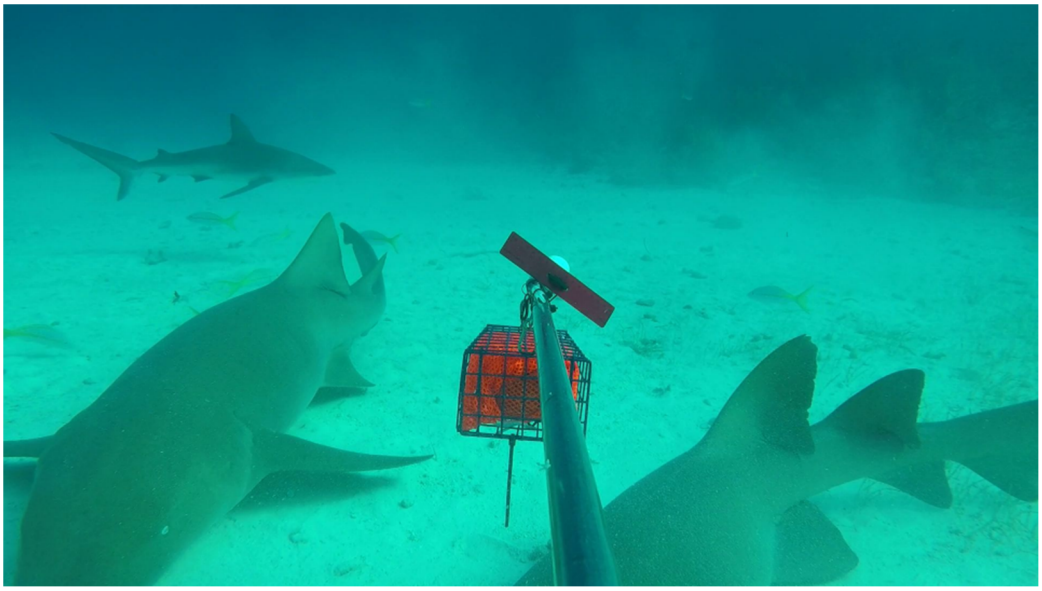
Project Location: The Bahamas



Google map with points marking where BRUVS were deployed of R/V Coral Reef II (John G. Shedd Aquarium) in August of 2019 near Berry Islands, The Bahamas

Shedd Aquarium has for many years worked with stakeholders in The Bahamas to protect marine and island resources. The largest remaining fishery for Nassau grouper (*Epinephelus striatus*) operates in The Bahamas. However, the catch totals have been declining since the 1990s when landings peaked. Nassau grouper reproduce by forming spawning aggregations at specific locations following the winter full moon (November to March). Historically, spawning aggregations were thought to number between 10,000 and 100,000 at a single aggregation. Now, it is rare to see more than 1,000 Nassau grouper at an aggregation in The Bahamas, and many have ceased to form altogether. As a result of the decline in catches and the shrinking populations at the spawning aggregations, The Bahamas has implemented a variety of management protections including: a closed season, minimum size limit, and protection or no-take areas. However, there is evidence that further management actions are needed to ensure the sustainable future of this fishery. A key part of assessing the sustainability of a fishery is a statistical stock assessment. Other species of grouper and snapper also face heavy levels of harvest and declining catch levels. Using Stereo Baited Remote Underwater Video Surveys (Stereo BRUVS) this study will assess the Nassau grouper assemblages occurring in Bahamian waters. This study will also work on assessing other elasmobranch and reef fish species (particularly grouper and snapper species) that are of interest to The Bahamas. The data produced will have relevance for various fisheries management plans and conservation in The Bahamas. Specifically, the length composition data will be used to highlight any critical habitats for life stages that are particularly vulnerable (i.e., spawning grounds or nursery

grounds). This work builds upon that of Dr. Kristine Stump, a prior postdoctoral researcher at Shedd Aquarium, and Dr. Krista Sherman, now with Perry Institute for Marine Sciences. All data will also be contributing to the larger Global FinPrint project, which focuses on assessing global shark populations and highlighting areas of concern.



Still image from BRUVS deployed off Berry Islands, The Bahamas in August 2019 off R/V Coral Reef II (John G. Shedd Aquarium). BRUV bait arm with bait in neon orange mesh bag inside cage in forefront of image, with 3 sharks shown (2 nurse sharks and 1 reef shark).

Evaluating the American Woodcock Diet Paradox in the Northern Breeding Range

Investigator: David E. Andersen, Dan Sullins (Kansas State University)

Student: None

Duration: June 2021 to July 2025

Funding Source: Kansas State University and Minnesota Cooperative Fish and Wildlife Research Unit

Project Location: Minnesota

Photo credit: Roger Stonebraker

American woodcock (*Scolopax minor*) are thought to feed primarily on earthworms with some estimates of earthworms exceeding 85% of their diet. Such a specialized diet on earthworms may not have always been the case as most earthworms in the northern portion of woodcock breeding distribution are invasive species from Europe and there are no known native earthworm species in the northern extent of the American woodcock breeding distribution. The paradox that American woodcock currently feed mostly on earthworms, yet nest and reproduce in areas where no known native earthworms were historically available as a food source, can now be efficiently examined with advanced DNA approaches. Recent advances in DNA methodologies allow for rapid assessment of diet contents, which are identified based on DNA barcodes in fecal material. In the past, diet study methods relied solely on identifying partially consumed foods, which can be effective but is time-intensive and challenging for soft-bodied prey items (e.g., earthworms) that are rapidly digested. We plan to use DNA metabarcoding of woodcock fecal material collected in locations invaded and not yet invaded by European earthworms to gain insight on woodcock diets pre-earthworm invasion. Although we generally expect introduced earthworms to benefit woodcock as an important food resource, further research is warranted as earthworms and other soil invertebrates can vary in nutrient quality, availability during critical periods for woodcock, and can alter forest cover as ecosystem engineers.

Project status: We solicited volunteers to help us collect American woodcock fecal samples in northeastern Minnesota during the autumn hunting season in 2021. Based on difficulties obtaining fecal samples from hunter-shot woodcock, we revised our protocol to ask volunteers to collect fresh fecal samples from the ground in the immediate vicinity of where shot woodcock were first located. We also encountered earthworms (based both on evidence of earthworm activity and in some cases, earthworms partially ingested by shot woodcock) in many of the locations we sampled. In 2022, we solicited partici-

pation of woodcock banders throughout Minnesota, who collected fecal samples from broods captured as part of banding activities during the spring. The summer and early autumn of 2022 were unusually dry, likely causing earthworms to estivate, making them unavailable to woodcock in many locations. We sampled (via hunter-shot woodcock) again in the autumn of 2022 in central and east-central Minnesota, but early winter weather (cold temperatures and snow cover) precluded sampling from northeastern Minnesota. Samples from 2021 have been analyzed via DNA metabarcoding, and samples from 2022 are awaiting DNA analysis.

Grouper Moon Project in the Cayman Islands

Investigator:	Lynn Waterhouse, Dr. Christy V. Pattengill-Semmens (Reef Environmental Education Foundation), Dr. Brice Semmens (Scripps Institution of Oceanography, University of California San Diego), Dr. Croy McCoy (Cayman Islands Department of the Environment), Dr. Scott Heppell (Oregon State University), Dr. Brian Stock (Institute of Marine Research, Norway)
Students:	Students from Oregon State University (Janelle Layton) and Scripps Institution of Oceanography (Toni Sleugh and Max Titcomb)
Duration:	January 2002 to ongoing
Funding Source:	Reef Environmental Education Foundation (REEF) and Cayman Islands Department of the Environment (CIDOE)
Project Location:	Cayman Islands

The Grouper Moon Project is a collaboration between the Reef Environmental Education Foundation (REEF) and the Cayman Islands Department of Environment (CIDOE) along with multiple governmental and university partners. The project started in 2001, when a spawning aggregation of Nassau grouper (*Epinephelus striatus*) were rediscovered by fishermen on the west end of Little Cayman Island. Following two years of intense fishing the spawning aggregation had dwindled from approximately 8,000 fish to perhaps 2,000 fish. The Cayman Island government intervened with management regulations, and the Grouper Moon Project began working to provide scientific evidence that the management regulations were protecting the Nassau grouper population, with the ultimate goal of recovery.

Original study questions included:

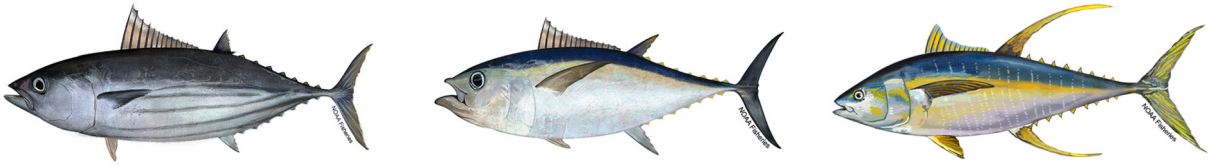
1. How many fish are there?
2. Are all the fish from the Cayman islands?
3. Where do the fish go during non-spawning times?

Since the inception of the project the study has expanded to include work with tiger grouper (*Mycteroperca tigris*), yellowfin grouper, (*Mycteroperca venenosa*), and black grouper (*Mycteroperca bonaci*).

Research methods employed annually include: collecting lengths *in situ*; mark recapture surveys for population estimation; video pan surveys; and egg collections for genetics. Recent work has also focused on: tracking egg and larvae movement following spawning; using passive and active acoustics to study the spawning aggregation; monitoring movement with acoustic tags; and evaluating fertilization rates. Current projects include: evaluating if environmental DNA techniques can be used to locate spawning aggregations; using facial recognition for mark recapture of Nassau grouper; looking at climate impacts of egg and larvae survival; and conducting surveys for juveniles. Field work takes place every year following the full moon in January or February.

Growth Studies of Atlantic Ocean Tropical Tunas: Skipjack, Bigeye, and Yellowfin Tuna

Investigator: Lynn Waterhouse, John M. Hoenig (Virginia Institute of Marine Sciences)
Students: none
Duration: May 2020 to ongoing
Funding Source: Atlantic Ocean Tuna Tagging Program, International Commission for the Conservation of Atlantic Tunas
Project Location: Virginia Institute of Marine Sciences at The College of William and Mary



Pictured: skipjack, bigeye, and yellowfin tuna. Photo credit: NOAA Images

This contract work specifically deals with estimating growth curves for three tropical tuna species: skipjack (*Katsuwonus pelamis*), bigeye (*Thunnus obesus*), and yellowfin tuna (*Thunnus albacares)* in the Atlantic Ocean using tagging data and hard part data collected by the Atlantic Ocean Tuna Tagging Program (AOTTP). This builds on the work of Dr. Lisa Ailloud, which used a systematic approach to examine tagging, hard part and length-frequency data for bluefin tuna (*Thunnus thynnus*) and an integrated modeling approach to estimate model parameters. The work builds on the approach of Ailloud by considering comparison of results from different hard parts and different readers, tackling the question of age validation for hard parts, examining the question of one- stage versus two-stage growth models for yellowfin tuna, proposing a way to deal with the uncertainty in asymptotic size for bigeye tuna and examining spatial variability in growth of skipjack. The original plan was to host workshops in multiple member countries of the AOTTP project; however, due to covid it was changed to uploading teaching materials online. The work slightly pivoted to focus on developing two new methods for taking spine data where vascularization has possibly obscured some rings and estimating the number of missing rings to provide accurate age estimates for use in growth models. Both new models perform better than previously proposed methods. As spine data are often easier to obtain than otolith data, these methods could become more widely used. The bigeye tuna growth paper is currently in review in *Fisheries Research*. It was determined that there was not enough data on skipjack to estimate a growth curve (largely due to the inability to utilize hard part data due to discoveries by other researchers in the AOTTP project). The yellowfin tuna growth project is ongoing and includes a vast amount of external data.

Status: Wrapping up final manuscripts from project. One paper has already been published in the special issue of *Fisheries Research* and another is in revision. An additional theoretical paper is in preliminary stages and the paper focusing on growth assessment for yellowfin tuna is in the data collection and preliminary exploration phase. Work will result in 3-4 papers including two on methodology developments for aging fish using spines.

Investigating Drivers of Cisco Recruitment in Lake Superior

Investigator: Lynn Waterhouse, Gretchen Hansen (University of Minnesota)
Student: Olivia Nyffeler, M.S. (Conservation Sciences)
Duration: February 2022 to January 2024
Funding Source: Minnesota Sea Grant
Project Location: Minnesota Cooperative Fish and Wildlife Research Unit

The Great Lakes featured high abundances of cisco (*Coregonus artedi*) until the mid-1900s when their stocks collapsed. Since that time, the stocks have rebounded in Lake Superior, although they once again appear to be in decline. The original decline in the mid-1900s was attributed to a variety of anthropogenic factors including overfishing, pollution, and introduced species. Even when stocks were abundant, it was noted that large spawning stocks did not necessarily lead to large recruitment classes and, similarly, small spawning stocks could sometimes result in large recruitment classes. Factors quantitatively linked to recruitment have been evaluated previously using Ricker stock recruitment models.

MS student Olivia Nyffeler working on Cisco project, on the deck of R/V Kiyi in Lake Superior while going between sampling points between Duluth, MN and the Apostle Islands, summer 2022

We propose using three quantitative methods to investigate the relationship of biotic and abiotic factors with cisco recruitment, including:

1. Multivariate Auto-Regressive State Space Models
2. Empirical Dynamic Models
3. Bayesian Spatial Delta-glmm models.

Particular note will be given to any factors that multiple methods identify as being important. These methods can be applied to other stocks or in other locations. Building on hypotheses established by prior researchers, we will be looking at climatic and temperature variables, indices of predators, indices of competitors, indices of spawners, and measures of habitat quality.

Results will be shared through an outreach plan that includes numerous meetings with stakeholders, presentations at professional societies, peer-reviewed publications, and quantitative workshops focused on teaching the three methods we will be applying.

Minnesota Trumpeter Swan Migration Ecology and Conservation

Investigator: David E. Andersen, John Fieberg (University of Minnesota)

Student: David Wolfson, Ph.D. (Conservation Sciences)

Duration: July 2019 to June 2024

Funding Source: Environmental and Natural Resources Trust Fund as recommended by the Legislative-Citizen Commission on Minnesota Resources

Project Location: Minnesota Cooperative Fish and Wildlife Research Unit

Trumpeter swans (*Cygnus buccinator*) have high intrinsic and economic value in Minnesota as a protected wildlife species. Minnesota citizens enthusiastically invested in the restoration of trumpeter swans through the check-off donation and other funding sources to the Minnesota Department of Natural Resources (MN DNR) Nongame Program since the mid-1980s. The Interior Population of trumpeter swans (of which Minnesota swans comprise ~63%) has increased dramatically since they were re-established in the 1960s and 1970s and both population size and distribution have expanded significantly in Minnesota since the MN DNR Alaska-egg project began in 1986. The original Minnesota reintroduction goal of 15 breeding pairs and the revised interim goal of 500 individuals by 2001 have been greatly exceeded, with a current estimate of nearly 30,000 swans (an average annual finite rate of increase of ~1.20 since 2000). Better understanding of trumpeter swan ecology will be useful in developing future management strategies for this growing population.

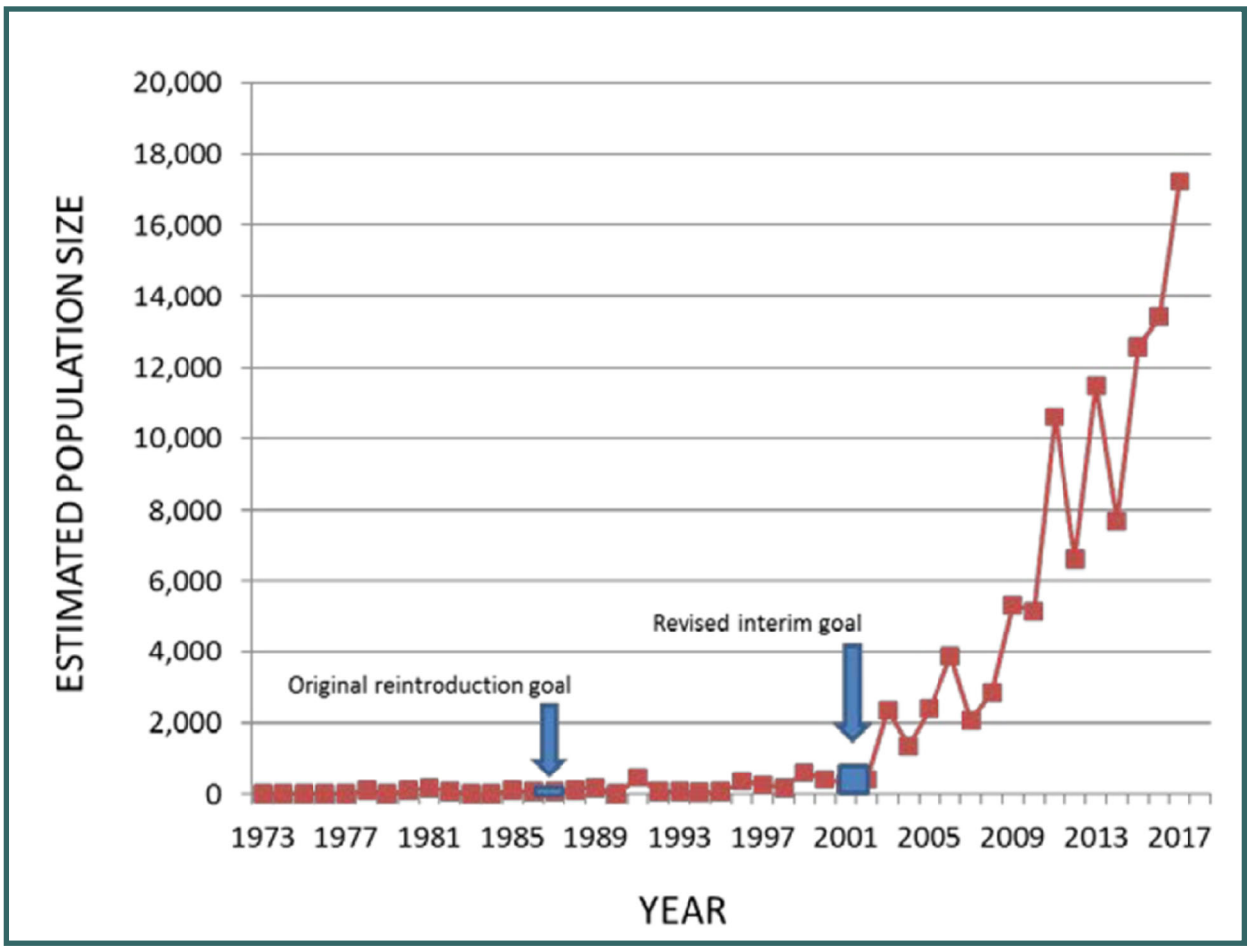
In Minnesota, trumpeter swans currently breed throughout most of the state, but beyond recent estimates of population size and trend and distribution, relatively little is known about their ecology, hindering conservation decision-making. To address current information needs, we marked a sample of Interior Population trumpeter swans in Minnesota (and in Iowa, Manitoba, Wisconsin, Michigan, and Ohio with project collaborators) with GPS-GSM transmitters. These transmitters record high-resolution, high frequency location and related data and transmit those data through cellular phone networks, and will allow us to:

1. Evaluate year-round swan movements, including determining what proportion of trumpeter swans winter outside of the state,

the locations where swans spend the winter, and the timing and duration of their movements.
2. Determine whether and where trumpeter swans make molt migrations.
3. Evaluate year-round habitat use and selection patterns of trumpeter swans.
4. Estimate annual survival rates of trumpeter swans, if sample sizes are adequate and fates (i.e., mortality events) can be determined.

Results of this study will inform current and future trumpeter swan conservation in Minnesota and the Interior Population of trumpeter swans more generally by providing basic information about migration, year-round movements, mortality risks, and use of agricultural landscapes. Data from the project are archived with Movebank (https://www.movebank.org/) and made available to the public via a website (https://trumpeterswan.netlify.app/index.html) that summarizes trumpeter swan movements and habitat use. Thus, the project will also offer the opportunity to actively engage and inform Minnesota citizens about how their past investment in conservation made a positive difference to Minnesota's natural heritage today.

Minnesota trumpeter swan population size estimated from waterfowl surveys conducted over approximately 39% of the area of the state (MN DNR, unpublished data). The trumpeter swan population in Minnesota has increased substantially, dramatically exceeding original and interim population goals, and is currently growing at an annual rate of ~1.20.



Using Horizon Mapping and Species Distribution Models to Predict Invasions, Resiliency, and Impacts of Climate Change to Aquatic Invasive Species

Investigator:	Lynn Waterhouse, Nick Phelps (University of Minnesota), Wesley Daniels (USGS), Ryan Burner (USGS), Richard Erickson (USGS)
Student:	Charlie Faude, M.S. (Water Resource Science Program)
Duration:	December 2022 to December 2025
Funding Source:	USGS Water Resources Research Act Program FY 22 104g Aquatic Invasive Species Grant (AIS)
Project Location:	Minnesota Cooperative Fish and Wildlife Research Unit

Species distribution models (SDM) are commonly used for modeling presence-only data using environmental covariates. We propose to use historical data on native ranges of aquatic species to train our machine learning SDMs. We propose to fit a commonly used machine learning SDM, boosted regression trees, to predict species occurrences based on input covariates. All analyses will be done using the freely available statistical software R. Boosted regression trees (BRT) have been shown to perform better than other machine learning SDM with presence-only data. The relative importance of each characteristic can be computed after the BRT is fit, meaning that this method combines the interpretability of conventional SDMs with the increased flexibility and predictive power of machine learning. We plan to use this modeling framework to focus on aquatic invasive species within the Upper Mississippi River Basin.

Waterbodies in the Upper Mississippi River Basin are at high risk of invasion by several aquatic invasive species (AIS), with often devastating ecological impacts to water quality and economic consequences for water-related infrastructure and management. Yet understanding which sites are most prone to invasion, and by which species, is lacking, making it difficult for managers and policy makers to know where to focus prevention and mitigation efforts. Some waterbodies in the region have proved resistant to forecasted invasion, and these situations may provide clues as to the conditions and processes producing this apparent resistance. If patterns can be revealed, this would allow managers to more accurately predict invasion risk throughout the region and thus to triage sites for prevention and mitigation efforts. Additionally, such knowledge may allow managers to develop and apply strategies that promote resistance to invasion in other waterbodies. We will use a combination of machine learning and statistical modeling to leverage region-wide waterbody invasion histories and datasets on the physical, biological, chemical, anthropogenic, and geographic characteristics of these waterbodies to: a) identify increase or decrease invasion risk, b) categorize all waterbodies in the region based on their invasion risk, and c) provide a decision support tools for managers and policy makers to identify at-risk sites.

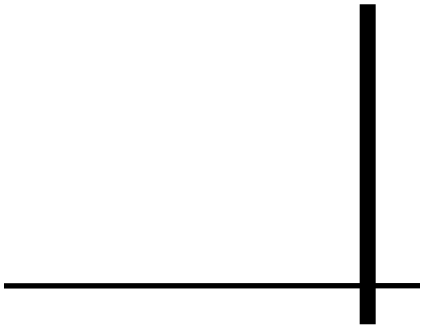
This project will result in three useful tools for managers focusing on endangered or threatened aquatic species. The first would be a list ranking the potential for future invasion by the aquatic invasive species selected by the advisory panel. The second tool would be a map showing water bodies that are predicted to experience invasions

and a list of the more resilient water bodies. The third tool would be a ranking of the most influential factors on individual species distributions. We will work with managers and policy makers in a series of workshops so they understand how to use and interpret the resulting tools. Together these tools should help managers better assess the risk of aquatic invasive species under future climate scenarios, identify key locations for preventative measures or additional monitoring, and highlight abiotic or biotic factors that can potentially be mitigated or restored (e.g., flow rates or dominant vegetation).

Using Roving Diver Citizen Science Surveys to Derive Abundance Estimates of Turtles in Tropical Locations

Investigator:	Lynn Waterhouse, Dr. Brice Semmens (Scripps Institution of Oceanography, University of California San Diego), Dr. Dan Greenberg (Fisheries and Oceans Canada), Dr. Christy Pattengill-Semmens (Reef Environmental Education Foundation), Dr. Rachel Walls (postdoctoral fellow with Reef Environmental Education Foundation)
Students:	none
Duration:	May 2022 to December 2024
Funding Source:	Reef Environmental Education Foundation (REEF)
Project Location:	Reef Environmental Education Foundation (REEF)

The Reef Environmental Education Foundation (REEF) collects citizen science surveys for a variety of marine species. REEF facilitates programs that actively engage divers, snorkelers, and other marine enthusiasts in marine conservation. This is primarily accomplished through the Volunteer Fish Survey Project. Since its launch in 1993, this citizen science program has generated one of the largest marine life databases in the world. In 2020, the database surpassed 250,000 surveys conducted at almost 15,000 sites throughout the world's oceans by over 16,000 volunteer divers and snorkelers worldwide. Anyone, anywhere, can participate in the Volunteer Fish Survey Project. REEF volunteers use the Roving Diver Technique (RDT), a visual survey method specifically designed for volunteer data. The only materials needed are an underwater slate and pencil, a good reference book, and access to the internet to submit the data online. The data are collated using a log scale for abundance where things are single (*n*=1), few (*n*=2-10), many (*n*=11-100), and abundant (*n*=101+). Recently Dr. Dan Greenberg developed a Bayesian model, which can create area- and species- specific abundance estimates through time based on REEF RDT surveys. The abundance estimates have been used for species that are data-limited (e.g., goliath grouper [*Epinephelus itajara*] in the southeastern U.S.) and have been compared to scientific abundance estimates (e.g., coral reef fishes in Florida). This project seeks to build estimates of abundance for a variety of turtles species (green turtles [*Chelonia mydas*], loggerhead turtles [*Caretta caretta*], and hawksbill turtles [*Eretmochelys imbricate*]) in multiple locations (Hawaii, Tropical Atlantic, and the Tropical Eastern Pacific). We hope to collaborate with scientists from NOAA to compare the abundance indices derived from REEF data to other indices and indicators of turtle populations. We anticipate this project to result in multiple publications.



Ongoing Research

Human Dimensions, Management, and Conservation

Assessing Deer Hunter Satisfaction and Attitudes toward Deer Management, and Minnesotans' Values, Beliefs, and Attitudes toward Moose and Moose Management

Investigator: David C. Fulton

Student: Kyle Smith, Ph.D. (Conservation Sciences)

Duration: July 2021 to June 2023

Funding Source: Minnesota Department of Natural Resources

Project Location: Minnesota Cooperative Fish and Wildlife Research Unit

This project supports two related studies on deer and moose (*Alces alces*) management.

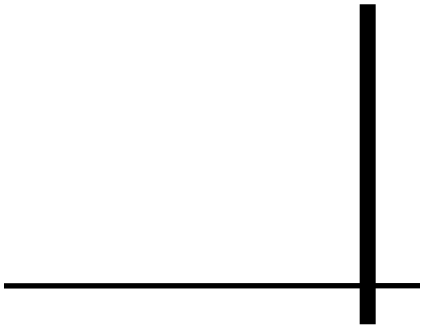
Deer hunter attitudes and satisfaction survey– This phase of the study is nearing completion. Data were collected and analyzed during the winter/spring of 2022. A draft final report has been authored by Kyle Smith and is under review. The Minnesota Deer Management Plan makes provisions for periodic assessment of hunters' satisfaction with aspects of their deer hunting experience, and their trust in the Minnesota Department of Natural Resources (MN DNR) deer management. Periodic measurement of these variables equips the agency with knowledge about constituents' experience with deer hunting and enhances their ability to make deer management decisions that improve constituents' experience while meeting deer management goals. Importantly, assessing deer hunters' satisfaction, and making decisions based in part on that knowledge, helps build trust, which is identified as a goal in the plan.

This study supports the goals articulated in the plan. The objective of the study is to conduct a survey of Minnesota deer hunters to understand the factors that affect their satisfaction with deer hunting, and their attitudes toward deer management.

Survey of moose stakeholder—An expert elicitation is being completed by Kyle Smith and Adam Landon during summer 2022. Findings from this effort will be used to develop a broader survey instrument to be administered in 2023. Minnesotans value moose for a variety of reasons, and understanding those values is an important part of the MN DNR's articulated vision for moose management. The 2011 Minnesota Moose Management Plan establishes an objective of integrating social science into moose management decisions. One strategy identified under this objective is to undertake an assessment of Minnesota moose stakeholders' values, beliefs, attitudes, and behaviors related to moose, moose management, and moose harvest. In this study we will conduct a survey of Minnesotans to support implementation of the 2011 Moose Management Plan and generate data to inform an update to this plan slated to begin in FY22. Specific topics for assessment will emerge from deliberation with MN DNR staff and external partners during survey design.

Potential topics for assessment include Minnesotans' willingness to pay for moose viewing opportunities, perceptions of moose hunting and moose harvest, tradeoffs in moose, wolf (*Canis lupus*), and deer management in moose range, and preferences for the MN DNR's approach to moose management, among others. The objec-

tive of this study is to conduct a survey of Minnesotans to understand their values, beliefs, attitudes, and behaviors about moose and moose management.



Chronic Wasting Disease Targeted Outreach to Engage Culturally Diverse Hunting Communities

Investigator:	David C. Fulton and Tiffany Wolf (Cooperating Faculty, University of Minnesota Veterinary Population Medicine)
Student:	Roger Faust, Ph.D. (Conservation Sciences)
Duration:	July 2020 to June 2023
Funding Source:	Environmental and Natural Resources Trust Fund as recommended by the Legislative-Citizen Committee on Minnesota Resources
Project Location:	University of Minnesota Veterinary Population Medicine & Minnesota Cooperative Fish and Wildlife Research Unit

Chronic wasting disease (CWD) is a 100% fatal, contagious neurological disease of wild and farmed cervids, such as deer (*Odocoileus* spp.), moose (*Alces alces*), elk (*Cervus canadensis*), and other deer species. It is caused by a prion, which is an infectious, misfolded version of a normal protein that is found in all mammals. Since first discovery in Colorado in 1960, CWD has spread to 26 states, including Minnesota. In heavily affected areas like Wyoming, Colorado, and Wisconsin, more than 40% of free-ranging cervids are infected; and managers and researchers have documented CWD-associated population declines in several cervid species, including white-tailed deer (*Odocoileus virginianus*).

Although transmission to humans has never been confirmed, the risks for human infection remain unclear. Thus, the best approach available to protecting wildlife and human health is controlling further spread. The success of Minnesota's efforts to control this disease hinges on the ability of government agencies, researchers, policy makers, and stakeholders to work together, particularly as this issue relates to deer hunting as a CWD management tool. However, in December 2019, our team became aware that culturally diverse hunting communities had not received critical information regarding CWD biology, management, and potential human health risks. Special outreach efforts are needed to reach diverse stakeholders, such as Minnesota Tribal Nations and southeast Asian and Amish communities. Additionally, the Grand Portage Band of Lake Superior Chippewa and our team have secured funding from the U.S. Fish and Wildlife Service to support the creation of a Tribal CWD Surveillance Network. A critical, yet unfunded need is simultaneous community engagement on Tribal Lands leading up to and during CWD surveillance in the 2020 hunting season. Our team has connected with these groups through grassroots efforts and is uniquely poised to engage them on CWD. Our goals for this project are to: 1) engage in culturally appropriate CWD outreach and education, and 2) learn more about community-specific hunting behavior and perceptions of CWD management, with an overall goal of achieving more inclusive, community-based CWD management.

In 2020, we developed a community-based participatory research design with several Native American communities in Minnesota, Wisconsin, and Michigan and Amish and Southeast Asian (Hmong) communities in Minnesota. This approached involved community interviews, focus groups, and surveys administered by members

of the communities. Through community-partner-led interviews conducted and analyzed during 2021 and 2022, we identified information sources, knowledge gaps, and perspectives on CWD. We also found that CWD may threaten hunting and cultural activities, and food security for some communities. Surveys provided further insights on hunting activities, perceptions, and responses to CWD management for each group. Using this information, we worked with our community partners to develop educational materials on CWD that reflect the communities' cultural values and perspectives on risk related to wildlife disease, in addition to better including these communities in CWD management and control. Roger Faust has developed several national and international presentations based on the project and is developing peer-reviewed manuscripts that will be used for his PhD Dissertation.

Diversity and Access to Wildlife Related Opportunities

Investigator:	David C. Fulton
Postdoc:	Alexandrea Safiq
Duration:	July 2022 to June 2025
Funding Source:	Environmental and Natural Resources Trust Fund as recommended by the Legislative-Citizen Commission on Minnesota Resources
Project Location:	Minnesota Cooperative Fish and Wildlife Research Unit

Profound changes with how the American public values and relates to nature and wildlife are occurring. Participation rates in traditional activities associated with fish and wildlife have dropped dramatically, putting into jeopardy the funding mechanisms for fish and wildlife conservation and potentially motivations to sustain these resources. In addition, there is an apparent broader disconnection of the American public to the outdoors and wildlife that could lead to substantive negative effects on human health and well-being, which depend on beneficial contact with nature. In response to this challenge, a variety of programs targeting the recruitment, reactivation, and retention of fish and wildlife-based recreationists have been developed. Because of the fundamental social and demographic changes in America that are driving much of the disconnection with nature and wildlife, however, the success of such programs is very uncertain. There is growing recognition that continuation of the conservation enterprise that oversees stewardship of our fish and wildlife resources will likely require more fundamental changes to broaden opportunities and inclusion for diverse communities.

A fundamental problem and opportunity in this endeavor is how to engage the communities that have not been actively encouraged to participate in nature- and wildlife-based activities. Extremely limited information exists concerning the value of and desire for experiences with nature and wildlife from African-American communities in Minnesota and the barriers that constrain African-Americans from desired experiences with nature and wildlife. This project will collect information from African-American Minnesotans concerning their values, attitudes, experiences, awareness of, and preferences for learning about, experiencing, or conserving nature and wildlife. This information will be collected during a two-year period in two phases. The first year, focus groups and in-depth interviews with members of the communities will be conducted to develop a deep and nuanced understanding of their awareness of and connections to nature and wildlife. In the second phase, more broadly generalizable data will be collected from these communities through multi-modal social surveys using established psychometric approaches for measuring values, beliefs, attitudes, motivations, and experience preferences. This information will serve as foundational information across Minnesota for better engaging and understanding these communities. In addition, the information will assist natural resource management agencies to design programming, experiences, and services that match to the motivations and desired experiences of members of these communities. Doing so could increase their participation in nature- and wildlife-based activities and conservation behaviors.

Genetic Biocontrol of Invasive Species: Understanding Attitudes and Risk Perceptions

Investigator:	David C. Fulton
Student:	Kiley Davan, M.S. (Conservation Sciences)
Duration:	January 2021 to June 2023
Funding Source:	Minnesota Aquatic Invasive Research Center; Environmental and Natural Resources Trust Fund as recommended by the Legislative-Citizen Committee on Minnesota Resources
Project Location:	Minnesota Cooperative Fish and Wildlife Research Unit

A web-based survey will evaluate Minnesotans' attitudes and risk perceptions related to the use of genetic modification techniques for the control of invasive species. Very little is known about public attitudes or risk perceptions concerning the use of genetic modifications for aquatic invasive species control. The purpose of this proposed project is to better describe public understanding and attitudes towards the use of advance genetic modification techniques as control tools for invasive species. To thoroughly address the purpose, this research must investigate attitudes towards these techniques within the context of specifically understanding attitudes toward invasive species and their impacts. Recent research on the human and social dimensions of invasive species provides guidance for the design of the proposed research. Although a robust literature concerning the human and social dimensions of invasive species management and governance has developed, there is limited research specific to the use of genetic techniques to control invasive species. The study proposed here addresses that gap in research.

This study represents a crucial upstream evaluation of public attitudes and perceptions that will enable subsequent engagement to develop governance in the use of genetic technology for these purposes in Minnesota. This project will provide baseline information about Minnesota residents' attitudes and risk perceptions toward genetic modification techniques as an approach for managing aquatic invasive species. The outcomes of this study include improving knowledge of the preferences and risk perceptions of using these techniques among the general population of Minnesota, tribal communities, and specific stakeholder and user groups such as anglers and boaters in the state. The focus will be on attitudes and risk perceptions toward using genetic modification to help control invasive species in general and two specific, widespread invasive species: common carp (*Cyprinus carpio*) and zebra mussels (*Dreissena polymorpha*). In addition, the project will help clarify the social psychological antecedents and consequences of these attitudes and risk perceptions. Focus groups and interviews will be used to assist survey design, and we will use mixed-modal surveys with web-based data collection. We will also implement a discrete choice experiment within the survey to better understand the attributes driving choices concerning the use of genetic technology. A total of 3,200 surveys are targeted for completion from the Minnesota general public, lakeshore homeowners, anglers, and boaters.

The objectives of this study are to understand :

1. the attitudes, risk perceptions, and level of support for using genetic techniques in con-

trolling two invasive aquatic species in Minnesota (i.e., common carp and zebra mussel);
2. the antecedents/consequences to attitudes, risk perceptions, and level of support for using genetic techniques in these two specific cases;
3. the general preferences for using genetic techniques in the management of invasive species in Minnesota, the antecedents/consequences of these preferences, and the population heterogeneity related to these preferences.

Public Acceptance and Preferences for Climate Change Adaptation in the Midwest

Investigator:	David C. Fulton
Postdoc:	Chad Kooistra
Duration:	July 2021 to December 2024
Funding Source:	U.S. Geological Survey Midwest/Midcontinent Climate Adaptation Science Center
Project Location:	Minnesota Cooperative Fish and Wildlife Research Unit

The objectives of this study are to:

1. understand public acceptance of climate change consequences and public preferences for climate change adaptation strategies and the stability of those preferences;
2. identify the key antecedents and consequences of stability of these preferences for climate change adaptation management strategies;
3. develop recommendations for engaging the public and stakeholders in developing climate change adaptation management strategies.

Very limited knowledge exists about key public stakeholders' (e.g., hunters, anglers, birdwatchers) perception of the conditions resulting from climate change to fish and wildlife resources or their preference for adaptation strategies to these changes. This limited understanding of public preferences has also impeded early, intensive interventions by resource managers to improve conservation outcomes. Recent research suggests that presentation of the uncertainty of consequences and information about the potential benefits of strategies can affect the trust the public has in information and preference for adaptation strategies and the malleability of those preferences. We will use social psychological experiments embedded in online social surveys to clarify relationships among uncertainty, trust, preference, and key characteristics of respondents. Project reports, information workshops, and presentations will be provided and stored digitally on a project website for peer scientists at universities and fish and wildlife managers at state and federal agencies, tribes, and non-governmental organizations. In addition, three peer-reviewed journal articles will be developed for publication in scientific journals.

Chad Kooistra began working on the project in March 2022. He has organized and led a series of workshops with state agency staff to better understanding key issues, species, and strategies that will inform the data collection effort. We anticipate data collection in 2023.

Tracking Bats and Coronaviruses through NABat: Human Dimensions of Viral Transfer

Investigator: David C. Fulton
Postdoc: Alexandrea Safiq
Duration: July 2021 to December 2023
Funding Source: U.S. Geological Survey, Fort Collins Science Center
Project Location: Minnesota Cooperative Fish and Wildlife Research Unit

The U.S. Fish and Wildlife Service (FWS), Center for Disease Control (CDC), and state wildlife and public health officials are concerned that there may be transmission of SARS-CoV-2 from infected humans to native U.S. wildlife populations, which could then serve as reservoirs to infect other wildlife and to reinfect humans in the future. This study will help CDC, FWS, and other agencies understand the risks of transmission between humans and bats, and to enhance wildlife management strategies that protect humans and wildlife from any risks that are found.

Actionable information will be provided from an intense wildlife coronavirus surveillance effort conducted with Federal, State, Tribal, and non-governmental organization partners. Data obtained from coronavirus surveillance in wildlife and the environment will be used to model SARS -CoV-2 spread and understand the role of wildlife and the environment in human COVID-19 infection dynamics. This will inform risk assessments on viral transfer between human and wildlife populations and would inform actions to help prevent or minimize recurrence of outbreaks in the future.

The social science research proposed at the Minnesota Cooperative Fish and Wildlife Research Unit (MN Coop Unit) will complement the coronavirus surveillance and modeling efforts described above. Human risk perceptions and behaviors will be documented that help to clarify relationships between human choices and behaviors that influence the potential spillover transmission of coronavirus.

To support the above objectives, we will collect and analyze data on human perception and behavior relevant to the issue. Specific tasks include:

1. The MN Coop Unit will participate in regular coordination calls and written communications with other project partners to optimize the overall study design for this cross-disciplinary research and support timely delivery of results.
2. The MN Coop Unit will design and execute current best practices survey methods to help answer the following questions
    a. How do human perceptions of bats influence how they interact with bats?
    b. How do human risk perceptions of disease influence how they interact with bats?
    c. Where is there real versus perceived risk?
    d. How are human behaviors informed by perceptions of bats?
    e. What human behaviors increase risk?
    f. What populations are most at risk as a result of risky behaviors?
    g. What interventions can mitigate risk/risky behavior?

Understanding Perceptions of Risk from Chronic Wasting Disease for Tribal Communities in the Midwest

Investigator: David C. Fulton
Student: Roger Faust, Ph.D. (Conservation Sciences)
Duration: September 2020 to December 2024
Funding Source: U.S. Fish & Wildlife Service
Project Location: Minnesota Cooperative Fish and Wildlife Research Unit

Chronic wasting disease (CWD) is an always fatal, prion-related spongiform encephalopathy that is transmissible among wild cervids in North America including deer (*Odocoileus* spp.) elk (*Cervus canadensis*) and moose (*Alces alces*) and farmed deer and elk. During the past 10 years, the disease has been spreading across state boundaries and the affected areas are likely to continue to expand. Whereas the overall infection rate in free-ranging deer and elk is low, rates of infection can exceed 10% once established in an area, with higher localized infection rates (25%) in free-ranging animals and very high infection rates (>70%) in some captive herds. (https://www.cdc.gov/prions/cwd/index.html).

As CWD continues to spread, concern has increased about the effect of CWD on wild cervids and other wildlife. Recreational hunting and subsistence harvest of cervids is important culturally and economically across most U.S. states with a nearly $40 billion annual nationwide economic contribution. In response to this threat, there has been broad response from state wildlife management agencies. In addition to affecting recreational hunting on public and private lands, however, increased effects on ungulate populations could also impact tribes and tribal communities using resources on reservation and ceded territory lands and other lands important to tribal members. Venison is not only a valuable food source to many tribal hunters, it is culturally important to many tribal communities. For this reason, the disease poses both a risk to food security for many tribal households and a threat to tribal cultural practices if deer and elk populations decline in areas affected by CWD. In addition, according to the Center for Disease Control and Prevention, the transmission of CWD to humans who consume infected venison (https://www.cdc.gov/prions/cwd/transmission.html) cannot be ruled out, and the threat of that possibility could have dramatic negative consequences for the North American Model of Wildlife Management in general. As CWD continues to spread it could lead to decreases in deer and elk hunting on tribally important lands, either through a decline in opportunity or through hunter perceptions of risk from CWD.

The U.S. Fish and Wildlife Service (USFWS) plays a critical role in providing help and support to federally recognized Tribes as they exercise their sovereignty in the management of their wildlife resources on Federal Indian trust land and in treaty reserved lands (https://www.fws.gov/nativeamerican/index.html). For this reason, the USFWS has a fundamental stake in addressing CWD on lands significant to the Tribes. National and state experts in public health, wildlife diseases, prion research, and laboratory diagnosis are urgently calling for broad interdisciplinary research to help forge a national strategy to limit the risk of CWD impacts. However, these efforts are primarily focused on state agency response to CWD and not tribal management or impacts. The proposed research would contribute to national efforts by helping to ensure tribal perspectives and concerns and indigenous knowledge are considered in broader efforts to manage

CWD. This exploratory research effort would use interviews and workshops with tribal leaders, wildlife biologists, and managers to identify and prioritize key concerns and actions that need to be addressed to manage CWD on lands important to the Tribes in USFWSA Region 3 (https://www.fws.gov/midwest/Tribal/tribes.html). The scope of this study includes: 1) completing a systematic review to determine the state-of-knowledge concerning management activities and human dimensions research related to CWD and the use of Indigenous knowledge for wildlife management; and 2) identifying and prioritizing the key concerns and perspectives of tribes related to CWD in Region 3 USFWS. The outcomes of this study will be used to provide direction for future human dimensions research and management action on CWD relevant to tribal communities.

The objectives of the project are to better understand key concerns and perspectives of tribes in Region 3 USFWS related to CWD management and CWD's potential to negatively affect hunting participation and the food security of tribal members for whom deer and elk are managed for hunting. Addressing CWD and its impacts will be a long-term, nationwide effort. This proposal will serve as a primary step to building essential knowledge about the potential for CWDs to affect the North American Model of Wildlife Management and for addressing CWD on tribal lands. We will use culturally appropriate ethnographic approaches to conduct in-depth interviews and nominal group research to better understand tribal perspectives and indigenous knowledge concerning the risks of CWD to hunting opportunities, food security, and cultural practices. Such systematic information concerning the perceived threat of CWD will be extremely useful to the tribes and wildlife management agencies in planning and prioritizing future research and management activities to address CWD and its impacts. Specifically, we will:

1. Complete a systematic review of research and activities addressing the human dimensions of CWD to develop a state-of-the-knowledge summary of the topic;
2. Complete interviews and nominal groups workshops with tribal leadership and members across USFWS Region 3 affected or potentially affected by CWD;
3. Identify participants' perceived risks of CWD to hunting, food security, and cultural practices;
4. Identify the Tribes' indigenous knowledge and participants' personal beliefs about research and management activities to address the perceived risks of CWD to hunting, food security, and cultural practices;
5. Identify participants' prioritization for research and management activities to address the perceived risks of CWD to hunting, food security, and cultural practices;
6. Use the study results to help information management plans and programs at the federal, state, and tribal levels design to address the threat of CWD to hunting and food security.

The proposed project is the first step in assessing the key threats posed by CWD for hunting participation, cultural practices, and food security for Tribes in the Midwest. A better understanding of these threats and management actions to address such threats could help in the design of the federal, state, and tribal programs that are resilient to such threats. Results of the group workshops will provide useful information about CWD threats and potential management actions and will be crucial to designing long-term management programs and research efforts.

Using information developed from our ENRTF-LCCMR funded project, Roger Faust is working with tribal biologists with several tribal nations to begin a process of developing tribal CWD plans in Minnesota using a Futures Wheel Planning process that has been used with tribal communities in Climate Change planning by the U.S. Forest Service.

Activities

Publications

Peer-Reviewed

2021

Andersen, D.E. 2021. A Most Remarkable Creature: The Hidden Life and Epic Journey of the World's Smartest Birds of Prey (*Review*). *Journal of Field Ornithology*. DOI: 10.1111/jofo.12377.

Harshaw, H.W., N.W. Cole, A.A. Dayer, J.D. Rutter, **D.C. Fulton,** A.H. Raedeke, R.M. Schuster, and J.N. Duberstein. 2021. Testing a continuous measure of recreation specialization among birdwatchers. *Human Dimensions of Wildlife* 26:472-480. https://doi.org/10.1080/10871209.2020.1843741

Landon, A.C., **D.C. Fulton**, A. Pradhananga, L.J. Cornicelli, and M.A. Davenport. 2021. Community attachment and stewardship identity influence responsibility to manage wildlife. *Society & Natural Resources* 34:571–584. https://doi.org/10.1080/08941920.2020.1852636

McCann, N. P., E.M. Walberg, J.D. Forester, M.W. Schrage, and **D.C. Fulton**, and M. Ditmer. 2021. Integrating socioecological suitability with human–wildlife conflict risk: case study for translocation of a large ungulate. *Journal of Applied Ecology* 58:2810–2820. https://doi.org/10.1111/1365-2664.14021

Moore, J.D., **D.E. Andersen**, T. Cooper, J.P. Duguay, S.L. Oldenburger, C.A. Stewart, and D.G. Krementz. 2021. Migratory phenology and patterns of American woodcock in central North America derived using satellite telemetry. *Wildlife Biology* 2021: wlb.00816.

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Rutter, J.D., A.A. Dayer, H.W. Harshaw, N.W. Cole, J.N. Duberstein, **D.C. Fulton**, A.H. Raedeke, and R.M. Schuster. 2021. Racial, ethnic, and social patterns in the recreation specialization of birdwatchers: an analysis of United States eBird registrants. *Journal of Outdoor Recreation and Tourism* 35. https://doi.org/10.1016/j.jort.2021.100400

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Schroeder, S.A., A. Landon, L. Cornicelli, **D.C. Fulton,** and L. McInenly. 2021. Institutional trust, beliefs and evaluation of regulations, and management of chronic wasting disease (CWD). *Human Dimensions of Wildlife* 26:228–244. https://doi.org/10.1080/10871209.2020.1808915

Schroeder, S.A., A.C. Landon, **D.C. Fulton**, and L. McInenly. 2021. Social identity, values, and trust in government: how stakeholder group, ideology, and wildlife value orientations relate to trust in a state agency for wildlife management. *Biological Conservation* 261:109285. https://doi.org/10.1016/j.biocon.2021.109285

Smith, K., S.A. Schroeder, A. C. Landon, L. Cornicelli, L. E. McInenly, and **D. C. Fulton**. 2021. A replication of proximity to chronic wasting disease, perceived risk, and social trust in managing agency between hunters in Minnesota and Illinois. *Human Dimensions of Wildlife* 26:503–506. DOI: 10.1080/10871209.2020.1860270

Stock, B. C., S.A. Heppell, **L. Waterhouse,** I.C. Dove, C.V. Pattengill-Semmens, C.M. McCoy, P.G. Bush, G. Ebanks-Petrie, and B. X. Semmens. 2021. Pulse recruitment and recovery of Cayman Islands Nassau grouper (*Epinephelus striatus*) spawning aggregations revealed by *in situ* length-frequency data. *ICES Journal of Marine Science* 78:277–292. https://doi.org/10.1093/icesjms/fsaa221.

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Goebel, K.M., N.M. Davros, **D.E. Andersen**, and P.J. Rice. 2022. Tallgrass prairie wildlife exposure to spray drift from commonly used soybean insecticides in Midwestern USA. *Science of the Total Environment* 818:151745. https://doi.org/10.1016/j.scitotenv.2021.151745

Kough, A., B. Gutzler, J. Tuttle, N. Palma, L. Knowles, and **L. Waterhouse**. 2022. Anthropause shows influence of tourism and a no-take reserve on the abundance and size of two fished species. *Aquatic Conservation Marine and Freshwater Ecosystems* 32:1693–1709. https://doi.org/10.1002/aqc.3856

LaSharr, K., **D.C. Fulton,** and L.J. Cornicelli. 2022. Investigating experience preferences as self- described by Minnesota wildlife management area users. *Human Dimensions of Wildlife.* https://doi.org/10.1080/10871209.2022.2077480

McEachran, M.C., A. Hofelich Mohr, T. Lindsay, **D.C. Fulton**, and N.B. D. Phelps. 2022. Patterns of live baitfish use and release among recreational anglers in a regulated landscape. *North American Journal of Fisheries Management* 42:295–306. https://doi.org/10.1002/nafm.10747

Munger, J. E., D.P. Herrara, S.M. Haver, **L. Waterhouse,** M.F. McKenna, R.P. Dziak, J. Gedamke, S.A. Heppell, and J. H. Haxel. 2022. Machine learning analysis reveals relationship between pomacentrid calls and environmental cues. *Marine Ecological Progress Series* 681:197–210. https://doi.org/10.3354/meps13912

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and movement in divided broods of golden-winged warblers. *Journal of Avian Biology* 2022:e02938. https://doi.org/10.1111/jav.02938

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Schroeder, S.A., A.C. Landon, **D.C. Fulton**, and L. McInenly. 2022. On the multiple identities of stakeholders in wolf management in Minnesota, United States. *Frontiers in Ecology and Evolution* 10:798795 https://doi.org/10.3389/fevo.2022.798795

Severud, W.J., D.Wolfson, J. Fieberg, and **D.E. Andersen**. 2022. Sandhill crane colt survival in Minnesota. *Journal of Fish and Wildlife Management* 13:494–501. https://doi.org/10.3996/JFWM-21-097

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In Press, Review, or Revision

Bruggeman, J.E., P.L. Kennedy, **D.E. Andersen**, S. Deisch, and E. Dowd Stukel. *In Revision*. Evaluating habitat suitability of a species of concern in a timber production landscape using non-systematic data**.** *Journal of Raptor Research*.

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

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? R. Danehy and A. Dolloff, Editors. American Fisheries Society, Bethesda, Maryland, U.S.A.

Goebel, K.M., N.M. Davros, P.J. Rice, and **D.E. Andersen**. *In Revision*. Effects of insecticide spray drift on arthropod prey resources of birds in grasslands in Minnesota. *Journal of Wildlife Management*.

Hawkinson, A.J., R.A. Montgomery, C.L. Roy, L.M. Shartell, **D.E. Andersen**, L.E. Frelich, and L.H. Knosalla. *In Revision*. Bird-habitat associations and local-scale vegetation structure in lowland brushlands. *Journal of Wildlife Management*.

Hill, N.M., D.H. Johnson, T.R. Cooper, and **D.E. Andersen**. *In Revision*. Secretive marshbird response to herbicide control of invasive cattail in northwestern Minnesota. *Journal of Wildlife Management*.

Kramer, G.R., **D.E. Andersen**, D.A. Buehler, P.B. Wood, S.M. Peterson, K.R. Aldinger, L.P. Bulluck, S. Harding, J.A. Jones, J.P. Loegering, C. Smalling, R. Vallender, and H.M. Streby. *In Revision*. Exposure to risk factors experienced during migration is not associated with recent *Vermivora* warbler population trends. *Landscape Ecology.*

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Landon, A. C., S.A. Schroeder, **D.C. Fulton**, L. Cornicelli, L. McInenly, and K. Smith. *In Revision*. The influence of CWD management on deer hunters' satisfaction. *Human Dimensions of Wildlife.*

Landon, A.C., K. Smith, L. Cornicelli, **D.C. Fulton**, L.E. McInenly, and S.A. Schroeder. *In Press*. Examining landowners' preferences for a chronic wasting disease management program. *Wildlife Society Bulletin*

LaSharr, K., J.H. Giudice, L.J. Cornicelli, and **D.C. Fulton**. *In Revision*. Visitor use on dispersed, state-owned land in Minnesota. *Wildlife Society Bulletin*.

McInenly, L.E., **D.C. Fulton**, and L. Cornicelli. *In Revision*. Beyond the status quo: choice experiments and preference simulation to inform deer season regulations. *Journal of Wildlife Management.*

Peterson, S.M., G.R. Kramer, H.M. Streby, and **D.E. Andersen**. *In Revision*. A call to incorporate a decade of full-life cycle research into management plans for golden-winged warblers in the western Great Lakes region. *Ornithological Applications*.

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

Smith, K., A.C. Landon, and **D.C. Fulton**. *In Revision*. The variable influence of autonomous and controlled motivation on identity salience among Minnesota deer hunters. *Leisure Science*.

Smith, K., A. Landon, **D.C. Fulton**, and G. Kyle. 2022. *In Review.* Self-determination theory as an alternate conceptual foundation for motivation in natural resource recreation. *Human Dimensions of Wildlife.*

Sleugh, T., C.M. McCoy, C.V. Pattengill-Semmens, B.C. Johnson, S.A. Heppell, **L. Waterhouse**, B.C. Stock, and B.X. Semmens. *In Press*. Migratory behavior of aggregating male tiger grouper (*Mycteroperca tigris*) in Little Cayman, Cayman Islands. *Environmental Biology of Fishes*. DOI: 10.1007/s10641-023-01399-w

Waterhouse, L., G. da Silva, L. Ailloud, and J. M. Hoenig. *In Revision.* Imputation of missing growth rings in fish spines, with application to skipjack tuna (*Katsuwonus pelamis*) age and growth. *Fisheries Research.*

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

Awards and Honors

2021. Performance Step Increase, U.S. Geological Survey (David E. Andersen)

2021. Journal Paper Award, The Wildlife Society:
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.

2021. Edited Book Award (Short List), The Wildlife Society:
Krementz, D.G., **D. E. Andersen**, and T.R. Cooper (eds.). 2019. Proceedings of the 11th American Woodcock Symposium. University of Minnesota Libraries Publishing, Minneapolis, Minnesota, U.S.A. ISB no. 978-1-946135-60-5. eISBN no. 978-1-946135-59-9.

2021. Performance Step Increase, U.S. Geological Survey (David C. Fulton)

2021. Performance Award, U.S. Geological Survey (David C. Fulton)

2021. Promotion to GS-15 through the Research Grade Evaluation Process (David C. Fulton)

2021. WMI (Wildlife Management Institute) Administrative Excellence Award (Hattie Saloka)

2022. Performance Award, U.S. Geological Survey (David E. Andersen)

2022. Academy for Excellence (Team Science-Minnesota Center for Prion Research and Outreach), Office of Academic Clinical Affairs, University of Minnesota (David C. Fulton)

2022. Excellence in Leadership Award, U.S. Geological Survey (David C. Futon)

2022. Performance Award, U.S. Geological Survey (David C. Fulton)

2022. Performance Award, U.S. Geological Survey (Lynn Waterhouse)

Completed Theses and Dissertations of Minnesota Coop Unit Students

2021

Goebel, K.M. 2021. Insecticide drift and impacts on arthropod prey resources of birds in public grasslands in Minnesota. M.S. Thesis, University of Minnesota, St. Paul, Minnesota, U.S.A. 188pp. (Andersen)

Soybean aphid (*Aphis glycines*) insecticides are widely used in the farmland region of Minnesota to combat insect pests. In Minnesota, the most commonly used broad spectrum foliar insecticides have been shown to be toxic to wildlife in laboratory settings. This is of concern to wildlife conservation because increasing evidence suggests that insecticide exposure is a significant threat to grassland birds and pollinators. However, little information exists regarding drift and deposition of insecticides in grasslands in the farmland region of Minnesota. To address this information gap, I measured insecticide drift and deposition onto passive samplers and arthropods in grasslands adjacent to soybean fields. I collected samples immediately following insecticide application at treatment sites and at control sites without insecticide application. I detected insecticides in grasslands up to 400 m from field edges regardless of whether adjacent fields were sprayed with insecticides, and deposition was greatest within 25 m of field edges. The insecticide chlorpyrifos is especially toxic to wildlife, and I measured residues that were above the contact LD_{50} for honey bees (*Apis mellifera*) up to 25 m from field edges in grasslands. The masses of chlorpyrifos that birds could consume in a day (if food items contained chlorpyrifos residues equivalent to those in my arthropod samples) were below the acute oral lethal doses (LD_{50} values) for common grackles (*Quiscalus quiscula*), house sparrows (*Passer domesticus*), northern bobwhites (*Colinus virginianus*), red-winged blackbirds (*Agelaius phoeniceus*), and ring-necked pheasants (*Phasianus colchicus*). I used linear mixed models in a hierarchical selection approach to assess the importance of distance from field edge, spray method (plane or ground sprayer), and sampler height (mid-canopy or ground) in explaining insecticide deposition in grasslands. The best-supported model of deposition on passive sampling devices included an inverse association of distance from the field edge with deposition (β = -0.62, 95% CI = -1.30 – 0.06) and positive association of samplers being placed at the mid-canopy level (β = 146.81, 95% CI = -28.99 – 322.60) compared to ground level. Canopy cover of live vegetation had an inverse association with deposition (β = -6.02, 95% CI = -12.06 – 0.12). The best-supported model of insecticide deposition on arthropods included effects of air temperature (β = -544.19, 95% CI = -937.41 – -150.98) and maximum height of vegetation (β = 272.97, 95% CI = 2.10 – 543.84). Grasslands with cover ≥25 m from row crop edges may provide wildlife habitat with lower exposure to insecticides. Management regimes that increase the percent canopy cover in grasslands also have the potential to reduce exposure of grassland wildlife to foliar insecticides.

Soybean aphid insecticides are used throughout the farmland region of Minnesota to combat insect pests. However, these foliar spray insecticides have the potential to drift beyond target fields into nearby grass-

land cover where birds and other insectivores forage. Arthropods serve important roles in grassland ecology and are susceptible to mortality from exposure to broad-spectrum insecticides. My objective was to assess impacts of soybean aphid insecticides on arthropods in grasslands, especially those that are important in grassland bird diets. I measured the abundance, consumable biomass, and family richness of insects and spiders in grasslands adjacent to soybean fields that were treated with chlorpyrifos, lambda-cyhalothrin, and bifenthrin—the 3 most common insecticides used to treat soybean aphids in Minnesota. I compared these measures to samples collected at control sites adjacent to corn fields not sprayed for aphids during 3 periods: 1–3 days before spraying, 3–5 days post-spraying, and 19–21 days post-spraying. Short-term reductions in total arthropod abundance, bird prey abundance, and Coleopteran family richness occurred in grasslands bordered by fields sprayed with foliar insecticides. The total abundance of arthropods in grasslands bordering sprayed soybean fields was lower 3–5 days after insecticide applications (β = -49.06, 95% CI = -89.84 – -8.28). The abundance of arthropods important in grassland bird diets (specifically, Araneaens, Coleopterans, Orthopterans, and Lepidopteran larvae) was also lower after nearby spraying, with lower abundance measured in treatments sites 19–21 days post-spraying (β = -23.94, 95% CI = -44.99 – -2.88). Coleopteran family richness at treatment sites was lower than control sites 3–5 days after insecticide applications (β = -0.94, 95% CI = -1.82 – -0.06). Measures of total consumable dry biomass, bird prey biomass, family richness of Araneaens, family richness of Hemipterans, and family richness of Orthopterans were not different between treatment and control sites post-spraying. My results suggest that reductions in arthropod food abundance for grassland birds are associated with insecticide spraying up to 21 days after the spraying event.

Hill, N.M. 2021. Secretive marshbird response to invasive wetland plant management in the Prairie Pothole Region of Minnesota. M.S. Thesis, University of Minnesota, St. Paul, Minnesota, U.S.A. 85pp. (Andersen)

Marshbirds are difficult to survey due their secretive nature and association with dense wetland vegetation. Recently developed standardized survey protocols are used to monitor patterns of abundance, primarily at large spatial scales, but also can be used to assess marshbird response to management. We estimated abundances of 5 species of marshbirds (American bittern [*Botaurus lentiginosus*], least bittern [Ixobrychus exilis], pied-billed grebe [*Podilymbus podiceps*], sora [*Porzana carolina*], and Virginia rail [*Rallus limicola*]) in relation to vegetation management techniques of Prairie Pothole wetlands. In northwestern Minnesota, management in autumn 2105 included herbicide application to wide-spread cattail (*Typha* spp.) mats with the goal to break up dense vegetation patches and restore wetlands to hemi-marsh conditions. In a before-after, control-impact study design we conducted standardized call-broadcast surveys for marshbirds during breeding seasons 2015 – 2018. We observed that American bittern, pied-billed grebe, sora, and Virginia rail abundances initially decreased, and then increased at 2nd and 3rd seasons post-treatment at sites where herbicides had been applied. In west-central Minnesota, long-term vegetation management included varying frequencies of multiple control methods. We compared abundances of marshbirds among categories of wetlands with management histories of low frequency of prescribed fire, high frequency of prescribed fire, and high frequency of prescribed fire and grazing. Fire and grazing as applied in the system we studied did not appear to influence Prairie Pothole Region wetland characteristics enough to result in changes in marshbird abundance, but abundance of marshbirds was related to characteristics of individual wetlands that did not appear to respond to fire and grazing. Pied-billed grebe abundance was positively associated with higher areas of open water, soras were more abundant in wetlands with high ratios of open water to emergent vegetation, and Virginia rails were more abundant in wetlands with scrub-shrub wetland cover types.

Coop Unit Student Awards and Grants

Awards

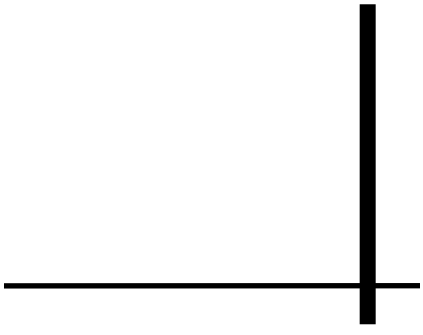
David Wolfson, Best Student Oral Presentation - The Wildlife Society 2021 Annual Conference

Funded Grant and Fellowship Applications

Briana Davis
- University of Minnesota DOVE Fellowship (2020 – 2021)
- University of Minnesota, College of Food, Agricultural and Natural Resource Sciences (CFANS) 2nd Year Fellowship Match for DOVE Fellowship (2020 – 2021)

Maddie Stevens
- University of Minnesota, College of Food, Agricultural and Natural Resource Sciences (CFANS) Diversity Fellowship (2020 – 2021)

David Wolfson
- University of Minnesota Conservation Sciences Travel Grant (2022)
- University of Minnesota Council of Graduate Students Conference Travel Grant (2022)
- University of Minnesota Council of Graduate Students Research Grant (2022)
- University of Minnesota Doctoral Dissertation Fellowship Presentation Grant (2022)
- University of Minnesota Graduate Student Board Professional Development Grant (2022)
- The Wildlife Society Wetland Working Group Travel Grant (2022)
- University of Minnesota Graduate Student Board Research Fellowship (2021)



Presentations

2021

Fulton, D.C. and K. Davan. 2021. Genetic biocontrol: understanding the public's attitudes and perspectives. Minnesota Aquatic Invasive Species Showcase. *Virtual meeting.*

Hoenig, J.M., L. Ailloud, G. DaSilva, and **L. Waterhouse.** 2021. Updated growth curves for Atlantic Ocean tropical tuna species (skipjack, yellowfin, and bigeye). The Atlantic Ocean tropical Tuna Tagging Programme (AOTTP) Final Symposium. *Virtual meeting.*

Kramer, G.R., S.M. Peterson, H.M. Streby, and **D.E. Andersen**. 2021. Conservation of golden-winged warblers in the western Great Lakes region based on regionally derived information. Midwest Fish and Wildlife Conference. *Virtual meeting*.

Smith, K., A.C. Landon, S. Schroeder, **D.C. Fulton**, and L. McInenly. Assessing deer carcass transportation, processing, and disposal habits among Minnesota hunters statewide and within disease management areas. Midwest Fish and Wildlife Conference. *Virtual meeting*.

Smith, K. A.C. Landon, and **D. C. Fulton**. 2021. Perceived risks from chronic wasting disease and risk mitigation behaviors among Minnesota deer hunters. Wildlife Disease Association. *Virtual meeting.*

Waterhouse, L., L. Ailloud, G. DaSilva, and J.M. Hoenig. 2021. Improving age composition estimates: evaluating a Bayesian method for estimating ages from spines with vascularized cores. The Atlantic Ocean tropical Tuna Tagging Programme (AOTTP) Final Symposium. *Virtual meeting*.

Waterhouse, L., L. Ailloud, G. DaSilva, and J.M. Hoenig. 2021. Improving age composition estimates: evaluating a Bayesian method for estimating ages from spines with vascularized cores. World Fisheries Congress. *Virtual meeting.*

Wolfson, D., R. Knapik, J. Fieberg, and **D.E. Andersen**. 2021. A range-wide assessment of Interior Population trumpeter swan migration patterns. Midwest Fish and Wildlife Conference. *Virtual meeting*.

Wolfson, D., J. Fieberg, and **D.E. Andersen**. 2021. A range-wide assessment of Interior Population trumpeter swan migration patterns. Mississippi Flyway Council Technical Section. *Virtual meeting*.

Wolfson, D., J. Fieberg, and **D.E. Andersen**. 2021. Using piecewise regression to identify biological phenomena in biotelemetry datasets. 7th International Bio-logging Science Symposium. *Virtual meeting*.

Wolfson, D., J. Fieberg, and **D.E. Andersen**. 2021. Using piecewise regression to identify biological phenomena in biotelemetry datasets. Annual Conference of The Wildlife Society. *Virtual meeting*.

2022

Bruggeman, J.E., P.L. Kennedy, **D.E. Andersen**, S. Deisch, and E. Dowd Stukel. 2022. Effects of abiotic, biotic, and forest management factors on changes in northern goshawk nest-site habitat suitability in the Black Hills National Forest. 2022 South Dakota Chapter of the Wildlife Society Annual Meeting. *Virtual meeting*.

Davan, K. and **D.C. Fulton.** 2022. Genetic biocontrol: understanding the public's attitudes and perspectives. Midwest Invasive Species Conference, Green Bay, Wisconsin, U.S.A.

Faust, R., T. Wolf, **D.C. Fulton**, L. Bernstein, A. Landon, M. Schwabenlander. 2022. (*Invited*). Partnering with diverse hunting communities to tackle CWD. Human Dimensions Pathways Conference, Bremerton, Washington, U.S.A.

Landon, A., **D.C. Fulton**, J. Hansen, H. Miller, J. Reed, A. Safiq, and S. Schroeder. 2022. Priorities for state fisheries management under fiscal constraint. Human Dimensions Pathways Conference, Bremerton, Washington, U.S.A.

Layton, J., A. Candelmo, B. X. Semmens, C.V. Pattengill-Semmens, B. Stock, **L. Waterhouse,** C. McCoy, B. Johnson, D. Heppell, S. Huber, S. Barkdoll, and S. Heppell. 2022. Early life history stages of yellowfin grouper in Little Cayman, Cayman Islands. American Fisheries Society. Spokane, Washington, U.S.A. [Poster]

Safiq, A., and **D. C. Fulton**. 2022. How nature-based spiritual value orientations influence pro-conservation behavior. American Psychological Association, Division 34 Society for Environmental, Population & Conservation Psychology. Minneapolis, Minnesota, U.S.A. *Virtual presentation.*

Safiq, A., and **D. C. Fulton**. 2022. How nature-based spiritual value orientations influence pro-conservation behavior. North American Congress for Conservation Biology, Restoring connections and building resilience in a changed world. Reno, Nevada, U.S.A. *Virtual presentation.*

Safiq, A., and **D. C. Fulton**. 2022. Nature spiritualism, marine mammal protection, and salmon restoration. Human Dimensions Pathways Conference, Bremerton, Washington, U.S.A.

Smith, K., A. Landon, L. McInenly, and **D.C. Fulton**. 2022. The variable influence of autonomous and controlled motivation on identity salience among Minnesota deer hunters. Midwest Fish and Wildlife Conference. *Virtual meeting*.

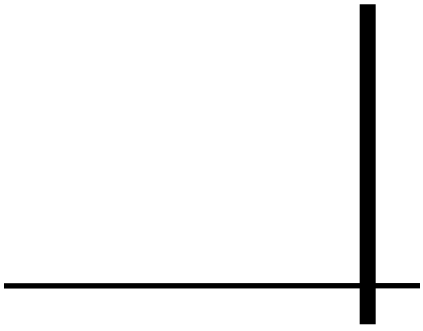
Smith, K., A. Landon, L. McInenly, and **D.C. Fulton**. 2022. Application of self-determination approach to hunting participation. Human Dimensions Pathways Conference, Bremerton, Washington, U.S.A.

Smith, K., E. Walberg, **D. C. Fulton**, A. C. Landon, M. Schrage, N. McCann, and J. Forester. 2022. Using best -worst scaling to assess stakeholder management preferences related to elk restoration in northern Minnesota. Elk Management Conference. Bemidji, Minnesota, U.S.A.

Wolfson, D., J. Fieberg, and **D.E. Andersen**. 2022. Using piecewise regression to identify biological phenomena in biotelemetry datasets. Midwest Fish and Wildlife Conference. *Virtual meeting*.

Wolfson, D., J. Fieberg, and **D.E. Andersen**. 2022. Interior Population trumpeter swan annual movement and migration patterns. 7th International Swan Symposium and 26th Swan Conference. Jackson Hole, Wyoming, U.S.A.

Wolfson, D., J. Fieberg, and **D.E. Andersen**. 2022. Interior Population trumpeter swan movement and migration patterns. The Wildlife Society's 29th Annual Conference, Spokane, Washington, U.S.A.



Unit News

For the first time in over 6 years, the Minnesota Cooperative Fish and Wildlife Research Unit (Minnesota Coop Unit) is fully staffed—we have a full complement of a Unit Leader (David Andersen), Assistant Leader—Wildlife (David Fulton), and an Assistant Leader—Fisheries (Lynn Waterhouse). Dr. Waterhouse joined the Minnesota Coop Unit in June 2021, in the heart of the Covid-19 pandemic, having gone through the application and selection process virtually. In spite of those complications in getting her here, and continuing to work under concerns around Covid, Dr. Waterhouse has rapidly begun to build her research and teaching program at the Minnesota Coop Unit. She continues working on stock assessment of marine fisheries, and population ecology of grouper in the Caribbean. Since coming to the Minnesota Coop Unit, Dr. Waterhouse has also developed several collaborative projects working on Great Lakes fisheries issues and ongoing issues around large-lake fisheries and co-management of those resources in Minnesota and taught the first iteration of her graduate course on experimental design and data analysis. We and our cooperators are excited to be fully staffed, and to have been able to convince Dr. Waterhouse to become the second Assistant Leader—Fisheries at the Minnesota Coop Unit.

Over the last several years, the Minnesota Coop Unit has continued to advance our mission of research, teaching, and technical assistance. For the first time in many years, the U.S. Geological Survey Cooperative Research Units Program has had funding to fill vacancies, replace aging vehicles, acquire new equipment, and provide support for safety training and acquiring safety equipment for federal scientists, students, postdocs, and project technicians. At the same time, the University of Minnesota, through our host Department of Fisheries, Wildlife, and Conservation Biology, provided support for Dr. Waterhouse in her transition to Minnesota by way of an office update and the usual support necessary for a new faculty member. As I mentioned in my update in our 2019—2020 biennial report, in our last Cooperative Agreement negotiations, the University of Minnesota rescinded return of indirect costs on federal grants (Research Work Orders) to the Minnesota Coop Unit, negating our ability to generate university funds that we use to maintain and service vehicles, cover unanticipated research costs, respond to unfunded university mandates, pay publication page charges, support graduate students, provide opportunities for graduate students to attend professional meetings, leverage research funding, and many related items. This change in access to recovering indirect costs is likely to become more burdensome through time, as we deplete the funds we have been able to rollover to support our operations. We also continue to struggle to maintain some key

aspects of our role as faculty in our host department. For example, Coop Unit scientists have been largely excluded from discussions about academic promotion, limited in our ability to serve in leadership roles in graduate programs, and reduction in staff support has been threatened on several occasions. We continue to work to keep those relationships strong, but we are concerned that over time, the faculty role of Coop Unit scientists seems to have been diminished through incremental reduction in rights and privileges codified in our Cooperative Agreement. In spite of those challenges, and with the continued support of our cooperators, David Fulton, David Andersen, and Lynn Waterhouse all continue to have active research programs that address priority research needs and support M.S. and Ph.D. graduate students and postdoctoral research associates.

Unfortunately, and as is the case everywhere, the influence of Covid-19 on the Minnesota Coop Unit has been substantive. Both the University of Minnesota and the U.S. Geological Survey were in reduced in-person operations well into 2022, and in early 2023, faculty presence in our host department is not yet back to pre-pandemic levels. Both the U.S. Geological Survey and the University of Minnesota took unprecedented steps to minimize risk associated with the pandemic. We are all grateful that we could continue working and that both the U.S. Geological Survey and the University of Minnesota worked to develop guidelines under which we could continue our operations, but obviously these pandemic health and safety conditions posed significant impediments to conducting research, interacting with graduate students, and day-to-day operation of the Minnesota Coop Unit. Working under established protocols and procedures, we were able to continue most of our research efforts, including all those involving graduate students and postdoctoral research associates. In many cases, that required safety protocols that increased project costs (e.g., single-occupancy vehicle requirements that increased the number of vehicles required to conduct field work)—costs that we covered with discretionary funds, including funds accumulated through prior return of ICR to the Minnesota Coop Unit.

We completed a number of research projects during 2021–2022, and initiated several new projects. As you can see in this report, our students continue to present their research results at professional conferences (although recently, primarily virtually) 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 other challenges, both ongoing and in the future for the Minnesota Coop Unit. On the federal side, the Cooperative Research Units Program is currently well funded and has strong bipartisan support. On the state side, budgets in both fisheries and wildlife have shrunk, and the Minnesota Department of Natural Resources is facing financial challenges in the absence of increases in revenue, which makes research collaboration more challenging. However, the Minnesota Department of Natural Resources has ongoing need of expertise in stock assessment and other fisheries issues, and Dr. Waterhouse is helping build back a strong relationship

Biology, in the midst of a review of collegiate structure and function. So, perhaps as is really always the case, we need support from our cooperators, collaborators, former students, colleagues, and friends to champion what we do and the contributions we have made and will make. If you have the opportunity, please put in a good word on our behalf!

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. David is currently working on a variety of projects within the State of Minnesota, and 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 marshbirds and exposure risk of grassland wildlife to agricultural insecticides, and is continuing projects on movement ecology of Interior Population trumpeter swans. As mentioned previously, Lynn Waterhouse is well on her way to establishing her research and teaching programs at the Minnesota Coop Unit. Finally, Hattie Saloka, who as everyone familiar with the Minnesota Coop Unit knows, continues to keep everything humming along, working remotely 2 days a week, and in the Coop Unit office the other 3 days a week.

with the Minnesota Department of Natural Resources in fisheries. Finally, the University of Minnesota, like many institutions of higher education, faces ongoing financial and structural challenges. Over the more than 30 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. Within the University system, the Minnesota Coop Unit needs a strong advocate to higher administration from the level of the Department of Fisheries, Wildlife, and Conservation