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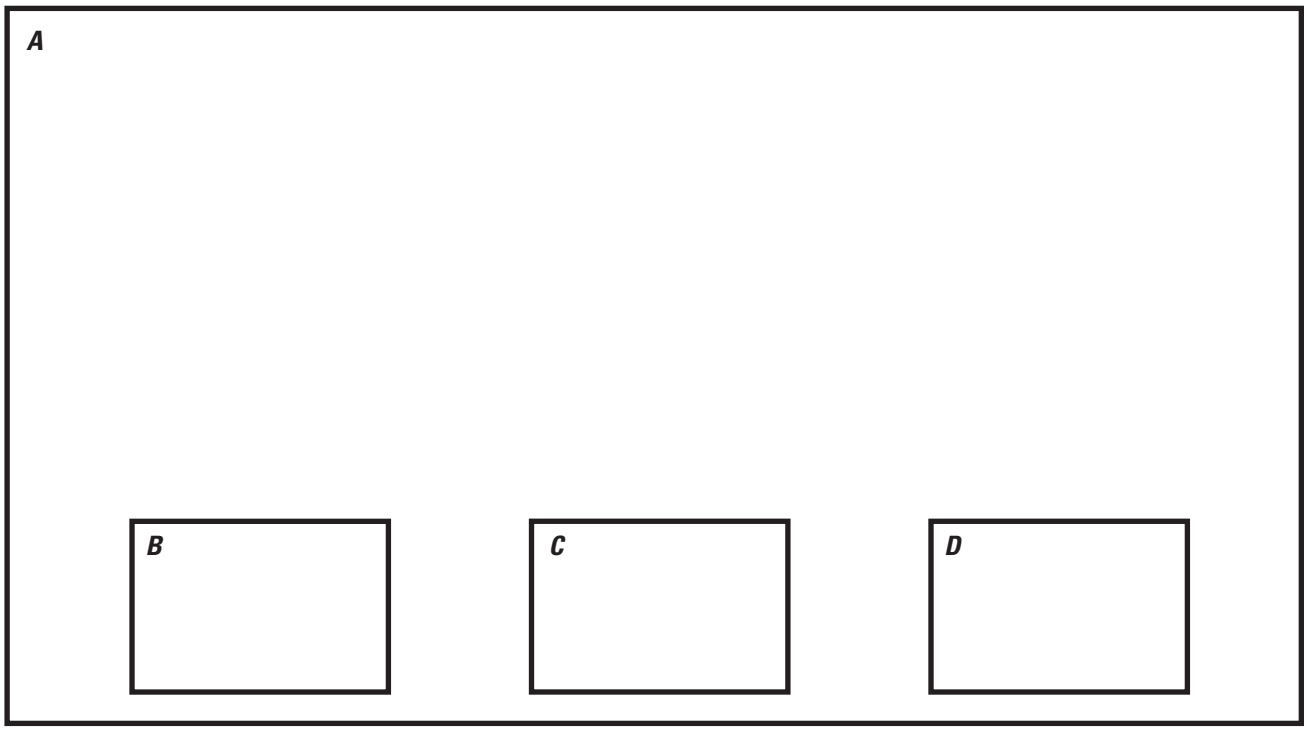
U.S. Geological Survey—Northern Prairie Wildlife Research Center

2021–23 Research Activity Report

Circular 1512

U.S. Department of the Interior
U.S. Geological Survey



Front cover. ***A***, Waterfowl using a partially plowed wetland in an agricultural field. ***B***, A pair of northern pintails (*Anas acuta*) in a wetland. ***C***, Adult sage thrasher (*Oreoscoptes montanus*) waiting to deliver food to its nestlings. ***D***, A piping plover (*Charadrius melodus*) sitting on a nest. Photographs by U.S. Geological Survey.

Back cover. Adult male bobolink (*Dolichonyx oryzivorus*) and cattle grazing in grassland. Photographs by Lawrence D. Igl, U.S. Geological Survey.

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Edited by Mark H. Sherfy

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U.S. Department of the Interior
U.S. Geological Survey

U.S. Geological Survey, Reston, Virginia: 2024

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Acknowledgments

This report is a compilation of narratives on the current science portfolio of Northern Prairie Wildlife Research Center. This work reflects our long and proud history of working with many partners and collaborators who have made much of the science presented here possible, and we thank each of them for their support of our research.

The content of this report was written by the scientific staff at the Northern Prairie Wildlife Research Center, whose devotion of time to preparing the content, and more importantly, to completing the underlying research, is greatly appreciated. Michael J. Anteau, David M. Mushet, Max Post van der Burg, and Amy Symstad provided critical reviews of earlier drafts and made many valuable suggestions about how best to organize and present Northern Prairie's science portfolio. Mona Khalil provided advice on the structure and display of the report.

Contents

Conversion Factors

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
kilometer (km)	0.5400	mile, nautical (nmi)
meter (m)	1.094	yard (yd)
	Area	
square meter (m^2)	0.0002471	acre
hectare (ha)	2.471	acre
square kilometer (km^2)	247.1	acre
square meter (m^2)	10.76	square foot (ft^2)
hectare (ha)	0.003861	square mile (mi^2)
square kilometer (km^2)	0.3861	square mile (mi^2)

Abbreviations

ABAM	Annual Brome Adaptive Management
ACBK	Association for the Conservation of Biodiversity in Kazakhstan
ACC	accelerometer
AIOM	avian-impact offset method
AMF	arbuscular mycorrhizal fungi
BBS	Breeding Bird Survey
CH_4	methane
CREP	Conservation Reserve Enhancement Program
CRP	Conservation Reserve Program
CWD	chronic wasting disease
DNA	deoxyribonucleic acid
DNR	Department of Natural Resources
DOI	Department of the Interior
EPA	U.S. Environmental Protection Agency
FWS	U.S. Fish and Wildlife Service
GHG	greenhouse gas
GPS	Global Positioning System
GPS–ACC	Global Positioning System-Accelerometer
GSM	global system for mobile communications
HAPET	Habitat and Population Evaluation Team
LTRM	long-term research and monitoring
MAPS	Monitoring Avian Productivity and Survivorship
NPAM	Native Prairie Adaptive Management
NPWRC	Northern Prairie Wildlife Research Center
NWRS	National Wildlife Refuge System
PHyLiSS	Pothole Hydrology Linked System Simulator
PPJV	Prairie Pothole Joint Venture
PRRIP	Platte River Recovery Implementation Program
RWBJV	Rainwater Basin Joint Venture
TAHD	treponeme-associated hoof disease
UAS	uncrewed aircraft systems
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey

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Northern Prairie Wildlife Research Center History and Science Focus

The Department of the Interior (DOI) conserves and manages the Nation's natural resources and cultural heritage, including public lands and minerals, national parks, national wildlife refuges, and western water resources. The DOI also is responsible for migratory wildlife conservation, historical preservation, endangered species conservation, and surface-mined land restoration. To meet these responsibilities, the DOI provides scientific information about natural resources and natural hazards to other Federal agencies and the public. The breadth of the DOI's science mission requires expertise in several disciplines to support informed and defensible management decisions on behalf of the American public. Much of this expertise is provided by way of the U.S. Geological Survey (USGS), the Nation's premier earth and biological science agency. Specifically, USGS biological and ecological research is completed through a network of 16 science centers throughout the Nation, each representing a distinct component of the USGS mission and a unique focal area of expertise in natural resource science.

The Northern Prairie Wildlife Research Center (NPWRC) was established in 1965 to address key information needs for managing nationally significant waterfowl populations and habitats. In the heart of the Nation's prairie wetland and grassland resources, NPWRC is ideally positioned for interdisciplinary research on migratory birds, land-use change, and wetland and grassland wildlife. NPWRC also is ideally positioned for quantifying ecosystem services as affected by land management, conservation programs, and climate variability. During its more than 50-year history, NPWRC has produced a wealth of information on applied management issues, focusing on the priorities and footprint of the DOI. NPWRC also has developed long-standing and productive partnerships with a variety of land-management agencies, nonprofit organizations, and universities; fostering opportunities for creative and cost-effective solutions to management and conservation issues.

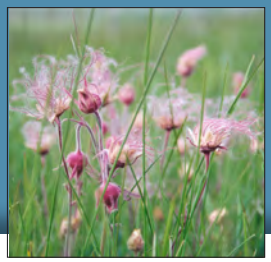
The NPWRC's science program is organized around the following five themes: (1) wildlife science, (2) ecosystem science, (3) climate-change science, (4) land-use change science, and (5) analytics and decision support. Together, research under these five themes addresses the primary information needs of land managers and policymakers across a vast part of the central United States and is strategically linked through NPWRC's organizational structure to facilitate interdisciplinary collaboration to address complex issues.

DOI Mission.—The DOI protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its trust responsibilities or special commitments to Native Americans, Alaska Natives, and affiliated island communities.

USGS Mission.—The USGS provides science about the natural hazards that threaten lives and livelihoods; the water, energy, minerals, and other natural resources we rely on; the health of our ecosystems and environment; and the effects of climate and land-use change. USGS scientists develop new methods and tools to supply timely, relevant, and useful information about the Earth and its processes.

NPWRC Mission.—The NPWRC provides scientific information needed to conserve and manage the Nation's natural capital for current and future generations, with an emphasis on migratory birds, DOI trust resources, and ecosystems of the Nation's interior.

The NPWRC celebrated its 50-year anniversary in 2015 and published a report describing the first 50 years of biological research at the NPWRC (Austin and others, 2017) along with a bibliography of scientific products (U.S. Geological Survey, 2017). The scientific foundation developed at the NPWRC during this timeframe provides the base for applied research and enables the NPWRC to quickly respond to emerging issues in the Northern Great Plains and beyond. The NPWRC has since published annual research activity reports (Sherfy, 2019, 2020, 2021) that provide details on the studies that constituted the NPWRC's 2016–20 science portfolio. This report updates the series by describing NPWRC's 2021–23 science portfolio. NPWRC recently filled five vacant positions through recruitment of new research scientists, who expand our capability to address a broad suite of complex natural resource issues. Each of these new scientists is highlighted in this report with a brief biographical sketch ("Scientist Spotlight" sections).


Lines of Work

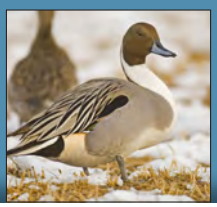
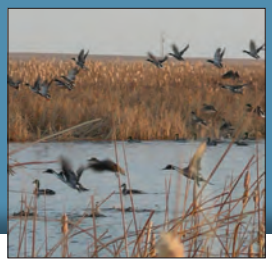
The NPWRC's science portfolio is built around a diverse suite of management questions, partnerships, and funding sources. The USGS Ecosystems Mission Area accounts for most of NPWRC's appropriated funding and has developed a hierarchical system to classify biological science portfolios into Lines of Work. The highest level of the hierarchy contains three Programs, each containing two Lines of Work that, in turn, contain many science subjects, or Sub-Lines of Work, as summarized parenthetically below. The time period covered by this report overlaps a transition in organization of the Ecosystem Mission Area that resulted in realignment of Programs and Lines of Work. This report aligns NPWRC studies with the Programs and Lines of Work in place during fiscal year 2023.

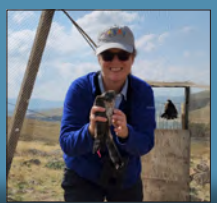
The Species Management Program encompasses research on *Species Biology* (research into life history, successful conservation, and recovery of threatened and endangered species listed under the Endangered Species Act; trust species that are protected by law; sensitive species that are declining, rare, or uncommon and are identified as candidates for future listing consideration; and species of management concern that warrant management or conservation attention as identified by a natural resource management agency) and *Species Stressors* (research into the cause and mitigation of environmental and anthropogenic stressors that potentially affect the health and reproductive capacity of species of management concern).

The Landscape Management Program encompasses research on *Management and Restoration* (understanding how ecosystems work and how chemical, geological, hydrological, and biological processes interact and change with human and natural alterations) and *Priority Landscapes* (place-based research to understand the biological and physical processes that affect change and management options across large geographic areas of management concern).

The Land Change Science Program focuses on *Climate Research and Development*, with a mission to provide foundational data and analyses needed to improve understanding of rates, causes, and consequences of environmental, land-use, and climate change.

The Biological Threats and Invasive Species Program encompasses research on *Invasive Species* (research, monitoring, and technology development for containing or eradicating nonindigenous species with potential to cause significant ecologic or economic damage or affect human health) and *Fish and Wildlife Disease* (ecology of fish and wildlife diseases, effect of diseases on wild populations with emphasis on federally listed species; development of surveillance, control, and risk-assessment tools; and decision support science for management agencies).

Grassland Ecosystems.—Temperate grasslands are one of the most imperiled ecosystems globally, facing threats including conversion to crop production, invasion by nonnative species, and loss of disturbance factors that favor diverse native plant communities.

Northern Forests.—Northern hardwood and conifer forest communities from the upper Midwest to the Rocky Mountains support ungulate and carnivore populations that are Federal management priorities owing to their population status and occurrence on Federal lands.

Prairie Pothole Region.—Known as "the duck factory of North America" because it supports the core breeding population of many migratory waterfowl species, the Prairie Pothole Region contains millions of depressional, glacially derived wetlands with dynamic and variable hydroperiods that generate periodic pulses of productivity.

Midcontinent River Systems.—Large river systems, such as the Missouri, Platte, and Mississippi Rivers, are major landscape features that provide ecosystem services, support populations of priority species, and provide linkages between terrestrial and aquatic habitats.

List of Projects

The 2021–23 science portfolio at NPWRC consisted of 103 studies covering a diverse suite of biological subjects and management applications. These studies are listed in table 1 and are organized by primary alignment with Research Programs, Lines of Work, and Sub-Lines of Work.

A Northern Great Plains grassland in North Dakota photographed during a survey for bees and flowers. Photograph by U.S. Geological Survey.

Table 1. Index number, lead principal investigator, and title of research studies constituting the 2021–23 science portfolio at Northern Prairie Wildlife Research Center.

[--, not applicable]

Index number	Lead investigator	Title
		Species Management Program, Species Biology, Migratory Birds
1	Anteau	Provide Support to the U.S. Fish and Wildlife Service and Prairie Pothole Joint Venture for Monitoring and Management of Migratory Bird Populations
2	Pearse	An Evaluation of Waterfowl Breeding Ecology in the Context of Their Predator Community in Eastern South Dakota
3	Anteau	Demographic Analysis of Waterfowl Populations
4	Pearse	Reconciling Competing Models of Temporospatial Variation in Duck Nest Survival
5	Anteau	Assessing Phenology of Grassland-nesting Birds to Inform Timing of Grassland Management Activities
6	Igl	Breeding Bird Use of Grasslands Enrolled in the Conservation Reserve Program in the Northern Great Plains
7	Igl/J. Shaffer	The Effects of Management on Grassland Birds—Literature Reviews
8	Pearse	Development of Survey Methods for Spring-Migrating Waterfowl in the Rainwater Basin
9	Pearse	Using Seasonal and Annual Movements to Assess Harvest Models and Monitoring Techniques of Northern Pintails in the Midcontinent of North America
10	Pearse	Postfledging Movement and Habitat Selection by Mallards in the Fall and Their Effect on Spring Recruitment
11	VonBank	Linking Wintering and Migration Strategies to Greater White-Fronted Goose Breeding Performance
12	VonBank	Effects of Landscape and Habitat on Nesting in Northern Pintails
13	VonBank	Texas Mottled Duck Movement Ecology
14	VonBank	Regional Movements of Rocky Mountain Population Sandhill Cranes
15	VonBank	Kansas Mallard Movement Ecology
16	VonBank	An Alternative Approach to Goose Harvest Estimation: Central Flyway Online Goose Harvest Assessment
17	VonBank	An Accelerometer-based Library of Waterfowl Behaviors
18	Igl	Developing Techniques to Census and Monitor American White Pelicans and Other Colonial Waterbirds at Chase Lake National Wildlife Refuge in North Dakota
19	Swift	Identifying Population Limiting Factors of Hudsonian Godwits
20	Swift	Predicting Climatic Impacts on the Network of Migratory Stopover Sites for Hudsonian Godwits in the Northern Great Plains
21	Swift	Developing Research Tools for Demographic Study of Thick-Billed Longspurs
22	Swift	Implementation of a Breeding Landbird Banding Station at NPWRC
		Species Management Program, Species Biology, Listed Birds
23	Swift	Population Dynamics of Piping Plovers in the Northern Great Plains
24	Anteau	Breeding Ecology and Demographics of Least Terns and Piping Plovers at the Central Platte River, Nebraska
25	Toy	Population Demographics of Least Terns and Piping Plovers in Colorado
26	Sherfy	Improving Monitoring Techniques for Nests of Interior Least Terns and Piping Plovers
27	Sherfy	Legacy Data Analysis – Northern Great Plains Least Terns and Piping Plovers
28	Ellis	Identifying Important Habitat, Developing Inexpensive Habitat Monitoring, and Developing Habitat-Based Abundance Estimates for Piping Plovers at Wetland Habitats in the Prairie Pothole Region

Table 1. Index number, lead principal investigator, and title of research studies constituting the 2021–23 science portfolio at Northern Prairie Wildlife Research Center.—Continued

[--, not applicable]

Index number	Lead investigator	Title
		Species Management Program, Species Biology, Listed Birds—Continued
29	Ellis	Optimizing Habitat Restoration Efforts for Great Lakes Piping Plovers Under Climate Change Uncertainty
30	Ellis	Impacts of Extreme Disturbances at Wintering Areas on Piping Plover Survival and Migratory Connectivity
31	Swift	Assessment of Northern Great Plains Piping Plover Population Viability and Trends
32	Swift	Demographic Analysis of Least Terns and Piping Plovers
33	Swift	Developing New Understandings of Piping Plover Breeding Habitat Suitability and Quality for Missouri River Sandbars
34	Swift	An Experimental Assessment of the Influence of Nest Exclosures ('Nest Cages') on Nest, Chick, and Adult Survival for Piping Plovers Breeding on Missouri River Sandbars
		Species Management Program, Species Biology, Whooping Cranes
35	Pearse	Cumulative Impacts of Energy Development and Other Anthropogenic Stressors for Migrating Whooping Cranes
36	Pearse	Identifying Potential Whooping Crane Migration Habitat for Assessing Risk of Disturbance
37	Pearse	Whooping Crane Flight Behavior to Support Aircraft-Bird Collision Risk Assessments at U.S. Air Force Installations
		Species Management Program, Species Biology, Pollinators
38	Otto	Understanding How Land-Use Change in the Northern Great Plains Affects Pollinator Health and Pollination Services
39	Otto	Improving Forage for Pollinators on Federal Conservation Lands
40	Otto	Forage and Habitat of the Endangered Rusty-patched Bumble Bee, Bombus affinis
41	Otto	Float Like a Butterfly—Employing Unmanned Aircraft Systems Technology to Quantify Milkweed for Monarch Butterflies
42	Otto	Native Bee Response to Warm- and Cool-Season Grassland Management at National Park Service Historical Sites in the Mid-Atlantic Region, United States
43	Post van der Burg	Understanding Spatiotemporal Patterns of Threatened and Endangered Butterflies in the Great Plains
44	Igl	Long-Term Changes in Pollinator Resources (Alfalfa, Sweetclover, and Milkweed) and Monarch Butterfly Populations in Conservation Reserve Program Grasslands
		Species Management Program, Species Biology, Wolves
45	Mech	Superior National Forest Wolf and Lynx Populations
46	Mech	Yellowstone Wolf Restoration
47	Mech	Ellesmere Wolf Movements
		Species Management Program, Species Biology, Ungulates
48	Sargeant	Integrated Conservation of Bison and Native Prairie at Badlands National Park, South Dakota
49	Sargeant	Movements and Distribution of Moose at Rocky Mountain National Park
		Species Management Program, Species Stressors, Wind Energy
50	Shaffer, J.	A Method for Mitigating the Behavioral Effects of Energy Development and Other Anthropogenic Disturbances on Grassland Birds and Waterfowl
51	Shaffer, J.	Spatial Models Inform Tradeoff Decisions Between Energy Development and Species Conservation

Table 1. Index number, lead principal investigator, and title of research studies constituting the 2021–23 science portfolio at Northern Prairie Wildlife Research Center.—Continued

[--, not applicable]

Index number	Lead investigator	Title
		Species Management Program, Species Stressors, Wind Energy—Continued
52	Shaffer, J.	Embassy Science Fellowship Technical Assistance to Kazakhstan in Developing Wind Energy
53	Shaffer, J.	Evaluating Bird Behavioral Response to Wind Turbines Across the Northern Plains
		Species Management Program, Species Stressors, Oil and Gas
54	Igl	Response of Grassland Birds to Habitat Characteristics, Oil Wells, and Roads in Managed Grasslands in the Little Missouri National Grassland in North Dakota
		Species Management Program, Species Stressors, Biofuels
55	Otto	Quantifying the Effects of Land-Use Change and Bioenergy Crop Production on Ecosystem Services in the Northern Great Plains
		Species Management Program, Species Stressors, Habitat Loss/Degradation
56	Post van der Burg	Inventory, Mapping, Estimation, and Monitoring of Least Tern and Piping Plover Habitats on the Upper Missouri River Using Satellite Imagery
57	Post van der Burg	Synthesizing Mapping and Monitoring Data to Understand Fluctuations in Prairie Dog Colony Size and Densities in Theodore Roosevelt National Park
		Landscape Management Program, Priority Landscapes, Platte River
58	Pearse	Ecology and Management of Midcontinent Sandhill Cranes
59	Pearse	Migration and Winter Ecology of the Aransas-Wood Buffalo Population of Whooping Cranes
60	Pearse	Independent Science Advisory Committee for the Platte River Recovery Implementation Program
		Landscape Management Program, Management and Restoration, Climate Change Adaptation
61	Symstad	Integrating Climate Change Scenario Planning into National Park Service Resource Management
62	Symstad	Climate Effects on Prescribed Fire Implementation and Efficacy in Northern Mixed-grass Prairie
		Landscape Management Program, Management and Restoration, Riparian/Wetland
63	McLean	A Biotic Inventory of Overlook and Mandel Springs in the North Unit of Theodore Roosevelt National Park
64	Anteau	Evaluating Wetland Ecosystem Health Using Real-Time Nutrient Dynamics of Ducks
65	Anteau	Restoration of Wetland Invertebrates to Improve Wildlife Habitat in Minnesota
66	Anteau	Importance of Wetlands in Intensively Farmed Landscapes to Duck Production
67	Anteau	Understanding Consequences of Management Strategies for Farmed Wetlands to Ecosystem Services in the Prairie Pothole Region
68	Anteau	Evaluating Dynamics of Habitat Resource Availability for Diving Ducks at Pools 13 and 19 of the Mississippi River
69	McLean	Application and Refinement of a Systems Model for Prairie-Pothole Wetlands
70	Mushet	Development and Validation of Wetland-Connectivity Indicators in the U.S. Prairie Pothole Region
71	McLean	Estimating Streamflow Duration in the Prairie Pothole Region of the United States
		Landscape Management Program, Management and Restoration, Ecosystem Services
72	McKenna	Quantification of the Multiple Services Performed by Wetland Ecosystems in the Prairie Pothole Region
73	McKenna	Development of a Conservation Reserve Enhancement Program (CREP) Reporting and Analysis Template

Table 1. Index number, lead principal investigator, and title of research studies constituting the 2021–23 science portfolio at Northern Prairie Wildlife Research Center.—Continued

[--, not applicable]

Index number	Lead investigator	Title
		Landscape Management Program, Management and Restoration, Ecosystem Services—Continued
74	Anteau	Using Ecosystem Services Modeling to Inform Water Management Decisions in the Prairie Pothole Region of Iowa
75	Symstad	Biodiversity-Productivity Relationships in a Natural Grassland Community Vary Under Diversity Loss Scenarios
		Landscape Management Program, Management and Restoration, Decision Analysis Frameworks
76	Post van der Burg	Decision Analysis and Support
77	Post van der Burg	Decision Analysis of Options for Controlling Asian Carp Invasion in the Tennessee River
78	Post van der Burg	Science support for Mississippi River Long Term Research and Monitoring Program
79	Post van der Burg	Decision-Making and Climate Adaptation Framework for Midwest Refuges
80	Post van der Burg	Decision Support for Update of Minnesota Invasive Carp Action Plan
		Landscape Management Program, Management and Restoration, Grazing
81	Larson	Evaluation of Conservation Grazing Compared to Prescribed Fire to Manage Tallgrass Prairie Remnants for Plant and Pollinator Species Diversity
82	Symstad/Sargeant	Grazing Resources for Integrated Conservation of Bison and Native Prairie at Badlands National Park, South Dakota
		Landscape Management Program, Management and Restoration, Restoration
83	Larson	Effects of Invasive Plant Species on Reproduction of the Rare Endemic Plant Dakota Buckwheat (Eriogonum visheri) at Badlands National Park
84	Larson	Evaluation of Tallgrass Prairie Restoration Methods to Improve Resistance to Invasive Species and Maintenance of Plant Species Diversity with Time
85	Shaffer, T.	Improving Wildlife Habitat Through Management and Restoration of Native Prairies on Lands Under U.S. Fish and Wildlife Service Ownership (NPAM)
86	Larson	Sourcing Plants for Conservation and Restoration—Developing a Risk Assessment Framework
		Land Change Science Program, Climate Research and Development, Greenhouse Gases
87	Bansal	Mechanisms, Models, and Management of Invasive Species and Soil Biogeochemical Process in Prairie Pothole Wetlands
88	Bansal	Assessing the Climate Change Mitigation Potential of Wetland Restoration in the Conservation Reserve Program: Measurements, Modeling, and Scaling Changes in Soil Carbon and Greenhouse Gas Fluxes
89	Bansal	Decoding the Unifying Microbial Metabolic Controllers on Soil Cycling Across Freshwater Wetlands
		Land Change Science Program, Climate Research and Development, Land-Cover Change Scenarios and Modeling
90	McKenna	The Impact of Future Changes in Climate on Breeding Waterfowl Pairs in the U.S. Prairie Pothole Region
91	McKenna	The Impact of Future Climate on Wetland Habitat in a Critical Migratory Waterfowl Corridor of the Prairie Pothole Region
		Land Change Science Program, Climate Research and Development, Wetlands
92	McKenna	Climate-Driven Connectivity Between Prairie-Pothole and Riparian Wetlands in the Upper Mississippi River Watershed: Implications for Wildlife Habitat and Water Quality

Table 1. Index number, lead principal investigator, and title of research studies constituting the 2021–23 science portfolio at Northern Prairie Wildlife Research Center.—Continued

[--, not applicable]

Index number	Lead investigator	Title
Land Change Science Program, Climate Research and Development, Wetlands—Continued		
93	McKenna	Mapping Effects of Wetland Change on Amphibians in the Upper Midwest
94	Bansal	OPERA DSWx Surface Water Extent Algorithm Development
95	Bansal	Fish and Wildlife Seasonal and Temporary Wetland Assessment
Biological Threats and Invasive Species Program, Invasive Species, Management and Control Tools		
96	Symstad	Grassland Plant Population and Community Dynamics In and Following Seasonal Drought
97	Symstad	Developing a Native Seed Strategy for the Northern Great Plains
98	Symstad	What Role Does Prescribed Fire Play in Managing Annual Bromes in Northern Great Plains Grasslands?
99	Symstad	An Adaptive Management Framework to Control Invasive Annual Brome Grasses in Northern Great Plains Parks (Annual Brome Adaptive Management Project)
Biological Threats and Invasive Species Program, Fish and Wildlife Disease, Chronic Wasting Disease		
100	Sargeant	Effects of Population Density on Prevalence of Chronic Wasting Disease, Physical Condition, and Vital Rates of Elk at Wind Cave National Park, South Dakota
101	Sargeant	Epizootiology of Chronic Wasting Disease in Mule Deer
Biological Threats and Invasive Species Program, Fish and Wildlife Disease, Ecology and Impact		
102	Sargeant	Treponeme-Associated Hoof Disease in Elk
Biological Threats and Invasive Species Program, Fish and Wildlife Disease, Avian Influenza		
103	Pearse	Science and Monitoring at Odds – Laying the Groundwork for Estimating Avian Influenza Infection Rates for North American Waterfowl

Study Narratives

Species Management Program—Species Biology

Migratory Birds

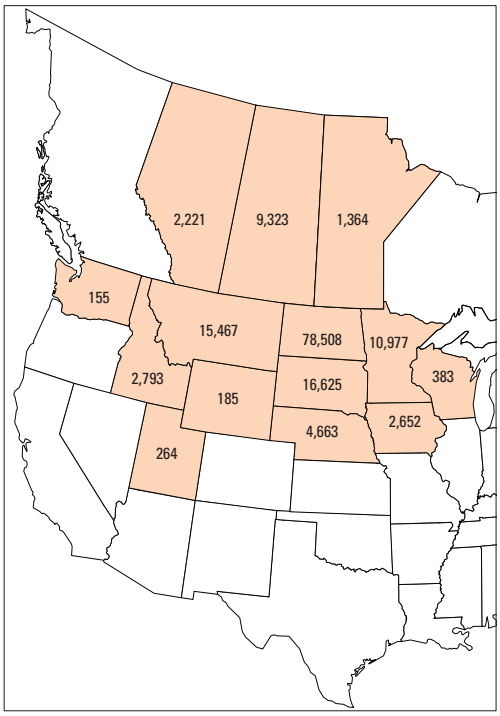
1. Provide Support to the U.S. Fish and Wildlife Service and Prairie Pothole Joint Venture for Monitoring and Management of Migratory Bird Populations

Sound management of migratory-bird breeding populations in the Prairie Pothole Region hinges on effective monitoring programs and comprehensive analyses of long-term survey data. To this end, the NPWRC provides support to the U.S. Fish and Wildlife Service (FWS) in several important areas. The Four-Square-Mile Breeding Duck and Habitat Survey was developed by the NPWRC in the mid-1980s and has been completed annually by FWS refuge personnel under leadership by their Habitat and Population Evaluation Team (HAPET) since the late 1980s. A concurrent effort to assemble and archive information on duck nest survival from studies completed by the NPWRC and dozens of partners has resulted in a database of more than 158,000 nest records spanning 66 years, 11 States, and 3 Provinces. The NPWRC, in cooperation with HAPET, periodically analyzes these two long-term datasets to improve understanding of duck settling ecology and to update estimates of duck nest survival. These and other analyses fuel decision support tools used by Prairie Pothole Joint Venture (PPJV) partners to prioritize and target conservation efforts.

Contact: Mike Anteau, manteau@usgs.gov

Collaborators: FWS, HAPET, National Wildlife Refuge System; PPJV

Timeline: Ongoing



Spatial distribution and count of nest records (1954–2020) that have been compiled and archived in the nest record file maintained at the Northern Prairie Wildlife Research Center.

2. An Evaluation of Waterfowl Breeding Ecology in the Context of Their Predator Community in Eastern South Dakota

Population growth in upland-nesting ducks is highly affected by spatial and temporal variation in nest survival, and mammalian predators are the major cause of nest failure. A graduate student from South Dakota State University (Fino, 2023), coadvised by a NPWRC scientist, has been studying predator communities and their movements in landscapes with varying grassland patch composition, while concurrently investigating nest-site selection and survival of upland duck nests. We anticipate that findings from this study will increase understanding of how grassland patches and vegetation composition, diversity, and structural heterogeneity affect predator habitat use and movements and survival of upland duck nests. We will use results to evaluate comprehensive management strategies for remnant grasslands, restoration efforts, and management programs that aim to modify grassland regimes to improve nesting habitat.

Contact: Aaron T. Pearse, apearse@usgs.gov

Collaborators: USGS South Dakota Cooperative Fish and Wildlife Research Unit (lead agency); South Dakota State University; South Dakota Department of Game, Fish, and Parks

Timeline: Fiscal years 2018–22

Products:

Fino, S.R., 2023, Relating predator community ecology and duck nest survival in eastern South Dakota, Brookings, South Dakota, South Dakota State University, Ph.D. Dissertation, 265 p.

Fino, S.R., Stafford, J.D., Pearse, A.T., and Jenks, J.A., 2019, Incidental captures of plains spotted skunks in central South Dakota: Prairie Naturalist, v. 51, p. 33–36.

Fino, S.R., Gigliotti, L.M., Stafford, J.D., and Pearse, A.T., 2023, Comparing landowner and biologist perceptions of game bird predators and management: Wildlife Society Bulletin, v. 47, p. e1443. [Also available at https://doi.org/10.1002/wsb.1443.]

3. Demographic Analysis of Waterfowl Populations

The NPWRC has a history of broad-scale demographic analyses on available waterfowl. Our current efforts are collaborative with a variety of partners. Current studies include (1) analysis of midcontinent waterfowl harvest information to identify predictable drivers of recruitment, (2) evaluation of the North American waterfowl survey for sources of changing bias in survey methods, and (3) an active research team exploring opportunities to investigate nesting ecology of waterfowl. The NPWRC recognizes the cultural and socioeconomic importance of waterfowl in North America, and each of these analyses are completed to inform pressing conservation decisions that are made by partners.

Contact: Michael J. Anteau, manteau@usgs.gov

Collaborators: FWS, HAPET and Division of Migratory Bird Management; North Dakota Game and Fish Department; Duke University

Timeline: Fiscal years 2016–Ongoing

The annual economic footprint of waterfowl hunting is more than $3 billion. Photograph by Glen Sargeant, U.S. Geological Survey.

4. Reconciling Competing Models of Temporospatial Variation in Duck Nest Survival

Conservation planning and management activities for upland-nesting ducks during the breeding season are based on decades of research. The results from the research have been distilled into various principles used to direct activities. The principle that abundant perennial-grassland cover increases nest survival has been brought into question by research proposing that nest survival is influenced by spatiotemporal variation in gross primary productivity. These conflicting models have expansive implications to allocation of conservation resources. To resolve uncertainty of which model best reflects current conditions in nest survival across the PPJV, we are

A blue-winged teal nest in grassland in the Sand Lake Wetland Management District. Photograph by Tom Koerner, U.S. Fish and Wildlife Service.

comparing two competing models of nest survival by using nest-fate data from other independent studies. Determining which model, or in which context each model, has the best performance will give managers an updated and expanded understanding of where to promote conservation actions and which actions would best meet long-standing objectives.

Contact: Aaron T. Pearse, apearse@usgs.gov

Collaborators: PPJV, FWS

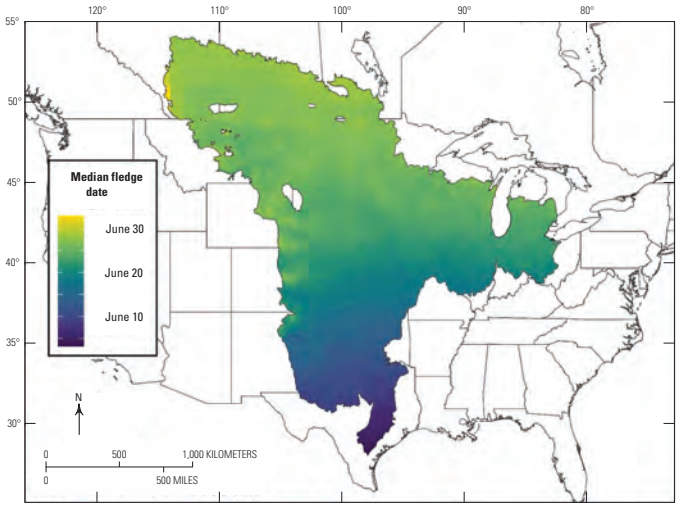
Timeline: Fiscal years 2019–22

Products:

Pearse, A.T., Anteau, M.J., Post van der Burg, M., Sherfy, M.H., Buhl, T.K., and Shaffer, T.L., 2022, Reassessing the role of perennial cover as a driver of duck nest survival, Journal of Wildlife Management, v. 86, p. e22227. [Also available at https://doi.org.10.002/jwmg.22227.]

5. Assessing Phenology of Grassland-Nesting Birds to Inform Timing of Grassland Management Activities

The NPWRC is leading a multi-agency effort to better understand the timing (phenology) of bird nests in grassland habitats of midcontinent North America. To maintain their quality, grasslands must have periodic disturbances, such as haying, grazing, or burning. However, the timing of these disturbances has population-level implications for grassland nesting birds. Accordingly, knowing the nesting phenology of grassland birds helps managers time grassland disturbances to minimize effects on these birds and inform complex management decisions. This team is taking a five-phase approach to provide iterative improvements in this information, so that our partners have the best available science to inform management decisions on working lands and the upcoming Farm Bill.



Map of United States and Canada showing model predicted median fledge date for 37 species of grassland nesting birds (Anteau and others, 2023).

Phases:

1. Meta-analysis of published information on timing of nesting for 37 grassland bird species
    a. Examine how nesting phenology varies with climate and geography, and through the years
    b. Make spatially explicit predictions for the day when one-half of nesting efforts would be complete
2. Synthesize qualitative information on timing and duration of nesting periods of grassland-nesting birds from published natural history accounts
3. Aggregation of nesting datasets and analysis of nesting phenology for 37 species that nest in grasslands of midcontinent North America (2023–24).
    a. Collaborate with researchers that conducted past nesting studies
    b. Aggregate a unifying dataset and use information within to simulate data for less represented species
    c. Examine spatial, climatological, and species-specific variation in nesting phenology
    d. Make spatially and temporally explicit predictions about when certain proportions (for example, 0.75, 0.80, 0.85, 0.90, 0.95) of grassland-nesting bird nests are no longer active

4. Quantify and evaluate patterns of nesting phenology for upland-nesting ducks across the U.S. Northern Great Plains in relation to spatiotemporal variation and environmental conditions
    a. Use a large-scale duck nest survival model, which allows estimation of nest depredation rates
    b. Examine spatial, temporal, climatological, and species-specific variation in nesting phenology of ducks in the Northern Great Plains
    c. Make spatially and temporally explicit predictions about when certain proportions (for example, 0.75, 0.80, 0.85, 0.90, 0.95) of duck nests are no longer active
5. Develop a data visualization and decision support tool
    a. Develop an interactive data visualization product that provides managers a web-based, user-friendly way to interface nesting-season duration predictions/summaries by taxa and region

Contact: Michael J. Anteau, manteau@usgs.gov

Collaborators: U.S. Department of Agriculture, Farm Service Agency, Prairie Pothole Joint Venture, U.S. Fish and Wildlife Service (Region 6, including Science Applications, Grassland Ecosystems Team; Division of Scientific Resources; Partners for Fish and Wildlife; Habitat and Population Evaluation Team), North Dakota Game and Fish Department, South Dakota Game Fish and Parks, University of Wisconsin, countless grassland nesting bird researchers

Timeline: Fiscal years 2022–24

Products:

Anteau, M.J., Ellis, K.S., MacDonald, G.J., Igl, L.D., Neimuth, N.D., and Vest, J.L., 2023, Climate-induced shifts in grassland bird nesting phenology have implications for grassland management: Global Ecology and Conservation, v. 48, e02700. [Also available at https://doi.org/10.1016/j.gecco.2023.e02700.]

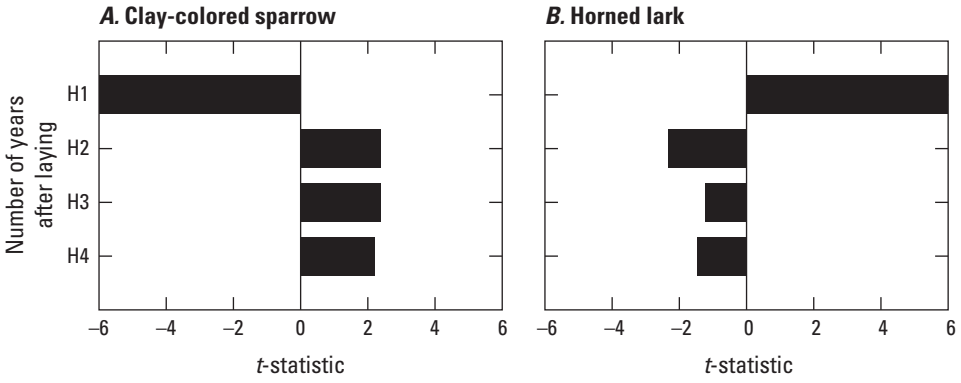
MacDonald, G.J., Anteau, M.J., Ellis, K.S., Igl, L.D., Niemuth, N.D., and Vest, J.L., 2024, Seasonal and breeding phenologies of 38 grassland bird species in the midcontinent of North America: U.S. Geological Survey Open-File Report 2024–1002, 43 p. [Also available at https://doi.org/10.3133/ofr20241002.]

6. Breeding Bird Use of Grasslands Enrolled in the Conservation Reserve Program in the Northern Great Plains

Agriculture is the dominant land use on privately owned lands in the Northern Great Plains of the United States. Management decisions on agricultural lands are heavily affected by a variety of policies and programs established by the Federal Government in periodic Farm Bills. In 1985, Congress passed the Food Security Act. Title XII of the Act established the Conservation Reserve Program (CRP), a voluntary, long-term, cropland retirement program that is available to agricultural producers to help safeguard environmentally sensitive land. From 1990 to 2017, the NPWRC evaluated breeding-bird use of several hundred grasslands enrolled in the CRP in four States (North Dakota, South Dakota, Minnesota,

Biological science technician surveying breeding birds on idle and hayed portions of a Conservation Reserve Program grassland in Sheridan County, Montana. Photograph by Lawrence D. Igl, U.S. Geological Survey.

and Montana) in the Northern Great Plains, in collaboration with the U.S. Department of Agriculture (USDA). This study is the longest evaluation of CRP grasslands for their contribution to breeding birds. Results from this study have been used by stakeholders to generate support for renewal of the CRP in subsequent Farm Bills and to make the Prairie Pothole Region a high-priority area for CRP in the United States. The results from this study also have served to inform private landowners, managers, and policy makers on program improvements for grassland birds related to CRP management (for example, haying and grazing), grassland patch size, and seeding mixtures (native compared to exotic).



The strength and direction of a bird species' response to emergency or managed haying in Conservation Reserve Program grasslands varies. The *t*-statistics or *t*-values show comparisons between idle and 1, 2, 3, and 4 years after haying (modified from Igl and Johnson, 2016).

Contact: Lawrence D. Igl, ligl@usgs.gov

Collaborators: Private landowners; USDA, Farm Service Agency and Natural Resources Conservation Service; FWS

Timeline: Fiscal years 1990–Ongoing

Products:

Elliott, L.H., Bracey, A.M., Niemi, G.J., Johnson, D.H., Gehring, T.M., Gnass Giese, E.E., Fiorino, G.E. Howe, R.W., Lawrence, G.J., Norment, C.J., Tozer, D.C., and Igl, L.D., 2023, Application of habitat association models across regions—Useful explanatory power retained in wetland bird case study: Ecosphere, v. 14, no. 5, e4499. [Also available at https://doi.org/10.1002/ecs2.4499.]

Elliott, L.H., Igl, L.D., Johnson, D.H., 2020, The relative importance of wetland area versus habitat heterogeneity for promoting species richness and abundance of wetland birds in the Prairie Pothole Region, USA: The Condor, v. 122, no. 1, 21 p. [Also available at https://doi.org/10.1093/condor/duz060.]

Igl, L.D., Buhl, D.A., Post van der Burg, M., and Johnson, D.H., 2023, Conversion of CRP grasslands to cropland, grazing land, or hayland—Effects on breeding bird abundances: Global Ecology and Conservation, v. 46, e02629. [Also available at https://doi.org/10.1016/j.gecco.2023.e02629.]

7. The Effects of Management on Grassland Birds—Literature Reviews

The ongoing decline of North American grassland bird populations has highlighted the need to better understand the habitat requirements of grassland birds and how management practices affect them. The demand for this information led to the writing of a compendium on "The Effects of Management Practices on Grassland Birds," in which more than 6,000 publications were consulted and several thousand publications were synthesized. The compendium consists of an introductory chapter, 40 species accounts, a chapter summarizing rates of cowbird parasitism for each species, and a concluding chapter. The species represent a taxonomically diverse group that includes grouse, shorebirds, owls, diurnal raptors, and songbirds. The species accounts include information on species' range, breeding habitat, area requirements, landscape associations, breeding-season phenology, brood parasitism, responses to habitat management, and management recommendations from the literature.

Contact: Lawrence D. Igl, ligl@usgs.gov; Jill A. Shaffer, jshaffer@usgs.gov

Adult male bobolink in a grazed grassland. Photographs by Lawrence D. Igl, U.S. Geological Survey.

Collaborators: PPJV; FWS, Migratory Bird Program, Denver, Colo.; U.S. Forest Service, Dakota Prairie Grasslands, Bismarck, N. Dak.; The Nature Conservancy; Plains and Prairie Potholes Landscape Conservation Cooperative; Cornell Lab of Ornithology

Timeline: Fiscal years 1996–Ongoing

Products:

Chalfoun, A.D., Johnson, T.N., and Shaffer, J.A., 2023, Rangeland songbirds, chap. 12 *of* McNew, L.B., Dahlgren, D.K., and Beck, J.L., eds., Rangeland wildlife ecology and conservation: Cham, Switzerland, Springer Nature Switzerland AG, p. 379–415. [Also available at https://doi.org/10.1007/978-3-031-34037-6_12.]

Johnson, D.H., Igl, L.D., Shaffer, J.A., and DeLong, J.P., eds., 2019, The effects of management practices on grassland birds: U.S. Geological Survey Professional Paper 1842, [variously paged]. [Also available at https://doi.org/10.3133/pp1842.]

Male lark bunting. Drawing by Christopher Goldade, U.S. Geological Survey.

The following is a list of published chapters of Johnson and others (2019); full citations are provided in the "References Cited" section at the back of this report.

Introduction; Shaffer and DeLong (2019), https://doi.org/10.3133/pp1842A

American Bittern (*Botaurus lentiginosus*); Shaffer and others (2019a), https://doi.org/10.3133/pp1842K.

Baird's Sparrow (*Centronyx bairdii*); Shaffer and others (2020a), https://doi.org/10.3133/pp1842HH.

Bobolink (*Dolichonyx oryzivorus*); Shaffer and others (2023a),

https://doi.org/10.3133/pp1842LL.

Burrowing Owl (*Athene cunicularia hypugaea*); Shaffer and others (2022), https://doi.org/10.3133/pp1842P.

Brewer's Sparrow (*Spizella breweri breweri*); Walker and others (2020), .

Brown-headed Cowbird (*Molothrus ater*) nest parasitism rates; Shaffer and others (2019b), https://doi.org/10.3133/pp1842PP.

Chestnut-collared Longspur (*Calcarius ornatus*); Shaffer and others (2020b), https://doi.org/10.3133/pp1842X.

Clay-colored Sparrow (*Spizella pallida*); Shaffer and others (2023b), https://doi.org/10.3133/pp1842Z.

Dickcissel (*Spiza americana*); Shaffer and others (2023c), https://doi.org/10.3133/pp1842OO

Eastern Meadowlark (*Sturnella magna*); Hull and others (2019), https://doi.org/10.3133/pp1842MM.

Ferruginous Hawk (*Buteo regalis*); Shaffer and others (2019c), https://doi.org/10.3133/pp1842N.

Golden Eagle (*Aquila chrysaetos*); Murphy and others (2023), https://doi.org/10.3133/pp1842O.

Grasshopper Sparrow (*Ammodramus savannarum*); Shaffer and others (2021b), https://doi.org/10.3122/pp1842GG.

Greater Prairie-Chicken (*Tympanuchus cupido pinnatus*); (Svedarsky and others, 2021), https://doi.org/10.3133/pp1842C.

Greater Sage-Grouse (*Centrocercus urophasianus*) Rowland (2019), https://doi.org/10.3133/pp1842B.

Horned Lark (*Eremophila alpestris*); Dinkins and others (2019), https://doi.org/10.3133/pp1842U.

Henslow's Sparrow (*Centronyx henslowii*); Herkert (2019), https://doi.org/10.3133/pp1842II.

Lark Bunting (*Calamospiza melanocorys*); Shaffer and others (2020c), https://doi.org/10.3133/pp1842EE.

Lark Sparrow (*Chondestes grammacus*); Shaffer and others (2021c), https://doi.org/10.3133/pp1842DD.

LeConte's Sparrow (*Ammospiza leconteii*); Shaffer and others (2020d), https://doi.org/10.3133/pp1842JJ.

Lesser Prairie-Chicken (*Tympanuchus pallidicinctus*); Jamison and others (2020), https://doi.org/10.3133/pp1842D.

Loggerhead Shrike (*Lanius ludovicianus*); Igl and others (2023), https://doi.org/10.3133/pp1842T.

Long-billed Curlew (*Numenius americanus*); Shaffer and others (2019d), https://doi.org/10.3133/pp1842G.

Marbled Godwit (*Limosa fedoa*), Shaffer and others (2019e), https://doi.org/10.3133/pp1842H.

McCown's Longspur (*Rhynchophanes mccownii*); Shaffer and others (2019f), https://doi.org/10.3133/pp1842Y.

Merlin (*Falco columbarius*); Konrad and others (2020), https://doi.org/10.3133/pp1842R.

Mountain Plover (*Charadrius montanus*); Shaffer and others (2019g), https://doi.org/10.3133/pp1842E.

Nelson's Sparrow (*Ammospiza nelsoni nelsoni*); Shaffer and others (2020e), https://doi.org/10.3133/pp1842KK.

Northern Harrier (*Circus hudsonius*); Shaffer and others (2019h), https://doi.org/10.3133/pp1842L.

Prairie Falcon (*Falco mexicanus*); DeLong and Steenhof (2020), https://doi.org/10.3133/pp1842S.

Savannah Sparrow (*Passerculus sandwichensis*); Swanson and others (2020), https://doi.org/10.3133/pp1842FF.

Sedge Wren (*Cistothorus platensis*); Shaffer and others (2020f), https://doi.org/10.3133/pp1842V.

Short-eared Owl (*Asio flammeus*); Shaffer and others (2021a), https://doi.org/10.3133/pp1842Q.

Sprague's Pipit (*Anthus spragueii*); Shaffer and others (2020g), https://doi.org/10.3133/pp1842W.

Swainson's Hawk (*Buteo swainsoni*); Shaffer and others (2019i), https://doi.org/10.3133/pp1842M.

Upland Sandpiper (*Bartramia longicauda*); Shaffer and others (2019j), https://doi.org/10.3133/pp1842F.

Willet (*Tringa semipalmata inornata*); Shaffer and others (2019k), https://doi.org/10.3133/pp1842I.

Wilson's Phalarope (*Phalaropus tricolor*); Shaffer and others (2019l), https://doi.org/10.3133/pp1842J.

8. Development of Survey Methods for Spring-Migrating Waterfowl in the Rainwater Basin

The Rainwater Basin of Central Nebraska is a midlatitude focal point of spring migration for many species of birds in the Great Plains. The RWBJV and partners desire geospatial models to identify characteristics of wetland complexes and understand local and landscape-level factors that affect habitat selection of migrating waterfowl. To support this effort, NPWRC scientists developed a monitoring strategy that incorporates the complexities of large spatial and temporal variation in ponded water during spring survey periods. Our strategy relies on the more than 10 years of surface-water data that the RWBJV has collected during spring. Development of these types of models and conservation planning tools requires long-term study; thus, the sampling strategy, which was initiated in 2017, will be completed annually for the next 5 years to collect data needed to develop models and describe habitat relationships.

Wetlands within the Rainwater Basin in south central Nebraska are randomly selected and visited multiple times each spring to count numbers of ducks and geese. Wetland and landscape characteristics corresponding to these counts will form basis of future conservation planning tools.

Contact: Aaron T. Pearse, apearse@usgs.gov

Collaborators: RWBJV; Nebraska Game and Parks Commission; Ducks Unlimited, Inc.

Timeline: Fiscal years 2017–24

9. Using Seasonal and Annual Movements to Assess Harvest Models and Monitoring Techniques of Northern Pintails in the Midcontinent of North America

For decades, researchers have developed and tested hypotheses to understand why pintail populations have underperformed compared to many other species of ducks. Considerable effort has been concentrated on developing pintail harvest strategies and models to integrate harvest management and habitat conservation. We plan to mark northern pintail (*Anas acuta*) females at breeding areas in North Dakota and wintering areas in New Mexico with intracoelomic transmitters surgically implanted by a licensed veterinarian, 2022–26, to test assumptions used in harvest management and conservation strategies for this species. Specific objectives include (1) estimating the settling location of breeding pintail females; (2) determining post-breeding movements in comparison to where birds settled and nested; and (3) describing movements and migratory patterns during autumn and winter.

A pair of northern pintails in a wetland.

Contact: Aaron Pearse, apearse@usgs.gov

Collaborators: North Dakota Game and Fish Department; FWS, Region 2 Migratory Bird Management

Timeline: Fiscal years 2022–29

10. Postfledging Movement and Habitat Selection by Mallards in the Fall and Their Effect on Spring Recruitment

Although most aspects of the annual cycle of North American mallards (*Anas platyrhynchos*) have received considerable scientific research, the period between when juveniles are capable of flight to their first southward migration remains an understudied period for all waterfowl species. This period can have implications to population recruitment and availability of birds to hunters. A graduate student from South Dakota State University (Anchor, 2022), coadvised by a NPWRC scientist, quantified movements during the postfledge period of juvenal mallards hatched in North and South Dakota. Using internally implanted transmitters that collect Global Positioning System (GPS) coordinates, we are investigating potential causes for movements of postfledging mallards, including the role of key landscape parameters in influencing habitat selection and space use. A research goal is to draw inferences of observed postbreeding movements and habitat use with respect to waterfowl hunters to assist State game agencies for conservation planning and management.

Contact: Aaron T. Pearse, apearse@usgs.gov

Collaborators: USGS South Dakota Cooperative Fish and Wildlife Research Unit (lead agency); North Dakota Game and Fish Department; South Dakota Department of Game, Fish, and Parks; South Dakota State University

Timeline: Fiscal years 2018–22

Products:

Anchor, C.E., 2022, Post-fledging habitat selection and movements of juvenile mallards in the Prairie Pothole Region, Brookings, South Dakota, South Dakota State University, M.S. Thesis, 119 p.

Pearse, A.T., Szymanski, M.L., Anchor, C.A., Anteau, M.J., Murano, R.M., Brandt, D.A., and Stafford, J.D., 2023, Factors influencing autumn-winter movements of midcontinent mallards and consequences for harvest and habitat management: Ecology and Evolution, v. 13, p. e10605. [Also available at http://doi.org/10.1002/ece3.10605.]

South Dakota State University graduate student, Cynthia Anchor, inspects a captured flightless mallard before implantation of transmitter. Photograph by Aaron Pearse, U.S. Geological Survey.

SCIENTIST SPOTLIGHT

Jay VonBank

Dr. Jay VonBank joined NPWRC in 2020 as a Research Ecologist through the USGS's Recent Graduate Pathways Program. Prior to joining NPWRC, Dr. VonBank was a postdoctoral fellow at the University of Missouri after completing his Ph.D. in Wildlife Science at Texas A&M University – Kingsville. His postdoctoral and Ph.D. research focused on movement ecology and decision-making strategies in greater white-fronted geese (*Anser albifrons*). Dr. VonBank used Global Positioning System-Accelerometer (GPS–ACC) tracking devices to understand intra- and interannual regional movements, behavioral influences on habitat use, spatiotemporal energy expenditure, and the influences of decision-making during migration on breeding performance throughout midcontinent North America. His research at NPWRC continues to use the movement ecology framework to understand effects of environmental and land-use change and individual decision-making on migratory bird population performance, particularly waterfowl.

Jay VonBank.

11. Linking Wintering and Migration Strategies to Greater White-Fronted Goose Breeding Performance

The greater white-fronted goose is an Arctic-nesting, long-distance, migratory bird with a circumpolar distribution. In North America, the midcontinent population of greater white-fronted geese nests in Taiga and Tundra ecosystems from the Interior to the North Slope of Alaska and eastward across the Canadian Arctic. Because white-fronted geese migrate long distances between breeding and wintering areas, they are exposed to a wide range of habitat types, quality, and availability, and must make behavioral and energetic decisions throughout migrations that ultimately affect fitness. Reproductive success and population performance are likely linked with different migration strategies. We are using GPS tracking devices equipped with accelerometers to understand movement strategies of midcontinent white-fronted geese. Specifically, we are investigating how

A female greater white-fronted goose is fit with a solar-powered Global Positioning System transmitter and morphometric measurements are collected. Photograph by J.D. Stanley III.

movement strategies and habitat use choices during winter translate into spring migration strategies, and how those movement strategies affect the probability of reproductive attempts and success in the subsequent breeding season. Investigations of winter movement and spring migration strategies that result in successful reproduction will provide insight into abundance trends, fill critical information gaps on how white-fronted geese cope with large-scale habitat changes during migration and winter, and improve conservation planning for North American white-fronted geese.

Contact: Jay VonBank, jvonbank@usgs.gov

Collaborators: University of Saskatchewan; Texas A&M University – Kingsville, FWS Southwest Region, Texas Parks and Wildlife Department, Louisiana Department of Wildlife and Fisheries, Arkansas Game and Fish Commission, Oklahoma Department of Wildlife Conservation

Timeline: Fiscal years 2021–27

12. Effects of Landscape and Habitat on Nesting in Northern Pintails

The northern pintail (*Anas acuta*) population has substantially declined in past decades and unlike other duck species, pintails have not recovered to their historical abundance. Declines in the pintail population are often attributed to characteristics of nesting behavior, primarily their strong association with nesting in croplands and idle grasslands. Changes in agricultural practices and breeding area landscapes further affect nesting success of pintails. Beginning in 2019, a graduate student from Texas A&M University – Kingsville and an NPWRC research scientist began using GPS devices equipped with accelerometers, combined with landscape and environmental data, to quantify factors affecting nesting propensity and nest site selection of female northern pintails. A combination of GPS locations, behaviors, and a proxy for energy expenditure derived from accelerometers is being used to understand how landscape features affect nesting propensity and nest site selection. This project is unique in that female pintails have been captured across most of their winter range to allow natural settling patterns on breeding areas. Results will improve our knowledge about life history traits of pintails during the breeding season and can be used to inform landscape and nest habitat selection planning tools used by partners for conservation planning.

Contact: Jay VonBank, jvonbank@usgs.gov

Collaborators: Texas A&M University – Kingsville, Texas Parks and Wildlife Department, Ducks Unlimited Canada

Timeline: Fiscal years 2021–24

13. Texas Mottled Duck Movement Ecology

The mottled duck (*Anas fulvigula*) is a nonmigratory resident species. The Western Gulf Coast population of the species resides primarily along the Gulf Coast of Louisiana and Texas. Mottled ducks have historically inhabited coastal marsh ecosystems and have undergone a moderate decline during the last several decades, especially apparent in the Texas portion of the population. Although the midwinter inventory surveys indicate the mottled duck population has declined along the coast, abundance estimates have recently identified increases in a noncoastal region—the South Texas Brushlands. During the last decade, midwinter survey estimates indicate that the Brushlands have accounted for as much as 76 percent of all mottled ducks counted in Texas. Because most of the Texas mottled duck population may persist in the Brushlands, NPWRC and collaborators are investigating how mottled ducks are using habitat features on this landscape, whether vital rates differ from coastal areas, and how movement rates affect connectivity with coastal areas and population estimates. Results of this research will aid in overall Federal species management, Western Gulf Coast population objectives and harvest management, and State level management actions.

Contact: Jay VonBank, jvonbank@usgs.gov

Collaborators: Texas Parks and Wildlife Department, FWS Southwest Region, Texas A&M University – Kingsville

Timeline: Fiscal years 2022–26

14. Regional Movements of Rocky Mountain Population Sandhill Cranes

The Rocky Mountain population of sandhill cranes (*Antigone canadensis*) breeds and stages in the intermountain west States of Idaho, Wyoming, Montana, and Colorado. The population is monitored by aerial survey each autumn, the results of which affect harvest allocations for each State. Recent analyses of movement data indicate the fall survey should be done later in autumn for maximum detection in northern survey areas. Currently, States use a quota system based on annual abundance, distribution, and productivity, with each State being allotted a specific quota of cranes that can be harvested each year. Managers have concerns that a survey done later than normal will affect harvest allocation among States. Therefore, understanding movements and distributions of the Rocky Mountain population of sandhill cranes prior to aerial surveys, as well as during current and proposed survey periods, is essential for understanding abundance estimates and equitable harvest allocation strategies. Current and historical GPS– global system for mobile communications (GSM) data (greater than 1,000,000 locations) from devices attached to Rocky Mountain Population sandhill cranes are being used to develop transition probabilities among States in the survey area and investigate movement effects on survey timing and subsequent harvest allocation. Results from this research will assist managers in determining effects of pre-season movements on harvest allocation to State management agencies.

Contact: Jay VonBank, jvonbank@usgs.gov

Collaborators: FWS Southwest Region

Timeline: Fiscal years 2021–23

Products:

VonBank, J.A., Collins, D.P., Ellis, K.S., Donnelly, J.P., and Knetter, J.M., 2023, Movement dynamics influence population monitoring and adaptive harvest management strategies in migratory birds: Global Ecology and Evolution, v. 48, e02715.

15. Kansas Mallard Movement Ecology

The mallard is one of the most important duck species to waterfowl hunters in Kansas and makes up greater than 50 percent of harvest. Southeast Kansas is an important area for waterfowl harvest, particularly mallards, yet there is no information of how mallards use and behave in southeast Kansas. Currently (2024), there are knowledge gaps on habitat use, selection, behaviors, or movement strategies of mallards during the fall and winter in southeast Kansas; it is imperative that land managers have current information on how waterfowl use this area to make management decisions. GPS/GSM transmitter technologies allow researchers to investigate the local and regional ecology of mallards at fine resolution. We are investigating the fall, winter, and spring, and breeding ecology of mallards captured during the late fall and early winter in southeast Kansas by way of GPS tracking devices. We will deploy more than 150 devices on adult female mallards during 2023–25 on public sanctuary. Study objectives are to investigate mallard habitat selection and energy expenditure, local and regional movements, patch-use and revisitation, spring migration, and breeding ecology. We expect that this research will inform waterfowl management because the area is likely to see increases in duck residency time during the fall and winter in the future.

Contact: Jay VonBank, jvonbank@usgs.gov

Collaborators: Kansas Department of Wildlife and Parks, University of Nebraska–Lincoln

Timeline: Fiscal years 2023–28

16. An Alternative Approach to Goose Harvest Estimation: Central Flyway Online Goose Harvest Assessment

To estimate the species and age composition of the U.S. goose harvest, the U.S. Fish and Wildlife Service annually conducts two separate surveys from a sample of hunters in each flyway: a Parts Collection Survey (PCS) used to identify age and species of goose, and the Migratory Bird Harvest Survey (i.e., Diary Survey) to estimate the total number of geese harvested. These monitoring efforts are essential to estimating annual harvest and subsequent population size, but managers have identified several potential biases that need to be addressed. In an effort to develop and evaluate an additional survey that may help to alleviate these concerns, we are developing an online/mobile application survey platform to allow goose harvest reporting of species and age directly from hunters. The study will investigate, within Central Flyway states, the design, implementation, comparability, and efficacy of an online survey methodology. This study will determine if such a survey is feasible to accurately estimate future goose harvests and reduce the identified biases, costs, burden, and time involved in the current PCS and Diary surveys. Understanding biases and assumptions in current harvest survey protocols has direct management implications as many goose harvest strategies are predicated on harvest and population estimates.

Contact: Jay VonBank, jvonbank@usgs.gov

Collaborators: Central Flyway Council, Arctic Goose Joint Venture, FWS Migratory Birds, USGS Fort Collins Science Center, North Dakota Game and Fish, Texas Parks and Wildlife Department

Timeline: Fiscal years 2024–28

17. An Accelerometer-Based Library of Waterfowl Behaviors

Recent advancements in animal tracking technologies allow for unprecedented insight into animal movements, behaviors, and decision making. One such advancement is the inclusion of onboard sensors, such as accelerometers (ACC), that record high-frequency data of fine-scale movements. Statistical advancements in machine learning allow behaviors (for example, foraging, walking, preening) to be predicted if validation data of known behaviors by way of video recordings are linked with ACC signatures. Acquiring the necessary amount of video of tagged, wild birds to accurately and precisely link ACC data with behaviors can pose multiple challenges (for example, weather, distance from tagged bird, observer effects on behavior). Behavior trials in captivity are reliable surrogates and are conducted by attaching a device to individuals, collecting video footage of behaviors, and linking those behaviors to the ACC measurements collected from the device. These behaviors can then be predicted from wild bird ACC data remotely via machine learning. The specific objectives of this project are to (1) develop an open-access library of validated behaviors and code to allow researchers to implement behavioral data in their specific studies and (2) determine optimal ACC settings (for example, frequency, burst length) and their efficiency at accurately predicting behaviors and the consequences on battery life to promote best practices for future studies.

Contact: Jay VonBank, jvonbank@usgs.gov

Collaborators: University of Saskatchewan

Timeline: Fiscal years 2024–26

18. Developing Techniques to Census and Monitor American White Pelicans and Other Colonial Waterbirds at Chase Lake National Wildlife Refuge in North Dakota

Monitoring is essential to detect colonial waterbirds and to provide insights about changes in waterbird distribution and abundance. For colonial waterbirds such as American white pelicans (*Pelecanus erythrorhynchos*), major population fluctuations often go undetected because surveys are not completed regularly, inventory methods are inconsistent, or estimates have unknown reliability. The waterbird colony at Chase Lake National Wildlife Refuge in North Dakota is one of the largest nesting colonies in the region. Abundance and species diversity of birds nesting at this refuge have generally increased but annually fluctuate. The NPWRC is assessing methods to estimate breeding populations of ground- and shrub-nesting waterbirds at Chase

Lake. The goal is to identify reliable methods for estimating abundance of different waterbird species and to provide protocols for monitoring colonial species at Chase Lake National Wildlife Refuge. The results from this study will increase our knowledge of waterbird abundance at this refuge and provide techniques for long-term monitoring of colonial waterbirds. The methods also will be applicable to other island-nesting waterbird colonies with similar attributes in the region and elsewhere.

Contact: Lawrence D. Igl, ligl@usgs.gov

Collaborators: FWS, Chase Lake Wetland Management District, Chase Lake National Wildlife Refuge, Arrowwood National Wildlife Refuge Complex

Timeline: Fiscal years 2011–24

Products:

Igl, L.D., Bartos, A.J., Woodward, R.O., Scherr, P., and Sovada, M.A., 2020, Evaluation of survey methods for colonial waterbirds at Chase Lake National Wildlife Refuge, North Dakota: U.S. Geological Survey Open-File Report 2020–1008, 44 p. [Also available at https://doi.org/10.3133/ofr20201008.]

SCIENTIST SPOTLIGHT

Rose Swift

Dr. Rose Swift joined NPWRC as a postdoctoral researcher in 2018. For her Ph.D. in Natural Resources from Cornell University, Dr. Swift focused on resighting individuals of an extreme long-distance migratory shorebird, the Hudsonian godwit (*Limosa haemastica*), throughout the annual cycle. Her research explored the causes and consequences of decisions about habitat use and species interactions on the survival, condition, and performance of individuals. At NPWRC, Dr. Swift concentrates on the ecology and conservation of migratory birds. Her research efforts are on population dynamics, effects of management actions, and habitat use questions. Her work has largely focused on least terns (*Sternula antillarum*) and the federally listed piping plovers (*Charadrius melodus*) breeding on large river and depressional wetlands, as well as prairie-breeding migratory birds and migrant shorebirds. Dr. Swift continues to collaborate with partners to employ full annual cycle conservation of listed and declining migratory birds.

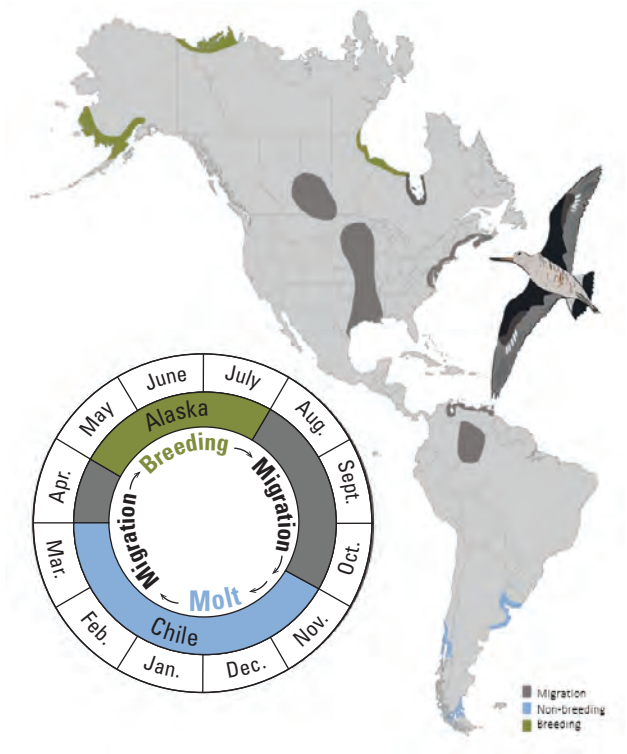
Rose Swift.

19. Identifying Population Limiting Factors of Hudsonian Godwits

Migratory species are among the most threatened on the planet and are predicted to be especially sensitive to rapid environmental change. Because of the immense scale of the movements by many migrants and the difficulty in tracking individual organisms across these large spatial scales, analyses are needed throughout the annual cycle to identify population limiting factors. This project will provide detailed answers that are relevant to our model species, the Hudsonian godwit, and to migratory species more generally. The Hudsonian godwit is among the most impressive migratory shorebirds, traveling nearly the length of North and South America. Current research topics include (1) how choices throughout the annual cycle affect survival, condition, and performance; and (2) how density-dependent heterospecific interactions and phenological mismatches affect populations. This study will inform conservation decisions that are made by partners throughout the annual cycle and identify conservation priorities related to changes in climate conditions, habitat quality, and species interactions.

Contact: Rose Swift, rswift@usgs.gov

Collaborators: University of South Carolina; University of Massachusetts, Amherst; USGS Alaska Science Center; FWS Migratory Bird Division; Cornell Lab of Ornithology



A graphic representation of the Hudsonian Godwit annual cycle (left) and year-round range (right).

Timeline: Fiscal years 2019–23

Products:

Swift, R.J., Rodewald, A.D., Johnson, J.A., Andres, B.A., and Senner, N.R., 2020, Seasonal survival and reversible state effects in a long-distance migratory shorebird: Journal of Animal Ecology, v. 89, no. 9, p. 2043–2055. [Also available at https://doi.org/10.1111/1365-2656.13246.]

Swift, R.J., Rodewald, A.D., MacDonald, G.J., and Senner, N.R., 2023, Perceived risks and rewards of foraging sites strongly affect density and condition of non-breeding Hudsonian Godwits: Ibis, v. 165, no. 4, p. 1169–1185. [Also available at https://doi.org/10.1111/ibi.13194.]

Wilde, L.R., Simmons, J.E., Swift, R.J., and Senner, N.R., 2022, Dynamic sensitivity to resource availability influences population responses to mismatches in a shorebird: Ecology, v. 103, no. 9, p. e3743. [Also available at https://doi.org/10.1002/ecy.3743.]

Wilde, L.R., Swift, R.J., and Senner, N.R., 2022, Behavioural adjustments in the social associations of a precocial shorebird mediate the costs and benefits of grouping decisions: Journal of Animal Ecology, v. 91, no. 4, p. 870–882. [Also available at https://doi.org/10.1111/1365-2656.13679.]

20. Predicting Climatic Impacts on the Network of Migratory Stopover Sites for Hudsonian Godwits in the Northern Great Plains

Hudsonian Godwits foraging along a wetland shoreline in South Dakota. Photograph by Jennifer Linscott, University of South Carolina.

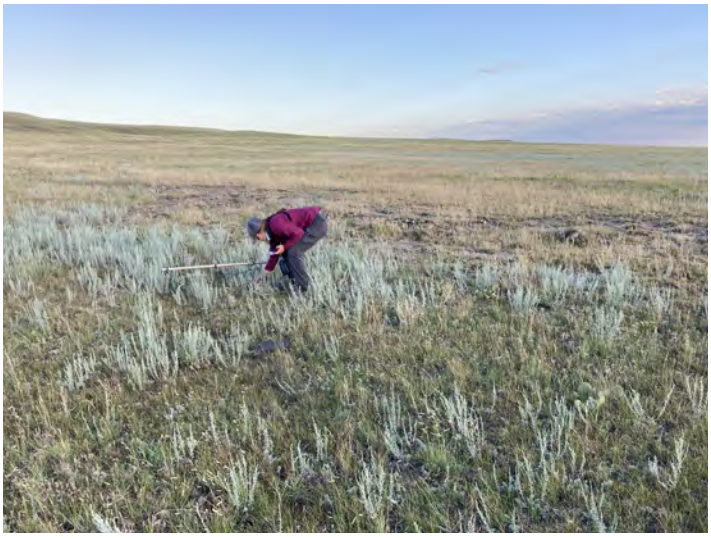
Migratory shorebird populations are undergoing steep declines over much of North America, and migration and migratory stopover sites have become increasingly recognized as critical components of the annual cycle. Hudsonian godwits are an extreme long-distance migrant that during northbound migration make a nonstop flight from nonbreeding areas in the Southern Cone of South America to the Great Plains and a second nonstop flight to breeding areas in the sub-Arctic, making godwits uniquely reliant on the hydrology of the Prairie Pothole Region. This graduate-student-led project, in collaboration with an NPWRC scientist, will address questions critical to our understanding of migratory stopovers using Hudsonian godwits as a model shorebird species. Using repeated surveys spanning the Northern Great Plains, the occurrence and abundance of godwits and the characteristics of used stopover sites will be determined. Ultimately, the aim is to examine the implications of climatic change on the distribution, synchrony, and availability of ephemeral wetlands that serve as stopover habitat for godwits and identify any spatiotemporal gaps in habitat to help conservation practitioners make informed decisions for future conservation and management priorities.

Contact: Rose Swift, rswift@usgs.gov

Collaborators: University of South Carolina; University of Massachusetts, Amherst

Timeline: Fiscal years 2021–24

21. Developing Research Tools for Demographic Study of Thick-Billed Longspurs



Field researcher deploying a horizontal mist net over a speaker used as an audio lure in native short-grass prairie. Photograph by Megan Ring, U.S. Geological Survey.

Grassland birds have recently undergone steep declines, with species like the thick-billed longspur (*Rhynchophanes mccownii*) having lost more than 90 percent of their population during the last 50 years. Habitat loss and degradation have been assumed to be a primary cause for grassland bird declines. To identify limiting factors throughout the annual cycle and estimate demographic vital rates, researchers must be able to capture, mark, and reencounter thick-billed longspurs, which have received little research attention. NPWRC scientists partnered with the FWS to develop techniques and to refine field efforts to estimate breeding season adult survival and fecundity of thick-billed longspurs in native prairie and cropland habitats in eastern Montana. NPWRC trialed various methods

for capturing adult and hatch-year thick-billed longspurs, evaluated the efficacy of multiple mark-reencounter regimes, and tested different reencounter strategies in an effort to set up future studies to fill knowledge gaps and aid effective conservation and management for thick-billed longspurs.

Contact: Rose Swift, rswift@usgs.gov

Collaborators: FWS, Division of Migratory Bird Management; FWS, Migratory Bird Program; FWS, Partners for Fish and Wildlife Program

Timeline: Fiscal years 2021–24

22. Implementation of a Breeding Landbird Banding Station at NPWRC

Conservation of bird populations requires detailed information about causes of declines and threats, but long-term monitoring is needed to identify species that require further studies. NPWRC participates in several monitoring programs that collaboratively collect data at large spatial scales (for example, the Audubon Christmas Bird Count, North American Breeding Bird Survey routes, and waterfowl banding with Flyway partners). These important programs contribute to annual information on bird populations and harvest management recommendations, but they fail to provide the necessary data to estimate vital rates for landbirds (passerines and near-passerines). In response to this need, the Institute for Bird Populations created the collaborative Monitoring Avian Productivity and Survivorship (MAPS) program which uses standardized, constant-effort mist-netting and banding during the breeding season to provide annual indices of adult population size, productivity, adult survival, recruitment, and population growth rates for North American landbirds. Initiated in 1989, the MAPS program has spawned about 1,200 banding stations that have collected data on avian productivity and survival in nearly every U.S. State and Canadian Province. Establishment of a MAPS banding operation at NPWRC has several benefits including to aid in staff training and skill maintenance, to provide the foundation for outreach events, and to contribute to a large-scale collaborative dataset on avian vital rates that will aid researchers in their efforts to conserve and manage landbird populations nationwide.

Field researcher holding a Common Grackle (*Quiscalus quiscula*) and writing down data after banding it. Photograph by Rose Swift, U.S. Geological Survey.

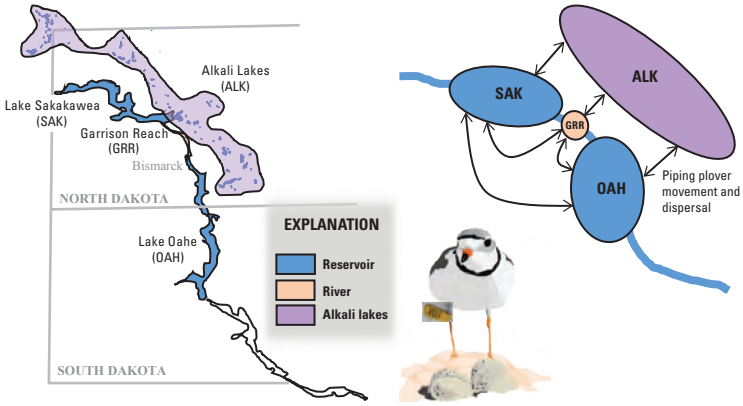
Contact: Rose Swift, rswift@usgs.gov

Collaborators: The Institute for Bird Populations

Timeline: Fiscal years 2023–28

Listed Birds

23. Population Dynamics of Piping Plovers in the Northern Great Plains



Study areas within the Northern Great Plains (left) and a graphic representation of movements and dispersal between the project-defined study areas (right).

The NPWRC is leading a multiagency regional study to understand population structure and dynamics of piping plovers (*Charadrius melodus*) in the Northern Great Plains. Piping plovers are a federally listed species that nests on riverine sandbars and shorelines of wetlands and reservoirs. These habitats are dynamic in response to climate and water-management regimes of the Missouri River. The USACE manages the Missouri River for hydropower, recreation, water supply, navigation, flood control, and fish and wildlife. That management strategy puts piping plovers in jeopardy. Accordingly, the USACE has prepared to spend more than 10 million U.S. dollars a year for the foreseeable future to create breeding habitat for plovers on the Missouri River. Additionally, the other key areas where plovers breed, wetlands in the Prairie Pothole Region, are under threat from changing climate and land-use practices. During 2019, NPWRC completed the final year of a 6-year field study that involved marking adults and chicks with alphanumeric color bands and resighting them at breeding areas throughout the Northern Great Plains. This study has provided population demographic and dispersal information that will inform decisions about management, conservation, and recovery of this species, as well as informing management of the Missouri River.

Contact: Michael J. Anteau, manteau@usgs.gov

Collaborators: USACE, Omaha District, Threatened and Endangered Species Section; Missouri River Recovery Implementation Committee; FWS, North Dakota Ecological Services Field Office and Region 6 Refuge System; The Nature Conservancy

Timeline: Fiscal years 2014–24

Products:

Anteau, M.J., Swift, R.J., Sherfy, M.H., Koons, D.N., Ellis, K.S., Shaffer, T.L., Toy, D.L., and Ring, M.M., 2022, Experimental evaluation of predator exclosures on nest, chick, and adult survival of piping plovers: Journal of Wildlife Management, v. 86, no. 1, 21 p. [Also available at https://doi.org/10.1002/jwmg.22139.]

Swift, R.J., Anteau, M.J., Ellis, K.S., Ring, M.M., Sherfy, M.H., and Toy, D.L., 2021, Dispersal distance is driven by habitat availability and reproductive success in Northern Great Plains piping plovers: Movement Ecology, v. 9, no. 1, p.1–14. [Also available at https://doi.org/10.1186/s40462-021-00293-3.]

Swift, R.J., Anteau, M.J., Ellis, K.S., Ring, M.M., Sherfy, M.H., Toy, D.L., and Koons, D.N., 2021, Spatial variation in population dynamics of northern great plains piping plovers: U.S. Geological Survey Open-File Report 2020–1152, 211 p. [Also available at https://doi.org/10.3133/ofr20201152.]

Swift, R.J., Anteau, M.J., Ellis, K.S., Ring, M.M., Sherfy, M.H., Toy, D.L., and Koons, D.N., 2022, Implications of habitat-driven survival and dispersal on recruitment in a spatially structured piping plover population: Ecosphere, v. 13, no. 7, p. e4190. [Also available at https://doi.org/10.1002/ecs2.4190.]

Swift, R.J., Anteau, M.J., Ellis, K.S., Ring, M.M., Sherfy, M.H., and Toy, D.L., 2023, Conspecific density and habitat quality affect breeding habitat selection: Support for the social attraction hypothesis: Ecosphere, v. 14, no. 5, p. e4524. [Also available at https://doi.org/10.1002/ecs2.4524.]

Swift, R.J., Anteau, M.J., Ring, M.M., Toy, D.L., and Sherfy, M.H., 2020, Low renesting propensity and reproductive success make renesting unproductive for the threatened Piping Plover (*Charadrius melodus*): The Condor, v. 122, no. 2, 18 p. [Also available at https://doi.org/10.1093/condor/duz066.]

Swift, R.J., Anteau, M.J., Roche, E.A., Sherfy, M.H., Toy, D.L., and Ring, M.M., 2020, Asymmetric benefits of a heterospecific breeding association vary with habitat, conspecific abundance and breeding stage: Oikos, v. 129, no. 10, p. 1504–1520. [Also available at https://doi.org/10.1111/oik.07256.]

24. Breeding Ecology and Demographics of Least Terns and Piping Plovers at the Central Platte River, Nebraska

U.S. Geological Survey field crew members nest searching for piping plover and least tern nests on a sandpit near the Central Platte River (U.S. Geological Survey photograph).

The Platte River Recovery Implementation Program (PRRIP) partnered with the NPWRC to study demographics of least terns and piping plovers at the Central Platte River in Nebraska. Because of water management and other alterations, riverine habitat for least terns and piping plovers has become degraded. Least terns and piping plovers, however, have begun breeding on sandpits that are immediately adjacent to the river. The NPWRC marked adults and chicks and resighted them to provide additional data for the PRRIP's monitoring practices. The NPWRC also analyzed data to provide information on dispersal, fidelity, and use of newly constructed or managed habitats that will be useful to make decisions to aid in the conservation and recovery of these species. In addition, results from the banding efforts along the Central Platte River have contributed to information for the NPWRC population dynamics study of piping plovers of the Northern Great Plains.

Contact: Michael J. Anteau, manteau@usgs.gov

Collaborators: PRRIP; Nebraska Public Power District; Nebraska Game and Parks Commission; Central Platte Natural Resources District; Crane Trust

Timeline: Fiscal years 2010–22

Products:

Sherfy, M.H., Ring, M.M., Stucker, J.H., Anteau, M.J., Shaffer, T.L., and Sovada, M.A., 2021, Foraging movements and colony attendance of least terns (*Sternula antillarum*) on the Central Platte River, Nebraska, USA: Waterbirds, v. 44, no. 1, p. 38–54. [Also available at https://doi.org/10.1675/063.044.0104.]

25. Population Demographics of Least Terns and Piping Plovers in Colorado

The NPWRC is helping to improve the monitoring of federally listed least terns and piping plovers by the USACE at John Martin Reservoir in southeastern Colorado. The NPWRC is providing information to the USACE to improve their habitat management and productivity monitoring. The NPWRC also is providing the capability to mark adults and chicks with alphanumeric color bands during a 5-year period that began in 2017. The USACE's monitoring program will benefit from having the population of least terns and piping plovers that use this area uniquely marked because the information will help to estimate recruitment and fidelity to breeding areas. The monitoring of marked birds at John Martin Reservoir as well as marked birds in other areas will answer broader questions about how isolated these populations are from other breeding areas. In addition, these banding efforts will contribute information for the NPWRC metapopulation study of piping plovers of the Northern Great Plains.

Least tern and piping plover monitoring staff and U.S. Army Corps of Engineers staff observe piping plover nest on John Martin Reservoir. Photograph by Dustin Toy, U.S. Geological Survey.

Contact: Dustin L. Toy, dtoy@usgs.gov

Collaborators: USACE, Albuquerque District; Colorado Parks and Wildlife

Timeline: Fiscal years 2016–26

26. Improving Monitoring Techniques for Nests of Interior Least Terns and Piping Plovers

Federally listed least terns and piping plovers are the subject of numerous large-scale population monitoring efforts that are used to assess needs and outcomes of management actions. Population monitoring requires periodic researcher visits to nesting areas to count and assess breeding status of the birds. At higher visit frequencies, detection of nests and chicks improves as does ability to determine outcomes of nesting attempts, resulting in more complete and accurate information about productivity. However, frequent visits may affect productivity of the birds by altering nest attendance or behavioral patterns. A University of North Dakota graduate student, coadvised by a NPWRC scientist, used concealed miniature video cameras to (1) observe responses of nesting Missouri River least terns and piping plovers to human activities typically associated with population monitoring (that is, nest visits, adult trapping, and chick banding), (2) evaluate accuracy of nest fate (success compared to failure) determined by field evidence obtained at various visitation frequencies, and (3) describe composition of the nest predator community on the Missouri River. Results from this study will aid management agencies in designing accurate population monitoring programs that minimize effects on the birds, thereby improving quality of monitoring datasets and contributing to species recovery.

Nocturnal image of a great-horned owl depredating a least tern nest on the Missouri River. Photograph by Alicia Andes, University of North Dakota.

Contact: Mark H. Sherfy, msherfy@usgs.gov

Collaborators: FWS, North Dakota Ecological Services Field Office; USACE, Omaha District, Threatened and Endangered Species Section; University of North Dakota

Timeline: Fiscal years 2015–21

Products:

Andes, A.K., Sherfy, M.H., Shaffer, T.L., and Ellis-Felege, S.N., 2020, Plasticity of least tern and piping plover nesting behaviors in response to sand temperature: Journal of Thermal Biology, v. 91, 9 p. [Also available at https://doi.org/10.1016/j.jtherbio.2020.102579.]

27. Legacy Data Analysis—Northern Great Plains Least Terns and Piping Plovers

The NPWRC has been conducting research on federally listed least terns (*Sternula antillarum*; endangered but downlisted in 2021) and piping plovers (*Charadrius melodus*; threatened) on major river systems, reservoirs, and wetland habitats in the Northern Great Plains since 2005. Numerous directed studies that focused on management priorities of the USACE, the FWS, and the PRRIP have generated large and diverse datasets on productivity, nesting ecology, habitat use, and movements of these species. These datasets have been extensively analyzed, resulting in dozens of journal articles, reports, and presentations to professional societies and partner organizations. Despite this ample body of work, opportunity remains for further data integration and exploration at previously infeasible temporal and spatial scales, as well as building on published results to meet contemporary management and monitoring needs. Specific questions will focus on demographic monitoring design, variable incubation lengths and clutch sizes, foraging movements of least terns on the Missouri River, and annual survival rates of least terns in the Northern Great Plains. Resulting products will aid in refining management and monitoring priorities for both species in their midcontinent ranges.

Contact: Mark H. Sherfy, msherfy@usgs.gov

Collaborators: FWS; USACE, Omaha District, Threatened and Endangered Species Section

Timeline: Fiscal years 2021–27

SCIENTIST SPOTLIGHT

Kristen Ellis

Dr. Kristen Ellis joined NPWRC as a Student Services Contractor in 2019 after completing her Ph.D. in Fish, Wildlife, and Conservation Biology at Colorado State University. Dr. Ellis' Ph.D. research focused on the breeding ecology of snowy plovers (*Charadrius nivosus*) and roles of shorebird nest predators, while using trail cameras to monitor nests. She developed an analytical framework for partitioning different sources of nest failure, which can be used by natural resource managers to understand how effective management actions might be for improving avian productivity when certain nest predators are present. In 2020, Dr. Ellis was hired at NPWRC as a Research Ecologist through the USGS's Recent Graduate Pathways Program. Since arriving at NPWRC, Dr. Ellis has further developed her quantitative skills focused on landscape ecology, predicting distributions, and other geospatial tools. Her research is focused on migratory bird ecology and understanding how environmental threats during different periods of the annual cycle affect population dynamics and species-habitat associations.

Kristen Ellis.

28. Identifying Important Habitat, Developing Inexpensive Habitat Monitoring, and Developing Habitat-Based Abundance Estimates for Piping Plovers at Wetland Habitats in the Prairie Pothole Region

Alkaline wetland in the Prairie Pothole Region featuring bare shorelines where piping plovers nest (U.S. Geological Survey photograph).

The NPWRC is leading a multiagency regional study to understand habitat features used by piping plovers at wetlands across the U.S. Prairie Pothole Region. Piping plovers are a federally listed species that nest throughout the Prairie Pothole Region on shorelines of wetlands. Recent research suggests that climate and land changes are decreasing the amount of available habitat for piping plovers at wetlands of the Prairie Pothole Region. A complete inventory of plover habitat for the wetlands of the Prairie Pothole Region is a component of the species recovery plan; but, the inventory has not been completed. The objectives of this project are to (1) define nesting habitat for piping plovers at prairie wetlands considering fine- and broad-spatial scale habitat features, (2) develop procedures for monitoring piping plover nesting habitat using remote sensing, (3) apply monitoring procedures to existing datasets to produce Prairie Pothole Region habitat maps for 2000–21, (4) evaluate habitat features that influence nesting density and evaluate annual nesting density variability, (5) examine temporal trends in habitat abundance during 2000–2021, (6) apply nest density to habitat relationships to predict the numbers of piping plover pairs in the U.S. Northern Great Plains during 2000–21, and (7) develop multiple options

and estimates of required effort for a piping plover monitoring program for the U.S. Northern Great Plains. Ultimately, having a model that can annually predict the abundance and location of plover habitat and the distribution of breeding piping plovers in the Prairie Pothole Region during early summer would (1) allow for predictions of breeding piping plover distribution, (2) improve efficiency of existing demographic monitoring of this population, (3) allow for evaluation of temporal trends in habitat abundance, (4) provide annual habitat abundance estimates that could be used to evaluate progress toward species recovery benchmarks, (5) provide the means to evaluate underlying mechanisms driving plover movement between Missouri River breeding areas and prairie wetland breeding areas, and (6) improve the ability of the FWS to rapidly respond to development requests (for example, oil, gas, or wind-energy development) in areas that may impact breeding plovers.

Contact: Kristen S. Ellis, kellis@usgs.gov

Collaborators: FWS, North Dakota Ecological Services Field Office and Region 6 Refuge System; The Nature Conservancy

Timeline: Fiscal years 2020–23

Products:

Ellis, K.S., Anteau, M.J., MacDonald, G.J., Swift, R.J., Ring, M.M., Toy, D.L., Sherfy, M.H., and Post van der Burg, M., 2023, Data integration reveals dynamic and systematic patterns of breeding habitat use by a threatened shorebird: Scientific Reports, v. 13, p. 6087. [Also available at https://doi.org/10.1038/s41598-023-32886-w.]

Ellis, K.S., Anteau, M.J., MacDonald, G.J., Ring, M.M., Sherfy, M.H., Swift, R.J., and Toy, D.L., 2024, Assessing trade-offs in developing a landscape-scale nest monitoring program for a threatened shorebird: Ecological Solutions and Evidence, v. 5, p. e12308. [Also available at https://doi.org/10.1002/2688-8319.12308.]

29. Optimizing Habitat Restoration Efforts for Great Lakes Piping Plovers Under Climate Change Uncertainty

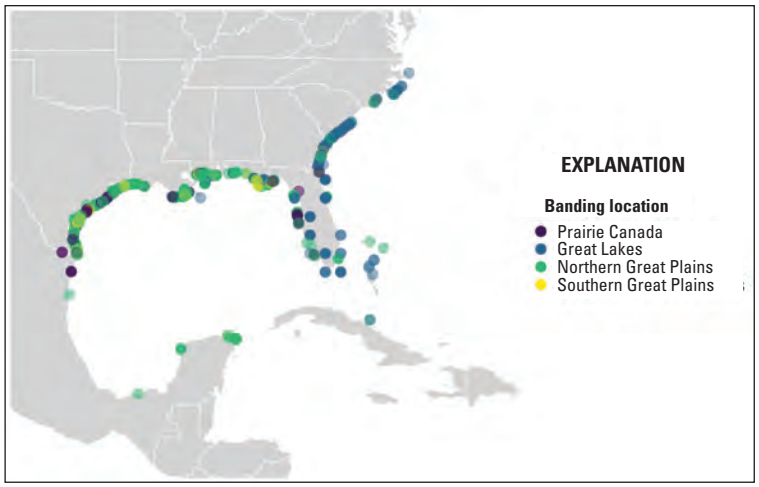
NPWRC scientists initiated a study funded by the Great Lakes Restoration Initiative to assess piping plover breeding habitat availability under climate change uncertainties. Of the three recognized breeding populations of piping plovers, the Great Lakes population is considered to be the most imperiled and is solely listed as endangered. Habitat loss and degradation from development and increased disturbances from recreational use of shorelines along the Great Lakes are primary drivers of population declines. The extent to which population growth of Great Lakes piping plovers continues to be limited by breeding habitats is poorly understood, primarily because unvegetated shorelines are transient over time and estimates of available habitat can be difficult to obtain. The objectives of the study are to (1) develop predictive piping plover breeding habitat maps under past and current conditions in the Great Lakes that are informed by a long-term dataset of nest locations and (2) simulate changes in habitat suitability under various climate scenarios, evaluate restoration feasibility, and identify sites that may be more resilient to change. This study will provide information on habitat conditions and restoration potential under environmental variability for conservation practitioners in the Great Lakes.

Contact: Kristen S. Ellis, kellis@usgs.gov

Collaborators: FWS, Michigan Ecological Services Field Office; University of Minnesota; National Park Service, Sleeping Bear Dunes National Lakeshore

Timeline: Fiscal years 2024–25

30. Impacts of Extreme Disturbances at Wintering Areas on Piping Plover Survival and Migratory Connectivity



Winter season locations of piping plovers on the Atlantic and Gulf of Mexico coasts between 2002 and 2019. Dot colors indicate breeding areas where individuals were first banded.

The NPWRC initiated a collaborative study to assess the influence of the wintering season on piping plovers that breed across the Great Plains of the United States and Canada and the Great Lakes of the United States. Piping plovers primarily spend the nonbreeding season along the Gulf of Mexico and Atlantic coasts of North America. In these nonbreeding areas, piping plovers can periodically experience extreme environmental disturbances, including oil spills, harmful algal blooms, and hurricanes. Recent evidence has suggested that these environmental disturbances, particularly hurricanes and harmful algal blooms, are increasing in frequency in part because of climate change. The objectives of this project are to (1) evaluate how extreme environmental disturbances impact adult survival and (2) quantify migratory connectivity for piping plovers breeding within the midcontinent of North America. We analyzed coastal mark-resight data collected by NPWRC, collaborators, and community members on piping plovers from 2002 to 2020. Information gained from this analysis will provide seasonal insights into the population dynamics of piping plovers and lead to better-informed conservation strategies for the species.

Contact: Kristen S. Ellis, kellis@usgs.gov; Michael J. Anteau, manteau@usgs.gov

Collaborators: Environment Canada; University of Minnesota; Nebraska Game and Parks Commission; Colorado State University; Coastal Bend Bays and Estuaries Program; University of Nebraska–Lincoln

Timeline: Fiscal years 2020–21

Products:

Ellis, K.S., Anteau, M.A., Cuthbert, F.J., Gratto-Trevor, C.L., Jorgensen, J.G., Newstead, D.J., Powell, L.A., Ring, M.M., Sherfy, M.H., Swift, R.J., Toy, D.L., and Koons, D.N., 2021, Impacts of extreme environmental disturbances on piping plover survival are partially moderated by migratory connectivity: Biological Conservation, v. 264, 11 p.. [Also available at https://doi.org/10.1016/j.biocon.2021.109371.]

31. Assessment of Northern Great Plains Piping Plover Population Viability and Trends

Piping plovers are listed under the Endangered Species Act of 1973 (Public Law 93–205) throughout their range, and despite years of monitoring and research, trends for separate breeding areas in the Northern Great Plains population are still unknown. Recently completed work indicated that two spatially distinct breeding groups within the Northern Great Plains are highly connected through dispersal, which previous simulations had shown to increase breeding group and population extinction risk. NPWRC scientists are evaluating population trends for Northern Great Plains piping plovers by updating the most recent population viability assessment to take advantage of recent estimates of connectivity among breeding groups. We aim to evaluate extinction probabilities, population trends, and predicted population abundance for the next 50 years to inform population recovery. We will also explore how potential management scenarios (for example, increasing nest caging efforts) might affect population trends. An update of the estimates within the population viability assessment will ultimately aid FWS in recovery planning for the Northern Great Plains piping plover.

Contact: Rose J. Swift, rswift@usgs.gov

Collaborators: FWS, Missouri River, North and South Dakota Ecological Services Field Offices

Timeline: Fiscal years 2021–22

Products:

Swift, R.J., Anteau, M.J., Ellis, K.S., MacDonald, G.J., Ring, M.M., Sherfy, M.H., and Toy, D.L., 2023, Estimating population viability of the northern Great Plains piping plover population considering updated population structure, climate change, and intensive management: Frontiers in Bird Science, v. 2, p. 1157682. [Also available at https://doi.org/10.3389/fbirs.2023.1157682.]

32. Demographic Analysis of Least Terns and Piping Plovers

The NPWRC has a long history of collaborating with other researchers on listed piping plovers and recently delisted least terns in the Northern Great Plains. In the Lower Platte River system, piping plovers and least terns often use human-created habitats (for example, gravel mines and lakeshore developments), but these habitats are expected to decline in the future. A University of Nebraska–Lincoln graduate student is conducting demographic analyses to understand nest, chick, and adult survival as well as chick growth rates for piping plovers and least terns on human-created off-river nesting sites in the Lower Platte River system. This study will help inform future management and the role of off-river nesting areas in sustaining populations of these species in the region.

Contact: Rose J. Swift, rswift@usgs.gov

Collaborators: University of Nebraska–Lincoln; Tern and Plover Conservation Partnership; Nebraska Game and Parks Commission

Timeline: Fiscal years 2022–25

33. Developing New Understandings of Piping Plover Breeding Habitat Suitability and Quality for Missouri River Sandbars

On the Missouri River, piping plovers nest on riverine sandbars and reservoir shorelines. Although broad- to fine-scale habitat requirements and their dynamics have been quantified for plovers using reservoir shorelines, an empirically based description of breeding habitat is lacking for plovers using riverine stretches of the Missouri River. At the request of the USACE, NPWRC scientists annually measure land-cover features (for example, unvegetated, sparsely vegetated, or vegetated emergent sand) of the riverine stretches of the Missouri River using remotely sensed satellite imagery. The USACE has devised a methodology for classifying a portion of those land-cover features as piping plover nesting habitat, which depends upon two assumptions: (1) that historical descriptions of piping plover nesting habitat are accurate even though they were based on studies that had small sample sizes and used methods now regarded as outdated; and (2) that each land-cover class translates to the on-the-ground definition of piping plover nesting habitat from those historical studies. The goals of this study are to (1) improve the definition of suitable nesting habitat for piping plovers breeding on sandbars of the Missouri River using rigorous selection versus availability approaches and considering features at multiple scales; (2) examine if selected nesting habitats lead to successful outcomes; (3) identify habitat features that are important for successful chick rearing; and (4) identify habitat features or conditions that lead to utilization and abundance of hatched nests and fledged chicks. This research effort will inform several critical uncertainties for the USACE and its management of the Missouri River and its habitat resources for nesting piping plovers.

Contact: Rose J. Swift, rswift@usgs.gov

Collaborators: USACE, Omaha District, Threatened and Endangered Species Section

Timeline: Fiscal years 2023–27

34. An Experimental Assessment of the Influence of Nest Exclosures ("Nest Cages") on Nest, Chick, and Adult Survival for Piping Plovers Breeding on Missouri River Sandbars

For listed species, one critical question is how different management actions may be able to improve survival and productivity to aid in population recovery efforts. Management actions need to be evaluated to ensure that they measurably improve survival or productivity, that any unintended negative consequences on other population vital rates are understood and estimable, and that actions are cost-effective and efficient. For piping plovers, the use of nest exclosures (that is, "cages") is one such management action where the presumed benefit, potential for negative side effects with population-level consequences, and decisions under which conditions implementation should occur are still unclear. The objectives of this study are to (1) evaluate the effectiveness of using nest exclosures to improve fecundity (that is, nest and chick survival); (2) examine if nest exclosures lead to negative consequences for adult plovers (that is, within-season and annual adult survival); (3) detect if increased nest survival may reduce fledgling rates via density dependent effects; and (4) identify how different intensities of caging may affect vital rates to improve our understanding of an optimal proportion of nests to cage. This research effort will provide information that would inform decisions toward management of Missouri River plover population survival and productivity.

Contact: Rose J. Swift, rswift@usgs.gov

Collaborators: USACE, Omaha District, Threatened and Endangered Species Section

Timeline: Fiscal years 2024–29

Whooping Cranes

35. Cumulative Impacts of Energy Development and Other Anthropogenic Stressors for Migrating Whooping Cranes

Whooping cranes encounter many human and natural disturbances during migration, including roads, development, agricultural activities, recreational activities, energy extraction, and predators. However, the level of exposure to potential disturbances and the relative magnitude of their effects, individually and collectively, are unknown. Understanding how disturbances influence whooping crane distribution during migration will provide insights for managers on how to determine potential effects to the population when consulting with developers under the Endangered Species Act.

Contact: Aaron T. Pearse, apearse@usgs.gov

Collaborators: Environment and Climate Change Canada, FWS

Timeline: Fiscal years 2020–21

Whooping cranes foraging in a harvested agricultural field in South Dakota. Photograph by Chris Bailey.

36. Identifying Potential Whooping Crane Migration Habitat for Assessing Risk of Disturbance

Whooping cranes encounter many human and natural disturbances during migration, including roads, development, agricultural activities, recreational activities, energy infrastructure, and predators. However, the level of exposure to potential disturbances and the relative magnitude of their effects, individually and collectively, are unknown. The Nebraska Army National Guard conducts year-round training and operational missions across Nebraska and other States in the whooping crane migration corridor. Of these operations, helicopter flights, primarily those at lower altitudes, constitute potential disturbances to whooping cranes during spring and autumn migrations. We are developing predictive maps representing relative probability of locations used by migrating whooping cranes to allow managers to assess potential exposure to disturbances related to National Guard activities and make more informed management plans.

Contact: Aaron T. Pearse, apearse@usgs.gov

Collaborators: Nebraska Army National Guard, U.S. Army Engineer R&D Center

Timeline: Fiscal years 2020–21

Products:

Ellis, K.S., Pearse, A.T., Brandt, D.A., Bidwell, M.T., Harrell, W., Butler, M.J., and Post van der Burg, M., 2022, Balancing siting of future energy infrastructure and associated habitat loss for migrating whooping cranes: Frontiers in Ecology and Evolution, v. 10, p. 931260. [Also available at https://doi.org/10.3389/fevo.2022.931260.]

37. Whooping Crane Flight Behavior to Support Aircraft-Bird Collision Risk Assessments at U.S. Air Force Installations

Interactions between whooping cranes and military aircraft constitute risk for the U.S. Air Force and the recovery of whooping cranes, and little is known regarding whooping crane use of areas surrounding U.S. Air Force bases in the Great Plains. The Kegelman airfield is within 6 kilometers of Salt Plains National Wildlife Refuge in northern Oklahoma, and the refuge has been designated as critical habitat for whooping cranes. Twenty-seven percent of marked whooping cranes stopped in this refuge each migration from 2010 to 2016. Information on migration timing, crane flight altitudes, and crane flight pathways can assist the U.S. Air Force in assessing potential risk to aircraft and pilots. The FWS also can use this information in developing appropriate avoidance and minimization measures that would reduce the risk of incidental take of this endangered species and, thus, support the recovery of whooping cranes.

Contact: Aaron T. Pearse, apearse@usgs.gov, 701–253–5509

Collaborators: U.S. Air Force; FWS Texas Ecological Services Field Office, Salt Plains National Wildlife Refuge

Timeline: Fiscal years 2020–24

Pollinators

38. Understanding How Land-Use Change in the Northern Great Plains Affects Pollinator Health and Pollination Services

A researcher conducts a health assessment on a honey bee colony in North Dakota. Photograph by Katie Lee, U.S. Geological Survey

Societal dependence on insects for pollination of agricultural crops has risen amidst concerns about global pollinator declines. Habitat loss and lack of forage have been implicated in the decline of managed and native pollinators in the United States. The NPWRC is leading a regional research project to understand how land use affects honey bee colony health and economic revenues received by beekeepers during the subsequent pollination season. Specifically, we are investigating how land use affects honey bee colony population size during the growing season (May–September) and if these effects have subsequent effect on colony population size and survival for almond pollination in central California the following February. Our work highlights the "downstream" effects of factors driving land-use decisions on the ability of beekeepers to provide robust honey bee colonies to support the pollination industry on a national scale. The work also demonstrates the direct linkages among grassland habitat in the Northern Great Plains, bee health, and pollination services rendered elsewhere in the United States.

Contact: Clint R.V. Otto, cotto@usgs.gov

Collaborators: USDA, Farm Service Agency and Natural Resources Conservation Service; Bee and Butterfly Habitat Fund; Keystone Institute; Project Apis m.

Timeline: Fiscal years 2015–21

Products:

Dixon, D.J., Zheng, H., and C.R.V. Otto, 2021, Land conversion and pesticide use degrade forage areas for honey bees in America's beekeeping epicenter: PLoS One, v. 16, no. 5, 15 p. [Also available at https://doi.org/10.1371/journal.pone.0251043.]

Otto, C.R.V., Zheng, H., Hovick, T., Post van der Burg, M., and Geaumont, B., 2022, Grassland conservation supports migratory birds and produces economic benefits for the commercial beekeeping industry in the U.S. Great Plains: Ecological Economics, v. 197, 107450. [Also available at https://doi.org/10.1016/j.ecolecon.2022.107450.]

Simanonok, M.P., Otto, C.R.V., and Smart, M.D., 2020, Do the quality and quantity of honey bee-collected pollen vary across an agricultural land-use gradient?: Environmental Entomology, v. 49, no. 1, p. 189–196. [Also available at https://doi.org/10.1093/ee/nvz139].

39. Improving Forage for Pollinators on Federal Conservation Lands

Since its inception in 1933, the U.S. Farm Bill has been one of the most influential Federal policies for agriculture and food production. Provisions within the Farm Bill have profound influence on global trade, nutrition programs, commodity crop programs, rural communities, and land conservation. The NPWRC's research quantifies the effect on pollinator forage and health of USDA conservation programs provisioned through the Farm Bill. The NPWRC is working with USDA partners to evaluate conservation seeding mixes with potential to improve pollinator health in the Great Plains and upper Midwest, if included in programs such as the CRP. To address partner research needs, a novel technique has been developed using genetic sequencing to identify pollen collected from the bodies of foraging bees. The work is designed to inform national policy decisions and assist with conservation planning across multiple States in the central United States.

Honey bee laden with pollen. The Northern Prairie Wildlife Research Center has developed a genetic sequencing strategy to identify bee-collected pollen. Photograph by Sarah Scott, U.S. Geological Survey.

Contact: Clint R.V. Otto, cotto@usgs.gov

Collaborators: USDA, Farm Service Agency, Natural Resources Conservation Service, and Agricultural Research Service

Timeline: Fiscal years 2015–21

Products:

Darby, B., Bryant, R., Keller, A., Jochim, M., Moe, J., Schreiner, Z., Pratt, C., Euliss, N.H., Jr., Park, M., Simmons, R., and Otto, C.R.V., 2020, Molecular sequencing and morphological identification reveal similar patterns in native bee communities across public and private grasslands of eastern North Dakota: PLoS One, v. 15, no. 1, 22 p. [Also available at https://doi.org/10.1371/journal.pone.0227918.]

Otto, C.R.V., Bailey, L.L., and Smart, A.H., 2021, Patch utilization and flower visitations by wild bees in a honey bee-dominated, grassland landscape: Ecology and Evolution, v. 11, no. 21, p. 14888–14904 . [Also available at https://doi.org/10.1002/ece3.8174.]

Otto, C.R.V., Smart, A., Cornman, R.S., Simanonok, M., and Iwanowicz, D.D., 2020, Forage and habitat for pollinators in the northern Great Plains—Implications for U.S. Department of Agriculture conservation programs: U.S. Geological Survey Open-File Report 2020–1037, 64 p. [Also available at https://doi.org/10.3133/ofr20201037.]

Simanonok, S., and Otto, C.R.V., 2020, Flowering plants preferred by bees of the Prairie Pothole Region: U.S. Geological Survey Fact Sheet 2020–3038, 2 p. [Also available at https://doi.org/10.3133/fs20203038.]

Simanonok, S.C., Otto, C.R.V., and Buhl, D.A., 2021, Floral resource selection by wild bees and honey bees in the Midwest United States—Implications for designing pollinator habitat: Restoration Ecology, v. 29, no. 8, 11 p. [Also available at https://doi.org/10.1111/rec.13456.]

Simanonok, S.C., Otto, C.R.V, and Iovanna, R., 2022, Forbs included in conservation seed mixes exhibit variable blooming detection rates and cost-effectiveness—Implications for pollinator habitat design: Restoration Ecology, v. 30, no. 8, e13657. [Also available at https://doi.org/10.1111/rec.13657.]

Smart, A.H., Otto, C.R.V., Gallant, A.L., and Simanonok, M.P., 2021, Landscape characterization of floral resources for pollinators in the Prairie Pothole Region of the United States: Biodiversity and Conservation, v. 30, 25 p. [Also available at https://doi.org/10.1007/s10531-021-02177-9.]

40. Forage and Habitat of the Endangered Rusty-Patched Bumble Bee (*Bombus affinis*)

Museum specimens of rusty-patched bumble bees. Photograph by Clint Otto, U.S. Geological Survey.

The rusty-patched bumble bee (*Bombus affinis*) was federally listed as an endangered species in 2017 and has been identified as a top priority species for recovery nationally. Shortly after listing the species, the FWS and other partners prioritized research needed to prevent extinction of the rusty-patched bumble bee. Among the top research needs that were identified were determining the floral resource needs of the species and understanding genetic population structure between extant and extinct populations. In 2021, the NPWRC completed a study that (1) quantified floral preferences of the rusty-patched bumble bee throughout its historical range and (2) mapped areas within the United States that support the highest richness of preferred forage plants. In partnership with the FWS, the NPWRC is currently identifying bee-collected pollen from active rusty-patched bumble bee nesting sites. These are the first rusty-patched bumble bee nests to be found since the early 1990s.

NPWRC scientists are also contributing to the design and implementation of national monitoring efforts of rusty-patched bumble bees that are being led by the FWS. Current research involves estimating the amount of sampling effort required to achieve unbiased estimates of rusty-patched bumble bee occupancy and also estimating how occupancy trends change through time. This research is designed to inform national recovery efforts of this endangered species.

Contact: Clint Otto, cotto@usgs.gov

Collaborators: FWS; USDA, Agricultural Research Service-Logan Bee Lab; Ohio State University

Timeline: Fiscal years 2019–25

Products:

Simanonok, M.P., Iwanowicz, D.D., Raines, C.D., Wood, T.J., Isaacs, R., Cornman, R.S., and Otto, C.R.V., 2023, Comparison of microscopy and metabarcoding to identify pollen used by the critically endangered rusty patched bumble bee, *Bombus affinis*: Insect Conservation and Diversity, v. 16, no. 2, p. 205–216. [Also available at https://doi.org/10.1111/icad.12622.]

Simanonok, M.P., Otto, C.R.V., Cornman, R.S., Iwanowicz, D.D., Strange, J.P., and Smith, T., 2021, A century of pollen foraging by the endangered rusty patched bumble bee (*Bombus affinis*)—Inferences from molecular sequencing of museum specimens: Biodiversity and Conservation, v. 30, p. 123–137 [Also available at https://doi.org/10.1007/s10531-020-02081-8.]

Otto, C.R.V., Schrage, A.C., Bailey, L.L., Mola, J.M., Smith, T.A., Pearse, I., Simanonok, S., and Grundel, R., 2023, Addressing detection uncertainty in *Bombus affinis* (Hymenoptera: Apidae) surveys can improve inferences made from monitoring: Environmental Entomology, v. 52, no. 1, p. 108–118. [Also available at https://doi.org/10.1093/ee/nvac090.]

41. Float Like a Butterfly—Employing Unmanned Aircraft Systems Technology to Quantify Milkweed for Monarch Butterflies

The annual migration of monarch butterflies in North America represents a biological phenomenon unique to our planet, covering more than 4,000 kilometers and requiring multiple generations of monarchs to complete. The monarch was proposed for listing under the Endangered Species Act in 2014 because of significant population declines and extinction risk. Disappearance of milkweed, the essential host plant for monarch larvae, has been implicated in the decline of the eastern monarch population. The objective of this study is to test the effectiveness of using uncrewed aircraft systems (UAS) and artificial neural networks to quantify the density of common and showy milkweed in working grasslands of Minnesota and North Dakota. First, NPWRC scientists will develop a machine learning algorithm for detecting milkweeds from UAS-collected aerial images. Second, NPWRC will validate the algorithm by comparing plot-level counts of milkweed estimated from UAS images to field count data across a range of milkweed densities. Lastly, NPWRC will take steps towards facilitating the integration of this technology into the Integrated Monarch Monitoring Program by estimating the number of spatially independent UAS images required for achieving accurate and precise estimates of milkweed across entire fields. In fiscal year 2019, preliminary UAS flights were completed; however, this project was put on hold because of a DOI ruling that grounded all UAS flights. No USGS UAS flights will be completed until this ruling is changed.

Contact: Clint Otto, cotto@usgs.gov

Collaborators: FWS; Sentera Precision Agriculture, Monarch Joint Venture

Timeline: Fiscal years 2019–23

42. Native Bee Response to Warm- and Cool-Season Grassland Management at National Park Service Historical Sites in the Mid-Atlantic Region, United States

The National Park Service properties of Antietam National Battlefield, Monocacy National Battlefield, and Chesapeake & Ohio Canal National Historical Park provide ideal locations for studying native bee response to grassland management. These locations are ideal because National Park Service biologists in these parks are managing warm- and cool-season grasslands and have kept detailed records of management strategies (for example, grazing, burning, and spraying) at the field level. The proposed research will provide the National Park Service with a baseline inventory of native bees and their response to grassland management at Antietam, Monocacy, and Chesapeake & Ohio Canal sites. Specifically, the objectives of this research are to (1) inform National Park Service managers about the distribution and relative abundance of native bees throughout the growing season at Antietam, Monocacy, and Chesapeake & Ohio Canal National Park Service properties; (2) quantify native-bee and flowering-plant abundance and richness for three land-management types; and (3) use structural equation modeling to understand how site management, local landscape factors, and soil type affect flowering plant availability and relative abundance of native bees.

Contacts: Clint Otto, cotto@usgs.gov; Diane Larson, dlarson@usgs.gov

Collaborators: National Park Service

Timeline: Fiscal years 2020–23

43. Understanding Spatiotemporal Patterns of Threatened and Endangered Butterflies in the Great Plains

The FWS has currently listed two butterflies (the Dakota skipper [*Hesperia dacotae*] and the Poweshiek skipperling [*Oarisma poweshiek*]) as threatened or endangered and is considering listing other butterflies such as the regal fritillary. To support future monitoring, management and listing decisions for these species, researchers are analyzing existing data from multiple sources. The results from these analyses will allow researchers to make inferences about temporal trends for these species as well as build spatial maps depicting where these species are likely to be on the landscape. These maps will help Federal partners in allocating monitoring efforts and targeting conservation actions.

Contact: Max Post van der Burg, maxpostvanderburg@usgs.gov

Collaborators: FWS

Timeline: Fiscal years 2019–21

Products:

Post van der Burg, M., Austin, J.E., Wiltermuth, M.T., Newton, W., MacDonald, G., 2020, Capturing spatiotemporal patterns in presence–Absence data to inform monitoring and sampling designs for the threatened Dakota skipper (Lepidoptera—Hesperiidae) in the Great Plains of the United States: Environmental Entomology, v. 49, no. 5, p. 1252–1261. [Also available at https://doi.org/10.1093/ee/nvaa081.]

Post van der Burg, M., MacDonald, G., Hefley, T., and Glassberg, J., 2023, Point-scale habitat and weather patterns influence the distribution of regal fritillaries in the central United States: Ecosphere, v. 14 no. 3, e4429. [Also available at https://doi.org/10.1002/ecs2.4429.]

44. Long-Term Changes in Pollinator Resources (Alfalfa, Sweetclover, and Milkweed) and Monarch Butterfly Populations in Conservation Reserve Program Grasslands

Federal cropland retirement programs are increasingly being used to provide resources for pollinators (for example, nectar, pollen, and host plants). Pollinator-friendly plant species (for example, alfalfa [*Medicago sativa*] and sweetclover [*Melilotus officinalis*]) were readily included in seed mixes in CRP grasslands since the CRP inception in the 1985 Farm Bill (Food Security Act of 1985; Public Law 99–198). Through time, some native plant species (for example, milkweeds [*Asclepias* spp.]) also colonized CRP grasslands. Between 1997 and 2017, the NPWRC quantified changes in pollinator resources (alfalfa, sweetclover, and milkweeds) and adult monarch butterfly abundance in several hundred CRP grasslands in nine counties in four States in the Northern Great Plains. Understanding the long-term persistence, increase, or decline of monarchs and pollinator resources in CRP grasslands will help managers and policy makers with the design and management of current and future long-term cropland retirement programs.

Contact: Lawrence D. Igl, ligl@usgs.gov.

Collaborators: Private landowners, USDA

Timeline: Fiscal years 1997–present.

Wolves

45. Superior National Forest Wolf and Lynx Populations

A radio-collared wolf is captured on a camera trap during March 2019 with a nonradioed packmate in the Superior National Forest, Minnesota (U.S. Geological Survey photograph).

When the wolf was listed as endangered, the last remaining mainland wolf population in the lower 48 States was in the Superior National Forest of northeastern Minnesota. Since then, radio collars and aerial tracking have been used to study the wolf population trend, factors influencing the trend, and prey species affected by wolves. In winter 2018–19, NPWRC scientists initiated a 3-year trial (that continued through winter 2020–21) of noninvasive winter wolf surveys to determine if resident wolves could be counted with reasonable precision using camera traps, genetics from scat and snow tracks, snow tracking, and citizen-scientist reports. Limited radio collaring of wolves was also done during summer 2021. During 2019, NPWRC researchers, along with international cooperators, commenced noninvasive summer research to determine if wolf howling rates at their homesites were similar across gradients of human impacts on landscapes. That research highlighted extensive domestic sled dog vocalizations as an issue when analyzing sympatric wild wolf vocalizations. During summer 2021, sled dog vocalizations were recorded to analyze differences from wolf vocalizations to aid in wild wolf research. NPWRC scientists also collaborated with multiple disease researchers investigating pathogen exposure across North America. The research analyzed serum collected during wolf captures for radio collaring purposes. The wolf was delisted on January 4, 2021, which triggered a required 5-year post-delisting monitoring period. Knowledge of changes in this natural, protected, wolf population provides insight valuable to State and Federal resource managers charged with managing recovered and recovering wolf populations.

Contact: L. David Mech, david_mech@usgs.gov; Shannon M. Barber-Meyer, sbarber-meyer@usgs.gov

Collaborators: U.S. Forest Service, Superior National Forest; Minnesota Department of Natural Resources, Northeastern Region; U.S. Forest Service, National Genomics Center for Wildlife and Fish Conservation, Missoula, Montana; International Wolf Center, Ely, Minnesota; Yellowstone National Park; ARCA, People and Nature, Spain; ACNHE, Association for the Conservation of Nature in Human Environments, Spain; University of Minnesota

Timeline: Fiscal years 1968–Ongoing

Products:

Ausband, D.E., and Mech, L.D., 2023, The challenges of success—Future wolf conservation and management in the United States: BioScience, v. 73, no. 8, p.587–591. [Also available at https://doi.org/10.1093/biosci/biad053.]

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Barber-Meyer, S.M., Mech, L.D., and Wheeldon, T.J., 2021, Wolf survival and cause-specific mortality from 1968-2018 in the Superior National Forest: U.S. Geological Survey data release. [Also available at https://doi.org/10.5066/P9KVM4IH.]

Barber-Meyer, S.M., Palacios, V., Marti-Domken, B., and Schmidt, L.J., 2020, Testing a new passive acoustic recording device to monitor wolves: Wildlife Society Bulletin, v. 44, no. 3, p. 590–598. [Also available at https://doi.org/10.1002/wsb.1117.]

Barber-Meyer, S.M., and Schmidt, L.J., 2020, Fish out of water—Insights from a case study of a highly social animal that failed the mirror self-recognition test: International Journal of Comparative Psychology, v. 33, p. 1–16. [Also available at https://doi.org/10.46867/C4KG6W.]

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Cronin, M., and Mech, L.D., 2019, E-letter response to "Genomic signatures of extensive costs inbreeding in Isle Royale wolves, a population on the threshold of extinction," by Robinson et al. 2019: Science Advances 5: no. 5, eaau0757. [Also available at https://doi.org/10.1126/sciadv.aau0757.]

Janssens, L.A.A., Boudadi Mligne, M., Mech, L.D., and Lawler, D., 2021, The enigma of the Předmostí protodog—A comment on Prassack et al. 2020: Journal of Archaeological Science, v. 126, 105160. [Also available at https://doi.org/10.1016/j.jas.2020.105160.]

Marti-Domken, B., Palacios, V., and Barber-Meyer, S.M., 2021, Acoustic interaction between a pair of owls and a wolf: Western North American Naturalist, v. 81, no. 3, article 15. [Also available at https://scholarsarchive.byu.edu/wnan/vol81/iss3/15.]

Mech, L.D., 2019, Do indigenous American peoples' stories inform the study of dog domestication from wolves?: Ethnobiological Letters, v. 10, no .1, p. 69–75. [Also available at https://doi.org/10.14237/ebl.10.1.2019.1474.]

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Mech, L.D., 2021, Should governments provide more grey wolf (*Canis lupus*) sanctuaries?: Canadian Wildlife Biology & Management, v. 10, no. 1, p. 25–32. [Also available at https://cwbm.ca/should-governments-provide-more-sanctuaries-for-grey-wolves-canis-lupus/#dearflip-df_3245/1/.]

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Mech, L.D., and Barber-Meyer, S.M., 2020, Sixty years of white-tailed deer (*Odocoileus virginianus*) yarding in a gray wolf (*Canis lupus*)-deer system: The Canadian Field Naturalist, v. 133, no. 4, p. 343–351. [Also available at https://doi.org/10.22621/cfn.v133i4.2136.]

Mech, L.D., and Breining, G., 2020, Wolf Island—Discovering the secrets of a mythic animal: Minneapolis, University of Minnesota Press, 188 p. [Also available at https://doi.org/10.5749/j.ctv15kxgdk.]

Mech, L.D., and Buhl, D.A., 2020, Seasonal cycles in hematology and body mass in free-ranging gray wolves (*Canis lupus*) from northeastern Minnesota, USA: Journal of Wildlife Diseases, v. 56, no. 1, p. 179–185. [Also available at https://doi.org/10.7589/2018-06-156.]

Mech, L.D., and Nowak, R.M., 2023, A plea for red wolf conservation throughout its recent distribution: Southeastern Naturalist, v. 22, no. 1, p. N23–N27.

Palmer, M.S., Portales-Reyes, C., Potter, C., Mech, L.D., and Isbell, F., 2021, Behaviorally-mediated trophic cascade attenuated by prey use of risky places at safe times: Oecologia, v. 195, p. 235–248. [Also available at https://doi.org/10.1007/s00442-020-04816-4.]

46. Yellowstone Wolf Restoration

The National Park Service and FWS reintroduced wolves into Yellowstone National Park in 1995 and 1996. This study helps assess that population's recovery and determines factors that affect the population, which include diseases, intraspecific strife, and interactions with prey. The restoration has been successful, and the population of wolves has persisted in Yellowstone National Park for more than 20 years despite being affected by canine distemper, mange, and other diseases. The Yellowstone wolves' primary prey has historically been elk, and we and other researchers have learned much about the interactions between the two species. In collaboration with the National Park Service, the NPWRC is addressing remaining questions about wolf and elk ecology such as (1) what physical and biological factors affect wolves' choice of dens and rendezvous sites, based on data from about 700 homesites; and (2) how wolves' scavenging on bison carcasses affects elk demography and populations.

Elk form the primary prey of wolves in Yellowstone. Photograph by L. David Mech, U.S. Geological Survey.

Contact: L. David Mech, david_mech@usgs.gov

Collaborators: National Park Service, Yellowstone National Park; University of Minnesota, Department of Fisheries, Wildlife and Conservation Biology

Timeline: Ongoing

47. Ellesmere Wolf Movements

Wolves on Ellesmere Island, just south of the North Pole, survive in extreme cold during 24 hours of darkness per day from November through January and survive in much higher temperatures during 24 hours of light per day from April through September. Partnering with other agencies, the NPWRC use GPS radio collars applied to wolves during summer to examine wolf-pack movements on Ellesmere Island throughout the year. Packs of 20 or more wolves travel more than 6,640 square kilometers within territories during winter darkness and summer total light; kill muskoxen, caribou, and arctic hares throughout the year; and produce litters averaging four pups each May. Sizes of six pack territories during summer varied from 688 to 4,728 square kilometers (95 percent minimum convex polygon). For three packs,

L. David Mech collars an Ellesmere wolf with a Global Positioning System (GPS) radio-collar. Photograph by Dean Cluff, Department of Environment and Natural Resources, Government of the Northwest Territories.

winter territory sizes varied from 1,260 to 6,026 square kilometers (95 percent minimum convex polygon). Deoxyribonucleic acid (DNA) from these and other Ellesmere Island packs are being analyzed to determine degree of inbreeding and heterozygosity for this island population at the extreme northern edge of the species' circumpolar distribution.

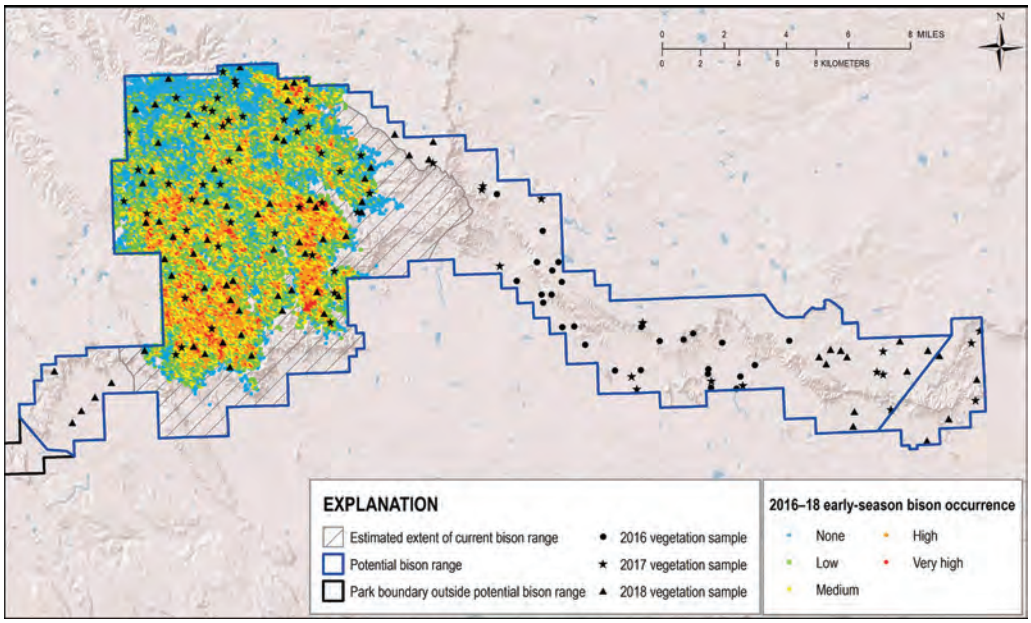
Contact: L. David Mech, david_mech@usgs.gov

Collaborators: Utah State University, Wildland Resources Department; Wildlife Research Station, Nunavut Department of Environment; Northwest Territories Department of Environment and Natural Resources; Polar Continental Shelf Project; Eureka Weather Station, Environment Canada

Timeline: Ongoing

Ungulates

48. Integrated Conservation of Bison and Native Prairie at Badlands National Park, South Dakota



Preliminary data from Global Positioning System (GPS)-collared bison showing the bison use of their current range and the locations of vegetation samples. Shaded background is Esri shaded relief.

Badlands National Park contains the largest contiguous bison range in the core of the historical bison range on the Northern Great Plains. The park is nevertheless too small to accommodate natural movements of free-ranging bison. As a result, continual grazing by resident bison has supplanted intense-but-ephemeral grazing by nomadic bison. The herd also is currently too small to prevent gradual loss of genetic diversity. Active management of abundance and distribution in the park is, therefore, necessary to conserve bison and their keystone role in natural processes. This research has involved the use of satellite GPS collars to locate marked bison at Badlands National Park at regular intervals since November 2015, expanding during 2018–20 to include bison at Theodore Roosevelt and Wind Cave National Parks. Locations are being used to map distributions of bison activity and develop models relating bison activity to landscape features, characteristics of vegetation, and proximity to water. Locations also are being used to assess the rate at which bison cows expand their range into areas recently made available after fence removal. A companion project (number 72 in this report) is assessing bison diets and the spatial distribution of productivity, composition, and consumption of park vegetation. Data resulting from these two studies will be used to evaluate potential bison population and vegetation management objectives under various weather scenarios. Results will be used by the National Park Service to refine and implement management strategies that benefit bison and native prairie vegetation in midwestern national parks.

Contact: Glen A. Sargeant, gsargeant@usgs.gov; Amy J. Symstad, asymstad@usgs.gov

Collaborators: National Park Service, Badlands National Park, Wind Cave National Park, and Theodore Roosevelt National Park

Timeline: Fiscal years 2015–Ongoing

49. Movements and Distribution of Moose at Rocky Mountain National Park

Twenty-four male and female moose were reintroduced to Jackson County, Colorado, from source populations in Wyoming and Utah during 1978. The population subsequently increased and numbers currently are in the thousands. Moose now range from North Park south to Breckenridge and occupy riparian and forested habitat on both sides of the continental divide in Rocky Mountain National Park, where they were not historically present. Non-native moose may be contributing to riparian degradation in some portions of the park, which has been a long-standing concern for park management. The USGS, Rocky Mountain National Park, and the Biological Resources Division of the National Park Service are using locations of moose marked with GPS collars to improve understanding of moose distribution and movements in the park, which will be essential for assessment of moose population status and impacts.

Contact: Glen A. Sargeant, gsargeant@usgs.gov

Collaborators: National Park Service, Rocky Mountain National Park and Biological Resources Division.

Timeline: Fiscal years 2021–23

Species Management Program—Species Stressors

Wind Energy

50. A Method for Mitigating the Behavioral Effects of Energy Development and Other Anthropogenic Disturbances on Grassland Birds and Waterfowl

An aerial view of the Tatanka Wind Farm in Dickey County, North Dakota, and McPherson County, South Dakota. The Tatanka Wind Farm is one of three wind farms included in the Northern Prairie Wildlife Research study evaluating avian displacement to wind infrastructure. Photograph by Chuck Loesch, U.S. Fish and Wildlife Service.

The avian-impact offset method (AIOM) quantifies the amount of habitat needed to provide equivalent biological value for birds displaced by energy and transportation infrastructure. The AIOM is applicable to situations where avian displacement (that is, behavioral avoidance) requires compensatory mitigation. The AIOM estimates the biological value (that is, number of birds pairs of grassland birds and waterfowl) displaced by development and calculates the hectares of grasslands and number of wetlands needed to compensate for the displaced pairs. By converting biological value to traditional units of measure in which land is described, purchased, and sold, the AIOM simplifies calculations for offsetting avian displacement for easements or restoration projects. The AIOM tool is applicable to wind, solar, oil, gas, and transportation infrastructure. The AIOM has been adopted by several State wildlife agencies, Federal natural-resource agencies, and energy developers, resulting in compensatory mitigation in the form of restoration of grassland and wetland acres.

Contact: Jill A. Shaffer, jshaffer@usgs.gov

Collaborators: FWS, Region 3 Migratory Birds Program, HAPET

Timeline: Fiscal years 2002–24

Products:

Shaffer, J.A., Loesch, C.R., and Buhl, D.A., 2019, Estimating offsets for avian displacement effects of anthropogenic impacts: Ecological Applications, v. 29, no. 8, 15 p. [Also available at https://doi.org/10.1002/eap.1983.]

Shaffer, J.A., Loesch, C.R., and Buhl, D.A., 2022, Understanding the avian-impact offset method—A tutorial: U.S. Geological Survey Open-File Report 2022–1049, 227 p. [Also available at https://doi.org/10.3133/ofr20221049.]

Shaffer, J.A., 2022, 10-year (2003–2012) bird and vegetation data collected at wind facilities in North Dakota and South Dakota: U.S. Geological Survey data release. [Also available at https://doi.org/10.5066/P9B75GL0.]

51. Spatial Models Inform Tradeoff Decisions Between Energy Development and Species Conservation

As human populations increase, decisions regarding use of the world's finite land base become increasingly complex. Efforts to ameliorate climate change through growth of renewable energy such as wind and solar require a large land footprint for turbine and solar arrays. Areas predicted for growth of these industries also harbor many species with populations in serious decline. Spatial models can highlight examples of forthcoming tradeoff decisions for human society and specifically for renewable energy industries and avian conservationists. NPWRC and collaborators are developing such models by examining land-use–conflict scenarios involving renewable energy and avian conservation. These models account for the multi jurisdictional regulations that developers encounter when searching for developable land, as well as motivation of conservationists to avoid prime wildlife habitat. By applying a uniform set of rules for renewable energy facilities to the Prairie Pothole Region and portions of the Northern Great Plains, the effects of regulations and avoidance of prime wildlife habitat on amount of land available for development can be evaluated and potential tradeoffs for the conservation efforts and renewable energy industries can be identified.

Contact: Jill A. Shaffer, jshaffer@usgs.gov

Collaborators: FWS, Region 3 Migratory Birds Program, HAPET; WEST-Inc.

Timeline: Fiscal years 2021–22

Products:

Shaffer, J.A., Niemuth, N.D., Loesch, C.R., Derby, C.E., Pearse, A.T., Barnes, K.W., Shaffer, T.L., and Ryba, A.J., 2022, Limited land base and competing land uses force societal tradeoffs when siting energy development: Journal of Fish and Wildlife Management, v. 13, no. 1, p. 106–123. [Also available at https://doi.org/10.3996/JFWM-21-036.]

52. Embassy Science Fellowship Technical Assistance to Kazakhstan in Developing Wind Energy

Jill Shaffer is a 2023 fellowship recipient of the U.S. Department of State's Embassy Science Fellows Program, which solicits expertise from Government scientists to work with foreign countries on specific issues. The U.S. Embassy in Astana, Kazakhstan, sought Fellows to work with the civil-society organization known as the Association for the Conservation of Biodiversity in Kazakhstan (ACBK). The ACBK is seeking ways to learn about the effects of renewable-energy developments on biodiversity and desires to spread that knowledge to other interested agencies and industries within Kazakhstan. Jill Shaffer and Todd Katzner (USGS Forest and Rangeland Ecosystems Science Center), another Fellow, visited Kazakhstan from September 17 to October 1, 2023. They met with U.S. Embassy officials in the divisions of Economics and in Environment, Science, Technology, and Health and with ACBK biologists. They also gave two presentations that described an eight-part virtual lecture series they developed to help Central Asians understand the effects of wind energy on biodiversity. The lecture series was presented monthly through March 2024. The recorded lectures, the pre-lecture readings, and post-lecture source material can be accessed from the ACBK website at https://www.acbk.kz/article/default/view/635. While in Kazakhstan, Jill and Todd also presented on the effects of wind-energy on golden eagles (*Aquila chrysaetos*) at the "Eagles of the Palearctic Conference" in Almaty. They participated in bird-banding activities using Heligoland traps at Chokpak Ornithological Station in the village of Chokpak.

Contact: Jill A. Shaffer, jshaffer@usgs.gov

Collaborators: USGS Forest and Rangeland Ecosystems Science Center, U.S. Department of State

Timeline: Fiscal years 2023–24

Jill Shaffer standing below a Heligoland trap at Chokpak Ornithological Station in Chokpak, Kazakhstan. Photograph by Nicole Ibrahim, University of Maryland.

Jill Shaffer holding a Eurasian sparrowhawk (*Accipiter nisus*) captured in the Heligoland trap. Photograph by Nicole Ibrahim, University of Maryland.

53. Evaluating Bird Behavioral Response to Wind Turbines Across the Northern Plains

NPWRC's previous research on behavioral avoidance (also referred to as "displacement") of wind facilities by breeding grassland birds was done in North Dakota and South Dakota. NPWRC is now collaborating on FWS-led research on grassland bird displacement using field methods of the North American Breeding Bird Survey (BBS) on newly selected routes through wind facilities in Montana, North Dakota, South Dakota, Nebraska, Minnesota, and Iowa. This approach broadens the geographic extent to include additional wind facilities and control areas, and the acquisition of a large sample size with high statistical power that can evaluate the response of many species during multiple years. Data gathered from new and existing BBS routes allow researchers to examine avoidance by modelling bird occurrence as a function of landscape composition, climate, topography, bird detection, and distance to nearest turbine. In addition to the above research, we used existing datasets from several sources to examine the effect of wind turbines on lek density and mean number of males per lek for sharp-tailed grouse (*Tympanuchus phasianellus*) at wind facilities in North Dakota and South Dakota.

Contact: Jill A. Shaffer, jshaffer@usgs.gov

Collaborators: FWS, HAPET; USGS Eastern Ecological Science Center; North Dakota Game and Fish Department; South Dakota Game, Fish and Parks Department; Nebraska Game and Parks Commission; Iowa Department of Natural Resources

Timeline: Fiscal years 2018–24

Products:

Shaffer, J.A., Buhl, D.A., and Newton, W.E., 2023, Assessing the use of long-term lek survey data to evaluate the effect of landscape characteristics and wind facilities on Sharp-tailed Grouse lek dynamics in North Dakota and South Dakota: U.S. Geological Survey Open-File Report 2023–1091, 33 p. [Also available at https://doi.org/10.3133/ofr20231091.]

Shaffer, J.A., 2023, 12-year (2003–2014) Sharp-tailed Grouse and Greater Prairie-Chicken lek data collected near wind facilities in North Dakota and South Dakota. U.S. Geological Survey data release. [Also available at https://doi.org/10.5066/P99NWAL5.]

Oil and Gas

54. Response of Grassland Birds to Habitat Characteristics, Oil Wells, and Roads in Managed Grasslands in the Little Missouri National Grassland in North Dakota

In collaboration with the U.S. Forest Service and North Dakota State University, the NPWRC is evaluating the effects of landscape-level (for example, oil development and roads) and site-specific (for example, vegetation structure and composition) factors on populations of Sprague's pipits (*Anthus spragueii*), Baird's sparrows (*Centronyx bairdii*), and other declining grassland birds in the Little Missouri National Grassland in western North Dakota. The Sprague's pipit and Baird's sparrow are listed as sensitive species in the Northern Region of the U.S. Forest Service, meaning these species need special management to maintain and improve their status on national forests and grasslands and to prevent a need for listing under the Endangered Species Act. These species are thought to require large patches of native grass cover throughout their life cycles. Large-scale losses and degradation of critical grassland habitat highlight the importance of appropriate management and conservation measures for remaining native grasslands. The results from this study will contribute to understanding grassland songbird responses to local and landscape factors and identify specific mechanisms by which conservation measures for declining grassland bird populations can be improved.

Contact: Lawrence D. Igl, ligl@usgs.gov

Collaborators: U.S. Forest Service, North Dakota State University

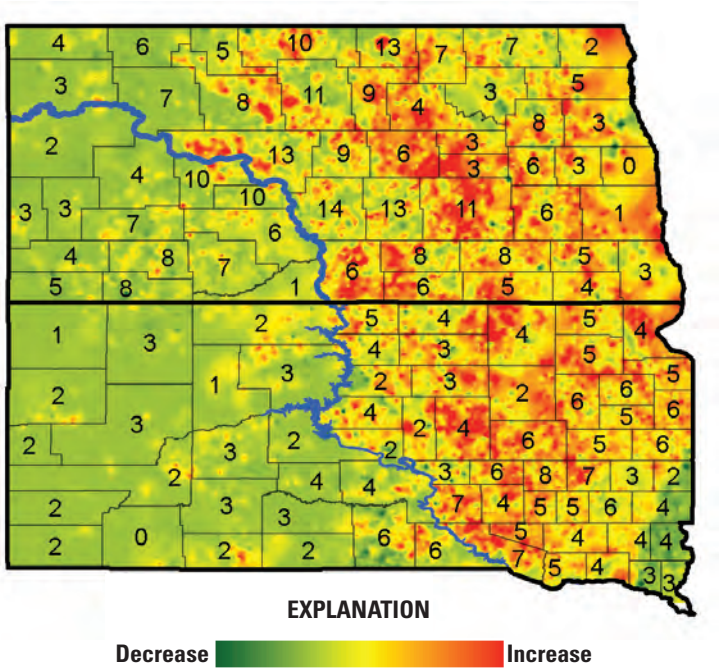
Timeline: Ongoing

Biofuels

55. Quantifying the Effects of Land-Use Change and Bioenergy Crop Production on Ecosystem Services in the Northern Great Plains

Rising commodity-crop prices, increased Federal subsidies for biofuels such as corn-based ethanol and soy-based biodiesel, and reduction in U.S. Farm Bill conservation programs have facilitated rapid land-use changes in the Northern Great Plains. Although renewable biofuels are touted as a mechanism for increasing energy security and potentially reducing greenhouse gas (GHG) emissions, little is known about how rapid expansion of biofuel crops will effect ecosystem services. The objective of this research is to understand how land-use changes and biofuel crop development affect ecosystem services in the Northern Great Plains. For example, the NPWRC biofuels research team studies how land-use change and habitat alteration affect pollinator health and the ability of bees to pollinate agricultural crops. Results from this research will improve societal understanding of the downstream effects of land-use change and the ecological and economic tradeoffs associated with bioenergy crop production. The NPWRC biofuels research has been featured in more than 15 national and international media outlets since 2014.

Contact: Clint R.V. Otto, cotto@usgs.gov



Heat maps representing the annual rate of change in corn and soybean area around honey bee apiaries from 2006 to 2014. Maps were created using interpolation and data from 18,363 registered apiary locations in North and South Dakota. Red represents regions with the greatest annual increase of corn and soybean area surrounding commercial apiaries. Values within county boundaries represent the average number of registered apiaries per 10,000 hectares (Otto and others, 2016).

Collaborators: USDA, Farm Service Agency and Natural Resources Conservation Service

Timeline: Fiscal years 2012–Ongoing

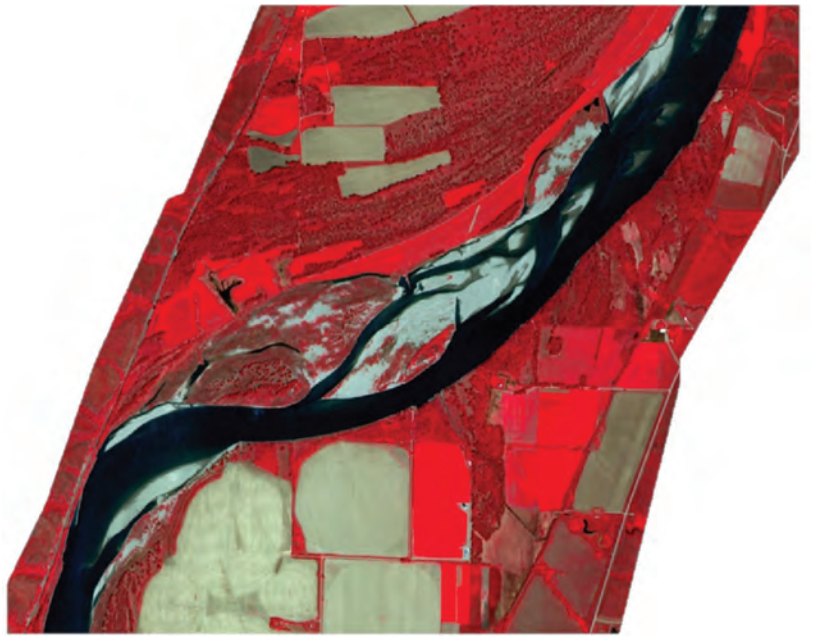
Products:

Dixon, D.J., Zheng, H., and Otto, C.R.V., 2021, Land conversion and pesticide use degrade forage areas for honey bees in America's beekeeping epicenter: PLoS One, v. 16:], no. 5, 15 p. [Also available at https://doi.org/10.1371/journal.pone.0251043.]

Habitat Loss/Degradation

56. Inventory, Mapping, Estimation, and Monitoring of Least Tern and Piping Plover Habitats on the Upper Missouri River Using Satellite Imagery

Emergent sandbar maps of the Missouri River produced by the NPWRC continue to be used by the USACE and FWS to monitor and manage critical breeding habitat for the endangered interior population of least terns and the threatened Northern Great Plains population of piping plovers. These maps have been created and refined annually for more than 10 years. Using high spatial resolution satellite imagery, Previously, we developed a database of spectral and spatial properties of potential habitat categories that are classified using a probability-based method. However, we are now updating this method using a cutting-edge machine learning approach using convolutional neural network models, which will allow us to automate the classification and mapping of piping plover critical habitat.



Satellite image of an area of the Missouri River used to classify potential breeding habitat for least terns and piping plovers on emergent sandbars.

Contact: Max Post van der Burg, maxpostvanderburg@usgs.gov

Collaborators: USACE, Omaha District, Threatened and Endangered Species Section

Timeline: Fiscal years 2005–Ongoing

57. Synthesizing Mapping and Monitoring Data to Understand Fluctuations in Prairie Dog Colony Size and Densities in Theodore Roosevelt National Park

There have been efforts to capture variation in the size and extent of prairie dog colonies at Theodore Roosevelt National Park in some form since the 1940s. Prairie dog colonies have been mapped semi-annually since the 1990s, but shifting priorities and a largely static budget have made it difficult for park staff to continue mapping. Furthermore, little research has been conducted with the existing mapping data to assess prairie dog habitat quality and the factors that affect colony size fluctuations. This project is aimed at developing more cost-efficient methods for prairie dog colony mapping (that is, remote sensing techniques) and developing indices and models that can help managers derive population inferences based on colony area.

Contact: Max Post van der Burg, maxpostvanderburg@usgs.gov

Collaborators: National Park Service, Theodore Roosevelt National Park

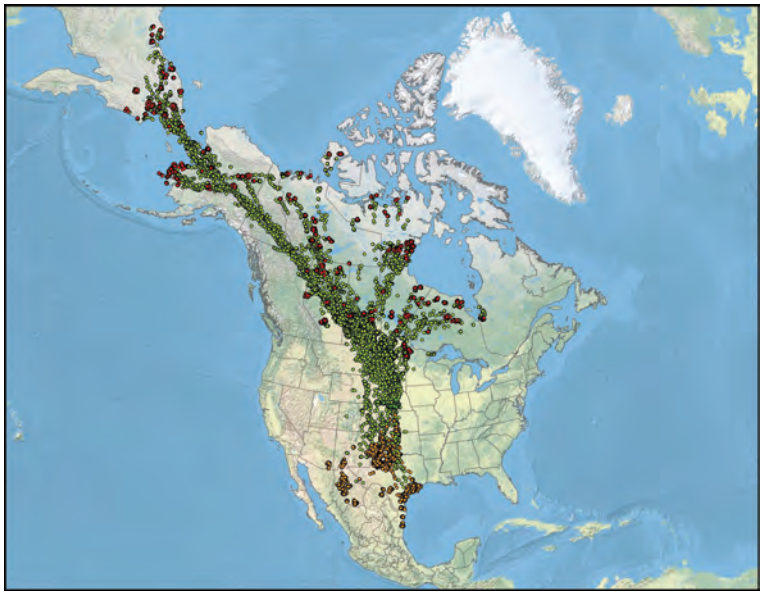
Timeline: Fiscal years 2021–Ongoing

Landscape Management Program—Priority Landscapes

Platte River

58. Ecology and Management of Midcontinent Sandhill Cranes

Midcontinent sandhill cranes occupy a large geographic area of central and western North America and northeastern Asia during breeding, winter, and migration. Sandhill cranes are a species with a unique convergence of user groups that have a unified interest in the continued health of this population. Tens of thousands of people view cranes during spring staging at the Platte River Valley in Nebraska, and hunters pursue and harvest cranes annually in most of their fall and winter range. The overall goal of this project is to provide information that will improve crane management. This research includes the following multiple objectives: (1) determination of geographic distribution, migration chronology, and spring-staging ecology in the Platte River Valley; (2) evaluation of survey methods; (3) estimation of survival and recruitment; and (4) modeling of population dynamics. Work completed will provide better information regarding harvest management strategies, opportunities for increased international conservation collaboration, conservation of crane habitats at multiple spring stopover sites, and insight into long-term monitoring of habitats and cranes.



Geographic distribution of midcontinent sandhill cranes as determined by satellite telemetry from cranes marked at the Platte River, Nebraska, United States. This project identified breeding areas (red circles), migration (green circles), and wintering locations (orange circles) that occurred over a broad area within North America and portions of Asia.

Contact: Aaron T. Pearse, apearse@usgs.gov

Collaborators: FWS, Ecological Services Nebraska Field Office, RWBJV; State and Provincial game and fish agencies of Colorado, Texas, Oklahoma, Kansas, Nebraska, South Dakota, North Dakota, Wyoming, Montana, New Mexico, Saskatchewan, and Alberta; International Crane Foundation; The Crane Trust; Playa Lakes Joint Venture; Russian Academy of Science–Sakha Division; Central Flyway Council; Texas Tech University; Texas A&M University

Timeline: Fiscal years 2010–Ongoing

Products:

Dinges, A.J., VonBank, J.A., Pearse, A.T., and Brandt, D.A., 2024, Developing a photography-based harvest survey to estimate age and subspecies composition of midcontinent sandhill cranes: Wildlife Society Bulletin, v. 48, no. 1, p. e1512. [Also available at https://doi.org/10.1002/wsb.1512.]

Pearse, A.T., Sargeant, G.A., Krapu, G.L., and Brandt, D.A., 2020, Population and harvest dynamics of midcontinent sandhill cranes: The Journal of Wildlife Management, v. 84, no. 5, p. 902–910. [Also available at https://doi.org/10.1002/jwmg.21865.]

Varner, D.M., Pearse, A.T., Bishop, A.A., Davis, J., Denton, J., Grosse, R., Johnson, H., Munter, E., Schroeder, K.D., Spangler, R., Vrtiska, M., and Wright, A., 2020, Roosting habitat use by sandhill cranes and waterfowl on the North and South Platte Rivers in Nebraska: Journal of Fish and Wildlife Management, v. 11, no. 1, p. 56–67. [Also available at https://doi.org/10.3996/042019-JFWM-030.]

59. Migration and Winter Ecology of the Aransas-Wood Buffalo Population of Whooping Cranes

A pair of whooping cranes walking along the edge of a wetland in central Kansas. The lead crane was marked with a satellite transmitter that collects multiple Global Positioning System (GPS) locations per day. Photograph by Travis Wooten, U.S. Geological Survey.

The only self-sustaining population of endangered whooping cranes nests within and near Wood Buffalo National Park, Canada; migrates through the Great Plains; and winters primarily along the Texas Gulf Coast. The objectives of this collaborative project are to address the annual life cycle of this species by advancing knowledge of breeding, wintering, and migration ecology, including threats to survival and population persistence. This research will allow researchers to identify potential barriers to species recovery. To complete this work, we have deployed and monitored more than 100 GPS-enabled satellite transmitters during 2010–20. Through coordination of international capture teams and development of innovative trapping techniques, our efforts represent the first time adult whooping cranes have been successfully captured and marked. We also are characterizing stopover sites used by whooping cranes to document surrounding habitat characteristics and land-management practices to better define habitat criteria required by the species at stopover sites like the Platte River. Results from this project will inform recovery and management of whooping cranes into the foreseeable future.

Contact: Aaron T. Pearse, apearse@usgs.gov

Collaborators: FWS, Regions 2 and 6; Canadian Wildlife Service; Crane Trust; PRRIP; International Crane Foundation; Parks Canada

Timeline: Fiscal years 2010–Ongoing

Products:

Butler, M.J., Stewart, D.R., Harris, G.M., Bidwell, M.T., and Pearse, A.T., 2022, Space use and site fidelity of whooping cranes during winter on the Texas Gulf Coast: Journal of Wildlife Management, v. 86, p. e22226. [Also available at https://doi.org.10.002/jwmg.22226.]

Caven, A.J., Pearse, A.T., Brandt, D.A., Harner, M.J., Wright, G.D., Baasch, D.M., Brinley Buckley, E.M., Metzger, K.L., Lacy, A.E., and Rabbe, M.R., 2022, Whooping crane stopover length in relation to stopover site characteristics: Proceedings of the North American Crane Workshop, v. 15, p. 6–33.

Mendgen, P., Converse, S.J., Pearse, A.T., Teitelbaum, C.S., and Mueller, T., 2023, Differential shortstopping behavior in whooping cranes: habitat or social learning?: Global Ecology and Conservation, v. 41, e02365. [Also available at https://doi.org/10.1016/j.gecco.2022.e02365.]

Metzger, K.L., Lehnen, S.E., Sesnie, S.E., Butler, M.J., Pearse, A.T., and Harris, G., 2020, Identifying sustainable winter habitat for whooping cranes: Journal for Nature Conservation, v. 57, 4 p. [Also available at https://doi.org/10.1016/j.jnc.2020.125892.]

Pearse, A.T., Metzger, K.L., Brandt, D.A., Bidwell, M.T., Harner, M.J., Baasch, D.M., and Harrell, W., 2020, Heterogeneity in migration strategies of whooping cranes: The Condor, v. 122, no. 1, 15 p. [Also available at https://doi.org/10.1093/condor/duz056.]

Pearse, A.T., Metzger, K.L., Brandt, D.A., Shaffer, J.A., Bidwell, M.T., and Harrell, W., 2021, Migrating whooping cranes avoid wind-energy infrastructure when selecting stopover habitat: Ecological Applications, v. 31, no. 5, 14 p. [Also available at https://doi.org/10.1002/eap.2324.]

60. Independent Science Advisory Committee for the Platte River Recovery Implementation Program

The Platte River in south-central Nebraska serves as a key location for migratory birds in the central Great Plains. The latest effort to manage lands and water in this area—the Platte River Recovery Implementation Program—has been in place since 2007, primarily for the benefit of threatened and endangered species. The program manages a standing advisory committee, the Independent Science Advisory Committee, consisting of independent scientists with knowledge in technical areas critical to the implementation of the program's science plan. Since 2022, a NPWRC scientist has served on this committee, providing expertise on avian ecology in general, with a focus on whooping crane ecology and management.

Contact: Aaron T. Pearse, apearse@usgs.gov

Collaborators: Platte River Recovery Implementation Program participants

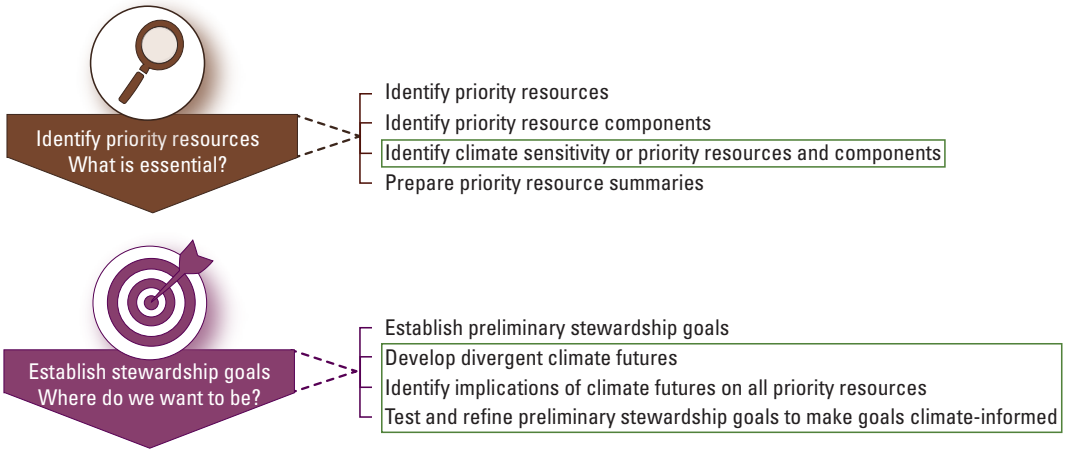
Timeline: Fiscal years 2022–25

Landscape Management Program—Management and Restoration

Climate Change Adaptation

61. Integrating Climate Change Scenario Planning into National Park Service Resource Management

Resource managers are tasked with managing complex systems with inherent uncertainty around how those systems might change with time and respond to management actions in a changing climate. Scenario planning—often implemented as a qualitative, participatory exercise for exploring multiple possible futures—is a valuable tool for addressing uncertainty. At the same time, quantitative information on projected climate changes and their effects is rapidly growing and evolving, but this information is often not at a scale or in a form that resource managers can use. This project piloted a process for combining qualitative scenario planning and quantitative modeling in a way that would create manager-usable information, largely by emphasizing the coproduction of this information by scientists and managers. Building on this success, we developed a process to incorporate climate-change scenario planning into Resource Stewardship Strategies, which is a planning tool developed and used by the National Park Service across the Nation. Insights gained in the first application of this process at Devils Tower National Monument in Wyoming were used to improve the process when applied at Wind Cave National Park in South Dakota. NPWRC scientists and collaborators synthesized the lessons learned from these and many other engagements into products that will guide future climate-change planning efforts. Participation in this work led to an NPWRC scientist



Climate change scenario planning (in green boxes) is incorporated into early steps of the National Park Service's standard Resource Stewardship Strategy development process to improve the robustness of park management actions in the face of a changing climate (National Park Service, 2020).

leading a chapter in the North Central Climate Adaptation Science Center's grassland synthesis.

Contact: Amy J. Symstad, asymstad@usgs.gov

Collaborators: DOI North Central Climate Adaptation Science Center; National Park Service, Badlands National Park, Devils Tower National Monument, Wind Cave National Park, Climate Change Response Program, and Denver Service Center Planning Office; U.S. Forest Service, Buffalo Gap National Grassland

Timeline: Fiscal years 2015–23

Products:

Participants in a scenario planning workshop for Wind Cave National Park consider the implications of four future climate scenarios for the park's streams, springs, and groundwater. Photograph provided by National Park Service.

Miller, B.W., Eaton, M.J., Symstad, A.J., Schuurman, G.W., Rangwala, I., and Travis, W.R., 2023, Scenario-based decision analysis—Integrated scenario planning and structured decision making for resource management under climate change: Biological Conservation, v. 286, p. e110275. [Also available at https://doi.org/10.1016/j.biocon.2023.110275.]

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National Park Service, 2020, Supplemental guidance—Integration of climate change scenario planning into the resource stewardship strategy process: Denver, Colo., National Park Service, 37 p. [Also available at https://irma.nps.gov/DataStore/Reference/Profile/2267238.]

Reynolds, J.H., Miller, B.W., Schuurman, G.W., Carr, W.A., Symstad, A.J., Gross, J.E., and Runyon, A.N., 2024, Accurately characterizing climate change scenario planning in the U.S. National Park Service—Comment on Murphy et al. 2023: Society & Natural Resources. [Also available at https://doi.org/10.1080/08941920.2024.2310226.]

Runyon, A.N., Schuurman, G.W., Miller, B.W., Symstad, A.J., and Hardy, A.R., 2021, Climate change scenario planning for resource stewardship at Wind Cave National Park—Climate change scenario planning summary: Fort Collins, Colo., National Park Service, Natural Resource Report NPS/NRSS/NRR—2021/2274, 114 p. [Also available at https://doi.org/10.36967/nrr-2286672.]

62. Climate Effects on Prescribed Fire Implementation and Efficacy in Northern Mixed-Grass Prairie

Prescribed burning is used by NPS, FWS, U.S. Forest Service, and other organizations to maintain and restore native prairies in the Northern Great Plains. However, climate change will affect the number of days in a year with suitable conditions for prescribed fires and when they occur. Further, climate change may affect the effects of prescribed fire on native and invasive plant species. This project will measure how the number and timing of suitable prescribed fire days has changed during the last 30 years and predict how they will change during the next 50 years under a small number of plausible future climate scenarios. Changes to longer-term weather patterns—in the seasons leading up to and following prescribed fires—may also change the

effectiveness of the fires in achieving their goals, like reducing Kentucky bluegrass (*Poa pratensis*), cheatgrass (*Bromus tectorum*), and other invasive grasses. To address this issue, the project will also use data from long-term plant monitoring programs to look for patterns in how grassland plant communities respond to prescribed fire in different seasonal and annual weather conditions. Results of these two analyses will inform simulations to compare the performance of different short-term and long-term prescribed fire strategies in uncertain future weather (short-term) and climate (long-term) conditions. Together, these results will provide science to help land managers plan for and implement effective prescribed fires in the face of future climate uncertainty.

Contact: Amy J. Symstad, asymstad@usgs.gov

Collaborators: USDA U.S. Forest Service, Rocky Mountain Research Station, Maintaining Resilient Dryland Ecosystems Program; FWS, Native Prairie Adaptive Management Program; National Park Service, Northern Great Plains Fire Ecology Program; DOI North Central Climate Adaptation Science Center

Timeline: Fiscal years 2023–27

SCIENTIST SPOTLIGHT

Kyle McLean

Dr. Kyle McLean began his appointment as a Research Ecologist with NPWRC in early 2021 after successfully completing his Ph.D. in Environmental and Conservation Sciences at North Dakota State University. Completion of his Ph.D. also marked completion of his USGS Pathways Internship. In his Ph.D. research, Dr. McLean used long-term, wetland monitoring data collected by NPWRC to investigate spatial and temporal processes affecting aquatic-macroinvertebrate community composition in prairie-pothole wetlands. Prior to his current appointment, Dr. McLean worked with NPWRC as a Student Services Contractor (2009–10), Masters Student studying fish and amphibian communities along salinity gradients in prairie-pothole wetlands (2012–14), a Term Ecologist (2014–16), and Pathways Intern Ecologist (2016–21). Dr. McLean's current research is focused on developing statistical and mechanistic models that can be used to better understand processes that maintain aquatic biodiversity in prairie-pothole wetlands and streams at different spatial and temporal scales. Dr. McLean's goal is to provide resource managers and other decision makers with science-derived information needed to inform local management strategies (that is, habitat improvement projects) and develop landscape-scale conservation plans. The information derived from Dr. McLean's research will lead to increased freshwater ecosystem resilience to climate and land-use change, and conservation of aquatic biodiversity in the nationally important freshwater ecosystems of the prairie-pothole region.

Kyle McLean.

Riparian/Wetland

63. A Biotic Inventory of Overlook and Mandel Springs in the North Unit of Theodore Roosevelt National Park

Photograph of Overlook Spring, located in the North Unit of Theodore Roosevelt National Park. Photograph by Kyle McLean, U.S. Geological Survey.

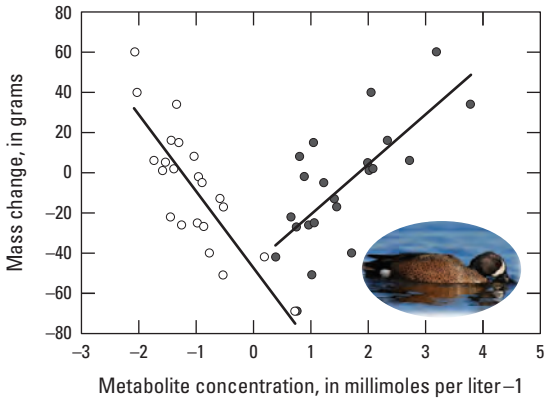
Freshwater springs are rare and unique habitats in the semi-arid Northern Great Plains. They are biodiversity hotspots known to support a variety of uniquely adapted aquatic flora and fauna. These springs also provide important water sources for terrestrial wildlife in semi-arid environments where perennial surface waters are often scarce. Concerned about the potential depletion of local groundwater sources, the National Park Service partnered with NPWRC to help characterize biotic communities present in freshwater springs located in Theodore Roosevelt National Park, North Dakota, by collecting baseline biotic data. In this effort, NPWRC scientists will surved vascular plant, aquatic-macroinvertebrate, amphibian, and reptile communities of Mandal Spring and Overlook Spring, which are two important spring systems in the North Unit of Theodore Roosevelt National Park. A total of 84 plant species and 57 aquatic-invertebrate taxa were found during the survey, including several taxa that have been rarely documented in the State. Information collected will help National Park Service partners better understand how freshwater spring habitats uniquely contribute to the local biodiversity present in the park.

Contact: Kyle I. McLean, kmclean@usgs.gov

Collaborators: National Park Service, Water Resources Division

Timeline: Fiscal years 2021–22

64. Evaluating Wetland Ecosystem Health Using Real-Time Nutrient Dynamics of Ducks



Relationships of two lipid metabolites (Triglycerides [shaded circles] and Beta-hydroxybutyrate [unshaded circles]) with 1-day mass changes in free living lesser scaup during spring migration (modified from Anteau and Afton, 2008). Photograph by Nick Smith, U.S. Geological Survey.

The NPWRC leads a collaborative effort, spanning several studies, with the objective of improving techniques to assess the quality of spring migration habitat for ducks. Spring is a critical time in the life cycle of migratory ducks because during migration, ducks experience peak energetic needs at a time when food resources are often at their scarcest. Accordingly, ducks must maximize energy acquisition by eating high-lipid forage on spring stopover habitats. This research is focused on assessing the quality of those stopover habitats and improving the techniques for assessing energetic status of ducks. Plasma-lipid metabolites of migratory ducks are being used to assess their real-time refueling rates on spring stopover wetland habitats. This work is being done by graduate students that are being

coadvised by a NPWRC scientist. The results will improve further research on spring stopover habitats and assess wetland ecosystem health on a broad scale to inform more efficient conservation efforts (for example, restoration and protection of wetland habitats).

Contact: Michael J. Anteau, manteau@usgs.gov

Collaborators: USGS South Dakota Cooperative Fish and Wildlife Research Unit; The Mississippi Flyway Council; Illinois Department of Natural Resources; South Dakota Game, Fish and Parks; South Dakota State University, Western Illinois University; Ducks Unlimited Canada; Forbes Biological Station; Illinois Natural History Survey

Timeline: Fiscal years 2014–Ongoing

Products:

Bortolotti, L.E., Emery, R.B., Kowal, P.D., Armstrong, L.M., Harriman, V.B., Singer, H.V., Anteau, M.J., Baldwin, F.B., Meuckon, C., and Wrubleski, D.A., 2023, Migrating ducks and submersed aquatic vegetation respond positively after invasive common carp (*Cyprinus carpio*) exclusion from a freshwater coastal marsh: Wetlands, v. 43, no. 25, 18 p.

Bouton, A.F., Anteau, M.J., Smith, E.J., Hagy, H.M., Lancaster, J.D., Jacques, C.N., 2024, Lipid metabolites index habitat quality for canvasbacks on stopover areas during spring migration: Ornithological Applications, v. 126, no. 1, duad058. [Also available at https://doi.org/10.1093/ornithapp/duad058.]

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65. Restoration of Wetland Invertebrates to Improve Wildlife Habitat in Minnesota

The NPWRC is investigating limitations to restoring abundant aquatic-macroinvertebrate populations to Minnesota wetlands and shallow lakes. Recent research on larger, more permanent wetlands in Minnesota indicates that the quality of wetlands used by ducks has decreased. That research also describes a decline in abundance of amphipods, a shrimp-like Crustacean. Amphipods are important forage for ducks during spring migration because amphipods are nutritious and can occur at high densities. This research is focused on understanding what factors limit super abundance of amphipods in Minnesota wetlands. NPWRC scientists will examine limitations of amphipod dispersal and factors that reduce wetland quality (for example, invasive species, agricultural effects, pesticides, and water quality). This study combines a large-scale observational study with laboratory toxicology experiments and a field experiment that involves stocking amphipods.

Contact: Michael J. Anteau, manteau@usgs.gov

Amphipods collected during spring when pairs cling together for breeding. Photograph by Michael J. Anteau, U.S. Geological Survey.

Collaborators: USGS Upper Midwest Environmental Sciences Center; Minnesota Department of Natural Resources (lead agency); Bemidji State University, Environment and Natural Resources Trust Fund; Idaho State University; Legislative-Citizen Commission on Minnesota Resources; Lincoln Bait Landscape Conservation Cooperative

Timeline: Fiscal years 2018–24

Products:

Carleen, J.D., 2022, The effects of fish on amphipods in wetlands of western Minnesota: Bemidji, Minnesota, Bemidji State University, M.S. Thesis, 128 p.

Keith, B.R., 2021, Interactions between wetland conditions and amphipod abundance across western Minnesota's diverse landscape: Bemidji, Minnesota, Bemidji State University, M.S. Thesis, 80 p.

Keith, B.R., Carleen, J.D., Larson, D.M., Anteau, M.J., and Fitzpatrick, M.J., 2022, Protocols for collecting and processing macroinvertebrates from the benthos and water column in depressional wetlands: U.S. Geological Survey Open-File Report 2022–1029, 22 p. [Also available at https://doi.org/10.3133/ofr20221029.]

Larson, D.M., DeJong, D., Anteau, M.J., Fitzpatrick, M., Keith, B., Schilling, E.G., and Thoele, B., 2022, High abundance of single taxon (amphipods) predicts aquatic macrophyte biodiversity in prairie wetlands: Biodiversity and Conservation, v. 31, p. 1073–1093.

66. Importance of Wetlands in Intensively Farmed Landscapes to Duck Production

The NPWRC is collaborating in a partnership to investigate the role of intensively farmed landscapes for production of ducks in the Prairie Pothole Region of the Northern Great Plains. The Prairie Pothole Region annually hosts 50–80 percent of North America's ducks during the breeding season. Accordingly, significant government and private funds go to conservation for the purposes of improving duck production in the Prairie Pothole Region. The Prairie Pothole Region ecosystem has several stressors, and intensive agriculture is chief among them. The current conservation paradigm focuses on protection of habitat in less-farmed landscapes; however, restoration of habitats in intensively farmed landscapes may prove to be an equally valuable approach because areas that are intensively farmed often have a greater baseline capacity for biological productivity. This research aims to evaluate tradeoffs of baseline productivity with potential negative agricultural effects on duck productivity, while exploring potential avenues to mitigate those negative effects. The work started with a pilot study in Iowa and Minnesota during summer 2018 and expanded into North and South Dakota during 2019 and 2020. Ultimately, this work will provide information as to where conservation efforts may be most beneficial to ducks, allowing for future work to address social and economic issues associated with where and how conservation is applied to the Prairie Pothole Region landscape.

Mallard brood in a prairie wetland (foreground) and a wetland in an intensively farmed landscape (background). Photographs provided by Ducks Unlimited, Inc.

Contact: Michael J. Anteau, manteau@usgs.gov

Collaborators: PPJV; Ducks Unlimited, Inc. (lead agency); Iowa State University; Louisiana State University

Timeline: Fiscal years 2018–23

Products:

Mitchell, B.J., Terry, C.V., Ringelman, K.M., Kemink, K.M., Anteau, M.J., Janke, A.K., 2023, Wetland occupancy by duck broods in cropland-dominated landscapes of the United States Prairie Pothole Region: Journal of Wildlife Management, v. 87, no. 2, e22347. [Also available at https://doi.org/10.1002/jwmg.22347.]

67. Understanding Consequences of Management Strategies for Farmed Wetlands to Ecosystem Services in the Prairie Pothole Region

Waterfowl using a partially plowed wetland in an agricultural field. Photograph by Dustin Toy, U.S. Geological Survey.

The NPWRC is leading a partnership with North Dakota State University to examine ecological, social, and financial considerations of farming practices within temporarily ponded wetlands. Farmers strive to maximize crop production on their land and, therefore, may be more successful with more information on costs and benefits of certain management practices. For many years, crops have been planted in prairie-pothole wetlands that are embedded within farm fields. For example, during dry falls, farmers often disturb or remove cattail within seasonal wetlands with hopes of planting crops in the wetlands during the subsequent spring. Wet conditions during spring or summer often prevent a harvestable yield from these areas; however, disturbance of these wetlands may be beneficial because wetlands choked with cattail provide little benefit for wildlife. This study incorporates precision agriculture data (provided by cooperating farmers), field surveys of bird use and wetland characteristics, and opinion surveys of farmers. Findings will provide insights about ecological implications of wetland disturbance to migrating birds, profitability of farming wetlands, and farmer motivations in making land-use decisions about wetlands. It is anticipated that this work will provide information for future experimental conservation practices whereby farming may become more profitable and management actions more beneficial to wetlands and wildlife, particularly migratory waterbirds.

Contact: Michael J. Anteau, manteau@usgs.gov

Collaborators: North Dakota State University

Timeline: Fiscal years 2017–24

Products:

Toy, D.L., 2022, Evaluating financial, social, and waterbird implications of farming within wetlands imbedded in agricultural fields: Fargo, North Dakota, North Dakota State University, PhD Dissertation, 252 p.

68. Evaluating Dynamics of Habitat Resource Availability for Diving Ducks at Pools 13 and 19 of the Mississippi River

NPWRC is co-leading a partnership with Western Illinois University to understand the dynamics of foods for diving ducks at two important migratory stopover areas on the Mississippi River. Navigational Pools 13 and 19 are crucial refueling sites for migratory waterfowl, especially diving ducks, before reaching these higher latitudes where food shortages have been documented. Pool 19 has had changes in hydrology, traffic, and sedimentation since the installation of the Keokuk lock and dam system in 1913. Unlike other navigational pools of the Mississippi River, few aquatic invertebrate and vegetation evaluations have been conducted on Pool 19 in relation to environmental factors. The objective of this research is to create a spatial and temporal habitat assessment of Navigational Pools 13 and 19 using historical and current data. Aquatic surveys will be used to characterize distribution and density of vegetation and macroinvertebrates. Waterfowl aerial survey data will be used to evaluate scaup abundance in relation to habitat factors. Lastly, true metabolizable energy trials will be done using wild-caught scaup to establish energy values for common diet items.

A lesser scaup fitted with an excrement collection harness during a true metabolizable energy trial, April 2019.

Contact: Michael J. Anteau, manteau@usgs.gov

Collaborators: Western Illinois University; Illinois Department of Natural Resources; FWS Region 4, Forbs Biological Station; Illinois Natural History Survey.

Timeline: Fiscal years 2018–24

Products:

Larson, L.D., 2021, Dynamics of habitat resource availability for lesser scaup at Pools 13 and 19 of the Mississippi River: Macomb, Illinois, Western Illinois University, 177 p.

69. Application and Refinement of a Systems Model for Prairie-Pothole Wetlands

In a recently completed effort, NPWRC scientists developed a process-based systems model for prairie-pothole wetlands, the Pothole Hydrology Linked System Simulator (PHyLiSS). The PHyLiSS model simulates changes in hydrology and water chemistry as a result of altered temperature, precipitation, and other environmental inputs to facilitate forecasts of how climate and land-use change will affect wetland hydrology and geochemistry. In the current effort, the extensive biotic and abiotic datasets from the Missouri Coteau Wetland Ecosystem Observatory (https://www.sciencebase.gov/catalog/item/52f0ffd9e4b0f941aa181fc6) are being used to incorporate wetland plant, invertebrate, and vertebrate communities into the PHyLiSS model. We will also use the model to address a variety of climate change and land-use related questions of interest to managers and policy makers.

Contact: Kyle I. McLean, kmclean@usgs.gov

Collaborators: FWS, Chase Lake Wetland Management District; North Dakota State University; University of Minnesota

Timeline: Fiscal years 2020–24

Products:

Epele, L.B., Grech, M.G., Williams-Subiza, E.A., Stenert, C., McLean, K., Greig, H.S., Maltchik, L., Pires, M.M., Bird, M.S., Boissezon, A., and Boix, D., 2022. Perils of life on the edge—Climatic threats to global diversity patterns of wetland macroinvertebrates: Science of the Total Environment, v. 820, 153052. [Also available at https://doi.org/10.1016/j.scitotenv.2022.153052.]

Epele, L.B., Williams-Subiza, E.A., Bird, M.S., Boissezon, A., Boix, D., Demierre, E., Fair, C.G., García, P.E., Gascón, S., Grech, M.G., and McLean, K.M., 2024, A global assessment of environmental and climate influences on wetland macroinvertebrate community structure and function: Global Change Biology, v. 30, no. 2, e17173. [Also available at https://doi.org/10.1111/gcb.17173.]

Kraus, J.M., Kuivila, K.M., Haldik, M.L., Shook, N., Mushet, D.M., Dowdy. K., and Harrington, R., 2021, Cross-ecosystem fluxes of pesticides from prairie wetlands mediated by aquatic insect emergence—Implications for terrestrial insectivores: Environmental Toxicology and Chemistry, v. 40, no. 8, p. 2282–2296. [Also available at https://doi.org/10.1002/etc.5111.]

McKenna, O.P., Mushet, D.M, Kucia, S.R, and McCulloch-Huseby, E.C., 2021, Limited shifts in the distribution of migratory bird breeding habitat density in response to future changes in climate: Ecological Applications, v. 31 no. 7,, p. 1–12. [Also available at https://doi.org/10.1002/eap.2428.]

McKenna, O.P., Renton, D.A., Mushet, D.M., and DeKeyser, E.S., 2021, Upland burning and grazing as strategies to offset climate-change effects on wetlands: Wetlands Ecology and Management, v. 29, p. 193–208. [Also available at https://doi.org/10.1007/s11273-020-09778-1.]

McLean, K.I., Mushet, D.M., Newton, W.E., and Sweetman, J., 2021, Long-term multidecadal data from a prairie-pothole wetland complex reveal controls on aquatic-macroinvertebrate communities: Ecological Indicators, v. 126, 11 p. [Also available at https://doi.org/10.1016/j.ecolind.2021.107678.]

McLean, K.M., Mushet, D.M., and Sweetman, J.N., 2022, Climate and land use driven ecosystem homogenization in the Prairie Pothole Region: Water, v. 14, no. 19, 3106. [Also available at https://doi.org/10.3390/w14193106.]

McLean, K.I., Mushet, D.M. and Sweetman, J.N., 2022, Temporal coherence patterns of prairie pothole wetlands indicate the importance of landscape linkages and wetland heterogeneity in maintaining biodiversity: Frontiers in Ecology and Evolution, v. 10, 897872. [Also available at https://doi.org/10.3389/fevo.2022.897872.]

McLean, K.I., Mushet, D.M., Sweetman, J., Anteau, M.J., and Wiltermuth, M.T., 2020, Invertebrate communities of prairie-pothole wetlands in the age of the aquatic homogenocene: Hydrobiologia, v. 847, no. 18, p. 3773–3793. [Also available at https://doi.org/10.1007/s10750-019-04154-4.]

Mushet, D.M., McKenna, O.P., and McLean, K.I., 2020, Alternative stable states in inherently unstable systems: Ecology and Evolution, v. 10, no. 2, p. 843–850. [Also available at https://doi.org/10.1002/ece3.5944.]

Neff, B.P., Rosenberry, D.O., Leibowitz, S.G., Mushet, D.M., Golden, H.E., Rains, M.C., Brooks, J.R., and Lane, C.R., 2020, A hydrologic landscapes perspective on groundwater connectivity of depressional wetlands: Water, v. 12, no. 1, 29 p. [Also available at https://doi.org/10.3390/w12010050.]

Pires, M.M., Garcia, P.E., Maltchik, L., Stenert, C., Epele, L.B., McLean, K.I., Kneitel, J.M., Racey, S., and Batzer, D.P., 2023. Searching for the Achilles heel(s) for maintaining invertebrate biodiversity across complexes of depressional wetlands: Journal for Nature Conservation, 72, p.126332. [Also available at https://doi.org/10.1016/j.jnc.2023.126332.]

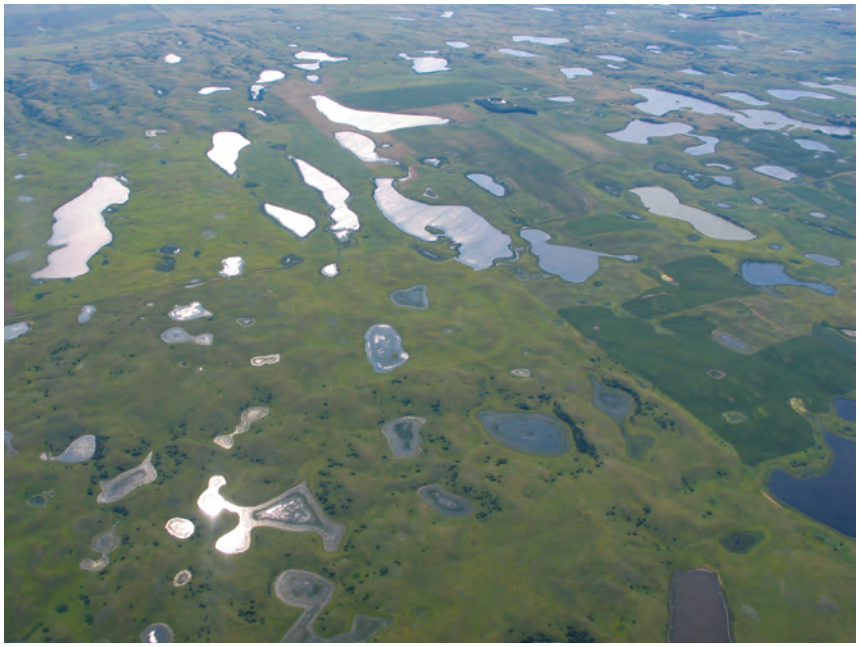
Reindl, S., McLean, K.I., Kneitel, J.M., Bell, D.A., and Batzer, D.P., 2023, Doing the same thing over and over again and getting the same result—Assessing variance in wetland invertebrate assemblages: Wetland*s*, v. 43, no. 84. [Also available at https://doi.org/10.1007/s13157-023-01734-y.]

Stenert, C., Pires, M.M., Epele, L.B., Grech, M.G., Maltchik, L., McLean, K.I., Mushet, D.M., and Batzer, D.P., 2020, Climate- versus geographic-dependent patterns in the spatial distribution of macroinvertebrate assemblages in New World depressional wetlands: Global Change Biology, v. 26, no. 12. p. 6895–6903. [Also available at https://doi.org/10.1111/gcb.15367.]

Williams, A.S., Mushet, D.M., Lang, M., McCarty, G.W., Shaffer, J.A., Kahara, N., Johnson, M-V.V., and Kiniry, J.R., 2020, Improving the ability to include freshwater wetland plants in process-based models: Journal of Soil and Water Conservation, v. 75, no. 6, p. 704–712. [Also available at https://doi.org/10.2489/jswc.2020.00089.]

70. Development and Validation of Wetland-Connectivity Indicators in the U.S. Prairie Pothole Region

NPWRC scientists, in partnership with the U.S. Environmental Protection Agency, are working to (1) quantify cumulative effects of prairie-pothole wetlands on stream communities; (2) explore relations between aquatic-system connectivity and genetic-, species-, and ecosystem-scale biological diversity at watershed and landscape scales; (3) develop mapping unit descriptors based on biotic community traits for ongoing hydrologic connectivity mapping efforts; and (4) facilitate data collection efforts associated with quantifications of watershed-scale hydrologic responses to the aggregate effects of prairie-pothole wetlands. This effort is associated with a USGS Powell Center for Analysis and Synthesis effort to develop aquatic system hydrological- and biological-connectivity maps for the Nation. In 2018, an exploration into wetland effects on freshwater mussel communities in streams and cascading environmental effects that result when mussel communities and associated "mussel beds" are degraded or lost was included in this work.



Wetlands in the Prairie Pothole Region of North American, although often appearing as isolated from each other, are interconnected through a variety of ways including temporary surface-water flows, long-term groundwater flows, and biotic movements. Photograph by David Mushet, U.S. Geological Survey.

Contact: David M. Mushet, dmushet@usgs.gov

Collaborators: U.S. Environmental Protection Agency, Office of Research and Development

Timeline: Fiscal years 2017–22

Products:

Yuan, Y., Zhu, X., Mushet, D.M., Solensky, M.J., and Otte, M.L., 2021, Chemical connectivity and multi-element composition of groundwater in depressional wetlands: Wetlands, v. 41, no. 73, 16 p. [Also available at https://doi.org/10.1007/s13157-021-01469-8.]

71. Estimating Streamflow Duration in the Prairie Pothole Region of the United States

Photograph of streamflow data logger in a small prairie stream located in Stutsman County, North Dakota. Photograph by Kyle McLean, U.S. Geological Survey.

The duration of streamflow is an important determinant of stream jurisdictional status and the ecosystem functions provided by streams. The U.S. Environmental Protection Agency partnered with NPWRC and other Federal partners to improve streamflow-duration modeling methods and inventory-mapping capabilities used to support Clean Water Act of 1972 (Public Law 92-500) jurisdiction determinations and other programmatic needs. NPWRC scientists will collect streamflow monitoring data for the Prairie-Pothole Region and provide technical expertise on stream habitats in the region. The streamflow-duration data will be used to support efforts intended to (1) build upon existing analyses and methods to improve geospatial mapping of the longitudinal and lateral extent of aquatic resources; (2) develop methods for quantifying spatial and temporal variability in streamflow duration; (3) develop and validate process-based and statistical models to predict streamflow in several test watersheds; (4) explore approaches for predicting the effects of climate change and drought on water availability at regional scales; and (5) aid in the development and refinement of regional, field-indicator-based, streamflow-duration assessment methods.

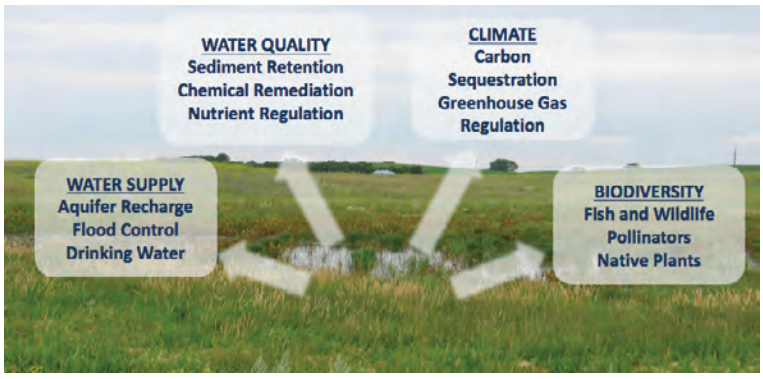
Contact: Kyle I. McLean, kmclean@usgs.gov

Collaborators: U.S. Environmental Protection Agency, Office of Research and Development

Timeline: Fiscal years 2020–22

Ecosystem Services

72. Quantification of the Multiple Services Performed by Wetland Ecosystems in the Prairie Pothole Region



Wetlands perform multiple services valued by society that can be affected in various ways by conservation programs and practices. Photograph by David Mushet, U.S. Geological Survey.

In response to the need to quantify wetland ecosystem services as affected by Federal conservation programs, the NPWRC initiated an effort to develop an integrated landscape model that would facilitate the simultaneous evaluation of multiple services performed by prairie-pothole wetland ecosystems. This effort is focused on incorporating land-use and land-cover change into forecasting models that accounted for variations in agricultural practices and conservation programs. The primary tool being used in this effort is the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) modeling suite. The modeling tool was parameterized for the Prairie Pothole Region

of the United States and new components were developed as needed to quantify conservation program and practice effects on wetland carbon stores; water quality; amphibian, waterfowl, and grassland-bird habitat; native-plant communities; and floral resources available to pollinators. A wetland systems model (PHyLiSS), developed under a separate project is also being used to explore land-use change effects on depressional wetlands and the reach of this effort has been expanded beyond the Prairie Pothole Region to include work in the upper Mississippi River watershed. Model results provide information used for the implementation of conservation activities, such as practices conducted within the USDA CRP and Wetland Reserve Program and policy making that affect wetland ecosystems throughout the agricultural landscape of the Northern Great Plains.

Contact: Owen P. McKenna, omckenna@usgs.gov

Collaborators: USDA, Farm Service Agency, Economics and Policy Analysis Staff, and Natural Resources Conservation Service

Timeline: Fiscal years 2012–25

Products:

McKenna, O.P., Ross, C.D., and Prenger, J.R., 2023, Maximizing the water quality benefits of wetlands in croplands: U.S. Department of Agriculture, Natural Resources of Conservation Service, 4 p. [Also available at https://www.nrcs.usda.gov/sites/default/files/2023-01/CEAP-Wetlands-2023-ConservationInsight-WetlandsWaterQuality.pdf.]

McKenna, O.P., Osorio, J.M., Behrman, K.D. Doro, L., and Mushet, D.M., 2020, Development of a novel framework for modeling field-scale conservation effects of depressional wetlands in agricultural landscapes: Journal of Soil and Water Conservation. v. 75, no. 6, p. 695–703. [Also available at https://doi.org/10.2489/jswc.2020.00096.]

Mushet, D.M., and Effland, W.R., 2020, Wetlands in agricultural landscapes—Significant findings and recent advances from CEAP–Wetlands: Journal of Soil and Water Conservation. v. 75, no. 6, p. 681–683. [Also available at https://doi.org/10.2489/jswc.2020.00092.]

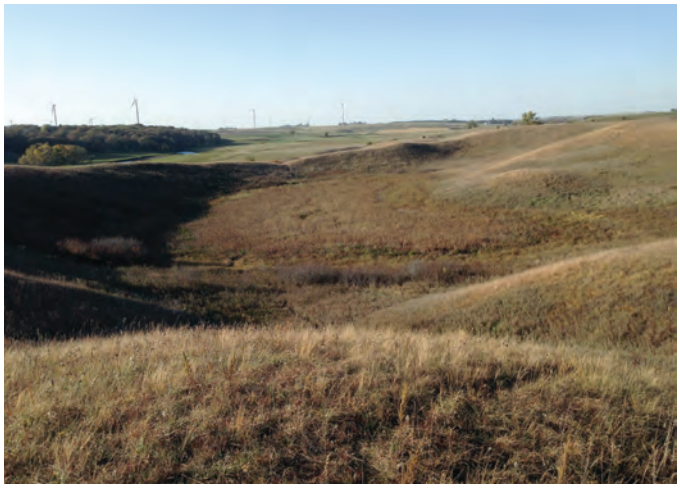
Mushet, D.M., and Roth, C.L., 2020, Modeling the multiple ecosystem services of wetlands in agricultural landscapes: Wetlands, v. 40, p. 1061–1069. [Also available at https://doi.org/10.1007/s13157-020-01297-2.]

Ross, C.D., and McKenna, O.P., 2023, The potential of prairie pothole wetlands as an agricultural conservation practice—A synthesis of empirical data: Wetlands, v. 43, no. 5. [Also available at https://doi.org/10.1007/s13157-022-01638-3.]

Williams, A.S., Mushet, D.M., Lang, M., McCarty, G.W., Shaffer, J.A., Kahara, N., Johnson, M.-V.V., and Kiniry, J.R., 2020, Improving the ability to include freshwater wetland plants in process-based models: Journal of Soil and Water Conservation, v. 75, no. 6, p. 704–712. [Also available at https://doi.org/10.2489/jswc.2020.00089.]

73. Development of a Conservation Reserve Enhancement Program (CREP) Reporting and Analysis Template

The NPWRC is working with the USDA Farm Production and Conservation Business Center to improve partner reporting of the Conservation Reserve Enhancement Program (CREP) reporting of annual accomplishments. In the first phase of this effort, NPWRC will work with the USDA Farm Services Agency to develop an online reporting template for partners to use in submitting annual reports. This template will be designed to collect information needed from partners in a standardized form that facilitates subsequent analyses and development of summary reports to Congress. In the second phase, mechanisms will be developed to facilitate the quantification of multiple ecosystem services from information provided by partners and identify additional information that



A glacially formed kettle-wetland landscape in northwest Iowa. Photograph by David Mushet, U.S. Geological Survey.

would lead to more robust quantifications of services currently being reported or that would be required to quantify additional services. In the third phase, the NPWRC will explore alternative approaches to enhance the quality of information received to generate CREP annual reports to Congress and assist in identifying tools to estimate conservation effects of CREP through geospatial analysis.

Contact: Owen McKenna, omckenna@usgs.gov

Collaborators: USDA, Farm Production and Conservation Business Center, Economic and Policy Analysis Division

Timeline: Fiscal years 2020–25

Products:

Mushet, D.M., and McKenna, O.P, 2022, Development of an online reporting format to facilitate the inclusion of ecosystem services into Conservation Reserve Enhancement Program reports: U.S. Geological Survey Open-File Report 2022–1104, 19 p. [Also available at https://doi.org/10.3133/ofr20221104.]

Mushet, D.M., Post van der Burg, M., and Anteau, M.J, 2022, Assessing conservation and management actions with ecosystem services better communicates conservation value to the public: Journal of Fish and Wildlife Management, v. 13, no. 1, p. 306–318. [Also available at https://doi.org/10.3996/JFWM-21-083.]

74. Using Ecosystem Services Modeling to Inform Water Management Decisions in the Prairie Pothole Region of Iowa

A wetland in Dallas County, Iowa that was created for the purposes of improving downstream water quality. Photo by Lynn Betts (CC BY-NC-SA 2.0 DEED).

Scientists at the NPWRC are collaborating with a U.S. Environmental Protection Agency (EPA) team to evaluate tradeoffs of improving wetland drainage infrastructure and the creation of water quality wetlands with respect to stopover habitat for spring migrating shorebirds and ducks. Water quality wetlands are a nature-based solution for denitrification of surface water. They typically are created at the base of local watersheds and have a semipermanent hydroperiod. The EPA has interest in expanding this practice throughout Iowa with the goal of reducing the Gulf of Mexico hypoxia zone by reducing nutrient inputs into the Mississippi River. Farmers in this region are interested in improving downstream water quality and may consider this proposed management tool, but they also have concerns that their existing wetland drainage infrastructure is outdated and undersized. Thus, the EPA is interested in understanding to what extent water quality wetlands mitigate spring migration habitat if there were improvements in drainage infrastructure. We are using ecosystem services modeling in a scenario-based approach to inform these land management decisions.

Contact: Michael J. Anteau, manteau@usgs.gov

Collaborators: EPA, Oak Ridge Institute for Science and Education Research Participation Program and Office of Research and Development; Iowa State University

Timeline: Fiscal years 2022–24

75. Biodiversity-Productivity Relationships in a Natural Grassland Community Vary Under Diversity Loss Scenarios

The biodiversity-productivity relationship is foundational to understanding and forecasting the impacts of biodiversity loss on ecosystem functioning and services. During the past two decades, hundreds of biodiversity experiments using synthesized communities have been conducted, in which the richness of species or plant functional groups was manipulated through random draws of different numbers of species from the same pool of species. However, the performance of a natural ecosystem under realistic diversity loss scenarios is determined by the abundance of the surviving species or plant functional groups and whether they compensate for lost species. Removal experiments are ideal for examining such scenarios, but they are rarely conducted in a manner useful for quantitatively evaluating the relative importance of abundance and compensation effects for determining the shape of the biodiversity-productivity relationship. In 2018, NPWRC was asked to collaborate on a study that combines data from a removal experiment with data from a similar experiment in Mongolia to explore this topic. The resulting work indicated that the direction and strength of compensation are highly dependent on diversity-loss scenarios, revealing the difficulty of predicting the effects of biodiversity loss from natural ecosystems.

Contact: Amy Symstad, asymstad@usgs.gov

Collaborators: State Key Laboratory of Vegetation and Environmental Change, Institute of Botany, Chinese Academy of Sciences

Timeline: Fiscal years 2018–21

Products:

Pan, Q., Symstad, A.J., Bai, Y., Huang, J., Wu, J., Naeem, S., Chen, D., Tian, D., Wang, Q., and Han, X., 2022, Biodiversity-productivity relationships in a natural grassland community vary under diversity loss scenarios: Journal of Ecology, v. 110, no. 1, p. 210–220. [Also available at https://doi.org/10.1111/1365-2745.13797.]

Decision Analysis Frameworks

76. Decision Analysis and Support

Natural resource decision makers face many challenges in terms of making choices to solve complex management problems. Many of these challenges stem from being overwhelmed by too many choices, uncertain or delayed outcomes, and multiple stakeholders with conflicting desires. Decision analysis (also known as structured decision making) is a set of qualitative and quantitative tools for structuring and analyzing the impediments to decision making, with a focus on overcoming those impediments. At the NPWRC, we use the principles of decision analysis, coupled with our expertise in ecological analysis and numerical optimization, to help our partners make more transparent and defensible management decisions. Projects that the NPWSC has supported have included finding optimal climate adaptation strategies for historical resources in the national parks, helping the FWS find solutions to specific refuge management problems, and helping our partners evaluate which scientific information is most important in their decisions. Our staff also participates in training and mentorship programs associated with the FWS National Conservation Training Center in Shepherdstown, West Virginia.

Contact: Max Post van der Burg, maxpostvanderburg@usgs.gov

Collaborators: FWS; National Park Service; USACE

Timeline: Ongoing

77. Decision Analysis of Options for Controlling Asian Carp Invasion in the Tennessee River

Range expansion of Asian carp along the Tennessee River is a concern because of potential negative impacts to the ecological and economic benefits provided by the river. Fisheries resource managers of Alabama, Mississippi, and Tennessee are urgently looking for management and control actions that will prevent further expansion of Asian carp. Other managers on the Tennessee river also have interest in managing Asian carp expansion. The Tennessee Valley Authority owns the lock and dam infrastructure on the river, and the USACE operates and manages the Tennessee Valley Authority infrastructure. Both organizations are preparing to develop a management framework using deterrent technologies to reduce or prevent fish passage with focus on Asian carp. We are using a quantitative decision analysis approach to help State and Federal decision makers make choices about where to place barriers and remove Asian Carp populations to prevent further expansion within the Tennessee River. The results from this analysis will be used by the Tennessee Valley Authority to draft an Environmental Assessment to support barrier installation.

Contact: Max Post van der Burg, maxpostvanderburg@usgs.gov

Collaborators: USACE; Tennessee Valley Authority; FWS, Tennessee Wildlife Resources Agency; Mississippi Wildlife, Fisheries and Parks; Kentucky Department of Fish and Wildlife

Timeline: Fiscal years 2020–21

Products:

Post van der Burg, M., Smith, D.R., Cupp, A.R., Rogers, M.W., and Chapman, D.C., 2021, Decision analysis of barrier placement and targeted removal to control invasive carp in the Tennessee River Basin: U.S. Geological Survey Open-File Report 2021–1068, 18 p. [Also available at https://doi.org/10.3133/ofr20211068.]

78. Science Support for Mississippi River Long-Term Research and Monitoring Program

The Upper Mississippi River Restoration Program is a multiagency federal-state partnership that was established in 1985 with the goal of restoring the health and resilience of the Upper Mississippi River System. The UMRR Program is administratively divided into two program elements: a restoration element that focuses on establishing and managing Habitat Rehabilitation and Enhancement Projects aimed at improving ecosystem functioning; and a long-term research and monitoring (LTRM) element that performs, facilitates, and synthesizes monitoring and research projects aimed at understanding the Upper Mississippi River System. Recently, The Water Resources Development Act of 2020 authorized budget increases to the LTRM component of the program. Selecting which science priorities to add as part of this increase is a difficult choice involving trade-offs among the preferences of LTRM partners and potentially long-term commitments of effort that could impact ongoing monitoring activities. We led LTRM leaders and stakeholders through a decision analysis process aimed at helping the LTRM program element of the Upper Mississippi River Restoration develop a comprehensive framework for prioritizing and selecting information needs.

Contact: Max Post van der Burg, maxpostvanderburg@usgs.gov

Collaborators: USACE, FWS, Upper Mississippi River Basin Association, Minnesota Department of Natural Resources, Wisconsin Department of Natural Resources, Iowa Department of Natural Resources, Illinois Natural History Survey, Missouri Department of Conservation

Timeline: Fiscal years 2021–22

79. Decision Making and Climate Adaptation Framework for Midwest Refuges

There are many issues that threaten the ability of Midwest National Wildlife Refuge System (NWRS) stations to meet conservation goals, including the effects of climate change such as increased flooding from heavy precipitation, changes in species phenology, or migration patterns and range shifts. Managers frequently cite a lack of climate expertise, lack of downscaled climate data, or the variability among projections as challenges to incorporating climate change into their planning. We will pilot an approach at select NWRS stations that integrates two frameworks: decision analysis and "resist-accept-direct." We will bring together climate scientists and managers at workshops to tailor these frameworks to the climate issues experienced at each refuge. The final products will document the integrated framework and workshop outcomes and provide guidance for application of the framework methods. Results will be shared nationally as the ultimate aim is for the FWS to adopt this approach and standardize a means of addressing climate change across the NWRS.

Contact: Max Post van der Burg, maxpostvanderburg@usgs.gov

Collaborators: FWS

Timeline: Fiscal years 2022–25

80. Decision Support for Update of Minnesota Invasive Carp Action Plan

Minnesota Department of Natural Resources (DNR) has an Invasive Carp Action Plan that guides work on invasive carp. The plan was first developed in 2011 by Minnesota DNR, partners, and stakeholders, with the goal of limiting the spread and effect of invasive carp. The plan was revised in 2014, and an addendum added in 2020 to provide additional detail on the status of invasive carp in Minnesota and on scientific developments. The original plan was written when invasive carp captures numbered less than 10 individuals per year. In recent years, captures of invasive carp in Minnesota have increased. Because of the changing status of invasive carp in Minnesota and the availability of new management options, the plan needs to be updated, and time is of the essence. The goal of this project is to use a structured decision making process that will incorporate diverse stakeholders and invasive carp experts from within and outside of DNR to evaluate options for managing invasive carp in Minnesota. This process will be transparent and inclusive and yield products that can be used to inform the update of the plan.

Contact: Max Post van der Burg, maxpostvanderburg@usgs.gov

Collaborators: FWS

Timeline: Fiscal years 2023–24

Grazing

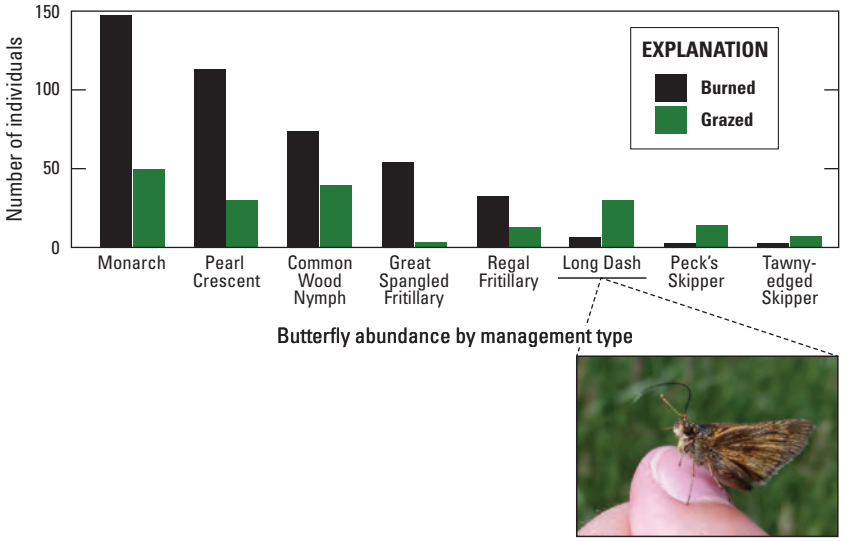
81. Evaluation of Conservation Grazing Compared to Prescribed Fire to Manage Tallgrass Prairie Remnants for Plant and Pollinator Species Diversity

With scarcely 2 percent of native tallgrass prairie remaining today, wisely managing what little remains is imperative to conserve prairie-dependent plants, pollinators, and other animals and ecosystem processes. Two commonly used methods of prairie management are prescribed fire and conservation grazing. Both of these methods may present tradeoffs with respect to conservation of vulnerable plant, bee, or butterfly species, but those tradeoffs are not well described, and resource managers do not have all the information necessary to develop optimal management plans for their goals. With this study, funded by the Minnesota Environment and Natural Resources Trust Fund, we aimed to fill that knowledge gap by characterizing effects on bees and butterflies that are related to the management practice alone compared to those effects mediated by management-caused changes in vegetation. Further, we related bee and butterfly life history traits to their responses to fire and grazing to clarify if results can be generalized or are species specific. We also extended this project to another fire-dependent ecosystem, Australian tropical savanna, to learn how different burning regimes affect butterfly species diversity and abundance.

Contact: Diane L. Larson, dlarson@usgs.gov

Collaborators: FWS, Morris Wetland Management District; Minnesota DNR, Division of Parks and Trails, Prairie Conservation Plan; University of Minnesota Department of Entomology and Graduate Program in Conservation Sciences; The Nature Conservancy; Minnesota Environment and Natural Resources Trust Fund; private landowners in western Minnesota; Charles Darwin University; Commonwealth Science and Industrial Research Organization, Australia.

Timeline: Fiscal years 2016–23



Several species of butterflies varied in abundance between burned (black bars) and grazed (green bars) sites. Some of the least commonly encountered butterflies were only on grazed sites (pooled 2016 and 2017 counts).

Products:

Larson, D.L., Hernández, D.L., Larson, J.L., Leone, J.B., and Pennarola, N.P., 2020, Management of remnant tallgrass prairie by grazing or fire—Effects on plant communities and soil properties: Ecosphere, v. 11, no. 8, 17 p. [Also available at https://doi.org/10.1002/ecs2.3213.]

Leone, J.B., Pennarola, N.P., Larson, J.L., Oberhauser, K., and Larson, D.L., 2022, Divergent responses of butterflies and bees to burning and grazing management in tallgrass prairies: Ecology and Evolution, v. 12, no. 12, p. e9532. [Also available at https://doi.org/10.1002/ece3.9532.]

Leone, J.B., Larson, D.L., Richards, A.E., Schatz, J., and Andersen, A.N., 2023, Fire regime shapes butterfly communities through changes in nectar resources in an Australian tropical savanna: Ecosphere, v. 14, no. 11, p. e4717. [Also available at https://doi.org/10.1002/ecs2.4717.]

82. Grazing Resources for Integrated Conservation of Bison and Native Prairie at Badlands National Park, South Dakota

Badlands National Park contains one of the largest protected expanses of mixed-grass prairie in the United States, much of which supports a herd of nearly wild bison. The park, nevertheless, is too small to accommodate bison's natural nomadic behavior, which in the past resulted in their ephemeral but intense effect on Great Plains grasslands. Consequently, active management of the number of bison in the park is necessary to conserve the plant species and communities on which the bison and other wildlife depend. This research assesses the spatial distribution of productivity, composition, and consumption of park vegetation; the location and condition of water resources in the park; and the temporal variation of bison diet. Results will be used to determine the park's capacity to simultaneously support desired vegetation conditions and more bison. A companion project (the "38. Understanding How Land-Use Change in the Northern Great Plains Affects Pollinator Health and Pollination Services"

Spatially heterogeneous bison grazing—from the square meter shown here to the park scale shown in the graphic in section "39. Integrated Conservation of Bison and Native Prairie at Badlands National Park, South Dakota"—reflects a diversity of grassland plant communities across Badlands National Park.

section in this report) is assessing the temporal and spatial distribution of bison in the park using GPS collars. Combined results from these studies will be used to explore the feasibility of various bison population and vegetation objectives under different management and weather scenarios. These evaluations are key for National Park Service managers to determine a successful management strategy for the mutual benefit of native prairie and bison at Badlands National Park.

Contact: Amy J. Symstad, asymstad@usgs.gov; Glen A. Sargeant, gsargeant@usgs.gov

Collaborators: National Park Service, Badlands National Park

Timeline: Fiscal years 2016–Ongoing

Restoration

83. Effects of Invasive Plant Species on Reproduction of the Rare Endemic Plant Dakota Buckwheat (*Eriogonum visheri*) at Badlands National Park

Our study system is at Badlands National Park. *A*, Yellow sweetclover dominating the landscape. *B*, Bumblebees visiting yellow sweetclover flowers. *C*, Dakota buckwheat, preferred by smaller bees, such as sweat bees. *D*, Russian thistle flowers, also preferred by smaller bees. Photographs by Milt Haar (*A*) and Diane Larson (*B–D*), U.S. Geological Survey

Endemism in plants is uncommon in the Great Plains. Dakota buckwheat (*Eriogonum visheri*) is a rare, endemic plant present in only a few locations at Badlands National Park and at sites with similar soils outside the park. In an earlier study, the NPWRC inferred that of two common, coflowering invasive plants, Russian thistle (*Salsola tragus*) was more likely than yellow sweetclover (*Melilotus officinalis*) to interfere with Dakota buckwheat pollination (Larson and others, 2021). This inference was based on an analysis that grouped pollinating insects and flowering plants into groups, called "modules," in which pollinators and plants were statistically more likely to interact with each other than with those outside their module. In this study, NPWRC scientists explicitly test the effect of these two invasive plants on visitation, pollen limitation, and seed set of Dakota buckwheat. By doing the meticulous work this study requires, we have been able to better interpret other studies that only investigate visitation without assessing seed set and provide managers with information needed to manage invasive plants near this rare endemic plant.

Contact: Diane L. Larson, dlarson@usgs.gov

Collaborators: National Park Service, Badlands National Park

Timeline: Fiscal years 2014–21

Products:

Larson, D.L., Larson, J.L., Symstad, A.J., Buhl, D.A., and Portman, Z.M., 2021, Coflowering invasive plants and a congener have neutral effects on fitness components of a rare endemic plant: Ecology and Evolution, v. 11, no. 9, p. 4750–4762. [Also available at https:doi.org/ https://doi.org/10.1002/ece3.7375.]

Larson, D.L., Portman, Z.M., Larson, J.L., and Buhl, D.A., 2022, Variation in foraging patterns as reflected by floral resources used by male vs female bees of selected species at Badlands National Park, SD, USA: Arthropod-Plant Interactions, v. 16, p. 145-157. [Also available at https://doi.org/10.1007/s11829-021-09881-x.]

84. Evaluation of Tallgrass Prairie Restoration Methods to Improve Resistance to Invasive Species and Maintenance of Plant Species Diversity with Time

Patience is necessary when reconstructing native tallgrass prairie from abandoned farmland. In this research effort, we observed that as reconstructions matured, Canada thistle (*Cirsium arvense*) cover declined even though herbicides were not applied. There is no single best planting method for all situations. Ten years after planting, cover of planted, native nonplanted, and exotic species varied little among three planting methods (dormant-season broadcast, growing-season broadcast, and growing-season drill) used in this study. Planting a seed mix with more species did result in reconstructions that harbored more species, but at the cost of lower proportional success. Exotic cool-season grasses may be the biggest threat to these reconstructions. None of the planting methods or seed mix richness levels slowed their increase. To address this issue, we are now exploring the effects of the mutualist fungi (arbuscular mycorrhizal fungi) on native seedling establishment and competitive ability of native versus invasive seedlings. Knowledge gained from this research effort is useful to land managers aiming to improve invasion resistance in tallgrass prairie restorations. The NPWRC also worked with restoration ecologists in other ecosystems to synthesize recommendations for using ecological restoration to curb biotic invasions and to review the literature around the role of pollinator ecosystem services in remediation and restoration of contaminated lands.

Contact: Diane L. Larson, dlarson@usgs.gov

Collaborators: FWS, Neal Smith National Wildlife Refuge, Litchfield Wetland Management District, Fergus Falls Wetland Management District, and Morris Wetland Management District; U.S. Forest Service, Eastern Forest Environmental Threat Assessment Center

Timeline: Fiscal years 2005–24

Products:

Drobney, P., Larson, D.L., Larson, J.L., and Viste-Sparkman, K., 2020, Toward improving pollinator habitat—Reconstructing prairies with high forb diversity: Natural Areas Journal, v. 40, no. 3, p. 252–261 [Also available at https://doi.org/10.3375/043.040.0322.]

Larson, J.L., Aldrich-Wolfe, L., Vink, S.N., Huerd, S.C., Vacek, S.C., Drobney, P.M., Jordan, N., and Larson, D.L., 2021, Arbuscular mycorrhizal fungi in remnant and reconstructed prairies in Minnesota and Iowa, 2019 (ver. 2.0, April 2022): U.S. Geological Survey data release. [Also available at https://doi.org/10.5066/P95R5UNN.]

Meldrum, J.R., Larson, D.L., Hoelzle, T.B., and Hinck, J.E., 2024, Considering pollinators' ecosystem services in the remediation and restoration of contaminated lands: Overview of research and its gaps: Integrated Environmental Assessment and Management, v. 20, no. 2, p. 322-336. [Also available at https://doi.org/10.1002/ieam.4808.]

Vink, S.N., Aldrich-Wolfe, L., Huerd, S.C., Larson, J.L., Sara, C.V., Drobney, P.M., Barnes, M., Viste-Sparkman, K., Jordan, N.R., and Larson, D.L., 2022, Belowground mutualisms to support prairie reconstruction—Improving prairie habitat using mycorrhizal inoculum: U.S. Geological Survey Open-File Report 2022–1055, 28 p. [Also available at https://doi.org/10.3133/ofr20221055.]

Typical early establishing species in a prairie reconstruction planted with a low-diversity seed mix. Photograph by Diane Larson, U.S. Geological Survey.

85. Improving Wildlife Habitat Through Management and Restoration of Native Prairies on Lands Under U.S. Fish and Wildlife Service Ownership

The extent of native prairie throughout the north-central United States has sharply declined since European settlement, and much of the native prairie that remains has been invaded by introduced cool-season grasses, reducing floristic diversity and quality. On lands under its ownership, the FWS is working to restore native prairie integrity by reducing introduced species under the Native Prairie Adaptive Management (NPAM) program. Restoration actions consist of forms and timing of defoliation, including burning and grazing. Each year, managers face a difficult decision about whether to defoliate a prairie or not and, if so, which defoliation treatment to apply given the current type and degree of invasion and recent history of defoliation. Managers desire to learn about effectiveness and efficiency of these approaches through the decision-making and implementation process. The NPAM program provides real-time decision support to managers with the objective of increasing the cover of native grasses and forbs.

Contact: Terry Shaffer, tshaffer@usgs.gov

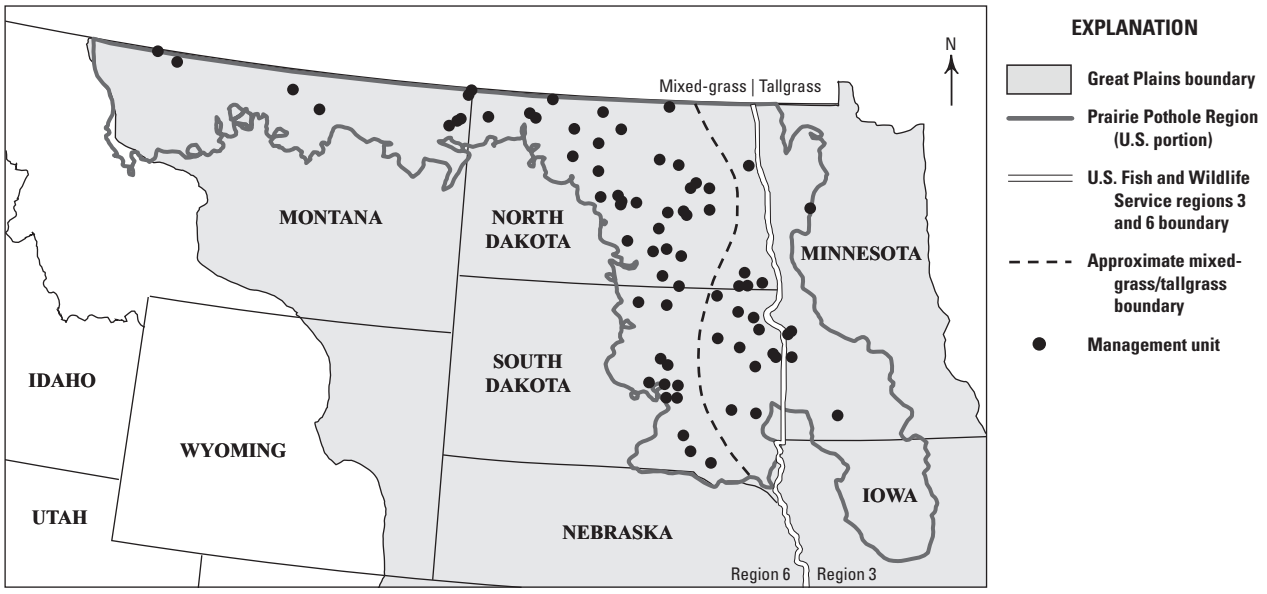
Collaborators: FWS (lead agency), National Wildlife Refuge System, Refuge Cooperative Research Program, and Inventory and Monitoring Program; USGS; Georgia Cooperative Fish and Wildlife Research Unit

Timeline: Fiscal years 2010–20

Products:

Grant, T.A., Shaffer, T.L., and Flanders, B., 2020, Patterns of smooth brome, Kentucky bluegrass, and shrub invasion in the Northern Great Plains vary with temperature and precipitation: Natural Areas Journal, v. 40, no. 1, p. 11–22. [Also available at https://doi.org/10.3375/043.040.0103.]

Grant, T.A., Shaffer, T.L., and Flanders, B., 2020, Resiliency of native prairies to invasion by Kentucky bluegrass, smooth brome, and woody vegetation: Rangeland Ecology & Management, v. 73, no. 2, p. 321–328. [Also available at https://doi.org/10.1016/j.rama.2019.10.013.]



Extent of the mixed-grass and tallgrass prairies in the Great Plains of the northern United States. The U.S. Fish and Wildlife Service (FWS) management units enrolled in the Native Prairie Adaptive Management (NPAM) program are contained within the U.S. portion of the Prairie Pothole Region, an ecoregion of soils and topography formed by glacial activity. The dashed line is the approximate demarcation of the mixed-grass (westerly) and tallgrass prairie (easterly) systems. Refuges from two FWS regions (3 and 6) participate in the NPAM program. Graphic from Moore and others (2020).

86. Sourcing Plants for Conservation and Restoration—Developing a Risk Assessment Framework

A tallgrass prairie planting being seeded. Photograph by Diane Larson, U.S. Geological Survey.

Tallgrass prairie species are planted in a variety of settings (for example, retired farmland and roadsides) for a variety of reasons (for example, plant conservation, pollinator diversity, and game-animal habitat). Much of the seed used for these plantings is produced commercially in agricultural-like conditions and can be contaminated by "weed seeds" (for example, exotic and invasive). In this study, funded by the USGS Northeast Climate Adaptation Science Center, an analytical tool was created to assess the risk of inadvertently introducing weed seeds into a prairie planting. An increase in the distance between the production location and the planting site increases the risk of introducing a new weed species to a landscape. However, increasing that distance also makes obtaining enough seed to create high-quality plantings more feasible. The new tool will balance two factors, weed risk and seed availability, and provide evidence-based guidance to land managers making seed sourcing choices. The analytical framework is broadly applicable to conservation concerns in tallgrass prairies. For example, the framework can be used to determine if the balance between weed risk and seed availability will change if managers adopt sourcing strategies that attempt to anticipate climate change (for example, sourcing seed from farther south). Another issue that arose from conversations with stakeholders was the role of interactions with below-ground biota in prairie restoration. The NPWRC addressed this issue with a literature review, currently in revision at Natural Areas Journal.

Contact: Diane L. Larson, dlarson@usgs.gov

Collaborators: USDA, U.S. Forest Service, Northern Research Station

Timeline: Fiscal years 2019–21

Products:

Larson, J.L., Larson, D.L., and Venette, R.C., 2021, Balancing the need for seed against invasive species risks in prairie habitat restorations: PLoS One, v. 16, no. 4, 17 p. [Also available at https://doi.org/10.1371/journal.pone.0248583.]

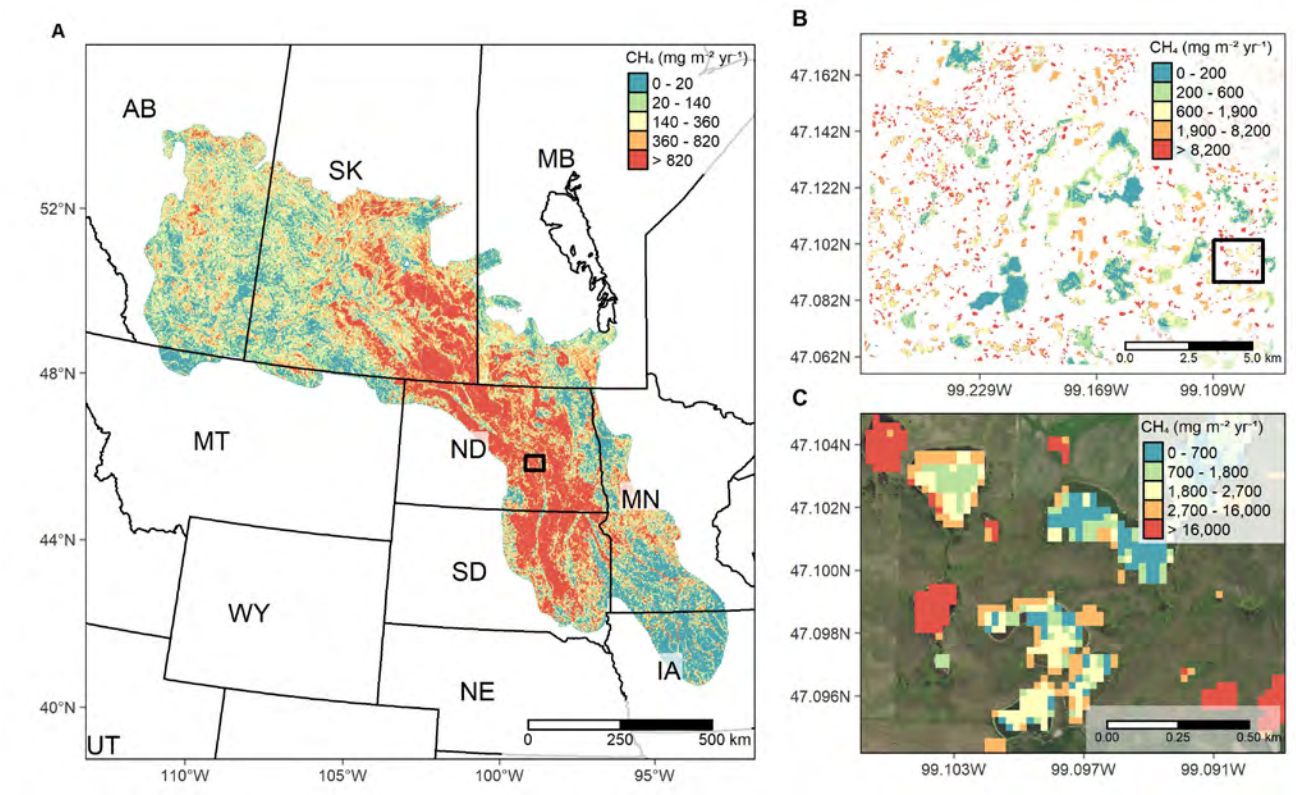
Larson, J.L., Venette, R.C., and Larson, D.L., 2022, Restoration for resilience—The role of plant–microbial interactions and seed provenance in ecological restoration: Natural Areas Journal, v. 42, no. 2, p. 152-159. [Also available at https://doi.org/10.3375/21-42.]

Land Change Science Program—Climate Research and Development

Greenhouse Gases

87. Mechanisms, Models, and Management of Invasive Species and Soil Biogeochemical Process in Prairie Pothole Wetlands

The ecological integrity of thousands of acres of wetland habitat is being impacted by changes in land cover, land use, climate, and invasive species. Previous work has indicated that Prairie Pothole Region wetlands are hotspots for rapid turnover and transport rates of GHG and storage and sequestration of soil organic carbon. Many of these changes in GHG fluxes are driven by changes in wetland plant communities from invasion of hybrid cattail (*Typha* X *glauca*). However, mechanisms controlling GHG and soil organic carbon fluxes and species invasion are not well understood, leading to high uncertainty in model estimates of these processes. The purpose of this project is to use USGS remotely sensed products, along with experimental and observational field data to develop spatially explicit, landscape-scale models of invasive cattails and soil biogeochemical processes. These models will assist in monitoring wetland habitat, in anticipating changes that may occur under various land-use, land-cover, and climate scenarios, and in choosing management strategies that reduce GHG emissions, facilitate soil organic carbon sequestration and storage, and preserve high-quality wetland habitat.



A, Prairie Pothole Region map of wetland methane (CH_4) emissions in 2011, representing a wet period in the region. *B*, Map of wetland CH_4 emissions demonstrating a high level of among-wetland variation. *C*, Fine-resolution (30-meter pixel) map showing within-wetland variation in CH_4 emissions. Legend colors correspond with quantiles of CH_4 flux rates within each map to help visualize spatial variation in CH_4 fluxes.<graphic>87.Bansal_60_methane_map_revision</graphic>

Contact: Sheel Bansal, sbansal@usgs.gov

Collaborators: USGS, Geology, Geophysics, and Geochemistry Science Center, National Research Program, Woods Hole Coastal and Marine Science Center, Wetland and Aquatic Research Center; FWS, Chase Lake Wetland Management District; U.S. Forest Service, Southern Research Station; USDA, Agricultural Research Service; Ducks Unlimited, Inc.; Olympia Circuits; Stanford University

Timeline: Fiscal years 2019–23

Products:

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88. Assessing the Climate Change Mitigation Potential of Wetland Restoration in the Conservation Reserve Program—Measurements, Modeling, and Scaling Changes in Soil Carbon and Greenhouse Gas Fluxes

Wetlands are an important part of the USDA CRP practices to improve water quality and wildlife habitat, but there are many unanswered questions about carbon cycling and GHG emission following wetland drainage and restoration. Wetland drainage for agricultural production has reduced wetland soil carbon stocks across the United States, and wetland restoration can re-build organic carbon. In this project, we measure soil carbon, vegetation, and GHGs from CRP wetlands to estimate their carbon and GHG fluxes. The study area is in the Great Plains (from Texas to North Dakota) and Glaciated Plains of Ohio and Illinois, which is where 80 percent of wetland CRPs are restored. The field data will be used to calibrate existing models such as DayCent and machine learning models as used in Bansal and others (2023). This information on wetlands will (1) inform the EPA's National Inventory of Greenhouse Gas Sources and Sinks to meet our national commitments to the Paris Climate Agreements, and (2) support the development of wetland management practices that utilize these natural ecosystems as climate-based solutions.

Contact: Sheel Bansal, sbansal@usgs.gov

Collaborators: Ducks Unlimited, USDA North Central Agricultural Research Laboratory, University of Missouri, Colorado State University Boulder, Kenyon College, Clemson University, Pennsylvania State University

Timeline: Fiscal years 2022–26

Using a gas powered post pounder to collect wetlands soil cores in clay-rich (cement like!) sediment.

89. Decoding the Unifying Microbial Metabolic Controllers on Soil Cycling Across Freshwater Wetlands

Although freshwater wetlands occupy only a small percentage of the land surface, they are some of the largest carbon sinks, storing 30 percent of global soil carbon. However, under certain conditions, this soil carbon is microbially available and decomposes to GHGs, such as methane (CH_4), carbon dioxide, and nitrous oxide. CH_4 fluxes from wetlands are the most concerning because they represent the largest natural source to the global CH_4 budget. These emissions are also the most difficult to predict because they vary greatly among wetlands of the same geographic region and type. Despite their global climatic significance and the clear contributions of microorganisms to GHGs, the microbial metabolic determinants governing the transformation of soil organic carbon into CH_4 are poorly understood, creating a knowledge gap that hinders accurate predictions. In this study, we will conduct high spatial resolution analysis of soil cores for chemistry and microbiology that affect GHGs from wetlands across North America. The data will be used to parameterize Earth Systems Models such as the Department of Energy's Energy Exascale Earth System Model.

Contact: Sheel Bansal, sbansal@usgs.gov

Brian Tangen (USGS) and Jorge Villa (Ohio State) inserting a 'peeper' into wetland sediment at Cottonwood Lake Study Area to collect water samples along a vertical gradient.

Collaborators: Department of Soil and Crop Science, Colorado State University; Department of Statistics, Colorado State University , Department of Soil and Crop Science, Colorado State University; Department of Civil and Environmental Engineering, The Ohio State University; School of Geosciences, University of Louisiana at Lafayette; Department of Civil and Environmental Engineering, University of Delaware; USGS Wetland and Aquatic Research Center; Lawrence Berkeley National Laboratory; Argonne National Laboratory

Timeline: Fiscal years 2023–25

Land Cover Change Scenarios and Modeling

90. The Impact of Future Changes in Climate on Breeding Waterfowl Pairs in the U.S. Prairie Pothole Region

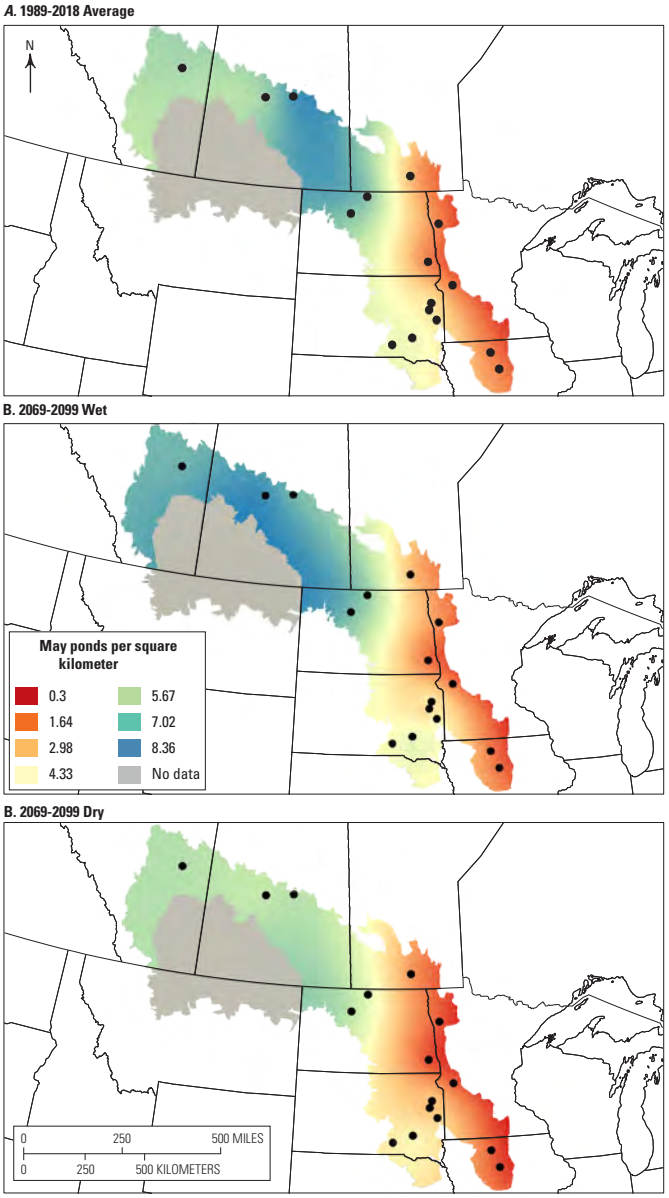
The Prairie Pothole Region is recognized as one of the most productive areas for waterfowl in North America and is used by an estimated 50–80 percent of the continent's breeding duck population. The ongoing acquisition program of the FWS National Wildlife Refuge System has conserved about 1.3 million hectares of critical breeding-waterfowl habitat. A major assumption inherent to the current conservation approach is that past distributions of waterfowl habitat and populations are relatively representative of future distributions. The goal of this project is to coproduce novel information for land-management agencies to better plan for future impacts of climate change on the wetland habitat for breeding waterfowl pairs in the U.S. Prairie Pothole Region. A mechanistic hydrology model is being used in combination with FWS multidecadal datasets and predictive breeding waterfowl pair statistical models to simulate wetland-waterfowl responses under different climate futures.

SCIENTIST SPOTLIGHT

Owen McKenna

Dr. Owen McKenna is a wetland ecosystem scientist who joined NPWRC as a Mendenhall Postdoctoral Fellow in 2016. Dr. McKenna received a Ph.D. in Environmental Life Sciences at Arizona State University where he studied how climate change might affect the ecological functioning of desert playa wetlands. In 2020, Dr. McKenna officially transitioned from Postdoctoral Fellow to Research Ecologist. His current research at NPWRC is focused on elucidating a more robust mechanistic understanding of how wetland ecosystems respond to changes in climate and land use in support of (1) migratory-bird habitat management and (2) water quality and water quantity issues in agricultural and grassland landscapes of the Northern Great Plains, Midwestern United States, and south-central Canada. His approach for addressing these scientific and management issues involves developing modeling tools that are informed by empirical data and scaling up patterns and processes across regions with geospatial tools. Through collaborations with the USGS Midwest and North Central Climate Adaptation Science Centers, the U.S. Department of Agriculture, and the Prairie Pothole Joint Venture, Dr. McKenna is applying these tools to help natural resource managers prepare for and adapt to future changes in climate and land use.

Owen McKenna.



Wetland pond density under three scenarios. Panel A is the historical May pond count mean (3.60 million) interpolated among the downscaled pond density of 16 study sites. Panels B and C are both future (2070–99) mean May pond count modeled estimates: *B*, the Wet Future had the highest number of May ponds (3.65 million, +1 percent) from historical means and C, the Dry Future had the lowest number of May ponds (3.17 million, –12 percent).

By working directly with scientists and decision makers at a DOI land management agency, delivery of actionable science that can readily provide information to FWS about potential climate-driven impacts to breeding waterfowl pairs on currently monitored wetlands will be ensured.

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Collaborators: FWS, HAPET, Bismarck, N. Dak.; University of Colorado-Boulder; USGS North Central Climate Adaptation Science Center

Timeline: Fiscal years 2018–24

Products:

McKenna, O.P., Mushet, D.M, Kucia, S.R, and McCulloch-Huseby, E.C., 2021, Limited shifts in the distribution of migratory bird breeding habitat density in response to future changes in climate: Ecological Applications, v. 31, no. 7, p. 1–12. [Also available at https://doi.org/10.1002/eap.2428.]

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91. The Impact of Future Climate on Wetland Habitat in a Critical Migratory Waterfowl Corridor of the Prairie Pothole Region

The southeast portion of the Prairie Pothole Region in Minnesota and Iowa has faced some of the greatest challenges in wetland conservation. Although advances have been made to restore these habitats, land managers face new challenges in the form of climate change and continued land-use change pressures. The goal of this research is to provide wetland managers with an assessment of wetland trends and forecasts to better plan and target conservation actions. By combining long-term monitoring and mechanistic modeling with the most current climate and land-use change projections, this effort will produce a reproducible workflow for assessing site-specific and regional changes in the hydrological functioning of critical waterfowl habitat. To ensure the most effective application of these results, a diverse set of wetland managers will provide feedback throughout the research process.

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Collaborators: USGS Midwest Climate Adaptation Science Center; FWS, Bloomington, Minn.; FWS, Morris Wetland Management District, Morris, Minn.

Timeline: Fiscal years 2020–22

Products:

McKenna, O.P., 2022, Final report—The impact of future climate on wetland habitat in a critical migratory waterfowl corridor of the Prairie Pothole Region: Final Report for the Midwest Climate Adaptation Science Center. [Also available at https://www.sciencebase.gov/catalog/item/621d2d93d34ee0c6b3891226.]

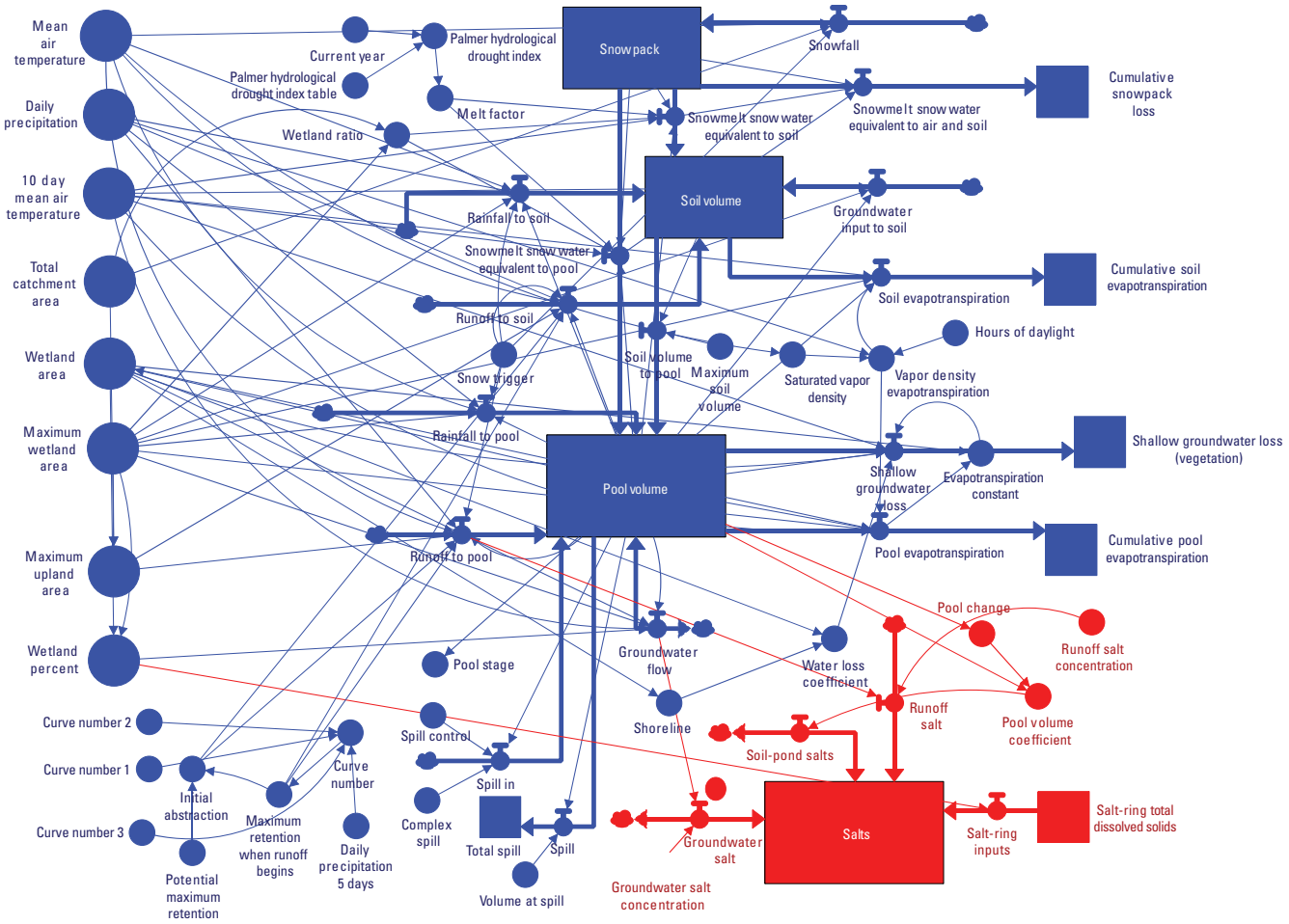

Diagram showing a Stella schematic of the Pothole Hydrology-Linked Systems Simulator (PHyLiSS) model. Red boxes and arrows represent salt stocks and flows, and blue boxes and arrows represent water stocks and flows.

Wetlands

92. Climate-Driven Connectivity Between Prairie-Pothole and Riparian Wetlands in the Upper Mississippi River Watershed—Implications for Wildlife Habitat and Water Quality

Wetland conservation in the Upper Mississippi River Basin is a priority for Federal, State, non-governmental organization, and Tribal land managers to support migratory bird habitat in Minnesota and Iowa. High intensity rainfall events can cause depressional wetlands to overflow and connect with Mississippi River tributaries, which reduces the wetlands' abilities to process nutrients and mitigate nutrient pollution in the Mississippi River. These overflow events are expected to increase owing to climate change, as extreme precipitation events become more common and more severe. The NPWRC is working to quantify the effect of wetlands on reducing nutrient inputs to the Minnesota River and to estimate the effects that increased precipitation and wetland drainage have on wetland ecosystems. The NPWRC will work with managers at a collaborative workshop to present modeling capabilities and to co-produce effective, interactive tools to assist managers in planning for conservation actions that can be taken to mitigate effects of future climate change on migratory bird habitat and water quality.

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Collaborators: USGS Midwest Climate Adaptation Science Center; EPA, Office of Research and Development, FWS Region 3, Minnesota Department of Natural Resources

Timeline: Fiscal years 2022–25

Products:

Ward, N.K., Lynch, A.J., Beever, E.A., Booker, J., Bouska, K.L., Embke, H., Houser, J.N., Kocik, J.F., Kocik, J., Lawrence, D.J., Lemon, M.G., Limpinsel, D., Magee, M.R., Maitland, B.M., McKenna, O.P., Meier, A., Morton, J.M., Muehlbauer, J.D., Newman, R., Oliver, D.C., Rantala, H.M.,Sass, G.G., Shultz, A., Thompson, L.M., and Wilkening, J.L., 2023, Reimagining large river management using the Resist–Accept–Direct (RAD) framework in the Upper Mississippi River: Ecological Processes, v. 12, no. 48. [Also available at https://doi.org/10.1186/s13717-023-00460-x.]

93. Mapping Effects of Wetland Change on Amphibians in the Upper Midwest

Many amphibian species are highly susceptible to changes in precipitation timing and volume because of their reliance on intermittently flooded surface water pools, which are primarily filled through snowmelt and precipitation runoff. With increasing evapotranspiration (that is, transfer of water from land to the atmosphere) owing to climate change, the timing and availability of water in key amphibian reproductive habitats will likely be altered. The NPWRC will produce a spatial interface of probable wetland change and corresponding amphibian distributions with current and future richness hotspots identified. The team will present findings to the Midwest Association of Fish and Wildlife Agencies and a remote workshop will be held for State and Tribal nongame wildlife biologists for informing 2025 State Wildlife Action Plan revisions and possible future Recovering America's Wildlife Act projects.

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Collaborators: USGS Midwest Climate Adaptation Science Center; Wisconsin Department of Natural Resources, Iowa Department of Natural Resources, Minnesota Department of Natural Resources

Timeline: Fiscal years 2022–25

94. OPERA DSWx Surface Water Extent Algorithm Development

The presence and permanence of surface water is a key driver of wetland function, including biogeochemical processes such as GHG emissions. However, our ability to monitor surface water using satellite-derived information is currently inadequate to fully capture wetland extent and dynamics, particularly under dense vegetation. New satellite missions by the National Aeronautics and Space Administration provide an opportunity to develop robust models of surface water, such as the Observational Products for End-Users from Remote Sensing Analysis (OPERA) Dynamic Surface Water Extent (DSWx) model. The next generation of surface-water models will require extensive ground data for calibration and validation of algorithms. The objective of this project is to calibrate and validate the Dynamic Surface Water Extent algorithm using harmonized Landsat and Sentinel-1 satellite imagery. Calibration and validation will occur using ground data collected at four sentinel sites around the conterminous United States, including at Cottonwood Lake Study Area.

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Collaborators: USGS Water Mission Area, National Aeronautics and Space Administration

Timeline: Fiscal years 2022–24

95. Fish and Wildlife Seasonal and Temporary Wetland Assessment

Wetlands of the Prairie Pothole Region are nested within a matrix of grassland and agriculture. Past and current management of Department of Interior lands by the U.S. Fish and Wildlife Service impact wetland habitat quality for wildlife such as migratory waterfowl, especially for smaller, temporary, and seasonal wetlands. Photograph by Ray Finocchiaro, U.S. Geological Survey.

The Prairie Pothole Region supports some of the most productive wetlands in the world for waterfowl. As much as 90 percent of seasonal and temporary wetlands have been lost in areas of the Prairie Pothole Region because of the conversion of grasslands to croplands and the drainage of wetlands. The DOI Waterfowl Production Areas and National Wildlife Refuges in North Dakota, South Dakota, and eastern Montana provide critical, remaining grassland and wetland habitat for nesting waterfowl. However, neighboring agricultural activities combined with invasion of nonnative plants (for example, cattail [*Typha* sp.] and reed canary grass [*Phalaris arundinacea*]) in temporary and seasonal wetlands makes them less attractive to breeding waterfowl. The FWS, USGS, and North Dakota State University are developing a multiphase plan to assess the current state of temporary and seasonal wetlands on Waterfowl Production Areas and National Wildlife Refuges. The first phase involves development of a spatially balanced, wetland-sampling design across the region, followed by a field campaign during the second phase. The third phase will use these data to develop models to predict wetland quality on the landscape. These findings will help to inform management decisions to effectively and efficiently protect wetland habitat.

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Collaborators: FWS, Chase Lake Wetland Management District; North Dakota State University

Timeline: Fiscal years 2019–23

Products:

Tangen, B., Bansal, S., Fern, R.R., DeKeyser, E.S., Hargiss, C.L.M., Mushet, D.M., and Dixon, C.S., 2019, Study design and methods for a wetland condition assessment on U.S. Fish and Wildlife Service fee-title lands in the Prairie Pothole Region of North Dakota, South Dakota, and Montana, USA: U.S. Geological Survey Open-File Report 2019–1118, 34 p. [Available at https://doi.org/10.3133/ofr20191118.]

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Biological Threats and Invasive Species Program—Invasive Species

Management and Control Tools

96. Grassland Plant Population and Community Dynamics In and Following Seasonal Drought

The Northern Great Plains hosts one of the largest extents of native grasslands remaining in the United States. The increasingly common occurrence of flash droughts in these water-sensitive grasslands challenges land managers deciding on their seasonal and annual grazing practices. To sustain long-term forage production, rangeland managers are cautioned not to resume grazing on drought-stressed areas too quickly after the end of a drought. Translating this general guidance into concrete decision points for a specific grassland requires (1) understanding the processes behind dominant plant species' and plant communities' recovery from drought; (2) information on how grazing during and after a drought affects these processes; and (3) a practical, robust indicator of grassland recovery following drought. This project will address these needs for northern grasslands through a combination of field and greenhouse experiments that measure plant susceptibility to, and recovery from, drought in different parts of the growing season and under different grazing conditions. Our goal is to provide information that will help land managers make decisions about stocking levels following drought that will ensure long-term sustainability of their operations and the natural resources on which they rely. In addition, our approach will provide mechanistic, species-specific information needed to predict how northern mixed-grass prairie will respond to new climate circumstances.

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Collaborators: USDA U.S. Forest Service, Rocky Mountain Research Station, Maintaining Resilient Dryland Ecosystems Program; USDA U.S. Forest Service, Buffalo Gap National Grassland; Colorado State University.

Timeline: Fiscal years 2021–Ongoing

97. Developing a Native Seed Strategy for the Northern Great Plains

In contrast to the robust native seed industry and long legacy of habitat reconstruction science in the tallgrass prairie portion of the Midwest, northwestern grassland regions of the central United States lack locally sourced and grown native seeds with the taxonomic and genetic diversity for true habitat restoration. In addition, the more arid conditions of these regions require different approaches to planting and post-planting management, but the science base testing these approaches is relatively small. Recognizing these shortcomings, the Northern Great Plains Native Seed Partnership coalesced in 2023 with the goals of (1) assessing and improving native seed resources in the Northern Great Plains and (2) improving habitat restoration outcomes in the region through a collaborative community of practice. Representatives from Federal and State agencies, Tribal and nongovernmental organizations, academia, and extension identified the Dakotas, far western Minnesota, northeastern Wyoming, and the eastern two-thirds of Montana as the partnership's geographical area and committed to creating a Native Seed Strategy for that geography. The draft strategy identifies six goals, objectives and action items to support each goal, and their relation to goals of the National Seed Strategy. Future work will identify entities that will steward work towards each objective, publish the strategy, grow the partnership, and identify paths for implementation.

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Collaborators: South Dakota State University; USDA Natural Resources Conservation Service, South Dakota Range Program

Timeline: Fiscal years 2023–24

98. What Role Does Prescribed Fire Play in Managing Annual Bromes in Northern Great Plains Grasslands?

Prescribed fire is used in grasslands throughout the Northern Great Plains National Park Service units (parks) to manage fuel loads, control nonnative species, and maintain a vital ecosystem process. Questions about the effects of prescribed fire in areas with invasive annual brome grasses require answers to ensure that the application of prescribed fire produces desired results. Using an experimental approach at two parks in South Dakota and Nebraska, the objectives of this project are to determine the efficacy of prescribed fire as an annual brome management tool across a range of infestation levels and to understand if follow-up herbicide application or seed addition improves adverse effects or enhances positive effects of fire. Fall prescribed fire significantly suppressed annual brome grasses and increased native plant species cover for at least two growing seasons, but only at lower invasion levels. At higher invasion levels, postfire application of imazapic was necessary to achieve this result. Ongoing monitoring of the experimental plots, some of which experienced a second prescribed fire, will provide information about the longevity of the original fire-alone and fire-herbicide treatments, as well as the effects of repeated fire on annual brome control and other plant community components.

Examples of grassland response to experimental fire treatments. *A*, Experimental plots burned in fall alone or followed up with a preemergent herbicide had lower invasive annual brome grass cover than *B*, unburned, untreated plots 1 year after treatment, but effectiveness of these treatments varies depending on the degree to which the system was invaded (U.S. Geological Survey photographs).

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Collaborators: National Park Service, Badlands National Park, Scotts Bluff National Monument, Northern Great Plains Fire Management Office, and Northern Great Plains Invasive Plant Management Team

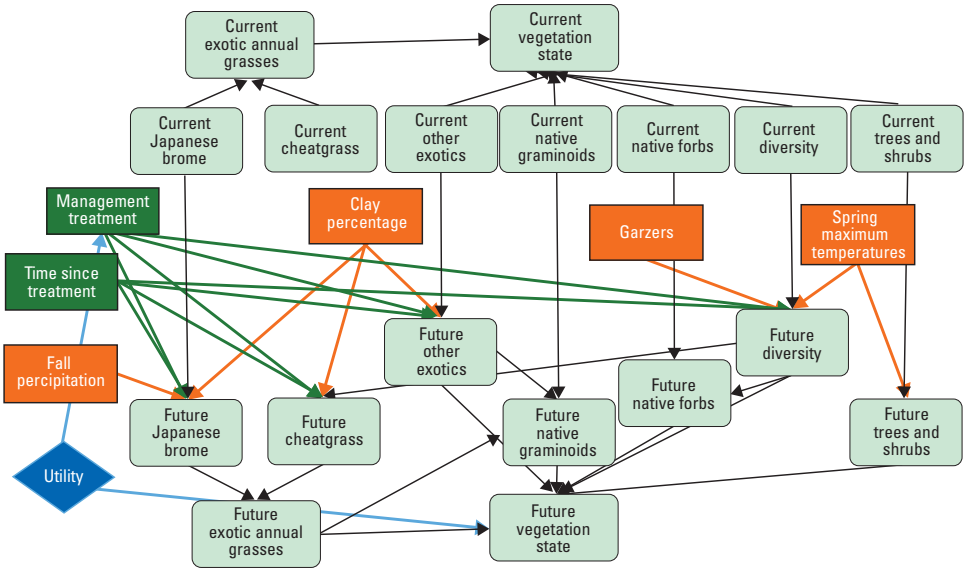
Timeline: Fiscal years 2015–22

Products:

Symstad, A.J., Buhl, D.A., and Swanson, D.J., 2021, Fire controls annual bromes in northern Great Plains grasslands—Up to a point: Rangeland Ecology & Management, v. 75, p. 17–28. [Also available at https://doi.org/10.1016/j.rama.2020.11.003.]

99. An Adaptive Management Framework to Control Invasive Annual Brome Grasses in Northern Great Plains Parks (Annual Brome Adaptive Management Project)

Invasion by annual brome grasses (cheatgrass and Japanese or field brome) into National Park Service units (parks) in the Northern Great Plains impacts park historical and ecological integrity by reducing native plant diversity and altering ecosystem functioning. Historically, parks have implemented few management actions targeting annual bromes; consequently, these species persist and have increased in some parks. Uncertainty about the effectiveness of specific management treatments in controlling annual bromes and limited capacity to apply management treatments make the problem of managing bromes complex. The Annual Brome Adaptive Management project tackles this problem through a cooperative effort between the NPWRC and seven parks and their supporting management and monitoring networks. The project has developed a structured adaptive management framework in which a Bayesian model built from previous monitoring data and experimental results predicts the effects of management actions on park management units. These predictions inform management decisions and management actions are



Schematic of the Annual Brome Adaptive Management (ABAM) decision-support tool. Pale green boxes (nodes) are vegetation metrics or states, orange nodes are environmental variables with significant effects on vegetation nodes, dark green nodes indicate management actions and time since those actions, and the blue "utility" node contains park-specific preferences for specific vegetation states and weighting of vegetation outcome versus cost of action. Arrows indicate how each node influences other nodes. Graphic from Ashton and others (2020).

applied. Vegetation monitoring data are collected and used to update model parameters, and the learning gained from actions is applied to the next year's decision making. Ongoing work will improve and/or extend the model based on project partner feedback.

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Collaborators: National Park Service, Agate Fossil Beds National Monument, Badlands National Park, Devils Tower National Monument, Fort Laramie National Historic Site, Little Bighorn Battlefield National Monument, Scotts Bluff National Monument, Wind Cave National Park, Northern Great Plains Invasive Plant Management Team, Northern Great Plains Fire Management Office, Northern Great Plains Inventory and Monitoring Network, Northern Rocky Mountains Invasive Plant Management Team, and Rocky Mountain Inventory and Monitoring Network.

Timeline: Fiscal years 2017–Ongoing

Products:

Ashton, I., Symstad, A., Baldwin, H., Post van der Burg, M., Bekedam, S., Borgman, E., Haar, M., Hogan, T., Rockwood, S., Swanson, D.J., Thomson, C., and Wienk, C., 2020, A new decision support tool for collaborative adaptive vegetation management in northern Great Plains national parks: Parks Stewardship Forum, v. 36, no. 3, p. 510–518. [Also available at https://doi.org/10.5070/P536349865.]

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Biological Threats and Invasive Species Program—Fish and Wildlife Disease

Chronic Wasting Disease

100. Effects of Population Density on Prevalence of Chronic Wasting Disease, Physical Condition, and Vital Rates of Elk at Wind Cave National Park, South Dakota

A bull elk with chronic wasting disease at Wind Cave National Park. The emaciated appearance and drooping ears are characteristic of latter stages of infection. Photograph provided by National Park Service.

Chronic wasting disease (CWD) is a degenerative neurological disease caused by infectious proteins called prions. Although documented cases are invariably fatal, infected elk commonly survive for months or years, passing prions directly to other individuals and into the environment, where they bind to surfaces and soils and can persist indefinitely. CWD reached Wind Cave National Park in about 1997 and rapidly became the leading cause of mortality for adult elk. By 2016, prevalence reached about 30 percent in the eastern portion of the park, an unsustainable level that threatens persistence of the population. Although CWD constitutes a crisis for park management, CWD also presents an unprecedented opportunity for studying effects of population density on CWD prevalence, physical condition, and vital rates of elk. During 2016 and 2017, the National Park Service removed 262 elk from Wind Cave National Park, reducing the population by about one-half. NPWRC is working with National Park Service partners to evaluate effects of the reduction and to develop guidance for management of CWD and high-density elk populations not only at Wind Cave National Park, but in other parks and preserves.

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Collaborators: National Park Service, Wind Cave National Park, Biological Resources Division, and Midwest Regional Office; Washington State University

Timeline: Fiscal years 2016–Ongoing

Products:

Sargeant, G.A., Wild, M.A., Schroeder, G.M., Powers, J.G., and Galloway, N.L., 2021, Spatial network clustering reveals elk population structure and local variation in prevalence of chronic wasting disease: Ecosphere, v. 12, no. 12, 16 p. [Also available at https://doi.org/10.1002/ecs2.3781.]

101. Epizootiology of Chronic Wasting Disease in Mule Deer

Prevalence of chronic wasting disease in mule deer is variable, owing presumably to differences in behavior, habitat, and land use, which mediate contacts among deer and exposure to environmental contamination. The NPWRC is participating in a multi-agency collaborative study of CWD hotspots in the Wind River Basin of Wyoming to identify aspects of deer behavior, landscape features, and land-use practices that are likely to promote disease transmission. Improved understanding of disease risk may enable wildlife managers to mitigate effects of CWD on mule deer populations by targeting population subsets and aspects of land use that contribute most to the spread of disease.

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Collaborators: USGS Northern Rocky Mountain Science Center; Department of Zoology and Physiology and Department of Veterinary Sciences, University of Wyoming; Wyoming Game and Fish Department; FWS; USDA National Wildlife Research Center

Timeline: Fiscal years 2022–Ongoing

Ecology and Impact

102. Treponeme-Associated Hoof Disease in Elk

Treponeme-associated hoof disease (TAHD) of elk was first diagnosed in southwest Washington in 2008–09, following a marked increase in reports of limping animals. Prevalence apparently increased rapidly thereafter—during 2016–18, hunter harvest reports for as much as 55 percent of adult bull elk in some game management units described hoof abnormalities characteristic of moderate to severe infection. The known distribution of TAHD now includes at least 17 counties in Washington, primarily in the western one-half of the State, as well as portions of Oregon, Idaho, and California. Symptoms range from interdigital skin ulceration to severe sole ulceration; deformed, asymmetric, or overgrown hooves; and in some cases, sloughed hoof capsules. Causes of TAHD and other possible effects on affected animals have been matters of controversy and are not well understood. NPWRC, Washington State University, and Washington Department of Fish and Wildlife have used hunter harvest reports to evaluate anecdotal reports of effects on antler development, which are of particular interest to stakeholders who enjoy hunting or observing elk, and are investigating features of landscapes and land use that may promote the spread of TAHD.

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Collaborators: Washington State University; Washington Department of Fish and Wildlife

Timeline: Fiscal years 2021–Ongoing

Products

Wild, M.A., Sargeant, G.A., Garrison, K., and Conradson, D. 2021, Association of antler asymmetry with hoof disease in elk: The Journal of Wildlife Management, v. 86, no, 6, e22245, 12 p. [Also available at https://doi.org/10.1002/ecs2.3781.]

Avian Influenza

103. Science and Monitoring at Odds—Laying the Groundwork for Estimating Avian Influenza Infection Rates for North American Waterfowl

A banded wood duck held by a wildlife biologist. Photograph provided by the U.S. Fish and Wildlife Service.

Waterfowl and waterbirds appear to be key species in a new (2022) epidemic of avian influenza, as carriers of the disease are dying by the thousands. Current monitoring frameworks for waterfowl are key to gathering more information related to this and possible future outbreaks. Specifically, thousands of ducks and geese are captured in late summer as part of a pre-hunting season banding effort conducted primarily to estimate rates of survival and harvest. This existing effort represents an opportunity to gather biological samples from birds to determine past and current active cases of avian influenza and other diseases, although challenges exist. Support for wildlife disease research integrated with operational banding, a long-standing monitoring activity, is contingent on testing the assumption that collecting certain biological samples does not affect survival, allowing birds that have been sampled to be used in monitoring programs without reservation. Testing this assumption constitutes groundwork required before leveraging operational waterfowl banding can be implemented with reduced concerns for how it might compromise the primary objectives of the monitoring activities.

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Collaborators: Louisiana Department of Wildlife and Fisheries; University of Minnesota, Department of Wildlife and Conservation Biology

Timeline: Fiscal years 2023–24

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