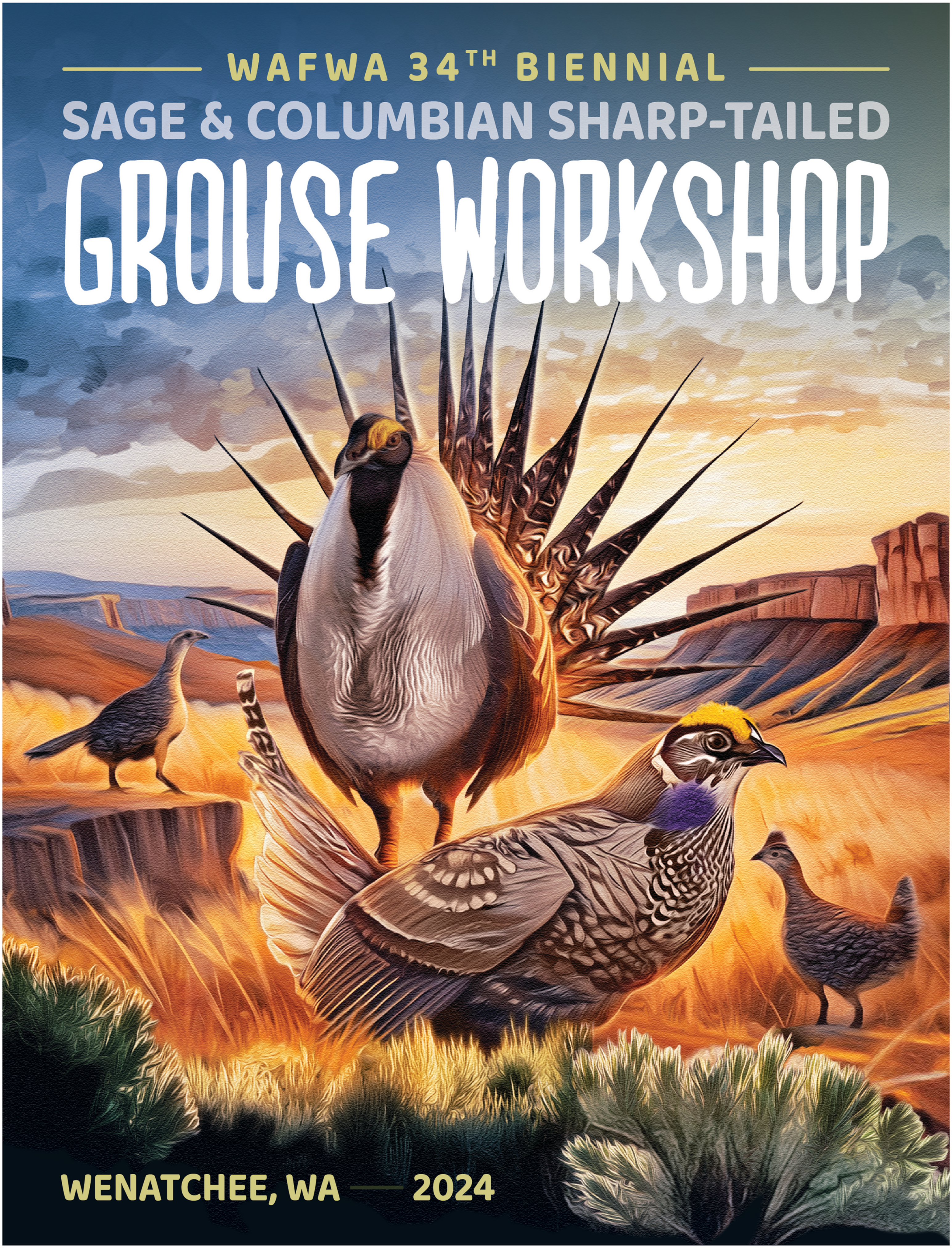
WAFWA 34TH BIENNIAL

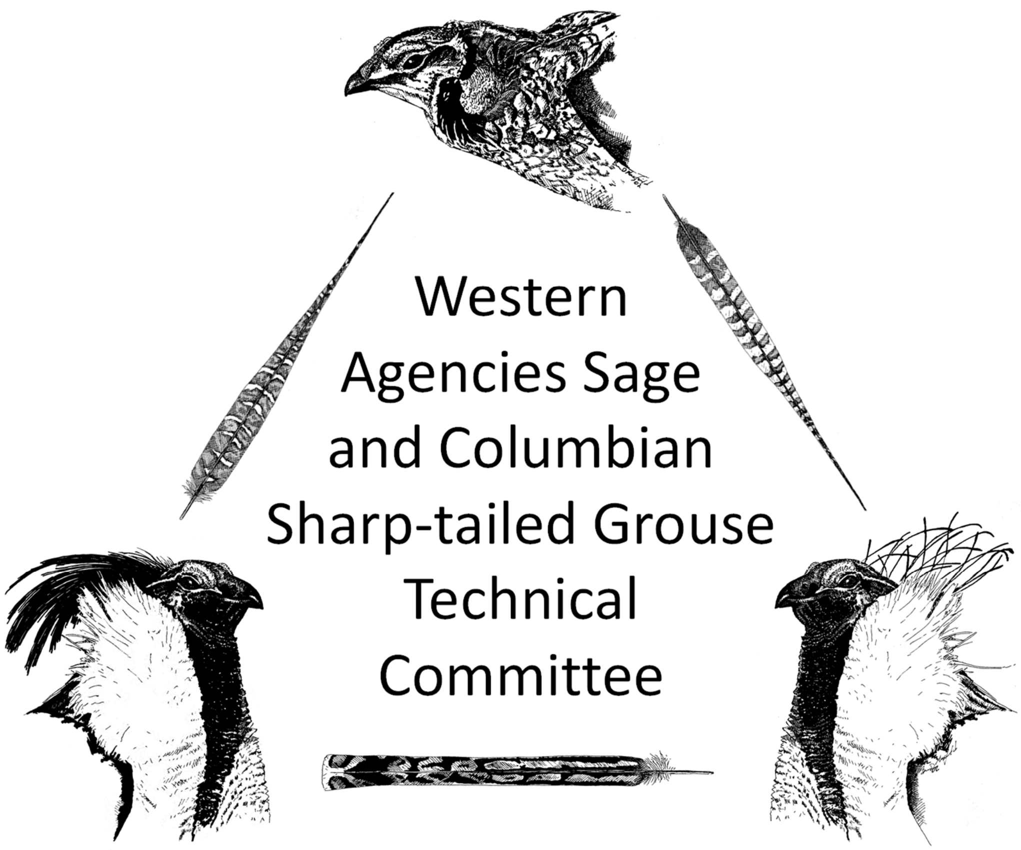
SAGE & COLUMBIAN SHARP-TAILED GROUSE WORKSHOP



WENATCHEE, WA — 2024

Proceedings

34th Meeting of the Western Association of Fish and Wildlife Agencies Sage and Columbian Sharp-tailed Grouse Technical Committee



Wenatchee, Washington

5 – 8 August 2024

Table of Contents

Acknowledgements

Thanks to all of you for participating in this workshop! Special thanks to all presenters, session moderators, and field trip speakers.

2024 Workshop Planning Team

Mike Schroeder, WDFW
Clarinda Wilson, BLM
Johnna Eilers, WDFW
Emily Jeffreys, WDFW
Matt Brinkman, WDFW
Stephanie Galla, BSU
Eric Braaten, WDFW
Daniel Peterson, WDFW
Mike Atamian, WDFW

WAFWA Team

Cortney Mycroft
Cathy Campbell

Workshop Artwork

Stephanie Galla, BSU
Brian Maxfield, UDWR
R Digital Design, Wenatchee, WA (Cover)

General program

Monday, 5 August 2024

Registration	Convention Center, Red Lobby	5:00 PM – 8:00 PM
Reception	Convention Center, Orchard Lobby	6:00 PM – 9:00 PM

Tuesday, 6 August 2024

Registration	Convention Center, Red Lobby	7:00 AM – 8:00 PM
Presentations	Convention Center, Orchard Exhibit North	8:15 AM – 12:00 PM
Lunch	Convention Center, Orchard Exhibit South	12:00 PM – 1:00 PM
Presentations	Convention Center, Orchard Exhibit North	1:00 PM – 5:00 PM
Poster session	Convention Center, Orchard Lobby	6:30 PM – 9:30 PM

Wednesday, 7 August 2024

Fieldtrip	Douglas County – Convention Center departure	8:00 AM – 4:00 PM
Banquet Buffet	Convention Center, Orchard Exhibit South	6:00 PM – 10:00 PM

Thursday, 8 August 2024

Presentations	Convention Center, Orchard Exhibit North	8:15 AM – 12:00 PM
Lunch	Convention Center, Orchard Exhibit South	12:00 PM – 1:00 PM
Presentations	Convention Center, Orchard Exhibit North	1:00 PM – 4:40 PM

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Map of Convention Center

The events will all be held on the lower floor of the Convention Center (shown below), primarily in the Orchard Exhibit Hall or in the adjacent lobbies. If you are staying in the Coast Wenatchee Center Hotel, you can reach the Convention Center via a Skybridge to the upper floor or by the doors adjacent to the Orchard Lobby.

History of the Sage and Columbian Sharp-tailed Grouse Technical Committee

The first known discussion about the need for a sage-grouse committee was held at the Western Association of Fish and Wildlife Agencies (WAFWA) conference in Las Vegas, Nevada in 1954. After additional informal meetings and discussions, the first official "Western States Sage Grouse Workshop" was held in 1959 in Farson, Wyoming. This workshop has subsequently been held every two years with a slight 1-year adjustment in schedule to coordinate with the Prairie Grouse Technical Council and a 1-year delay due to COVID. WAFWA has expanded the group to include the Columbian sharp-tailed grouse as well as Canadian provinces (hence, the name changes).

- Organized a long-term mechanism (now going on 70 years) for states and provinces to exchange population, habitat and management information on sage-grouse and later Columbian sharp-tailed grouse.
- Produced different sets of guidelines for managing/conserving sage-grouse habitats.
- Produced different sets of guidelines for managing Columbian sharp-tailed grouse habitats.
- Formally identified sage-grouse population declines as a concern.
- Produced assessments of current and historic distribution of sage-grouse in North America.
- Produced documents for monitoring greater sage-grouse habitats and populations.
- Produced conservation assessments of greater sage-grouse and sagebrush habitats.

Year	Location
1959	Farson, Wyoming
1961	Elko, Nevada
1963	Lima, Montana
1965	Walden, Colorado
1967	Boise, Idaho
1969	Rock Springs, Wyoming
1971	Salt Lake City, Utah
1973	Lewistown, Montana
1975	Reno, Nevada
1977	Grand Junction, Colorado
1979	Twin Falls, Idaho
1981	Bowman, North Dakota
1983	Ontario, Oregon
1985	Alturas, California
1987	Midway, Utah
1989	Moses Lake, Washington
1991	Pocatello, Idaho

Year	Location
1993	Fort Collins, Colorado
1994	Reno, Nevada
1996	Gillette, Wyoming
1998	Billings, Montana
2000	Redmond, Oregon
2002	Bicknell, Utah
2004	Wenatchee, Washington
2006	Spearfish, South Dakota
2008	Mammoth Lakes, California
2010	Twin Falls, Idaho
2012	Craig, Colorado
2014	Elko, Nevada
2016	Lander, Wyoming
2018	Billings, Montana
2021	Oregon (virtual)
2022	Logan, Utah
2024	Wenatchee, Washington

Patterson Award

Award Criteria

To recognize individual(s) and organization(s) who have made significant contributions to sage and sharp-tailed grouse research, management, or other support programs, which have enhanced the welfare of any of these three species. The contribution should be evidenced by a sustained effort over at least 10 years. The contribution may be related to research, management activity, promotion of an integrated program, or some combination thereof.

Selection Procedure

The Awards Committee is made up of a chairman and additional members of the Sage and Columbian Sharp-tailed Grouse Technical Committee, appointed to the committee by the Chairman. Anyone can submit nominations to the Awards Committee, including members of the Awards Committee. Nominations are submitted to the Awards Committee Chairman at least one month prior to the biennial Sage and Columbian Sharp-tailed Grouse Workshop.

Award Committee

Pat Deibert, BLM

Shawn Espinosa, NDOW

Mike Schroeder, WDFW

Dawn Davis, USFWS

Mike Atamian, WDFW

Past Award Recipients

2008 – Clait E. Braun in Mammoth, California

2010 – Randall B. Smith and John W. Connelly, Jr. in Twin Falls, Idaho

2012 – San J. Stiver and Michael A. Schroeder in Steamboat Springs, Colorado

2014 – Clinton McCarthy and Kerry P. Reese in Elko, Nevada

2016 – Patricia A. Deibert and Steven T. Knick in Lander, Wyoming

2018 – James S. Sedinger and Thomas J. Christiansen in Billings, Montana

2021 – Peter S. Coates and Shawn P. Espinosa (Virtual meeting in Oregon)

2022 – Sara Oyler-McCance and Terry Messmer in Logan, Utah

2024 – Paul Makala and Cameron L. Aldridge in Wenatchee, Washington

Detailed Program, Morning 6 August 2024

7:00 AM	Registration (Convention Center, Red Lobby)
8:15 AM	Introduction and opening announcements – **Michael A. Schroeder**
8:20 AM	Welcome – **Nathan Pamplin** (Director of External Affairs, Washington Department of Fish and Wildlife)
8:25 AM	Video: This Land is Part of Us
	Session 1 – Kim Thorburn, Chair (Convention Center, Orchard Exhibit North)
8:40 AM	A High-Quality Genome Assembly of the Columbian Sharp-Tailed Grouse Provides an Important Resource for Future Prairie Grouse Conservation – Morgan Calahan, Natalie Forsdick, Jennifer S. Forbey, Jonathan Lautenbach, Jacob Northuis, Jeff A. Johnson, and **Stephanie J. Galla**
9:00 AM	Using Genetic, Morphological, and Ecological Evidence to Identify the Subspecies of Sharp-Tailed Grouse in South-Central Wyoming – **Jonathan D. Lautenbach** (Student), Andrew J. Gregory, Stephanie J. Galla, Aaron C. Pratt, and Jeffrey L. Beck
9:20 AM	Restoring Western Montana's Sharp-Tailed Grouse – **Kristina Harkins**, Mikel Newberg, Ty Smucker, and Chris Hammond
9:40 AM	Current State of the Columbian Sharp-Tailed Grouse Population in Nevada's Bull Run Basin – **Justin R. Small**, Matt Jeffress, Shawn Espinosa, Stephanie J. Galla, Steven Matthews, and Peter S. Coates
10:00 AM	Break
	Session 2 – Lief Wiechman, Chair (Convention Center, Orchard Exhibit North)
10:20 AM	Novel Environmental Variables Help Explain Winter Weather Effects on Activity and Habitat Selection of Greater Sage-Grouse – **Caitlyn P. Wanner**, Aaron C. Pratt, Adele K. Reinking, Glen E. Liston, and Jeffrey L. Beck
10:40 AM	Nesting Ecology of Sage-Grouse: Vegetative Correlates of Success in Central Oregon – **Rebecca Kelble** (Student), Christian A. Hagen, Larry Ashton, Brieana Porter, Skyler Vold, Greg Jackle, and Andrew Walch
11:00 AM	Addressing Uncertainty in Greater Sage-Grouse Daily Lek Attendance and Inter-Lek Movement – **Rebekah E. Ruzicka**, Brett L. Walker, and William L. Kendall
11:20 AM	Adaptive Divergence May Influence Greater Sage-Grouse Conservation Translocations in Washington – **Shawna J. Zimmerman**, Cameron L. Aldridge, Michael A. Schroeder, Jennifer A. Fike, Robert Scott Cornman, and Sara J. Oyler-McCance
11:40 AM	Synthesizing Sage-Grouse Genetic Information to Support Conservation and Management Actions – **Sara J. Oyler-McCance**, Tait K. Rutherford, Patricia A. Deibert, Dawn M. Davis, Lief Wiechman, and Sarah Carter
12:00 PM	Lunch buffet (Convention Center, Orchard Exhibit South)

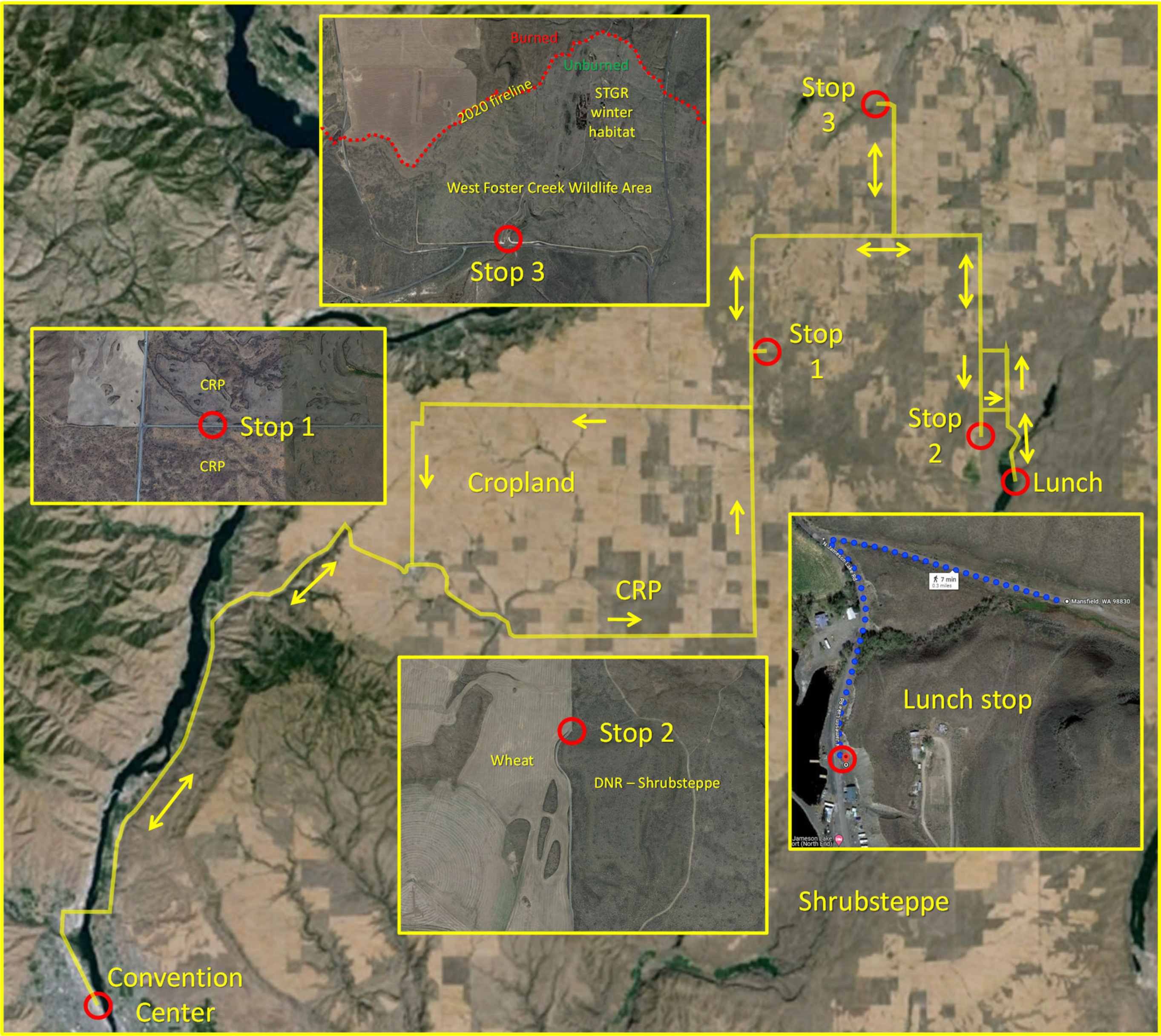
Detailed Program, Afternoon 6 August 2024

	Session 3 – Cameron Aldridge, Chair (Convention Center, Orchard Exhibit North)
1:00 PM	Relationship Between Cattle Grazing and Demographic Traits of Greater Sage-grouse: The Grouse and Grazing Project – **Courtney J. Conway**, Cody Tisdale, Karen L. Launchbaugh, Shane B. Roberts, Paul Makela, and Bryan S. Stevens
1:20 PM	Nevada Common Raven Management: A Journey – **Pat J. Jackson**
1:40 PM	From Pellets to Prey: Dietary Analysis of Breeding Ravens Via DNA Metabarcoding of Regurgitated Pellets – **Lindsey R. Perry**, Shawn B. Szabo, Jacqueline B. Cupples, Pat J. Jackson, Julie C. Brockman, Peter S. Coates, Shawn T. O'Neil, Sarah C. Webster, Jonathan B. Dinkins, Jennifer M. Allen, and Taal Levi
2:00 PM	Testing of Greater Sage-Grouse and Sharp-Tailed Grouse for Pathogens of Concern – **Michael A. Schroeder**, Michael T. Atamian, and Katherine H. Haman
2:20 PM	Comparing The Effects of Lethal and Non-Lethal Raven Management on Sage-Grouse Reproductive Success in Eastern Oregon – **Richard Rich** (Student), Lindsey Perry, Terrah Owens, Stephanie Lequier, Skyler Vold, Jacqueline Cupples, Brain Ratliff, Jimmy D. Taylor, and Jonathan B. Dinkins
2:40 PM	Effects of Manipulating Common Raven (*Corvus corax*) Breeding Success on Raven and Greater Sage-grouse (Centrocercus urophasianus) Populations in Nevada and California, USA – **Austin L. Nash**, Steven R. Mathews, Corina A. Sanchez, Shawn T. O'Neil, David J. Delehanty, and Peter S. Coates
3:00 PM	Break
	Session 4 – Kathy Griffin, Chair (Convention Center, Orchard Exhibit North)
3:20 PM	Assessing Influences of Livestock and Anthropogenic Features on Seasonal Habitat Use of Sage-Grouse in the Bighorn Basin, Wyoming – **Kayla A. Ruth** (Student), Jimmy D. Taylor, and Jonathan B. Dinkins
3:40 PM	Free-roaming horses exceeding appropriate management levels affect multiple vital rates in greater sage-grouse – **Jeffrey L. Beck**, Megan M. Milligan, Kurt T. Smith, Phillip A. Street, Aaron C. Pratt, Christopher P. Kirol, Caitlyn P. Wanner, Jacob D. Hennig, Jonathan B. Dinkins, J. Derek Scasta, and Peter S. Coates
4:00 PM	Investigating Relationships Between Livestock Grazing, Horse Abundance, and Habitat of Greater Sage-Grouse Within the Sagebrush Biome – **Austin L. Nash**, Shawn T. O'Neil, Adrian P. Monroe, Nicholas J. Van Lanen, Cali L. Weise, Derek A. Friend, Lea A. Condon, Kathryn A. Schoenecker, Peter S. Coates, and Cameron L. Aldridge
4:20 PM	Greater Sage-Grouse (*Centrocercus Urophasianus*) Population Responses to Wild Horses and Livestock Across the Sagebrush Biome – **Adrian P. Monroe**, Shawn T. O'Neil, Cali L. Weise, Nicholas J. Van lanen, Austin L. Nash, Derek A. Friend, Kathryn A. Schoenecker, Peter S. Coates, and Cameron L. Aldridge
4:40 PM	Avian Predator Occupancy at Communication Sites in Sage-Grouse Habitat – **Shawn Szabo** (Student), Taal Levi, Jackie Cupples, Steve Abele, Peter S. Coates, Shawn T. O'Neil, Sarah C. Webster, Jenny Hill, and Jonathan B. Dinkins
5:00 PM	Dinner on your own and/or relaxation

Detailed Program, Poster Session 6 August 2024

6:30 PM – 9:30 PM: Session 5 – Poster session/social with hors d'oeuvres and no-host bar (Convention Center, Orchard Lobby)
Common Ravens Disrupt Greater Sage-Grouse Lekking Behavior in the Great Basin – **Joseph L. Atkinson**, Peter S. Coates, Brianne E. Brussee, Ian A. Dwight, Mark A. Ricca, and Pat J. Jackson
Citizen Science Contributions to Greater Sage-Grouse Monitoring on Parker Mountain, Utah – **Ruger Carter** (Student), David K. Dahlgren, and Eric T. Thacker
Response of Endangered Greater Sage-Grouse to Oil and Gas Reclamation in Critical Habitat in Southeastern Alberta – **Melissa Chelak**, Joel Nicholson, Samantha Price, Mecah Klem, Layton McAndrew, Julie Heinrichs, Amelia Coleing, Shelley Nelson, Stefano Liccioli, Troy Wellicome, and Theresa Burg
Maximizing Translocation Success for Greater Sage-Grouse Population Restoration – **Nicole I. Lindenauer** (Student), Peter S. Coates, Megan C. Milligan, Steven R. Mathews-Sanchez, and Gail L. Patricelli
Greater Sage-Grouse and Fences – Monitoring for Fence Collisions in Wyoming Suggests Continued Cause for Concern – Dale Woolwine, **Patricia Deibert**, and Matt Holloran
Body Mass At Time of Capture Affects Survival of Radio-Marked Greater Sage-Grouse (*Centrocercus Urophasianus*) Chicks – **Belle Malley** (Student), Peter S. Coates, Steven R. Mathews-Sanchez, and Gail L. Patricelli
Evaluation of Sex and Age Identification Characteristics in Sharp-Tailed Grouse – **Mikel Newberg**, Kristina Harkins, and Ty Smucker
Characterizing Genetic Diversity and Connectivity in Genetically Distinct Bi-State Greater Sage-Grouse (*Centrocercus Urophasianus*) – **Cammi A. Norville** (Student), Peter S. Coates, Sara J. Oyler-McCance, and Stephanie J. Galla
Prairie Grouse Recovery Work by Volunteers in Washington – **Kim Thorburn**, Lindell Haggin, Josh Nicholas, Mike Atamian, Mike Finch, and Carrie Lowe
Use of Water Birch by Wintering Sharp-tailed Grouse in North-Central Washington – **Michael A. Schroeder**, Sidra A. Blake, Amy E. Pavelcheck, and Daniel J. Peterson.
Assessing Potential Physiological Challenges Faced by Greater Sage-Grouse When Transitioning from a Captive to a Wild Diet – **Amelia Coleing**, Jennifer S. Forbey, Emma Vaasjo, and Douglas Whiteside
Assessment of Modified Harness Systems for Rump-Mounted Transmitters Aimed at Reducing Skin Lesions and Other Effects on Male Greater Sage-Grouse – **Amelia Coleing**, Adriana Pastor, Douglas Whiteside, Alyssa Kircher, and Dario Fernandez-Bellon

Fieldtrip, 7 August 2024

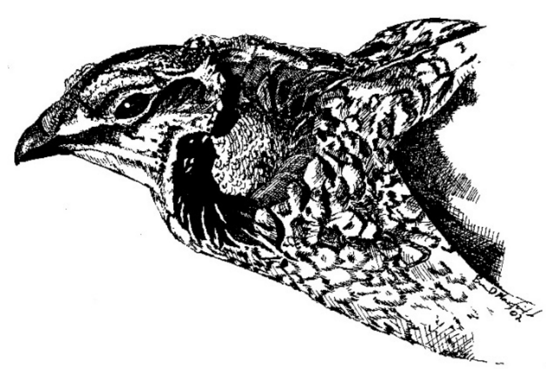


7:45 AM	Meet buses at Convention Center.
8:00 AM	Depart on fieldtrip – Drive north and east on Highway 2 past Waterville, north 10 miles on Highway 172, and east ½ mile on Road 10^{NW} to Stop 1.
9:15 AM	Stop 1 – Examine CRP/SAFE on north side of Road 10 with shrubsteppe fragments (3 miles from Glessner sage-grouse lek). Speakers include Eric Braaten (Wildlife Biologist, WDFW), Scott Scroggie (Sage Grouse Coordinator, NRCS), and Michael A. Schroeder (Research Scientist, WDFW)
10:00 AM	Drive west on Road 10^{NW}, north and east ~12 miles to Mansfield on Highway 172, and south ~7 miles on Road E^{NE} to Stop 2.
10:30 AM	Stop 2 – DNR shrubsteppe (1 mile from Kester Draw lek). Speakers include Kurt F. Merg (Environmental Planner, WDFW), Clarinda Wilson (Natural Resources Specialist, BLM), and Erik Ellis (Wildlife Biologist, BLM).

11:30 PM	Drive ~1 mile north on Road E^{NE}, east 1 mile on Road 8^{NE}, and south on North Jameson Lake Road to Jameson Lake Resort.
11:45 PM	Lunch at Jameson Lake Resort
12:45 PM	Optional short walk to view riparian restoration project on BLM property. Speaker is Clarinda Wilson (Natural Resources Specialist, BLM)
1:30 PM	Drive ~8 miles north on North Jameson Lake Road to Mansfield, west ~3 miles west on Highway 172, north ~4.5 miles on Road B^{NE}, and west about 0.5 miles on Dyer Hill Road to Stop 3 at north entrance to West Foster Creek Wildlife Area.
2:00 PM	Stop 3 – West Foster Creek Wildlife Area (near sage-grouse & sharp-tailed grouse leks). Speakers include Daniel J. Peterson (Wildlife Area Manager, WDFW), Becca Hebron (District Manager, Foster Creek Conservation District), and Michael A. Schroeder (Research Scientist, WDFW)
3:00 PM	Drive east about 0.5 miles to Road B^{NE}, south ~4.5 miles to Highway 172, west and south ~11 miles to Sprauer Road, west and south on Sprauer Road, and west and south on Highway 2 to Wenatchee.
4:30 PM	Arrive at Convention Center. Relax and/or eat dinner.
6:00 PM	Banquet buffet in Orchard Exhibit South room at Convention Center. Performance of "This Land is Part of Us" video by Ted Grundowski and Darrin Gunkel. This is followed by the Patterson Award ceremony conducted by Michael A. Schroeder (WDFW).

Detailed Program, Morning 8 August 2024

8:15 AM	Opening announcements – **Michael A. Schroeder**
	Session 6 – Christian A. Hagen, Chair (Convention Center, Orchard Exhibit North)
8:20 AM	Climate, Landscape Context, and Wildfire Predict Greater Sage-Grouse Population Trends Over 25 Years in Idaho – **Robert S. Arkle**, David S. Pilliod, Michelle I. Jeffries, Justin L. Welty, Ann Moser, Ethan Ellsworth, and Donald J. Major
8:40 AM	Sage-Grouse Responses to Weather and Climate Depend on Precipitation Timing and Life Stage – **Carl G. Lundblad**, Shawn T. O'neil, Brianne E. Brussee, John B. Bradford, Gregory T. Wann, John C. Tull, Michael Casazza, Cameron L. Aldridge, and Peter S. Coates
9:00 AM	Incubation Behavior Influences Nest Survival in Greater Sage-Grouse – Erin L. Gelling, **Aaron C. Pratt**, and Jeffrey L. Beck
9:20 AM	Assessing The Effect of Hunter Harvest on Greater Sage-Grouse Survival in Southeastern Oregon – **Keifer L. Titus**, Katie M. Dugger, and Christian A. Hagen
9:40 AM	Using Precision Nutrition Interventions to Manage Sage-Grouse – **Jennifer S. Forbey**, John W. Connelly, Michael A. Schroeder, Gail L. Patricelli, Stephanie J. Galla, Stephanie Hudon, Mario Muscarella, Ólafur K. Nielsen, and K. P. Mangnússon
10:00 AM	Break
	Session 7 – Patricia Deibert, Chair (Convention Center, Orchard Exhibit North)
10:20 AM	Sage-Grouse Habitat and Scale: Scale? – **Eric T. Thacker** and David K. Dahlgren
10:40 AM	Sage-Grouse Habitat and Scale: Lek Persistence and Landscapes with Usable Space – **David K. Dahlgren** and Eric T. Thacker
11:00 AM	Variation in Spatial Scales of Effect and Effect of Sagebrush Cover Across the Sage-Grouse Range: Implications for Management – **Adrian P. Monroe**, Michael S. O'Donnell, Julie A. Heinrichs, Matthew B. Rigge, Erin K. Buchholtz, Ashley L. Whipple, Benjamin C. Augustine, Brian G. Prochazka, Peter S. Coates, and Cameron L. Aldridge
11:20 AM	Extensive Use of Agricultural and Restoration Fields by Greater Sage-Grouse in Washington – **Peter Olsoy**, Daniel Thornton, Michael A. Schroeder, and Michael T. Atamian
11:40 AM	Range-Wide Predictive Seasonal Habitat Mapping for Greater Sage-Grouse – Gregory T. Wann, **Cameron L. Aldridge**, Megan M. Mclachlan, Jeffrey L. Beck, Timothy Bowden, Peter S. Coates, Courtney J. Conway, David K. Dahlgren, Jonathan B. Dinkins, Aaron N. Johnston, Christian A. Hagen, Paul D. Makela, David E. Naugle, Michael A. Schroeder, James S. Sedinger, Leah Waldner, Brett L. Walker, Perry J. Williams, and Ashley L. Whipple
12:00 PM	Lunch buffet (Convention Center, Orchard Exhibit South)



Detailed Program, Afternoon 8 August 2024

	Session 8 – Nyssa Whitford, Chair (Convention Center, Orchard Exhibit North)
1:00 PM	Conservation Credit System: Enhancing Greater Sage-Grouse Habitat Protection in Nevada – **Cheyenne Acevedo**, Casey Adkins, Sarah Hale, Skyler Monaghan, and Kathleen Steele
1:20 PM	PReSET: a tool to optimize conservation, restoration, and management actions across the sagebrush biome – **Cameron L. Aldridge**, Bryan C. Tarbox, Nicholas J. Van Lanen, Adrian P. Monroe, Jessica E. Shyvers, and Courtney J. Duchardt
1:40 PM	Evaluating the Conservation Design Strategy and Targeted Conservation Efforts Using a Sagebrush Indicator Species, the Greater Sage-Grouse – Peter S. Coates, Brian G. Prochazka, Kevin E. Doherty, **Carl G. Lundblad**, Sarah C. Webster, Shawn T. O'Neil, John C. Tull, Cali L. Weise, Cameron L. Aldridge, Michael S. O'Donnell, and Lief Wiechman
2:00 PM	Data-Driven State-and-Transition Models to Inform Sagebrush Management in the Upper Colorado River Basin – **John P. Severson**, Tara B. B. Bishop, Anna C. Knight, Travis W. Nauman, Brandon E. Mcnellis, Miguel L. Villarreal, Sasha C. Reed, Kristina E. Young, Mark W. Brunson, and Michael C. Duniway
2:20 PM	A Decision Support Tool for Planning and Assessing the Impact of Infrastructure Development on Greater Sage-Grouse Populations – **Cali L. Weise**, Peter S. Coates, Brian G. Prochazka, Derek A. Friend, Justin Small, and Shawn Espinosa
2:40 PM	Combining Space Use, Habitat Selection, and Survival to Inform Habitat Management Areas for Greater Sage-Grouse in Nevada and Northeastern California – **Megan C. Milligan**, Peter S. Coates, Shawn T. O'Neil, Brianne E. Brussee, Michael P. Chenaille, Derek Friend, Kathleen Steele, Justin R. Small, Timothy S. Bowden, and Arlene D. Kosic
3:00 PM	Break
	Session 9 Chair – Justin Small (Convention Center, Orchard Exhibit North)
3:20 PM	Greater Sage-Grouse Occurrence at a Solar Energy Facility – **Carly S. Kelly**, Barbara J. Stone, Jared K. Swenson, Everette A. Abhainn, John D. Llyod, and Chad W. LeBeau
3:40 PM	Surface Mining Impacts to Sagebrush Vegetation Communities and Greater Sage-Grouse Populations – **Sarah C. Webster**, Brian G. Prochazka, Brianne E. Brussee, Steve Abele, Justin Small, Shawn Espinosa, and Peter S. Coates
4:00 PM	Landscape Configuration Impacts Spring Space Use and Survival of Female Sage-Grouse – **Terrah M. Owens**, Calla R. Hagle, and Jonathan B. Dinkins
4:20 PM	Raven Nest-Site Selection in Sage-Grouse Habitat in Oregon – **Lindsey R. Perry**, Terrah M. Owens, Skyler T. Vold, Brian S. Ratliff, Lee J. Foster, Jacqueline B. Cupples, Jimmy D. Taylor, and Jonathan B. Dinkins
4:40 PM	One more talk and/or wishes for safe travel

Abstracts (alphabetical by senior author)

CONSERVATION CREDIT SYSTEM: ENHANCING GREATER SAGE-GROUSE HABITAT PROTECTION IN NEVADA

CHEYENNE ACEVEDO, Nevada Department of Wildlife – Sagebrush Ecosystem Technical Team, 201 S. Roop Street, Carson City, Nevada, 89701, USA; cheyenne.acevedo@ndow.org
CASEY ADKINS, Nevada Division of Forestry – Sagebrush Ecosystem Technical Team, 201 S. Roop Street, Carson City, Nevada, 89701, USA
SARAH HALE, Nevada Division of State Lands – Sagebrush Ecosystem Technical Team, 201 S. Roop Street, Carson City, Nevada, 89701, USA
SKYLER MONAGHAN, Nevada Department of Agriculture – Sagebrush Ecosystem Technical Team, 201 S. Roop Street, Carson City, Nevada, 89701, USA
KATHLEEN STEELE, Nevada Department of Conservation and Natural Resources – Sagebrush Ecosystem Technical Team, 201 S. Roop Street, Carson City, Nevada, 89701, USA

Nevada has experienced a significant decline in greater sage-grouse (*Centrocercus urophasianus*) populations compared to historical numbers. This decline is attributed to habitat loss, fragmentation, disturbances from wildfire, invasive annual grass species, and pinyon-juniper encroachment. Additionally, anthropogenic disturbances from infrastructure, mineral and energy development, and improper grazing practices contribute to habitat degradation for the species. The Conservation Credit System (CCS) was developed to generate a net conservation benefit for greater sage-grouse habitat by offsetting the impacts of anthropogenic disturbances. We incorporate the best available science into the program's tools (e.g., habitat quantification tool) and processes to achieve these goals. These tools include indices informed by population density, spatial configurations, and seasonal habitat suitability, providing a holistic approach to account for potential effects on greater sage-grouse populations and loss in habitat functionality. Since the inception of the CCS, over 50 mitigation transactions have occurred, resulting in the conservation of over 30,000 acres of land across Nevada. Here, we provide a detailed update on the scientific methods, successes, and future directions of the CCS. While the near-term goal of the Nevada CCS focuses on greater sage-grouse habitat, the system may be adapted in the future to support the ongoing preservation, enhancement, and restoration of Nevada's sagebrush ecosystem and other sagebrush obligate species.

PReSET: A TOOL TO OPTIMIZE CONSERVATION, RESTORATION, AND MANAGEMENT ACTIONS ACROSS THE SAGEBRUSH BIOME

CAMERON L. ALDRIDGE, U.S. Geological Survey, Fort Collins Science Center, 2150 Centre Ave., Building C, Ft. Collins, CO 80526, USA; aldridgec@usgs.gov
BRYAN C. TARBOX, U.S. Geological Survey, Fort Collins Science Center, 2150 Centre Ave., Building C, Ft. Collins, CO 80526, USA
NICHOLAS J. VAN LANEN, U.S. Geological Survey, Fort Collins Science Center, 2150 Centre Ave., Building C, Ft. Collins, CO 80526, USA
ADRIAN P. MONROE, U.S. Geological Survey, Fort Collins Science Center, 2150 Centre Ave., Building C, Ft. Collins, CO 80526, USA
JESSICA E. SHYVERS, U.S. Geological Survey, Fort Collins Science Center, 2150 Centre Ave., Building C, Ft. Collins, CO 80526, USA; Current Address, The Nature Conservancy, Global Protect Oceans, Lands, and Freshwater, Ft. Collins, CO, USA
COURTNEY J. DUCHARDT, Oklahoma State University, Stillwater, OK, USA

The arid sagebrush-steppe ecosystems of western North America are undergoing substantial loss and degradation, primarily due to accelerating effects of climate change, human development, and the spread of invasive species. Decision-support tools are needed to facilitate strategic selection of where and how to efficiently and effectively allocate resources to ensure future functionality and persistence of these ecosystems. We originally developed a spatial conservation prioritization tool called PReSET (Prioritizing Restoration of Sagebrush Ecosystems Tool), to optimize sagebrush restoration in southwestern Wyoming, and have since expanded this tool across the sagebrush biome within the state. Our tool leverages emerging spatial data resources to produce decision-support resources with direct utility for landscape conservation and restoration planning. The flexibility in the tool's framework allows for the development of customized optimization scenarios that consider current ecological status of habitats, best-available species suitability metrics, restoration potential, habitat connectivity, future risk related to climate change. We demonstrate how such tools can be used to develop adaptable decision-support resources that incorporate multiple factors and improve management outcomes across a wide array of systems and species. We are also developing iterations of PReSET for guiding management across sagebrush ecosystems, exploring opportunities for additional regional or biome-wide applications.

CLIMATE, LANDSCAPE CONTEXT, AND WILDFIRE PREDICT GREATER SAGE-GROUSE POPULATION TRENDS OVER 25 YEARS IN IDAHO

ROBERT S. ARKLE, U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center, 230 N. Collins Rd, Boise, ID 83702, USA; rarkle@usgs.gov
DAVID S. PILLIOD, U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center, 230 N. Collins Rd, Boise, ID 83702, USA
MICHELLE I. JEFFRIES, U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center, 230 N. Collins Rd, Boise, ID 83702, USA
JUSTIN L. WELTY, U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center, 230 N. Collins Rd, Boise, ID 83702, USA
ANN MOSER, Idaho Department of Fish and Game, 600 S. Walnut St, Boise, ID 83707, USA
ETHAN ELLSWORTH, U.S. Bureau of Land Management, Idaho BLM T&E Program, 1387 South Vinnell Way, Boise, ID 83709, USA
DONALD J. MAJOR, U.S. Bureau of Land Management, Idaho BLM T&E Program, 1387 South Vinnell Way, Boise, ID 83709, USA

Greater Sage-grouse (*Centrocercus urophasianus*) populations have been in decline for decades across much of the Intermountain West. However, findings from 25 years of lek counts in Idaho indicate that many populations are stable, or even increasing. After accounting for potential biases in past lek count data, we sought to explain the variability in population trends among all 70 lek clusters (i.e., populations) we identified in the state. For each population, we identified lek count troughs, or low-point years, that occurred between the mid-1990s and 2021 and used a regression slope of those abundance low points to quantify each population's trend over the 25-year timespan. We related the 70 populations' slopes to climate, fire, topographic, vegetation, and landcover variables. Our analyses revealed that populations with negative trends tend to occur towards the ends of climate gradients (i.e. range of conditions) and in locations with more wildfire, agriculture, and riparian landcover. Populations with positive trends generally occur in landscapes toward the middle of the climate gradient, with high amounts of low sagebrush landcover, and intermediate amounts of riparian and agricultural landcover. Post hoc analysis indicated the latter two drivers were strongly associated with raven occupancy rates. When modeled separately for different regions however, various region-specific drivers were identified, including tree cover, annual herbaceous cover, and human development. This information can help guide sage-grouse habitat management decisions and set expectations for population recovery given the diversity of habitats occupied by the species and the cyclic nature of sage-grouse populations.

COMMON RAVENS DISRUPT GREATER SAGE-GROUSE LEKKING BEHAVIOR IN THE GREAT BASIN

JOSEPH L. ATKINSON, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA; jatkinson@usgs.gov
PETER S. COATES, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA
BRIANNE E. BRUSSEE, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, California 95620 USA
IAN A. DWIGHT, California Department of Fish and Wildlife, West Sacramento, CA 95605, USA
MARK A. RICCA, U.S. Geological Survey, Corvallis, Forest and Rangeland Ecosystem Science Center, 777 NW 9th Street, Suite 400, OR 97330, USA
PAT J. JACKSON, Predator Management Staff Specialist, Nevada Department of Wildlife, 6980 Sierra Center Parkway, Suite 120, Reno, NV 89511, USA

Expansion of human enterprise has contributed to increased abundance and distribution of common ravens (*Corvus corax*; ravens) across sagebrush (*Artemisia* spp.) ecosystems within western North America. Ravens are highly effective nest predators of greater sage-grouse (*Centrocercus urophasianus*; sage-grouse), a species of high conservation concern. Sage-grouse population trends are estimated using count survey data of males attending traditional breeding grounds, known as leks. We sought to investigate associations of ravens to sage-grouse lek sites and document interactions between the sage-grouse and ravens as well as those between sage-grouse and other animals observed around leks. First, we used extensive raven point counts and sage-grouse lek observation data collected across Nevada and California, USA, from 2009–2019 to evaluate spatial associations between sage-grouse and ravens while accounting for other environmental covariates. We found that ravens were more likely to be observed closer to lek sites, especially as leks increased in size. Second, we used a subset of the lek dataset from 2006–2019 to describe behavioral changes of male sage-grouse in the presence of ravens and other predators. Our analysis indicated that ravens were attracted to leks and disrupted lekking by flushing sage-grouse and interrupting behaviors. These results suggest that adult and yearling sage-grouse perceive ravens as a reason to alter breeding activity, and ravens may adversely influence their reproduction during the lekking stage. Additionally, standardized techniques

to count sage-grouse on leks for population trend analyses could be biased low if raven presence during surveys is not accounted for.

FREE-ROAMING HORSES EXCEEDING APPROPRIATE MANAGEMENT LEVELS AFFECT MULTIPLE VITAL RATES IN GREATER SAGE-GROUSE

JEFFREY L. BECK, Department of Ecosystem Science and Management, University of Wyoming, Laramie, WY 82071, USA; jlbeck@uwyo.edu
MEGAN M. MILLIGAN, U.S. Geological Survey, Western Ecological Research Center, Reno, NV 89512, USA
KURT T. SMITH, Department of Ecosystem Science and Management, University of Wyoming, Laramie, WY 82071, USA
PHILLIP A. STREET, U.S. Fish and Wildlife Service, Sacramento, CA 95825, USA
AARON C. PRATT, George Miksch Sutton Avian Research Center, Bartlesville, OK 74005, USA
CHRISTOPHER P. KIROL, Department of Ecosystem Science and Management, University of Wyoming, Laramie, WY 82071, USA
CAITLYN P. WANNER, Department of Ecosystem Science and Management, University of Wyoming, Laramie, WY 82071, USA
JACOB D. HENNIG, Department of Ecosystem Science and Management, University of Wyoming, Laramie, WY 82071, USA
JONATHAN B. DINKINS, Department of Animal and Rangeland Sciences, Oregon State University, 1500 SW Jefferson Way, Corvallis, OR 97331, USA
J. DEREK SCASTA, Department of Ecosystem Science and Management, University of Wyoming, Laramie, WY 82071, USA
PETER S. COATES, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA

Across portions of their range greater sage-grouse (*Centrocercus urophasianus*) have coexisted with free-roaming horses (*Equus caballus*) since they were introduced to western North America by European settlers. However, numbers of free-roaming equids (horses and burros [*E. asinus*]) have increased to approximately three times Appropriate Management Levels (AML) of 26,785 for all 177 designated Herd Management Areas (HMA) administered by the Bureau of Land Management. Recent research has implicated increasing horse populations as a driver of greater sage-grouse population declines. To evaluate potential demographic mechanisms driving declines, we compiled greater sage-grouse survival data from 4 studies in central Wyoming including 995 females, 1,075 nests, 372 broods, and 136 juveniles, across 15-years (2008–2022). Population estimates of horses for 9 HMAs in our study ranged from 59–700% of the maximum appropriate management level (AMLmax). Sage-grouse monitored outside HMAs represented control populations. To evaluate whether free-roaming horses were negatively impacting sage-grouse, we modeled daily survival of females, nest, broods, and juveniles. We found strong or moderate evidence that overabundant free-roaming horses negatively impacted nest, brood, and juvenile survival. When horse abundance increased to 300% from 100% of AMLmax, the relative change (decline) in survival was 8.1%, 18.3%, 18.2%, and 18.2% for nests, early broods (≤20 days after hatch), late broods (>20 days to 35 days after hatch), and juveniles, respectively. Our results indicate increasing free-roaming horses affected vital rates for critical life stages of greater sage-grouse, suggesting the need to maintain horse numbers below AMLmax to minimize impacts to sage-grouse populations.

A HIGH-QUALITY GENOME ASSEMBLY OF THE COLUMBIAN SHARP-TAILED GROUSE PROVIDES AN IMPORTANT RESOURCE FOR FUTURE PRAIRIE GROUSE CONSERVATION

MORGAN CALAHAN, Boise State University, Boise, ID 83725, USA
NATALIE FORSDICK, Manaaki Whenua, Auckland, 1072, New Zealand
JENNIFER S. FORBEY, Boise State University, 1910 University Drive, Boise, ID 83725, USA
JONATHAN LAUTENBACH, University of Wyoming, Laramie, WY 82071, USA
JACOB NORTHUIS, Pheasants Forever, Inc. and Quail Forever, Blackfoot, ID 83221, USA
JEFF A. JOHNSON, The Peregrine Fund, Boise, ID 83709, USA
STEPHANIE J. GALLA, Conservation Genetics Lab, Boise State University, Boise, ID 83725, USA; stephaniegalla@boisestate.edu

Columbian Sharp-tailed Grouse (*Tympanuchus phasianellus columbianus*; hereafter CSTG) were once widespread in shrub-steppe ecosystems in western North America, but experienced significant decline due to anthropogenic change. CSTG are estimated to occupy less than 5% of their former range, have been extirpated from four US states, are considered endangered in Washington state, and have been petitioned twice for the Endangered Species Act. To facilitate the characterization of remaining diversity, estimate population structure, connectivity, and demographic histories of CSTG, we have produced the first high quality reference genome assembly for this declining subspecies. Genome assembly produced a reference that is 1.07 Gb in length, is highly contiguous (scaffold N50= 70.8 Mb), and complete (avian ortholog completeness (BUSCO) = 99%). Analyses of this assembled genome indicated that Sharp-tailed Grouse experienced a historic bottleneck during the Pleistocene. Further, genome-wide heterozygosity is low, indicating the potential for recent decline. As we resequence individuals across the CSTG range, this reference genome will support accurate estimates of inbreeding through runs of

homozygosity to prioritize populations in need of intervention. The characterization of adaptive loci will allow us to understand local adaptation of populations across the western US and how these loci affect translocation success. Finally, this assembled reference genome is the first for Sharp-tailed Grouse, providing an important genomic resource for a genus where most extant taxa are in decline (Lesser Prairie-chicken, *T. pallidicinctus*), endangered (Attwater's Prairie-chicken, *T. cupido attwateri*), or extinct (Heath Hen, *T. c. cupido*).

CITIZEN SCIENCE CONTRIBUTIONS TO GREATER SAGE-GROUSE MONITORING ON PARKER MOUNTAIN, UTAH

RUGER CARTER (Student), Utah State University, Logan, UT, 84322, USA; ruger.carter@usu.edu
DAVID K. DAHLGREN, Wildland Resources Department, Utah State University, Old Main Hill, Logan, UT 84322, USA
ERIC T. THACKER, Wildland Resources Department, Utah State University, Logan, UT 84333, USA

Wildlife management relies heavily on extensive data collection, especially for sensitive species. Researchers and wildlife managers can use citizen science as cost effective tool to increase the temporal and spatial resolution of data being collected. Furthermore, participants of citizen science are provided with hands on learning opportunities about the management and conservation of the wildlife resource. We present a case study utilizing volunteers from the Utah Chukar and Wildlife Foundation (UCWF) to assess greater sage-grouse response (*Centrocercus urophasianus*) to sagebrush management on Parker Mountain located in Central Utah. These efforts have been continued annually for 20 years. Utilizing volunteers from the UCWF has provided a substantial amount of data that has been used to guide sage-grouse habitat management in the state of Utah. This collaborative effort highlights the potential for citizen science partnerships to advance sage-grouse conservation throughout their range.

RESPONSE OF ENDANGERED GREATER SAGE-GROUSE TO OIL AND GAS RECLAMATION IN CRITICAL HABITAT IN SOUTHEASTERN ALBERTA

MELISSA CHELAK, University of Lethbridge, Lethbridge, AB T1K 3M4, Canada; melissa.chelak@uleth.ca
JOEL NICHOLSON, Alberta Environment & Protected Areas, Medicine Hat, AB T1A 0G7, CANADA
SAMANTHA PRICE, Orphan Well Association, Calgary, AB T2P 0B4, CANADA
MECAH KLEM, Alberta Environment & Protected Areas, Medicine Hat, AB T1A 0G7, CANADA
LAYTON MCANDREW, Alberta Environment & Protected Areas, Medicine Hat, AB T1A 0G7, CANADA
JULIE HEINRICHS, Computational Ecology Group, Canmore, AB T1W, CANADA
AMELIA COLEING, Wilder Institute Calgary Zoo, Calgary, AB T2E 7V6, CANADA
SHELLEY NELSON, Computational Ecology Group, Canmore, AB T1W, CANADA
STEFANO LICCIOLI, Alberta Environment & Protected Areas, Lethbridge, AB T1J 4L1, CANADA
TROY WELLICOME, Environment & Climate Change Canada, Edmonton, AB T6B, CANADA
THERESA BURG, University of Lethbridge, Lethbridge, AB T1K 3M4, CANADA

Greater sage-grouse (*Centrocercus urophasianus*) in Canada have experienced significant declines resulting from a combination of factors severely fragmenting and degrading their habitat. These factors include native sagebrush (*Artemesia* spp.) prairie-to-cropland conversion, agricultural development south of the Canada-US border, altered hydrological processes (e.g., canals, dams, etc.), industrial activity related to the oil and gas sector, road and other infrastructure development, disease (particularly West Nile Virus), and increased predation. Between the 1940s and early 2000s, 756 oil and gas sites were developed within the 3900km^2 sage-grouse study area, with the highest densities reaching 3.09 wells/km^2. To combat the sage-grouse declines and habitat loss, Alberta's sage-grouse population has been the focus of research-driven recovery efforts since the late 1990s. Recovery efforts have included translocations from Montana sage-grouse populations, extensive predator management, removal of anthropogenic structures (e.g., powerlines and abandoned sheds/homesteads), land acquisition, sagebrush-prairie restoration, ranch-based conservation planning, and, increasingly, oil and gas site reclamation. Recent analyses identified habitat restoration through removing anthropogenic structures and reclaiming oil and gas sites as focal management actions to maximize the probability of population recovery. Consequently, ~350 oil and gas sites have begun reclamation in southern Alberta to date. We will evaluate if the reclamation has affected sage-grouse habitat selection and survival using data from 152 marked sage-grouse from 2011 to present. Understanding whether oil and gas reclamation benefits sage-grouse is integral to evaluating the benefits of reclamation for the sage-grouse population recovery in Alberta.

EVALUATING THE CONSERVATION DESIGN STRATEGY AND TARGETED CONSERVATION EFFORTS USING A SAGEBRUSH INDICATOR SPECIES, THE GREATER SAGE-GROUSE

PETER S. COATES, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA; pcoates@usgs.gov

BRIAN G. PROCHAZKA, U.S. Geological Survey, Western Ecological Research Center, Dixon, CA 95620, USA
KEVIN E. DOHERTY, U.S. Fish and Wildlife Service, Science Applications, Evergreen, CO 80235, USA & U.S. Department of Agriculture Forest Service Research and Development, Missoula, MT 59801, USA
CARL G. LUNDBLAD, U.S. Geological Survey, Western Ecological Research Center, Reno, NV 89512, USA
SARAH C. WEBSTER, U.S. Geological Survey, Western Ecological Research Center, Reno, NV 89512, USA
SHAWN T. O'NEIL, U.S. Geological Survey, Western Ecological Research Center, Dixon, CA 95620, USA
JOHN C. TULL, U.S. Fish and Wildlife Service, Science Applications, Reno, NV 89502, USA
CALI L. WEISE, U.S. Geological Survey, Western Ecological Research Center, Dixon, CA 95620, USA
CAMERON L. ALDRIDGE, U.S. Geological Survey, Fort Collins Science Center, 2150 Centre Ave., Building C, Ft. Collins, CO 80526, USA
MICHAEL S. O'DONNELL, U.S. Geological Survey, Fort Collins Science Center, 2150 Centre Ave., Building C, Ft. Collins, CO 80526, USA
LIEF WIECHMAN, U.S. Geological Survey, Land Management Research Program, Ft. Collins, CO 80526, USA

The North American sagebrush biome is facing accelerating threats from altered wildfire regimes, sagebrush loss, anthropogenic development, conifer expansion, and conversion to invasive annual grasslands. The Sagebrush Conservation Design (SCD) strategy was recently developed as an overarching framework to guide targeted and adaptive management of sagebrush ecosystems and their sensitive species. The SCD focuses on areas for protection, threat mitigation, and ecosystem restoration by delineating the landscape into different condition categories (core, potential, and other areas) using a Sagebrush Ecosystem Integrity (SEI) index, which was developed using five key landcover and human modification variables. Here, we first evaluated the SCD through the lens of greater sage-grouse (*Centrocercus urophasianus*), an indicator species at the center of national land use policies, by relating SEI to population growth using Bayesian hierarchical state-space models. We found growth rates were stable to positive in core areas and negative to strongly negative across the remainder of the biome, supporting the utility of SEI within the SCD framework. We further developed a map that reflected grouse-centric condition categories using the same five key covariates and found strong spatial congruence between the two outputs. Second, we employed a progressive change before-after-control-impact paired series design within Bi-State Distinct Population Segment to evaluate the efficacy of targeted sagebrush ecosystem conservation actions. Although effectiveness varied, we found clear evidence that management actions increased sage-grouse population abundance by an average of 4.4% annually, resulting in 37.4% cumulative increases over the past decade. Information is preliminary and provided for best timely science.

ASSESSING POTENTIAL PHYSIOLOGICAL CHALLENGES FACED BY GREATER SAGE-GROUSE WHEN TRANSITIONING FROM A CAPTIVE TO A WILD DIET

AMELIA COLEING, Wilder Institute, Calgary Zoo, Calgary, AB, T2E 7V6, Canada; milliec@calgaryzoo.com
JENNIFER S. FORBEY, Boise State University, Boise, ID, 83725, USA
EMMA VAASJO, Wilder Institute, Calgary Zoo, Calgary, AB, T2E 7V6, Canada
DOUGLAS WHITESIDE, Wilder Institute, Calgary Zoo, Calgary, AB, T2E 7V6, Canada

Greater Sage-Grouse (*Centrocercus urophasianus*) are classified as Endangered under the Species at Risk Act in Canada. Following a feasibility assessment, a conservation breeding and translocation program for sage-grouse was initiated in 2014. Fewer than 1% of individuals released in 2018-2023 have survived to the breeding season following release. Poor post-release survival likely has multiple contributing factors, including diet, health and behaviour of released grouse and the environment into which they are released. Investigative work indicates that recently released sage-grouse may experience physiological challenges transitioning from a captive diet to a wild diet. A pilot release of a hen and 6-week-old juveniles revealed that some juveniles developed gastrointestinal impaction 4-8 days post-release, with associated with clostridial necrotic enteritis in some cases. Potential causes of these impaction events may include infection, dehydration or other physiological challenges. Community composition of gastrointestinal microbiota of sage-grouse under managed care differs significantly from wild sage-grouse perhaps due to significant differences in diet, local environment or other variables related to captivity. We propose that the morphological, physiological and behavioural mechanisms that mediate intake and digestion of forage are both a barrier to and potential conservation target for successful conservation breeding and translocation of sage-grouse. We will explore how modifications to the captive diet and gastrointestinal microbiome of sage-grouse will prime the host to consume and digest local plants at release sites. Understanding potential approaches to prepare captive-raised sage-grouse for release may improve post-release survival and evaluation of conservation breeding as a viable recovery tool for sage-grouse.

ASSESSMENT OF MODIFIED HARNESS SYSTEMS FOR RUMP-MOUNTED TRANSMITTERS AIMED AT REDUCING SKIN LESIONS AND OTHER EFFECTS ON MALE GREATER SAGE-GROUSE

AMELIA COLEING, Wilder Institute, Calgary Zoo, Calgary, AB, T2E 7V6, Canada; milliec@calgaryzoo.com
ADRIANA PASTOR, Wilder Institute, Calgary Zoo, Calgary, AB, T2E 7V6, Canada
DOUGLAS WHITESIDE, Wilder Institute, Calgary Zoo, Calgary, AB, T2E 7V6, Canada
ALYSSA KIRCHER, Colorado Parks & Wildlife, 2300 S. Townsend Ave. Montrose, CO 81401, USA
DARIO FERNANDEZ-BELLON, Wilder Institute, Calgary Zoo, Calgary, AB, T2E 7V6, Canada

Rump-mounted transmitters have been employed extensively to monitor wild greater sage-grouse (*Centrocercus urophasianus*). Despite their widespread use, few studies have evaluated short- or long-term effects of harnesses on individual health, and those that have often report skin lesions. Three harness modifications were trialed on seven subadult/adult male sage-grouse in a conservation breeding program: PVC tubing over Teflon ribbon (n=2), neoprene sleeve over Teflon ribbon (n=3) and neoprene inserted into Teflon ribbon (n=2). Birds were visually monitored daily, and in-hand checks were performed opportunistically with other clinical procedures or if concerns were noted. One of each harness design (3/7; 43%) incited severe inguinal abrasions and ulceration with skin attachment to the harness, necessitating harness removal. Mild skin thickening and callous formation in the absence of more serious abrasions was observed in the remaining 4/7 (57%) of the birds within 12 days post-fitting. Two grouse, fitted with the internal neoprene and PVC tubing harness modifications, died from unrelated causes 35- and 124-days post-fitting, with mild skin thickening and no lesions noted. One grouse became entangled in a neoprene sleeve harness 63 days post-fitting and the harness was removed. A neoprene sleeve harness became very loose and was removed after 197 days, with no associated lesions. More research is needed to evaluate harness designs and their potential impacts. A captive population is ideal for evaluating transmitter attachment methods since it allows frequent monitoring and evaluation of impacts over longer periods than is typically feasible in the wild.

RELATIONSHIP BETWEEN CATTLE GRAZING AND DEMOGRAPHIC TRAITS OF GREATER SAGE-GROUSE: THE GROUSE AND GRAZING PROJECT

COURTNEY J. CONWAY, U.S. Geological Survey, Idaho Cooperative Fish and Wildlife Research Unit, 875 Perimeter Drive, University of Idaho, Moscow, ID 83844, USA; cconway@uidaho.edu
CODY TISDALE, University of Idaho, 875 Perimeter Drive, Moscow, ID 83844, USA
KAREN L. LAUNCHBAUGH, University of Idaho, 875 Perimeter Drive, Moscow, ID 83844, USA
SHANE B. ROBERTS, Idaho Department of Fish and Game, 600 South Walnut, Boise, ID 83712, USA
PAUL MAKELA, U.S. Bureau of Land Management, Idaho State Office, Boise, Idaho 83709, USA
BRYAN S. STEVENS, U.S. Forest Service-Pacific Northwest Research Station, 1401 Gekeler Lane, La Grande, OR 97850, USA

Livestock grazing is common within greater sage-grouse (*Centrocercus urophasianus*) habitat and livestock grazing has been implicated as one factor that may contribute to sage-grouse population declines, but few studies have explicitly tested this common assertion. We recently completed a 10-year experimental study with randomized grazing and non-grazing treatments at 5 study sites to quantify the extent to which cattle grazing affects sage-grouse demographic traits. We radio-collared 1,343 sage-grouse hens and monitored 1,285 nesting attempts and documented fate of 392 broods. We also measured 305,484 perennial grasses within 5,033 vegetation plots. Grass heights were lower in grazed pastures than in non-grazed pastures, and were lower at failed nests than at successful nests (more so within non-grazed pastures). Spring temperature, spring precipitation, study site, year, incubation stage, and initiation date influenced daily nest survival, but we found no evidence that grazing (at the levels in our study allotments) reduced nest survival. Spring temperature and spring precipitation influenced brood fate, but we found no evidence that brood fate was lower in pastures with spring grazing (and pastures with spring and fall grazing had slightly higher survival than the other 2 treatments). Nest density was higher in the non-grazing treatments and spring grazing treatments compared to the spring and fall grazing treatment, but the decrease in nest density from pre- to post-treatment years was most pronounced in the spring grazing treatments. We found no difference among treatments in subsequent year's nest-site fidelity. These patterns suggest that hens are making nest placement decisions based partly on grazing and that successful hens are selecting sites that offset any negative effects of grass offtake at the pasture scale.

SAGE-GROUSE HABITAT AND SCALE: LEK PERSISTENCE AND LANDSCAPES WITH USABLE SPACE

DAVID K. DAHLGREN, Wildland Resources Department, Utah State University, Old Main Hill, Logan, UT 84322, USA; dave.dahlgren@usu.edu
ERIC T. THACKER, Wildland Resources Department, Utah State University, Logan, UT 84333, USA

Sage-grouse (*Centrocercus* spp.) are sagebrush (*Artemisia* spp.) obligates that need large intact landscapes of contiguous sagebrush to support survival and productivity at population levels. The proportion of a landscape dominated by sagebrush cover is the key determinant of population persistence. Within seasonal habitat specific vegetation characteristics are important, such as herbaceous and sagebrush canopy cover, but only within the context of the larger sagebrush landscape. By synthesizing past research that assessed lek persistence we developed the ¼ - ½ - ⅔ - Rule. The Rule is that within a buffer of 18 or 31 km of a lek, if < 25%, 25–50%, 50–66%, or > 66% of the buffer is dominated by sagebrush, then the probability of that lek persisting is 0, > 0 but < ~ 0.9, > ~ 0.9, or 1, respectively. This Rule can be applied across sage-grouse range regardless of habitat quality. For example, the proportion of landscape dominated by sagebrush trumps habitat quality when comparing Utah's Strawberry Valley and Parker Mountain sage-grouse populations. F. Guthery argued that usable space explained population change better than habitat quality and focusing on usable space would increase management effectiveness. We believe that combining the concepts of our ¼ - ½ - ⅔ - Rule and usable space and applying them to sage-grouse conservation would provide more certainty in achieving our shared objective of population persistence.

USING PRECISION NUTRITION INTERVENTIONS TO MANAGE SAGE-GROUSE

JENNIFER S. FORBEY, Boise State University, 1910 University Dr, Boise, ID, USA; jenniferforbey@boisestate.edu,
JOHN W. CONNELLY, 83 W 215 N, Blackfoot, ID 83221, USA
MICHAEL A. SCHROEDER, Washington Department of Fish and Wildlife, P.O. Box 1077, Bridgeport, WA 98813, USA
GAIL L. PATRICELLI, Department of Evolution and Ecology, University of California, One Shields Avenue, 2320 Storer Hall, Davis, CA 95616, USA
STEPHANIE J. GALLA, Conservation Genetics Lab, Boise State University, Boise, ID 83725, USA
STEPHANIE HUDON, Boise State University, Boise, ID 83725, USA
MARIO MUSCARELLA, University of Alaska Fairbanks, Fairbanks, AK 99775, USA
ÓLAFUR K. NIELSEN, Icelandic Institute of Natural History, Garðabñr, Iceland
KRISTINN PÉTUR MANGNÚSSON, University of Akureyri, Akureyri, Iceland

The behavior, physiology, and overall productivity of herbivores are mediated by the distribution of specific chemicals that comprise the "nutritional phenotype" of plants. As such, plant chemistry offers an innovative target to proactively manage threatened herbivores in changing landscapes. We use the sage-grouse (*Centrocercus urophasianus*) system to demonstrate how precision nutrition interventions, similar to personalized nutrition and medicine in humans, can be used to conserve, restore, and monitor the health of threatened herbivores. We demonstrate how mapping variation in nutritional phenotypes of sagebrush (*Artemisia* spp.) represents a critical and missing component of intraspecific variation among vegetation that can be remotely sensed to predict and manage winter habitat use by sage-grouse. First, we show how advances in near-remote and remote sensing of sagebrush chemistry can predict the foraging behavior of sage-grouse. Then, we show how advances in plant propagation can support precision nutrition interventions as an innovative restoration strategy in sage-grouse core areas. Finally, we show how advances in genomics and chemistry can be used to monitor the outcomes of precision nutrition interventions. The goal is to recruit new partners to co-develop and implement customized precision nutrition interventions that benefit sage-grouse and other wildlife of conservation concern or bioeconomic value across land use types.

INCUBATION BEHAVIOR INFLUENCES NEST SURVIVAL IN GREATER SAGE-GROUSE

ERIN L. GELLING, University of Wyoming, Laramie, WY 82071, USA; erinbirt@gmail.com
AARON C. PRATT, George Miksch Sutton Avian Research Center, Bartlesville, OK 74005, USA
JEFFREY L. BECK, Department of Ecosystem Science and Management, University of Wyoming, Laramie, WY 82071, USA

Nesting is a critical stage and important vital rate that influences population dynamics for greater sage-grouse (*Centrocercus urophasianus*) who exhibit low productivity that is limited, in part, by nest survival. Our objectives were to describe sage-grouse incubation behavior, examine whether sage-grouse incubation behavior influenced nest survival, and evaluate factors that influenced average recess duration, the sage-grouse incubation behavior that most influenced nest survival in our study. We used 5-min GPS locations with accelerometer data from two separate study areas: Bridger in south-central Montana, USA (2018–2019) and Red Desert in south-central Wyoming, USA (2019–2020). We used 131 nests (1557 incubation days) to describe sage-grouse incubation behavior and 118 nests (1544 incubation days) to examine nest survival and average recess duration. Bridger had lower incubation constancy, longer recess times, greater number of recesses, and greater apparent nest success than Red Desert. Adult females had higher incubation constancy and lower recess duration compared to yearling females, though first and renest attempts did not differ. Average recess duration had a negative effect and average minimum temperature on the day prior to nest fate had a positive effect on risk of nest mortality. Day of incubation and minimum temperature from the previous day had a positive effect and sagebrush cover had a negative effect on recess duration. Understanding factors affecting nest survival is important for directing management to improve sage-grouse nest success.

Knowledge of factors influencing incubation patterns helps researchers and managers understand the basics of sage-grouse nesting biology.

RESTORING WESTERN MONTANA'S SHARP-TAILED GROUSE

KRISTINA HARKINS, Montana Fish, Wildlife and Parks. 490 North Meridian, Kalispell, MT 59901, USA; Kristina.Harkins@mt.gov
MIKEL NEWBERG, Montana Fish, Wildlife and Parks. 490 North Meridian, Kalispell, MT 59901, USA
TY SMUCKER, Montana Fish, Wildlife and Parks. 490 North Meridian, Kalispell, MT 59901, USA
CHRIS HAMMOND, Montana Fish, Wildlife and Parks. 490 North Meridian, Kalispell, MT 59901, USA

Sharp-tailed grouse (*Tympanuchus phasianellus*) have remained a Montana Fish, Wildlife and Parks (FWP) priority for 32 years, dating back to the Libby Mitigation Plan that quantified habitat and wildlife losses after Koocanusa Reservoir was created. Most recently, FWP's State Wildlife Action Plan (SWAP) identifies sharp-tailed grouse as a species of greatest conservation need. The SWAP identified the current state of sharp-tailed grouse population west of the continental divide as "isolated and extremely small" but was essentially extirpated in the early 2000s. Two conservation actions identified in the plan were to "evaluate potential for sharp-tailed grouse reintroduction" and "increase abundance and distribution of sharp-tailed grouse with a reintroduction program to western Montana". We addressed the first conservation action with the completion of an evaluation of sharp-tailed grouse habitat suitability in western Montana that identified multiple areas with habitat suitable for sustaining sharp-tailed grouse populations. The second conservation action required a restoration plan and an environmental assessment which was completed in 2019. Sharp-tailed grouse were translocated beginning in the fall of 2021 with 75 males. The following spring our efforts were shortened due to avian influenza and only 22 birds were moved. In 2023 and 2024, 144 and 212 birds were translocated respectively. We observed successful first nest attempts as well as successful renest attempts after our first release of hens in 2022. We observed overwinter survival of translocated birds and of broods hatched in western Montana. We will share preliminary results on survival, nest success, brood success, and lek establishment.

NEVADA COMMON RAVEN MANAGEMENT: A JOURNEY

PAT J. JACKSON, Predator Management Staff Specialist, Nevada Department of Wildlife, 6980 Sierra Center Parkway, Suite 120, Reno, NV 89511, USA; pjackson@ndow.org

Abstract: The common raven (*Corvus corax*) has been identified as the most widespread nest predator of greater sage-grouse (*Centrocercus urophasianus*). Although the common raven is a natural predator of greater sage-grouse nests, human subsidies, including non-traditional food sources (e.g., roadkill, landfills) and artificial nesting structures (e.g., power and utility lines), dramatically increased common raven abundance as much as 1600% in some areas. Increased common raven abundance coupled with greater sage-grouse habitat loss and degradation (e.g., invasive annual grass invasion, tightened wildfire cycles and anthropogenic surface disturbance projects) have resulted in decreased greater sage-grouse population growth and stability in portions of its range. We intend to present: 1) common raven population growth, 2) potential factors that influence population growth, 3) an overview of a Science-based Management of Ravens Tool (SMaRT), 4) a three-tied management approach, and 5) a summary of common raven management in Nevada.

NESTING ECOLOGY OF SAGE-GROUSE: VEGETATIVE CORRELATES OF SUCCESS IN CENTRAL OREGON

REBECCA KELBLE (student), Oregon State University, Corvallis, OR 97331, USA; rebecca.kelble@oregonstate.edu
CHRISTIAN A. HAGEN, Oregon State University, Corvallis, OR 97331, USA
LARRY ASHTON, Bureau of Land Management, Prineville District Office, Prineville, OR 97754, USA
BRIEANA PORTER, Bureau of Land Management, Prineville District Office, Prineville, OR 97754, USA
SKYLER VOLD, Oregon Department of Fish and Wildlife, Hines District Office, Hines, OR 97738, USA
GREG JACKLE, Oregon Department of Fish and Wildlife, Prineville Field Office, Prineville, OR 97754, USA
ANDREW WALCH, Oregon Department of Fish and Wildlife, Bend Deschutes Watershed District Office, Bend, OR 97702, USA

Sagebrush (*Artemisia* spp.) ecosystems face numerous threats throughout western North America. Greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse) are an indicator species for this ecosystem's health, and populations are declining range wide due to habitat loss, fragmentation, and degradation. Sage-grouse populations in central Oregon include two Priority Areas for Conservation, Brothers and Paulina. The Brothers population is declining more steadily than Paulina and occupies the western edge of its distribution. In 2022 and 2023, we tagged female sage-grouse with GPS-PTT transmitters to begin investigating factors leading to declines in these populations. We monitored 62 nests (Brothers = 27; Paulina = 35) and 27-d nest survival was 0.21 (95% CI 0.11–0.36) and 0.26 (95% CI 0.14–0.41) in Brothers and Paulina. These estimates of

reproductive output bring into question long-term population viability. Micro-habitat measurements were taken at 57 nests (Brothers = 27; Paulina = 30) to assess vegetative structure and composition. Shrub cover was similar at failed nests in Brothers and Paulina ($\overline{x}$ = 31% ± 14, ($\overline{x}$ = 30% ± 11) compared to greater cover at successful nests in Brothers ($\overline{x}$ = 34% ± 9) and less cover at successful nests in Paulina ($\overline{x}$ = 20% ± 13). Grass height was greatest at successful and failed nests in Paulina ($\overline{x}$ = 19 cm ± 11, $\overline{x}$ = 18 cm ±11) compared to successful and failed nests in Brothers ($\overline{x}$ = 15 cm ± 11, $\overline{x}$ = 15 cm ±10). We will explore the predictive relationships of vegetative characteristics and landscape covariates as it relates to nest success. These habitat characteristics should aid local management efforts to improve conditions for sage-grouse populations.

GREATER SAGE-GROUSE OCCURRENCE AT A SOLAR ENERGY FACILITY

CARLY S. KELLY, Western Ecosystems Technology, Inc., 1610 Reynolds Street, Laramie, WY 82072, USA; ckelly@west-inc.com
BARBARA J. STONE, Western Ecosystems Technology, Inc., 1610 Reynolds Street, Laramie, WY 82072, USA
JARED K. SWENSON, Western Ecosystems Technology, Inc., 2121 Midpoint Drive, Suite 201, Fort Collins, CO 80525, USA
EVERETTE A. ABHAINN, Western Ecosystems Technology, Inc., 1610 Reynolds Street, Laramie, WY 82072, USA
JOHN D. LLYOD, Western Ecosystems Technology, Inc., 1610 Reynolds Street, Laramie, WY 82072, USA
CHAD W. LEBEAU, Western Ecosystems Technology, Inc., 1610 Reynolds Street, Laramie, WY 82072, USA

Opportunistic observations during standardized post-construction monitoring have revealed greater sage-grouse (*Centrocercus urophasianus*) loafing and foraging within Sweetwater Solar, an 80-megawatt photovoltaic utility-scale solar energy (PV USSE) facility near Rock Springs, Wyoming. To better understand how greater sage-grouse use space within and adjacent to the facility, we collected data on their occurrence, using pellet surveys, inside the fenced facility and within a 2-km buffer around the facility. We supplemented pellet surveys with qualitative observations of greater sage-grouse obtained with game cameras placed throughout the facility. We also quantified vegetation conditions inside and outside of the facility to explore whether structure and composition of the plant assemblage could explain patterns of greater sage-grouse occurrence. Preliminary results suggest that greater sage-grouse use the facility more often during winter and brood-rearing periods than during the nesting period. Results also suggest that occurrence was greater within the facility than in the 2-km buffer adjacent to the facility during winter and brood-rearing periods. Vegetation surveys indicated that shrub cover was substantially lower within the facility, but that grass and forb cover were higher; this reflects the revegetation approach taken following construction of the facility. Overall, results suggest that land within the facility offers a distinct suite of conditions that greater sage-grouse may use during certain times of year. This study may serve as a useful foundation for longer-term studies of both the impact of PV USSE on greater sage-grouse and restoration strategies that may help minimize negative effects.

USING GENETIC, MORPHOLOGICAL, AND ECOLOGICAL EVIDENCE TO IDENTIFY THE SUBSPECIES OF SHARP-TAILED GROUSE IN SOUTH-CENTRAL WYOMING

JONATHAN D. LAUTENBACH (Student), University of Wyoming, Laramie, WY 82071, USA; jlauten1@uwyo.edu
ANDREW J. GREGORY, University of North Texas, Denton, TX 76201, USA
STEPHANIE J. GALLA, Conservation Genetics Lab, Boise State University, Boise, ID 83725, USA
AARON C. PRATT, George Miksch Sutton Avian Research Center, Bartlesville, OK 74005, USA
JEFFREY L. BECK, Department of Ecosystem Science and Management, University of Wyoming, Laramie, WY 82071, USA

Within Wyoming, there are three populations of Sharp-tailed Grouse (*Tympanuchus phasianellus*): Columbian sharp-tailed Grouse (cSTGR) in western Wyoming, plains Sharp-tailed Grouse (pSTGR) in eastern Wyoming, and a population of Sharp-tailed Grouse in southcentral Wyoming (unknown STGR) with an unknown subspecific status. Our study used genetic, morphological, and ecological data collected from known cSTGR in eastern Idaho, known pSTGR in eastern Wyoming, and the unknown STGR population to better understand the subspecies status of unknown STGR. Using 2,500 single nucleotide polymorphisms and a discriminant analysis of principal components (DAPC), we found that cSTGR in Idaho formed a distinct group, while pSTGR and the unknown STGR populations demonstrated considerable admixture between them. Using a DAPC on nine microsatellite loci, we found that the three populations of interest formed three distinct groups. Using a DAPC to evaluate differences in morphological characteristics between the populations, we found that cSTGR and unknown STGR were similar morphologically when including mass; however, when excluding mass, unknown STGR birds were more similar to pSTGR. Comparing habitat characteristics between the three populations, we found that there was limited overlap in habitat characteristics between pSTGR and unknown STGR; cSTGR shared some habitat characteristics with both pSTGR and unknown STGR populations. Our results suggest that the unknown STGR population may be descended from pSTGR, with subsequent genetic differentiation occurring through drift and differentiation. These results contribute towards our understanding of the range-wide distribution of cSTGR and will affect consideration of conservation and management options for Sharp-tailed Grouse in southcentral Wyoming.

MAXIMIZING TRANSLOCATION SUCCESS FOR GREATER SAGE-GROUSE POPULATION RESTORATION

NICOLE I. LINDENAUER (Student), University of California Davis, Davis, CA 95616 USA and U.S. Geological Survey, Western Ecological Research Center, Dixon, CA 95620, USA; nlindenauer@ucdavis.edu
PETER S. COATES, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA
MEGAN C. MILLIGAN, U.S. Geological Survey, Western Ecological Research Center, Reno, NV 89512, USA
STEVEN R. MATHEWS-SANCHEZ, U.S. Geological Survey, Western Ecological Research Center, Reno, NV 89512, USA
GAIL L. PATRICELLI, Department of Evolution and Ecology, University of California, One Shields Avenue, 2320 Storer Hall, Davis, CA 95616, USA

Greater sage-grouse (*Centrocercus urophasianus*; hereafter, "sage-grouse") populations have declined significantly across the western United States, including in the Bi-State Distinct Population Segment (Bi-State DPS), with declines largely attributed to habitat loss, degradation, and fragmentation. Parker Meadows is an isolated sub-population within the Bi-State DPS that has experienced steep population decline, likely due to landcover changes combined with inbreeding depression. To prevent local extirpation, translocations were conducted from 2017–2023. As part of this translocation effort, we compared the efficacy of two translocation methods during 2022–2023 to inform management decisions that optimize population restoration efforts. We compared whole-brood translocations (relocation of females with their broods) to mixed-brood translocations, a novel approach where translocated broods were augmented with chicks from a different donor brood from the same source population. We evaluated initial chick retention rates within translocated mixed-broods, and compared survival estimates between translocated whole-broods and mixed-broods, as well as between donor and non-donor broods within the source population. We also compared habitat selection and survival between resident and translocated broods over the 6-year period to create source-sink habitat maps that could be used to inform suitable future release site locations. By identifying the most effective translocation method and optimal release locations, we will provide valuable insights for conservation managers aiming to restore sage-grouse populations. This work will also have broader implications for translocation efforts for other threatened Galliformes species. These findings are preliminary, subject to change, and provided for best timely science.

SAGE-GROUSE RESPONSES TO WEATHER AND CLIMATE DEPEND ON PRECIPITATION TIMING AND LIFE STAGE

CARL G. LUNDBLAD, U.S. Geological Survey, Western Ecological Research Center, Reno, NV 89512, USA; clundblad@usgs.gov
SHAWN T. O'NEIL, U.S. Geological Survey, Western Ecological Research Center, Dixon, CA 95620, USA
BRIANNE E. BRUSSEE, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA
JOHN B. BRADFORD, U.S. Geological Survey, Climate Adaptation Science Centers, Flagstaff, AZ 86001, USA
GREGORY T. WANN, U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO 80526, USA
JOHN C. TULL, U.S. Fish and Wildlife Service, Science Applications, Reno, NV 89502, USA
MICHAEL CASAZZA, U.S. Geological Survey, Western Ecological Research Center, Dixon, CA 95620, USA
CAMERON L. ALDRIDGE, U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO 80526, USA
PETER S. COATES, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA

Greater sage-grouse (*Centrocercus urophasianus*; sage-grouse) populations track climate variability in the sagebrush biome, and sage-grouse populations are considered vulnerable to increasing aridity and drought conditions that are expected to intensify under climate change. However, the underlying direct and indirect mechanisms, their relative importance, and net effects on sage-grouse remain poorly understood. We reviewed the literature on the effects of weather and climatic factors on sage-grouse population trends and demography. These results helped inform our own analyses of the effects of precipitation, drought, and other climatic factors on sage-grouse population growth and vital rates (adult, brood, and nest survival) in the Great Basin of California, Nevada, Oregon, and Idaho. We used hierarchical models to explore the relative effects of concurrent and lagged (up to 1.5 years) precipitation and drought indices on sage-grouse, dating back to 1985. Nuanced responses to precipitation, whether positive or negative, largely depended on precipitation timing and life stage requirements. Sage-grouse population rates of change increased in years following above average growing season precipitation, and that overall population-level effects appear to be mediated by positive influences of prior-summer and fall precipitation on adult and brood survival. Nest survival responded negatively, and adult survival increased, in response to concurrent drought, suggesting a trade-off between adult survival and reproduction that is mediated by interannual climate variability. Our results help identify management strategies that may support sage-grouse's adaptive capacity and performance under intensifying wet-dry cycles and exacerbated ecological drought conditions. Findings are preliminary and provided for best timely science.

BODY MASS AT TIME OF CAPTURE AFFECTS SURVIVAL OF RADIO-MARKED GREATER SAGE-GROUSE (CENTROCERCUS UROPHASIANUS) CHICKS

BELLE MALLEY (Student), University of California, Davis, Davis, CA; bmalley@usgs.gov
PETER COATES, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA
STEVEN MATHEWS-SANCHEZ, U. S. Geological Survey, Western Ecological Research Center, Dixon, CA 95620, USA
GAIL L. PATRICELLI, Department of Evolution and Ecology, University of California, One Shields Avenue, 2320 Storer Hall, Davis, CA 95616, USA

Chick survival is a critical vital rate for greater sage-grouse (*Centrocercus urophasianus*; hereafter 'sage-grouse') populations and several other grouse species in the American West. Thus, management actions that focus on improving chick survival may be most beneficial at increasing population growth rates. Estimating chick survival is often challenging given the degree of uncertainty in detection probabilities through conventional methods of chick count surveys over time. One robust method of estimating survival and relating survival to individual and environmental characteristics is direct marking of chicks with sutured radio-transmitters. However, potential adverse effects on survival of this suture technique is uncertain and may bias estimation. In this study, we marked a subset of chicks within a brood by suturing small (range 0.6 – 1.4 g) transmitters and employed Bayesian hierarchical frailty models to estimate 35-d survival and covariates (e.g., body mass, age, date of capture). Models revealed that chick body mass at the time of marking was positively related to their survival, such that heavier chicks exhibited increased survival compared to lighter chicks. We also tested our method of marking chicks by using generalized linear models (binomial error distribution) to test if chick survival differed between marked and non-marked chicks, and we found marginal evidence of reduced survival for marked chicks. Data are preliminary, subject to change, and provided for best timely science.

COMBINING SPACE USE, HABITAT SELECTION, AND SURVIVAL TO INFORM HABITAT MANAGEMENT AREAS FOR GREATER SAGE-GROUSE IN NEVADA AND NORTHEASTERN CALIFORNIA

MEGAN C. MILLIGAN, U.S. Geological Survey, Western Ecological Research Center, Reno, NV 89512, USA; mmilligan@usgs.gov
PETER S. COATES, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA
SHAWN T. O'NEIL, U.S. Geological Survey, Western Ecological Research Center, Dixon, CA 95620, USA
BRIANNE E. BRUSSEE, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, California 95620 USA
MICHAEL P. CHENAILLE, U.S. Geological Survey, Western Ecological Research Center, Dixon, CA 95620, USA
DEREK FRIEND, U.S. Geological Survey, Western Ecological Research Center, Dixon, CA 95620, USA
KATHLEEN STEELE, Nevada Department of Conservation and Natural Resources, Reno, NV 89521, USA
JUSTIN R. SMALL, Nevada Department of Wildlife, 1100 Valley Rd, Reno, NV 89512, USA
TIMOTHY S. BOWDEN, Bureau of Land Management, 1340 Financial Blvd., Reno, NV 89502, USA
ARLENE D. KOSIC, Bureau of Land Management, 602 Cressler Street, Cedarville, CA 96104, USA

Declines in greater sage-grouse (*Centrocercus urophasianus*) populations are largely linked to habitat loss, and a key component of conservation and land use planning efforts for the species involves the continued monitoring and modeling of habitat requirements and suitability across its range. To inform management actions, we investigated habitat responses of sage-grouse in California and Nevada, USA, across six distinct annual life stages and seasons using >1 decade of location data from marked sage-grouse and incorporating information on survival during reproductive life stages using known fate datasets. This comprehensive approach allowed us to identify habitat features that were consistently important across their annual life cycle while also delineating areas where selection and survival responses differed, suggesting potential maladaptive selection. Importantly, by evaluating both selection and demographic performance across multiple life stages, we highlighted important source habitats that support both high selection and high survival and sink habitats that support high selection but low survival. Source habitats have critical value for long-term conservation, while sink habitats may represent key areas to target for restoration. In addition, we incorporated corridors connecting key nesting and brood-rearing habitats, and we also corrected for pre-fire habitat conditions. Overall, by combining predictive habitat map surfaces for each life stage and season with updated information on current occupancy patterns and connectivity, we delineated specific example habitat management categories that can be used by land managers to guide conservation and management decision-making.

GREATER SAGE-GROUSE (*CENTROCERCUS UROPHASIANUS*) POPULATION RESPONSES TO WILD HORSES AND LIVESTOCK ACROSS THE SAGEBRUSH BIOME

ADRIAN P. MONROE, U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO 80526, USA; amonroe@usgs.gov
SHAWN T. O'NEIL, U.S. Geological Survey, Western Ecological Research Center, Dixon, CA 95620, USA
CALI L. WEISE, U.S. Geological Survey, Western Ecological Research Center, Dixon, CA 95620, USA
NICHOLAS J. VAN LANEN, U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO 80526, USA
AUSTIN L. NASH, U.S. Geological Survey, Western Ecological Research Center, Dixon, CA 95620, USA
DEREK A. FRIEND, U.S. Geological Survey, Western Ecological Research Center, Dixon, CA 95620, USA
KATHRYN A. SCHOENECKER, U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO 80526, USA
PETER S. COATES, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA
CAMERON L. ALDRIDGE, U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO 80526, USA

Livestock grazing is a widespread land use across the western United States, overlapping much of the Greater sage-grouse (hereafter, sage-grouse; *Centrocercus urophasianus*) range. During recent decades, populations of wild free-roaming horses (*Equus caballus*) increased substantially on land managed by the Bureau of Land Management (BLM) within horse Herd Management Areas; these areas are also typically grazed by livestock. A recent study indicated sage-grouse populations often declined when horse populations exceeded BLM-established appropriate management levels in the Great Basin. Further, sage-grouse population trends were associated with the timing and level of livestock grazing based on allotment records across Wyoming, depending on local vegetation productivity. However, a comprehensive study of both horses and livestock effects on sage-grouse populations has yet to be conducted across the sagebrush biome. To address this information gap, we are studying whether population trends of sage-grouse are associated with horse population size (relative to BLM appropriate management levels) and livestock grazing indices across gradients of vegetation productivity within the sagebrush biome. This study will provide broad-scale ecological information for decision-makers to balance multiple land uses in this complex system.

VARIATION IN SPATIAL SCALES OF EFFECT AND EFFECT OF SAGEBRUSH COVER ACROSS THE SAGE-GROUSE RANGE: IMPLICATIONS FOR MANAGEMENT

ADRIAN P. MONROE, U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO 80526, USA; amonroe@usgs.gov
MICHAEL S. O'DONNELL, U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO 80526, USA
JULIE A. HEINRICHS, Colorado State University, Natural Resource Ecology Laboratory, Fort Collins, CO 80526, USA
MATTHEW B. RIGGE, U.S. Geological Survey, Earth Resources, Observation, and Science (EROS) Center, Sioux Falls, SD 57198, USA
ERIN K. BUCHHOLTZ, U.S. Geological Survey, South Carolina Cooperative Fish and Wildlife Research Unit, Clemson, SC 29634, USA
ASHLEY L. WHIPPLE, U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO 80526, USA
BENJAMIN C. AUGUSTINE, U.S. Geological Survey, Northern Rocky Mountain Science Center, Bozeman, MT 59715, USA
BRIAN G. PROCHAZKA, U.S. Geological Survey, Western Ecological Research Center, Dixon, CA 95620, USA
PETER S. COATES, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA
CAMERON L. ALDRIDGE, U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO 80526, USA

Greater sage-grouse (hereafter, sage-grouse; *Centrocercus urophasianus*) respond to components of their landscapes at different spatial scales, and identifying relevant scales of effect is needed to plan for multiple land uses and mitigate or avoid scale-dependent population effects. However, scales of effect may vary with study location, response type, and environmental variable, and therefore generalizing from previous, localized studies to other locations is uncertain. Previously, we applied a scale selection approach to estimate relevant spatial scales of effect for sagebrush cover (Artemisia spp.) around leks in southwestern Wyoming. We extended this approach across the sage-grouse range using a standardized database of lek counts, testing whether the spatial scale of effect for sagebrush varied with topography, edge density, and sagebrush connectivity. We then summarized scales of effect within spatial units (clusters) defined across the sage-grouse range and relevant to management. We also evaluated whether the relationship between sage-grouse population trends and sagebrush cover was context-specific, differing among population clusters. These analyses will allow managers to anticipate how spatial scales of effect may vary across these vast landscapes, mitigate or avoid scale-dependent population effects, and inform multiple land-use plans, particularly as they relate to changes in sagebrush cover.

INVESTIGATING RELATIONSHIPS BETWEEN LIVESTOCK GRAZING, HORSE ABUNDANCE, AND HABITAT OF GREATER SAGE-GROUSE WITHIN THE SAGEBRUSH BIOME

AUSTIN L. NASH, U.S. Geological Survey, Western Ecological Research Center, Reno, NV 95620, USA; anash@usgs.gov
SHAWN T. O'NEIL, U.S. Geological Survey, Western Ecological Research Center, Dixon, CA 95620, USA
ADRIAN P. MONROE, U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO 80526, USA
NICHOLAS J. VAN LANEN, U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO 80526, USA
CALI L. WEISE, U.S. Geological Survey, Western Ecological Research Center, Dixon, CA 95620, USA
DEREK A. FRIEND, U.S. Geological Survey, Western Ecological Research Center, Dixon, CA 95620, USA
LEA A. CONDON, U.S. Geological Survey, Western Ecological Research Center, Reno, NV 89502, USA
KATHRYN A. SCHOENECKER, U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO 80526, USA
PETER S. COATES, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA
CAMERON L. ALDRIDGE, U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO 80526, USA

Non-native ungulate grazing can influence both the structure and function of vegetation communities in the sagebrush steppe, thereby shaping habitat composition for sagebrush-obligate wildlife. Greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse) populations have tracked a long-term pattern of ecosystem decline in the American west. Recent research suggested sage-grouse population growth was negatively associated with free-roaming horse (*Equus caballus*) populations exceeding appropriate management levels in Nevada and livestock grazing intensity prior to peak vegetation productivity in Wyoming. Alterations in vegetation structure from herbivory are the most likely mechanisms for these associations, but relationships between livestock grazing, free-roaming horses, and vegetation structure have not been evaluated across the sagebrush ecosystem. To address this research gap, we collected grazing records from the Bureau of Land Management's (BLM) rangeland administration system, horse population records from BLM Herd Management Areas, remotely sensed vegetation measures (RAP and RCMAP), and vegetation characteristics from BLM's Assessment, Inventory, and Monitoring (AIM) program. We investigated sage-grouse habitat responses to livestock grazing and feral horse populations across the sagebrush biome using two approaches; 1) Bayesian hierarchical models to examine AIM data in a space-for-time substitution framework, and 2) a time series analysis of remotely sensed vegetation dynamics. These analyses will describe potential mechanisms to inform concurrent research estimating associations between sage-grouse population performance and records of livestock grazing and free-roaming horse abundance across the sage-grouse range. This information is preliminary and is subject to revision. It is being provided to meet the need for timely best science.

EFFECTS OF MANIPULATING COMMON RAVEN (*CORVUS CORAX*) BREEDING SUCCESS ON RAVEN AND GREATER SAGE-GROUSE (*CENTROCERCUS UROPHASIANUS*) POPULATIONS IN NEVADA AND CALIFORNIA, USA.

AUSTIN L. NASH, U.S. Geological Survey, Western Ecological Research Center, 800 Business Park Drive, Suite D, Dixon, CA 95620 USA; anash@usgs.gov
STEVEN R. MATHEWS, U.S. Geological Survey, Western Ecological Research Center, 800 Business Park Drive, Suite D, Dixon, CA 95620 USA
CORINA A. SANCHEZ, U.S. Geological Survey, Western Ecological Research Center, 800 Business Park Drive, Suite D, Dixon, CA 95620 USA; Idaho State University, 921 S. 8th Ave, Pocatello, ID 82309 USA; University of Nevada Reno, 1664 North Virginia Street, Reno, NV 89557 USA
SHAWN T. O'NEIL, U.S. Geological Survey, Western Ecological Research Center, 800 Business Park Drive, Suite D, Dixon, CA 95620 USA
DAVID J. DELEHANTY, Idaho State University, 921 S. 8th Ave, Pocatello, ID 82309 USA
PETER S. COATES, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA

Common ravens (*Corvus corax*; raven) are generalist predators whose behavioral flexibility in foraging and reproductive decisions have allowed for concomitant increases in populations with anthropogenic development across North America, resulting in increased raven predation on sensitive prey species. Greater sage-grouse (*Centrocercus urophasianus*; sage-grouse) are behaviorally inflexible and are experiencing elevated predation from ravens and loss of habitat from anthropogenic disturbances across much of their range. Previous research indicates that manipulating raven breeding success by oiling raven eggs results in increased sage-grouse nest survival probabilities, but it is unclear if egg-oiling of raven eggs has meaningful impacts on population growth rates of sage-grouse. In this study, we answered four questions regarding oiling of raven eggs and the effect of egg-oiling on overlapping sage-grouse populations. First, we experimentally showed that it was oil applied to eggs that caused embryonic failure of raven eggs, a previously assumed relationship. Second, we found that causing raven nests to fail by oiling eggs resulted in an immediate decline of raven densities at treatment sites compared with

control sites. Third, we confirmed previous findings that oiling eggs resulted in a large increase in sage-grouse nest survival probabilities by adding one year of novel data to previous analyses. Finally, we determined that overlapping sage-grouse populations at sites where egg-oiling was applied displayed population growth rates that exceeded population growth rates of sage-grouse populations at nearby control sites, as quantified in a Before-After-Control-Impact study design. This information is preliminary, subject to change, and provided for best timely science.

EVALUATION OF SEX AND AGE IDENTIFICATION CHARACTERISTICS IN SHARP-TAILED GROUSE

MIKEL NEWBERG, Montana Fish Wildlife and Parks. 490 North Meridian Rd, Kalispell, MT 59901; Mikel.Newberg@mt.gov
KRISTINA HARKINS, Montana Fish Wildlife and Parks. 490 North Meridian Rd, Kalispell, MT 59901
TY SMUCKER, Montana Fish Wildlife and Parks. 490 North Meridian Rd, Kalispell, MT 59901

Sharp-tailed grouse (*Tympanuchus phasianellus*) are a popular upland game bird for sportsman and a species with a long history of population reintroductions and augmentations. Center rectrices have been used as a dominant sex identifier for sharp-tailed grouse with an accuracy rate of 85% to 93%. When managing small populations or reintroduction efforts for a species, error rates as small as 7% could still have significant consequences when calculating population parameters. Often sex and age characteristics are reevaluated for a species, or experts are tested on this knowledge for accuracy. Our objectives are (1) to evaluate the specific measurements or characteristics present to determine sex and age in sharp-tailed grouse and (2) to develop a more detailed key to aid in effective management and monitoring of sharp-tailed grouse populations. To evaluate these characteristics, we will test wildlife professionals at the 34th Biennial Sage and Columbian sharp-tailed grouse Workshop on sex and age of sharp-tailed grouse using harvested feathers and wings. Identification data from professionals will be compared against genetic results of the grouse samples. Following the comparative analysis, feather characteristics will be evaluated and an identification key will be developed and tested on a group of non-experts. Creating thorough tools towards proper sex criteria will strength adaptive management for sharp-tailed grouse in the future.

CHARACTERIZING GENETIC DIVERSITY AND CONNECTIVITY IN GENETICALLY DISTINCT BI-STATE GREATER SAGE-GROUSE (*CENTROCERCUS UROPHASIANUS*)

CAMMI A. NORVILLE (Student), Boise State University, Boise, ID 83725, and U.S. Geological Survey, Western Ecological Research Center, US Geological Survey, Dixon, CA 95620; cnorville@usgs.gov
PETER S. COATES, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA
SARA J. OYLER-MCCANCE, U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO, 80526
STEPHANIE J. GALLA, Conservation Genetics Lab, Boise State University, Boise, ID 83725, USA

Greater sage-grouse (*Centrocercus urophasianus*) within the Bi-State Distinct Population Segment (DPS) are genetically distinct and listed with a proposed “threatened status” under the ESA. Parker Meadows (hereafter PM), a Bi-State DPS subpopulation, has experienced drastic declines, a suspected genetic bottleneck, and subsequent population collapse. Translocation efforts were carried out and ongoing studies indicate that these translocations were successful at increasing the PM subpopulation size. However, it is unclear if the increased subpopulation is likely to sustain itself due to higher genetic variation, or if more translocations will be needed in the future. Further, conservation researchers and practitioners are interested in understanding diversity and barriers to connectivity across the Bi-State DPS over space and time. Here, we propose a study to address both knowledge gaps regarding genetic variation and connectivity using feather samples and a genetic-based approach. We will amplify 15 microsatellite markers and characterize genetic variation across seven Bi-State DPS populations, including pre- and post-translocations for PM. We will use diversity metrics—including observed (HO) and expected heterozygosity (HE)—to characterize changes in genetic diversity over space and time. We will also use STRUCTURE analyses to characterize isolation between subpopulations. This work will add to the understanding of the long-term genetic effects of translocations and will alert researchers and practitioners of other at-risk sub-populations within the Bi-State DPS. We anticipate this work will have applications to diverse avian species that undergo conservation translocations worldwide. These findings are preliminary, subject to change, and provided for best timely science.

EXTENSIVE USE OF AGRICULTURAL AND RESTORATION FIELDS BY GREATER SAGE-GROUSE IN WASHINGTON

PETER OLSOY, USDA Agricultural Research Service, 67826A OR-205, Burns, OR 97720; peter.olsoy@usda.gov
DANIEL THORNTON, Washington State University, School of the Environment, PO Box 642812, Pullman WA 99164
MICHAEL A. SCHROEDER, Washington Department of Fish and Wildlife, P.O. Box 1077, Bridgeport, WA 98813
MICHAEL T. ATAMIAN, Washington Department of Fish and Wildlife, 2315 North Discovery Place, Spokane Valley, WA 99216

Sage grouse (*Centrocercus urophasianus*) have seen large declines across much of their range, including extirpation of many populations at the range edge. In Washington, the existing populations are isolated from the core species range, and sagebrush habitat is heavily fragmented within a matrix of agricultural fields. Recently, one of the Washington populations has been extirpated and the other three have seen sharp declines, therefore, it is vital to understand how resident populations have adapted to a fragmented agriculture-dominated landscape and use that information to better equip land managers and wildlife agencies managing sage grouse populations in a rapidly changing environment. In this study, we analyzed GPS collar data from 24 male sage grouse to assess habitat selection. We found that sage grouse utilized both agricultural and restoration (i.e., CRP and SAFE) fields more than they were available across the landscape, but that use varied seasonally. Additionally, we have observed anecdotal evidence of sage grouse in Washington eating wheat and selecting for fallow wheat fields in the winter. These results highlight the need for nuanced land management for sage-grouse in Washington. More research is needed to determine what stage(s) of crops are utilized by sage-grouse. Importantly, this confirms the need to maintain CRP and SAFE fields in Washington to slow population declines.

LANDSCAPE CONFIGURATION IMPACTS SPRING SPACE USE AND SURVIVAL OF FEMALE SAGE-GROUSE

TERRAH M. OWENS, Idaho National Laboratory, 1955 N Fremont Ave, Idaho Falls, ID 83401, USA; terrah.owens@inl.gov
CALLA R. HAGLE, Bureau of Land Management, 28910 US-20, Hines, OR 97738, USA
JONATHAN B. DINKINS, Department of Animal and Rangeland Sciences, Oregon State University, 1500 SW Jefferson Way, Corvallis, OR 97331, USA

Landscape composition and configuration are essential factors for species distribution and persistence. Disturbance changes landscapes and can impact individuals' movement and space use based on mobility with tradeoffs between resource acquisition and survival. Our study evaluates how landscape composition and configuration of habitat and disturbance classes affect the area of spring space use and survival of female greater sage-grouse (*Centrocercus urophasianus*; hereafter, sage-grouse). We created annual spring neighborhoods for individual female sage-grouse using location data from GPS-marked birds. We calculated the proportion, clumpiness index, and interspersion and juxtaposition index (IJI) for each cover class within each neighborhood. We used linear mixed and Cox proportional hazards models to examine the interactive effects of composition and configuration on the area of space-use and survival. Spring neighborhood size decreased when the proportion and interspersion of non-sagebrush and sagebrush cover was high but increased when interspersion was low. Neighborhood size decreased when interspersion and proportion of anthropogenic footprint was high but increased when proportion was low. Sage-grouse survival decreased as the proportion of anthropogenic footprint increased, regardless of configuration. Survival decreased when the proportion of juniper cover was high, and interspersion was moderate. Our results indicate that heterogeneity of habitat and disturbance reduces spring neighborhood size in human-altered landscapes and decreases survival of female sage-grouse. These results suggest that management actions should focus on reducing or removing pinyon-juniper where interspersion is high and reducing or removing anthropogenic disturbance near sage-grouse breeding areas.

SYNTHESIZING SAGE-GROUSE GENETIC INFORMATION TO SUPPORT CONSERVATION AND MANAGEMENT ACTIONS

SARA J. OYLER-MCCANCE, U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO 80526; soyler@usgs.gov
TAIT K. RUTHERFORD, U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO 80526
PATRICIA A. DEIBERT, Bureau of Land Management, Headquarters Office, Cheyenne, WY 82009
DAWN M. DAVIS, U.S. Fish and Wildlife Service, Ecological Services, Cheyenne, WY 82007
LIEF WIECHMAN, U.S. Geological Survey, Land Management Research Program, Fort Collins, CO 80526
SARAH CARTER, U.S. Geological Survey, Fort Collins Science Center, Fort Collins, C0 80526

For over two decades, genetic studies have been used to assist in the conservation and adaptive management of both Greater (*Centrocercus urophasianus*) and Gunnison sage-grouse (*C. minimus*), addressing a wide variety of topics including taxonomy, parentage, population connectivity, and demography. Such genetic information can help inform priorities for habitat protection and restoration as well as strategies for translocations. The U.S. Geological Survey is working with the Bureau of Land Management and the U.S. Fish and Wildlife Service to synthesize available published science related to sage-grouse genetics for both species to help inform future conservation, restoration, and management actions on public and private lands within the extent of their ranges. We are using a newly developed synthesis format – structured science syntheses – that centers management decisions, and the processes that agencies use to make those decisions, to help facilitate use of the synthesized information to benefit sage-grouse populations. Structured science syntheses bring together science and data relevant to priority management issues and are coproduced with resource managers. Our synthesis is explicitly structured to facilitate the use of science and data about sage-grouse genetics in land use planning, project-level decisions, and monitoring

and adaptive management on and around public lands, helping agencies to better understand potential effects of proposed actions and meet their conservation and resource management goals.

FROM PELLETS TO PREY: DIETARY ANALYSIS OF BREEDING RAVENS VIA DNA METABARCODING OF REGURGITATED PELLETS.

LINDSEY R. PERRY, Oregon State University, 1500 SW Jefferson Way, Corvallis, OR 97331, USA; lindsey.perry@oregonstate.edu
SHAWN B. SZABO, Oregon State University, 1500 SW Jefferson Way, Corvallis, OR 97331, USA
JACQUELINE B. CUPPLES, U.S. Fish and Wildlife Service, LaGrande, OR, 97850, USA
PAT J. JACKSON, Predator Management Staff Specialist, Nevada Department of Wildlife, 6980 Sierra Center Parkway, Suite 120, Reno, NV 89511, USA
JULIE C. BROCKMAN, University of Nevada, Reno, NV, 89557, USA
PETER S. COATES, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA
SHAWN T. O'NEIL, U.S. Geological Survey, Western Ecological Research Center, Dixon, CA 95620, USA
SARAH C. WEBSTER, U.S. Geological Survey, Reno, NV 89502, USA
JONATHAN B. DINKINS, Department of Animal and Rangeland Sciences, Oregon State University, 1500 SW Jefferson Way, Corvallis, OR 97331, USA
JENNIFER M. ALLEN, Oregon State University, 1500 SW Jefferson Way, Corvallis, OR 97331, USA
TAAL LEVI, Oregon State University, 1500 SW Jefferson Way, Corvallis, OR 97331, USA

Common raven (*Corvus corax*) populations are increasing throughout western North America, where they commonly exploit anthropogenic subsidies. As opportunistic omnivores and efficient nest predators, ravens pose significant management challenges due to their impacts on sensitive species such as greater sage-grouse (*Centrocercus urophasianus*). Breeding ravens intensify foraging activities in a constrained foraging area while nesting. This behavior offers a unique opportunity for spatially explicit dietary analysis through DNA metabarcoding of regurgitated pellets collected at nests. Using this novel technique on raven pellets provides quantitative insights into the diet of breeding ravens. We present initial results from three studies currently processing raven diet data collected within sage-grouse habitat. We analyzed 718 samples collected from 19 nests in eastern Oregon (2018–2022) to demonstrate the method's ability to detect avian nest depredation from samples collected where evidence of nest depredation was observed. We analyzed 2,114 samples collected from 52 nests across 8 western states (2021–2023) and evaluated dietary variations and influence of anthropogenic nesting subsidies on raven diet. Lastly, we analyzed 215 samples collected from 2 nests in northern Nevada (2018), which suggested prey-switching behavior by ravens throughout the breeding season. These ongoing studies vary in temporal resolution and spatial extent and described a diverse diet that varied by location and included human-related food items, sage-grouse, and other species of conservation concern. Dietary analyses will inform subsidy management and siting guidelines, directing the timing and location of efforts to manage growing populations of this subsidized predator and mitigate effects on sensitive species.

RAVEN NEST-SITE SELECTION IN SAGE-GROUSE HABITAT IN OREGON

LINDSEY R. PERRY, Oregon State University, 1500 SW Jefferson Way, Corvallis, OR 97331, USA; lindsey.perry@oregonstate.edu
TERRAH M. OWENS, Idaho National Laboratory, Idaho Falls, ID 83415, USA
SKYLER T. VOLD, Oregon Department of Fish and Wildlife, Hines, OR 97738, USA
BRIAN S. RATLIFF, Oregon Department of Fish and Wildlife, Baker City, OR 97814, USA
LEE J. FOSTER, Oregon Department of Fish and Wildlife, Hines, OR 97738, USA
JACQUELINE B. CUPPLES, U.S. Fish and Wildlife Service, LaGrande, OR 97850, USA
JIMMY D. TAYLOR, U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services, National Wildlife Research Center, Fort Collins, CO 80521, USA
JONATHAN B. DINKINS, Department of Animal and Rangeland Sciences, Oregon State University, 1500 SW Jefferson Way, Corvallis, OR 97331, USA

Common ravens (*Corvus corax*) utilize anthropogenic subsidies, allowing more breeding ravens to thrive in ecosystems relatively devoid of natural nesting substrates or food resources, such as the sagebrush (*Artemesia* spp.) ecosystem. Constricted home ranges of nesting ravens concentrate their foraging and potentially elevate predation pressure on nearby sensitive prey species, including greater sage-grouse (*Centrocercus urophasianus*). Precipitous declines in sage-grouse numbers and anecdotally high raven abundance in parts of Oregon prompted the evaluation of raven nesting relative to sage-grouse habitat. During 2017–2022, we monitored 289 raven nests at 154 unique locations in eastern Oregon and used resource selection functions to evaluate the influence of anthropogenic and natural resources on nest-site selection. In addition, we tested two post hoc hypotheses that ravens would select nest sites in areas with 1) low raven density and

occupancy and 2) high sage-grouse nesting probability. Our results indicated negative relationships between raven nest-site selection and tree cover, burn proportion, proportion of riparian area, distance from roads, and distance from overpasses or bridges; and positive relationships between raven nest-site selection and sagebrush cover, topographic position index, and distance from primary roads and transmission lines as a 0.5-km distance decay function. Additionally, there were positive relationships between raven nest-site selection and average raven density and relative probability of grouse nesting. Linear anthropogenic features, such as roads, provided nest structures and reliable food resources and strongly influenced raven nest-site selection in our study area. These findings suggest a possible focus for implementing raven deterrents and resource removal.

COMPARING THE EFFECTS OF LETHAL AND NON-LETHAL RAVEN MANAGEMENT ON SAGE-GROUSE REPRODUCTIVE SUCCESS IN EASTERN OREGON

RICHARD RICH (Student), Oregon State University, 1500 SW Jefferson Way, Corvallis, OR 97331, USA; richard.rich@oregonstate.edu
LINDSEY PERRY, Oregon State University, 1500 SW Jefferson Way, Corvallis, OR 97331, USA
TERRAH OWENS, Oregon State University, 1500 SW Jefferson Way, Corvallis, OR 97331, USA
STEPHANIE LEQUIER, Oregon State University, 1500 SW Jefferson Way, Corvallis, OR 97331, USA
SKYLER VOLD, Oregon Department of Fish and Wildlife, Burns, OR 97720, USA
JACQUELINE CUPPLES, U.S. Fish and Wildlife Service, LaGrande, OR 97850, USA
BRAIN RATLIFF, Oregon Department of Fish and Wildlife, Baker City, OR 97814, USA
JIMMY D. TAYLOR, USDA, APHIS, Fort Collins, CO 80521, USA
JONATHAN B. DINKINS, Department of Animal and Rangeland Sciences, Oregon State University, 1500 SW Jefferson Way, Corvallis, OR 97331, USA

Common raven (*Corvus corax*) populations have been increasing throughout much of western North America thanks largely to increasing anthropogenic activity which subsidizes raven populations by increasing the amount of food sources available like roadkill and landfills or by increasing the amount of nesting substrate on the landscape like transmission lines, towers, and other structures. Ravens prey on sensitive species including the greater sage-grouse (*Centrocercus urophasianus*) and recent studies indicate sage-grouse nest success is negatively impacted by high raven densities within sage-grouse breeding habitat. Raven reduction by lethal means has been determined to be a viable strategy to alleviate potential negative pressures on sage-grouse populations and increase sage-grouse nest success. However, the efficacy of removing subsidies used by ravens as a form of non-lethal management has not been researched. Thus, non-lethal management of ravens as a potential alternative to lethal control has yet to be tested or quantified. We aim to evaluate raven and sage-grouse population responses to lethal and non-lethal raven management actions meant to reduce predation and pressure on sage-grouse by comparing pre- and post-manipulation raven density and sage-grouse nest success across five study sites in eastern Oregon, including a lethal management site, a non-lethal management site, and two reference sites. I will present nest success data from 2017–2023, including four pre-treatment and three post-treatment years. These preliminary analyses will compare the efficacy of varying raven management methods and their impacts on sage-grouse populations and can help inform management agencies about sage-grouse conservation and raven management.

ASSESSING INFLUENCES OF LIVESTOCK AND ANTHROPOGENIC FEATURES ON SEASONAL HABITAT USE OF SAGE-GROUSE IN THE BIGHORN BASIN, WYOMING

KAYLA A. RUTH (Student), Department of Animal and Rangeland Sciences, Oregon State University, Corvallis, OR 97331, USA; kayla.ruth@oregonstate.edu
JIMMY D. TAYLOR, USDA Wildlife Services, National Wildlife Research Center, Fort Collins, CO 80521, USA
JONATHAN B. DINKINS, Department of Animal and Rangeland Sciences, Oregon State University, 1500 SW Jefferson Way, Corvallis, OR 97331, USA

Greater sage-grouse (*Centrocercus urophasianus*; hereafter "sage-grouse") are a species of great conservation concern in the western US. Like all wildlife species, successful management requires a strong understanding of how individuals select and use their habitat throughout different seasons and life stages. Sage-grouse populations are known to be negatively affected by reductions in habitat quality during three crucial life stages; nesting, brood-rearing, and wintering. Many past studies and management decisions have focused on essential breeding habitat. However, there has been less focus on habitat resources during the winter. Using GPS hen location data from 316 hens during 2011–2014 and 2019–2022 in the Bighorn Basin of Wyoming, we tested the hypotheses that hens will select habitat farther from anthropogenic disturbance and seasonal cattle grazing. We also predicted habitat quality and selection would differ across seasons because most management and policy actions have focused primarily on breeding habitat. Using resource selection functions (RSFs), we estimated seasonal habitat

use including nesting, brood-rearing, and overwinter periods and present our results on how these different anthropogenic impacts influence habitat selection across seasons. Our findings provide important seasonal habitat use information to guide future management and policy decisions. Additionally, our work highlights potential effects of anthropogenic features and livestock operations in Wyoming rangelands.

ADDRESSING UNCERTAINTY IN GREATER SAGE-GROUSE DAILY LEK ATTENDANCE AND INTER-LEK MOVEMENT

REBEKAH E. RUZICKA, Colorado Cooperative Fish and Wildlife Research Unit, Colorado state University, 1484 Campus Delivery, Fort Collins, CO 80523, USA; becky.ruzicka@colostate.edu

BRETT L. WALKER, Colorado Parks and Wildlife, 711 Independent Ave., Grand Junction, CO 81505, United States

WILLIAM L. KENDALL, U.S. Geological Survey, Colorado Cooperative Fish and Wildlife Research Unit, Colorado State University, 1484 Campus Delivery, Fort Collins, CO 80523, USA

Lek counts of Greater Sage-Grouse (*Centrocercus urophasianus*) males are universally used as an index of abundance by state and federal wildlife management agencies. The number of males available to be counted (i.e., the number of males on leks during morning counts) is a function of population size at the beginning of lekking season, survival, lek attendance, and inter-lek movement. Because indices of abundance are assumed to reflect changes in populations year-to-year, obtaining unbiased estimates of other parameters impacting lek counts is critical. However, morning movements of males during lekking season are common and cause uncertainty in the number of males available to be counted when monitoring data are imperfect. Ignoring uncertainty surrounding the classification of whether a grouse is on or off lek may result in biased parameter estimates. Our objective is to compare daily probabilities of lek attendance and inter-lek movements conditional on survival for GPS-marked male sage-grouse between traditional multistate mark-recapture (MSMR) models and MSMR models that account for uncertainty to determine if modeling uncertainty reduces bias in lek attendance and inter-lek movements. We will model survival, lek attendance, and inter-lek movement as a function of individual and environmental covariates for both model types. We expect our results will demonstrate a framework for future researchers to reduce bias in estimates of lek attendance and inter-lek movements. Additionally, we expect our results will provide unbiased estimates of lek attendance, inter-lek movement, survival, and the factors influencing these parameters for managers seeking to better understand how population indices may be impacted.

TESTING OF GREATER SAGE-GROUSE AND SHARP-TAILED GROUSE FOR PATHOGENS OF CONCERN

MICHAEL A. SCHROEDER, Washington Department of Fish and Wildlife, P.O. Box 1077, Bridgeport, WA 98813, USA; michael.schroeder@dfw.wa.gov

MICHAEL T. ATAMIAN, Washington Department of Fish and Wildlife, 2315 North Discovery Place, Spokane Valley, WA 99216, USA

KATHERINE H. HAMAN, Washington Department of Fish and Wildlife, 1111 Washington Street SE, Olympia WA, 98501, USA

For at least 70 years, personnel with the Washington Department of Fish and Wildlife have been involved in translocating grouse. There have been multiple purposes of these translocations including reestablishment of extirpated populations, augmentation of declining, threatened, and/or endangered populations, and reinvigoration of the genetic heterogeneity of populations. One of the challenges associated with these translocations has been assurance that the birds are healthy and do not carry various pathogens. Sometimes this is a requirement of the agency providing the birds, but it almost always has been a requirement of the state of Washington and/or the U.S. government. As a result, we have tested 323 sharp-tailed grouse (*Tympanuchus phasianellus*, STGR) and 89 greater sage-grouse (*Centrocercus urophasianus*, GRSG) for various pathogens. The list includes salmonella bacteria (SB), *Mycoplasma* spp. (MSP), avian influenza virus (AIV), avian paramyxovirus-1 (AP1), *Escherichia coli*, *Streptococcus gallolyticus*, and West Nile Virus (WNV), though most birds were only tested for a portion of these pathogens. One GRSG was positive for AIV (prevalence of 1.7%), but none of 278 STGR was positive for AIV. There was no effort to determine if the positive AIV in GRSG was highly pathogenic avian influenza (AIV), though the outward good health of the bird indicated this was unlikely. Other common tests with a reasonable sample size included WNV (0 positives for 55 GRSG), SB (0 positives for 295 STGR and 27 GRSG), MSP (1 positive for 149 STGR and 0 positives for 17 GRSG), and AP1 (0 positives for 65 STGR). This baseline information will be very useful for future monitoring efforts. We also hope that the rarity of these pathogens in native populations will reduce some of the logistical challenges that disease testing has placed on translocation efforts.

USE OF WATER BIRCH BY WINTERING SHARP-TAILED GROUSE IN NORTH-CENTRAL WASHINGTON

MICHAEL A. SCHROEDER, Washington Department of Fish and Wildlife, P.O. Box 1077, Bridgeport, WA 98813, USA; michael.schroeder@dfw.wa.gov

SIDRA A. BLAKE, Washington Department of Fish and Wildlife, 54 Moe Road, Brewster, WA 98812, USA
AMY E. PAVELCHECK, Washington Department of Fish and Wildlife, 3860 Highway 97A, Wenatchee, WA 98801, USA
DANIEL J. PETERSON, Washington Department of Fish and Wildlife, 54 Moe Road, Brewster, WA 98812, USA

Sharp-tailed grouse (*Tympanuchus phasianellus*) in north-central Washington depend on shrubsteppe for year-round survival, and deciduous trees and shrubs during the snowiest times of the winter. In north-central Washington these habitats have been severely impacted by habitat conversion, degradation, and wildfire. Standardized lek counts have been used to monitor breeding populations, but observations of birds during winter have been opportunistic and anecdotal. For six straight winters (15 Dec-10 Mar), starting in 2017–2018, trail cameras were used to monitor areas of water birch, a tree species which appears to be critical for grouse in Washington. Cameras were placed for a total of about 11,500 daylight hours in 50 different locations within 23 water birch sites. Grouse were observed a combined total of 128 of those observation hours. Assessment of photos provided information on diurnal use (heaviest about 1 hour after sunrise), flock size (up to 25 birds), and distribution (observations of birds in areas with no known leks). These observations have subsequently aided our management efforts.

DATA-DRIVEN STATE-AND-TRANSITION MODELS TO INFORM SAGEBRUSH MANAGEMENT IN THE UPPER COLORADO RIVER BASIN

JOHN P. SEVERSON, U.S. Geological Survey, Southwest Biological Science Center, 2290 SW Resource Blvd., Moab, UT 84532, USA; jpseverson@usgs.gov
TARA B. B. BISHOP, Utah Valley University, Department of Earth Science, Orem, UT 84058, USA
ANNA C. KNIGHT, U.S. Geological Survey, Southwest Biological Science Center, 2290 SW Resource Blvd., Moab, UT 84532, USA
TRAVIS W. NAUMAN, Natural Resources Conservation Service, Soil Survey Division, Moab, UT 94532, USA
BRANDON E. MCNELLIS, U.S. Forest Service, Pacific Southwest Research Station, Hilo, HI 96721 USA
MIGUEL L. VILLARREAL, U.S. Geological Survey, Western Geographic Science Center, Moffett Field, CA 94035, USA
SASHA C. REED, U.S. Geological Survey, Southwest Biological Science Center, 2290 SW Resource Blvd., Moab, UT 84532, USA
KRISTINA E. YOUNG, Agricultural Research Service, USDA Jornada Experimental Range, Las Cruces, NM 88012, USA
MARK W. BRUNSON, Utah State University, Department of Environment and Society, Logan, UT 84322, USA
MICHAEL C. DUNIWAY, U.S. Geological Survey, Southwest Biological Science Center, 2290 SW Resource Blvd., Moab, UT 84532, USA

Understanding changing habitat conditions and their causes is crucial to wildlife habitat restoration and management. State-and-transition models (STMs) describe the plant communities (‘states’) possible given site-specific edaphic and climatic characteristics as well as the drivers that cause shifts between states (‘transitions’). Wildlife and natural resource professionals can use STMs to assess habitat quality and evaluate potential management actions that can transition habitat into more desirable states for a given objective. Until recently, STMs have been difficult to scale up to large areas due to limited time, data, and resources. Here, we leverage newly available Ecological Site Group (ESG) maps for the Upper Colorado River Basin along with large existing field-based vegetation and soil monitoring databases in a machine learning framework to produce yearly maps of vegetation states. We then used these maps to model state transition probabilities and their mechanistic drivers, such as fire, grazing, land treatments, and climate. Our focus ESGs include transitions among states including sagebrush, various conifer phases, and annual grass invasion. A critical component of this project was a collaborative framework using a cross-agency steering committee to ensure utility, robustness, and reproducibility of mapped products to end-users. This information provides regional-scale spatial decision support tools for management of sagebrush and associated wildlife of conservation concern, including sage-grouse (*Centrocercus* spp.), and will be beneficial for managing threats such as fire, invasive annuals, and conifer expansion. Our evolving, but reproducible, methodology will allow us to expand our scope to the entire sagebrush biome in the future.

CURRENT STATE OF THE COLUMBIAN SHARP-TAILED GROUSE POPULATION IN NEVADA’S BULL RUN BASIN

JUSTIN R. SMALL, Nevada Department of Wildlife, 1100 Valley Rd, Reno, NV 89512, USA; justin.small@ndow.org
MATT JEFFRESS, Nevada Department of Wildlife, Elko, NV 89801, USA
SHAWN ESPINOSA, Nevada Department of Wildlife, 1100 Valley Rd, Reno, NV 89512, USA
STEPHANIE J. GALLA, Conservation Genetics Lab, Boise State University, Boise, ID 83725, USA
STEVEN MATTHEWS, U.S. Geological Survey, Western Ecological Research Center, Reno, NV 89512, USA
PETER S. COATES, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA

Driven by climate variation, anthropogenic disturbances and habitat loss, some native galliform species have succumbed to range contraction, population reduction and local extirpation events. Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*; hereafter sharp-tailed grouse) were historically a prevalent prairie grouse species found across northern Nevada, however, by the 1980s, native sharp-tailed grouse populations were regionally extirpated. By the mid-2000s, through habitat restoration efforts, the Bull Run Basin of northern Nevada was identified as a suitable translocation site to reestablish sharp-tailed grouse back into their native range. In collaboration with Idaho Fish and Game (IDFG) and the U.S. Geological Survey, the Nevada Department of Wildlife (NDOW) from 2013 to 2017 translocated 215 sharp-tailed grouse from southeast Idaho to Nevada. Following translocation efforts, four resident leks have been established and the population has demonstrated resiliency. However, to prevent a demographic trap scenario or fitness mechanisms driving Allee effects (i.e., inverse density dependence) from occurring, NDOW has again partnered with IDFG to augment the Bull Run sharp-tailed grouse population with 20 females annually from spring 2024 to 2026. To quantify the change in heterozygosity and genetic stability through time, blood and fecal samples were taken from both Nevada resident and Idaho translocated populations. The end goal of this effort is to improve demographic fitness and increase genetic diversity to a level that would eliminate the need for future population augmentations and buffer against a local extirpation event.

AVIAN PREDATOR OCCUPANCY AT COMMUNICATION SITES IN SAGE-GROUSE HABITAT

SHAWN SZABO (Student), Oregon State University, Corvallis, OR 97331, USA; shawn.szabo@oregonstate.edu
TAAL LEVI, Oregon State University, Corvallis, OR 97331, USA
JACKIE CUPPLES, U.S. Fish and Wildlife Service, LaGrande, OR 97850, USA
STEVE ABELE, U.S. Fish and Wildlife Service, Reno, NV 89502, USA
PETER S. COATES, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA
SHAWN T. O'NEIL, U.S. Geological Survey, Dixon, CA 95620, USA
SARAH C. WEBSTER, U.S. Geological Survey, Reno, NV, 89502, USA
JENNY HILL, U.S. Fish and Wildlife Service, Cheyenne, WY, 82007, USA
JONATHAN B. DINKINS, Department of Animal and Rangeland Sciences, Oregon State University, 1500 SW Jefferson Way, Corvallis, OR 97331, USA

Habitat fragmentation resulting from anthropogenic features can pose threats to Greater Sage-Grouse (*Centrocercus urophasianus*; hereafter, Sage-Grouse). Studies have shown that Sage-Grouse avoid tall structures, and transmission lines and communication towers have been linked to Sage-Grouse nest failure, lek abandonment, and extirpation. These unnatural features provide nesting and perching substrates for ravens and other avian predators of Sage-Grouse and their nests. We designed a field study to assess how the design, arrangement, and location of communication towers influence nest site selection and diet of avian predators within Sage-Grouse habitat. We surveyed 1078 communication sites across California, Colorado, Idaho, Montana, Nevada, Oregon, Utah, and Wyoming during March-June nesting seasons in 2021–2023. Site visits involved point count surveys, measurements of available nesting substrates, inventory of avian predator nests, and collection of genetic materials for dietary analysis. Within communication sites, avian predators showed a stark preference for sections of communication towers with dense steel lattice and for large, wind-blocking antenna types without microwave emissions or with very unidirectional emissions. Among communication sites, occupancy was influenced by tower type as well as topographic, landcover, and land-use characteristics. Notably, occupancy decreased at communication sites when other anthropogenic substrates were available nearby. These results suggest that communication sites are possible but not preferred nesting substrate for avian predators and may not have additive impacts in developed landscapes. Ultimately, our goal is to provide information to guide new tower development and retrofits of existing towers in sagebrush ecosystems to mitigate impacts to Sage-Grouse.

SAGE-GROUSE HABITAT AND SCALE: SCALE

ERIC T. THACKER, Wildland Resources Department, Utah State University, Logan, UT 84333, USA; eric.thacker@usu.edu
DAVID K. DAHLGREN, Wildland Resources Department, Utah State University, Old Main Hill, Logan, UT 84322, USA

Concern over declining sage-grouse (*Centrocercus* spp.) populations has led to developing conservation plans to conserve sage-grouse populations. Loss of sage-grouse habitat is the leading cause for declining populations; therefore, conservation plans rely on habitat guidelines and objectives to conserve sage-grouse habitat and thus preserve sage-grouse populations. Decades of Sage-grouse research has described seasonal sage-grouse habitats (vegetation structure) at use sites (non-random). The resulting vegetation data was then averaged across the sage-grouse populations, states, and regions to develop sage-grouse habitat guidelines. Habitat guidelines have been subsequently adopted by land and wildlife management agencies to provide habitat management objectives for sage-grouse management. Most habitat objectives primarily focus on

the quality of seasonal habitat structure. Land management agencies have employed monitoring and assessment programs to ensure that sage-grouses have suitable habitats, which should result in persistent populations. These assessment and monitoring efforts describe the quality of seasonable sage-grouse habitat using random points across a landscape to assess the suitability for sage-grouse. Our presentation will provide insights into whether sage-grouse habitat guidelines provide appropriate habitat objectives for managing sage-grouse habitat at relevant scales. We will also discuss spatial inference of the current assessment and monitoring approaches and whether they meet the needs of sage-grouse populations and land management agencies.

PRAIRIE GROUSE RECOVERY WORK BY VOLUNTEERS IN WASHINGTON

KIM THORBURN, Spokane Audubon Society, Spokane, WA 99208, USA; kthorburn@msn.com
LINDELL HAGGIN, Spokane Audubon Society, Spokane, WA 99208, USA
JOSH NICHOLAS, Washington Department of Fish and Wildlife, Olympia, WA 98501, USA
MIKE ATAMIAN, Washington Department of Fish and Wildlife, Spokane Valley, WA 99216, USA
MIKE FINCH, Washington Department of Fish and Wildlife, Creston, WA 99117, USA
CARRIE LOWE, Washington Department of Fish and Wildlife, Spokane Valley, WA 99216, USA

Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*) and greater sage-grouse (*Centrocercus urophasianus*), Washington's two native prairie grouse species, are listed as endangered by the state. Recovery plans for both species call for population monitoring, habitat protection and improvement, translocations for population augmentation or reintroduction, and predator management. The statutory mandate of the Washington Department of Fish and Wildlife includes the clause, "Recognizing that the management of our state wildlife, food fish, game fish, and shellfish resources depends heavily on the assistance of volunteers, the department shall work cooperatively with volunteer groups and individuals to achieve the goals of this title to the greatest extent possible." The Spokane Audubon Society has coordinated a volunteer project, entitled "Lek Surveys and other Prairie Grouse Recovery Activities," to assist with all aspects of prairie grouse recovery since 2008. The project has been funded by the department's ALEA volunteer grant program since 2012 to support reimbursable volunteer expenses, acquire equipment, and enhance infrastructure needed for volunteer participation. The project has successfully achieved two objectives: 1) amplification of effort in essential and time-intensive recovery work and 2) hands-on engagement for stakeholders to participate in conservation and management. This presentation will demonstrate the implementation of an effective wildlife volunteer endeavor.

ASSESSING THE EFFECT OF HUNTER HARVEST ON GREATER SAGE-GROUSE SURVIVAL IN SOUTHEASTERN OREGON

KEIFER L. TITUS, Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries, Wildlife, and Conservation Science, Oregon State University, Corvallis, OR, 97333, USA; tituske@oregonstate.edu
KATIE M. DUGGER, U.S. Geological Survey, Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries, Wildlife, and Conservation Science, Oregon State University, Corvallis, OR, 97333, USA
CHRISTIAN A. HAGEN, Department of Fish, Wildlife, and Conservation Science, Bend, OR, 97702, USA

The sagebrush (*Artemisia* sp.) ecosystem is increasingly threatened by environmental change and anthropogenic disturbance. Consequently, many sagebrush obligate species like greater sage-grouse (*Centrocercus urophasianus*; hereafter, sage-grouse) have experienced population declines. While these threats are pervasive throughout the Great Basin, sage-grouse remains a popular game species and harvest is closely regulated. Our objective was to assess the effect of hunter harvest on sage-grouse survival between two distinct populations subject to different environmental, anthropogenic, and harvest pressures in the Trout Creek and Warner Mountains of southeastern Oregon. We analyzed data from 363 adult female sage-grouse fit with GPS transmitters to estimate monthly and annual survival from 2015–2022 under a known-fate framework. We had 4 years (2015–2018) of data from the Trout Creeks where harvest did not occur, compared to all years in the Warners, and Trout Creeks after harvest was reinstated (2019–2022). Preliminary results suggest that monthly survival varied within and between years and areas [Best Model: S(Area + Year + Month); AICc wt = 0.59], but the area affect was imprecise and survival was lower in the Warners in all years ($\hat{\beta}_{Warners}$ = -0.20; 95% CI: -0.46 to 0.06). In addition, no differences in monthly survival in September, the month in which harvest occurs, were observed before vs. after reinstating the hunting season. Additional investigations into the potential long-term effects of harvest on annual survival of sage-grouse in the Great Basin are ongoing, but our results suggest current harvest levels were not an additive source of mortality in the Trout Creek Mountains.

RANGE-WIDE PREDICTIVE SEASONAL HABITAT MAPPING FOR GREATER SAGE-GROUSE

GREGORY T. WANN, U.S. Geological Survey, Fort Collins Science Center, 2150 Centre Ave., Building C, Ft. Collins, CO 80526, USA
CAMERON L. ALDRIDGE, U.S. Geological Survey, Fort Collins Science Center, 2150 Centre Ave., Building C, Ft. Collins, CO 80526, USA; aldridgec@usgs.gov
MEGAN M. MCLACHLAN, Bureau of Land Management, Denver Federal Center, Building 50, 695 Kipling Street, Denver, CO 80225, USA
JEFFREY L. BECK, Department of Ecosystem Science and Management, University of Wyoming, Laramie, WY 82071, USA
TIMOTHY BOWDEN, Bureau of Land Management, Sierra Front Field Office, 5665 Morgan Mill Road, Carson City, NV 89701, USA
PETER S. COATES, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA
COURTNEY J. CONWAY, U.S. Geological Survey, Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, 875 Perimeter Drive MS 1141, Moscow, ID 83844, USA
DAVID K. DAHLGREN, Wildland Resources Department, Utah State University, Old Main Hill, Logan, UT 84322, USA
JONATHAN B. DINKINS, Department of Animal and Rangeland Sciences, Oregon State University, 1500 SW Jefferson Way, Corvallis, OR 97331, USA
AARON N. JOHNSTON, U.S. Geological Survey, Northern Rocky Mountain Science Center, 2327 University Way, Suite 2, Bozeman, MT 59715, USA
CHRISTIAN A. HAGEN, Department of Fisheries, Wildlife and Conservation Sciences, Oregon State University, Corvallis, OR 97331, USA
PAUL D. MAKELA, Bureau of Land Management, Idaho State Office, 1387 S. Vinnell Way, Boise, ID 83709, USA
DAVID E. NAUGLE, College of Forestry and Conservation, University of Montana, 32 Campus Drive, Missoula, MT 59812, USA
MICHAEL A. SCHROEDER, Washington Department of Fish and Wildlife, P.O. Box 1077, Bridgeport, WA 98813, USA
JAMES S. SEDINGER, Department of Natural Resources and Environmental Science, University of Nevada Reno, Reno, NV 89557, USA
LEAH WALDNER, Bureau of Land Management, Grand Junction Field Office, 2815 H Road, Grand Junction, CO 81506, USA
BRETT L. WALKER, Colorado Parks and Wildlife, 711 Independent Ave., Grand Junction, CO 81505, USA
PERRY J. WILLIAMS, Department of Natural Resources and Environmental Science, University of Nevada Reno, Reno, NV 89557, USA
ASHLEY L. WHIPPLE, U.S. Geological Survey, Fort Collins Science Center, 2150 Centre Ave., Building C, Ft. Collins, CO 80526, USA

Greater sage-grouse (*Centrocercus urophasianus*) demonstrate seasonal variation in habitat associations leading to seasonal changes in spatial-use patterns. For the Bureau of Land Management (BLM), a challenge has been identifying and evaluating seasonal habitats across the species' range, half of which is managed by BLM. Although many mapping products exist for sage-grouse at the level of study areas, regions, or states, differences in study design choices like scale, covariates, and habitat availability can prevent comparability among maps. Therefore, a consistent set of seasonal habitat maps can aid BLM in range-wide habitat evaluations. Our goals were to compile a range-wide telemetry dataset for habitat mapping and fit habitat selection models to used-available locations within discrete seasonal periods. We compiled telemetry data across the U.S. sage-grouse range from over 14,000 VHF and GPS marked individuals. We developed models for each season (spring, summer-fall, and winter) and periods targeting specific reproductive states (nesting and brood habitats). Models were validated regionally and temporally using data from withheld test sites and years in cross validation. All models demonstrated moderate to high predictive performance. However, across the range, spring, nest, and winter models had the highest predictive performance, and validation performance showed regional variation, with the southern range generally having higher predictive performance than parts of the northern range (i.e., Washington, Montana, and Dakotas). We present mapped predictions and habitat associations and discuss important considerations for using these maps for the purpose of habitat evaluations and land-use planning scenarios.

NOVEL ENVIRONMENTAL VARIABLES HELP EXPLAIN WINTER WEATHER EFFECTS ON ACTIVITY AND HABITAT SELECTION OF GREATER SAGE-GROUSE

CAITLYN P. WANNER, University of Wyoming, Laramie, WY, 82071, USA; current affiliation: Caribou-Targhee National Forest, Island Park, ID 83420, USA; cait92lyn@gmail.com
AARON C. PRATT, George Miksch Sutton Avian Research Center, Bartlesville, OK 74005, USA
ADELE K. REINKING, Colorado State University, Fort Collins, CO 80523, USA

GLEN E. LISTON, Colorado State University, Fort Collins, CO 80523, USA
JEFFREY L BECK, Department of Ecosystem Science and Management, University of Wyoming, Laramie, WY 82071, USA

High winter survival of greater sage-grouse (*Centrocercus urophasianus*, hereafter "sage-grouse") populations has been attributed to physical adaptations to winter conditions and availability of adequate winter habitat. However, the habitat characteristics that sage-grouse select during periods of severe winter weather is largely unknown. Our study demonstrates how modeled, biologically relevant snow and weather information can help identify important relationships between habitat selection and dynamic winter landscapes. We evaluated whether sage-grouse responded to weather conditions in two ways: through (1) positive selection for refugia habitat to minimize adverse weather exposure, or (2) lowered activity level to minimize thermoregulation and locomotion expense. Our results indicate that sage-grouse respond to winter weather conditions by seeking refugia rather than changing daily activity levels. During periods of lower wind chill temperatures and greater wind speeds, sage-grouse selected areas with sheltered aspects and greater sagebrush (*Artemisia* spp.) cover. Broadly, sage-grouse selected winter home ranges in sagebrush shrublands characterized by higher wind chill temperatures, greater wind speeds, and greater blizzarding conditions. However, within these home ranges, sage-grouse specifically selected habitats with greater above-snow sagebrush cover, lower wind speeds, and lower blizzarding conditions. Our study underscores the importance of examining habitat selection at narrower temporal scales than entire seasons and demonstrates the value of incorporating targeted weather variables that wholistically synthesize winter conditions. Habitat that provides refugia during periods of severe weather may sustain populations during winter disproportionate to the spatial extent; therefore, identification of refugia habitat may facilitate more targeted efforts towards sage-grouse winter range conservation.

SURFACE MINING IMPACTS TO SAGEBRUSH VEGETATION COMMUNITIES AND GREATER SAGE-GROUSE POPULATIONS

SARAH C. WEBSTER, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, California 95620 USA; swebster@usgs.gov
BRIAN G. PROCHAZKA, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, California 95620 USA
BRIANNE E. BRUSSEE, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, California 95620 USA
STEVE ABELE, U.S. Fish and Wildlife Service, Interior Region 10, 1340 Financial Blvd, Suite 234, Reno, NV 98502, USA
JUSTIN SMALL, Nevada Department of Wildlife, 1100 Valley Rd, Reno, NV 89512, USA
SHAWN ESPINOSA, Nevada Department of Wildlife, 1100 Valley Rd, Reno, NV 89512, USA
PETER S. COATES, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA

Surface mining activities can have cascading effects within sagebrush ecosystems, fundamentally altering multiple components such as soil composition and topography, which can impact vegetation communities and ultimately wildlife populations. Within sagebrush ecosystems, this disturbance and alteration of the soil and plant communities may leave mine sites susceptible to invasion by non-native annual grasses which can outcompete native sagebrush, ultimately leading to long-term changes in landcover at mining sites. These landcover changes could impact wildlife species, particularly sagebrush obligate species such as the greater sage-grouse (*Centrocercus urophasianus*). Despite the potential for significant disruption of ecosystem function and species composition, the impacts of surface mining within sagebrush ecosystems are relatively understudied. We assessed changes in vegetation community composition and sage-grouse populations at varying distances around mine sites within the state of Nevada both during active mining operations and post-mining operations. We found that vegetation communities were substantially altered at mining locations, with the presence of annual grasses increasing across multiple distance classes following mining operations. Further, we found that sage-grouse population annual rates of change (λ) declined near mining sites, with substantive declines in λ detected up to ~8 km from mining sites, even after active mining operations had ended. Ultimately, we demonstrate evidence that surface mining alters sagebrush vegetation communities and affects sage-grouse populations during and following active mining operations. Results can inform conservation efforts to mitigate impacts of future mining operations. Information is preliminary and provided for best timely science.

A DECISION SUPPORT TOOL FOR PLANNING AND ASSESSING THE IMPACT OF INFRASTRUCTURE DEVELOPMENT ON GREATER SAGE-GROUSE POPULATIONS

CALI L. WEISE, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, California 95620 USA; croth@usgs.gov

PETER S. COATES, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA
BRIAN G. PROCHAZKA, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, California 95620 USA
DEREK A. FRIEND, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, California 95620 USA
JUSTIN SMALL, Nevada Department of Wildlife, 1100 Valley Rd, Reno, NV 89512, USA
SHAWN ESPINOSA, Nevada Department of Wildlife, 1100 Valley Rd, Reno, NV 89512

Growing demand for renewable energy sources has resulted in expanded infrastructure development across sagebrush ecosystems of western North America. Conventional surface disturbance activities have well-documented impacts on local wildlife populations, and recent research has found similar effects from geothermal energy development on populations of greater sage-grouse (*Centrocercus urophasianus*), a species of high conservation concern. We developed an infrastructure impact tool that allows users to quantify the impact of proposed energy infrastructure development on sage-grouse population performance. Tool users can upload footprints for new or additions to existing infrastructure. The tool simulates changes to a topographic impedance surface (TIS) which is a proxy for sound and light dispersion emanating from infrastructure. The updated TIS is incorporated into a population matrix model to derive estimates of expected population growth rate. The tool generates these predictions 'before' and 'after' hypothetical infrastructure development to explore overall impact, as indicated by predicted change in population abundance. The tool incorporates information about sage-grouse relative abundance by multiplying the expected change in population abundance by a sage-grouse abundance and space use index surface (ASUI). The product of the change in abundance and ASUI surfaces represents the predicted relative impact of potential infrastructure on sage-grouse population performance. Multiple proposed infrastructure footprints can be ranked by the tool based on least impact on sage-grouse population performance. This decision support framework helps guide locations for future infrastructure development that balance the need for domestic energy production while minimizing adverse effects on wildlife populations. Information is preliminary and provided for best timely science.

GREATER SAGE-GROUSE AND FENCES – MONITORING FOR FENCE COLLISIONS IN WYOMING SUGGESTS CONTINUED CAUSE FOR CONCERN

DALE WOOLWINE, Bureau of Land Management, Pinedale Field Office, Pinedale, WY 82941, USA
PATRICIA DEIBERT, Bureau of Land Management, Headquarters, Cheyenne, WY 82009, USA; pdeibert@blm.gov
MATT HOLLORAN, Bureau of Land Management, Wyoming State Office, Cheyenne, WY 82009, USA

Fences are a known risk to greater sage-grouse (*Centrocercus urophasianus*), especially fences located near leks. Marking fences near leks to make them more visible has been shown to reduce, but not eliminate the risk of collision. Biologists in southwestern Wyoming have monitored fences in the region for wildlife collisions since 2003, with increased effort using standardized protocols since 2010. Over 1000 greater sage-grouse collisions have been recorded over that time-series, with approximately 50% of those collisions resulting in a "verified" or likely mortality. Of the data records that noted if a fence was marked or not, approximately 60% of the recorded collisions occurred on marked fences. Biologists have observed high numbers of collisions on fences near where greater sage-grouse congregate, regardless of the time of year. For example, substantial numbers of collisions have been consistently recorded near known geophagy (the intentional consumption of soil or soil-like substances) sites in the region during the winter. The BLM is working to analyze the long-term dataset from southwest Wyoming to further elucidate the conditions resulting in high-risk fences, assess the potential for a population-level impact of fence-collision mortality on greater sage-grouse, and to update fence-strike monitoring protocols to standardize data collection across the State so that impacts over broader spatial scales can be examined.

ADAPTIVE DIVERGENCE MAY INFLUENCE GREATER SAGE-GROUSE CONSERVATION TRANSLOCATIONS IN WASHINGTON

SHAWNA J. ZIMMERMAN, U.S. Geological Survey, Fort Collins Science Center, 2150 Centre Ave., Building C, Ft. Collins, CO 80526, USA; szimmerman@usgs.gov
CAMERON L. ALDRIDGE, U.S. Geological Survey, Fort Collins Science Center, 2150 Centre Ave., Building C, Ft. Collins, CO 80526, USA
MICHAEL A. SCHROEDER, Washington Department of Fish and Wildlife, P.O. Box 1077, Bridgeport, WA 98813, USA
JENNIFER A. FIKE, U.S. Geological Survey, Fort Collins Science Center, 2150 Centre Ave., Building C, Ft. Collins, CO 80526, USA
ROBERT SCOTT CORNMAN, U.S. Geological Survey, Fort Collins Science Center, 2150 Centre Ave., Building C, Ft. Collins, CO 80526, USA

SARA J. OYLER-MCCANCE, U.S. Geological Survey, Fort Collins Science Center, 2150 Centre Ave., Building C, Ft. Collins, CO 80526, USA

Conservation translocations are an important wildlife management tool commonly employed to augment declining or re-establish extirpated populations. One goal of augmentation is to increase genetic diversity and reduce the risk of inbreeding depression (i.e., genetic rescue). However, introducing individuals from significantly diverged populations risks disrupting co-adapted traits and reducing local fitness (i.e., outbreeding depression). Genetic data is increasingly more accessible for wildlife species and can provide unique insight regarding the presence and retention of introduced genetic variation from augmentation as an indicator of effectiveness and adaptive similarity as an indicator of source and recipient population suitability. Here we used two genetic datasets to evaluate augmentation of greater sage-grouse (*Centrocercus urophasianus*) in Washington and to retrospectively evaluate adaptive divergence among source and recipient populations. We first developed and implemented two models using before and after microsatellite-based data to predict genetic diversity post-augmentation for comparison to our observation (proof of genetic change) and to quantify the amount of observed reproduction attributed to transplants (proof of population integration). We found higher genetic diversity than predicted had no augmentation occurred, but less than was predicted by our model. Surprisingly, we also found evidence of periodic gene flow between the two isolated resident populations. We then characterized genome-wide adaptive divergence among source and recipient populations. Among candidate adaptive genes, we found groups of related genes that may influence transplants through differing abilities to use local resources, navigate unfamiliar environments, and reproductive potentials all of which are possible reasons for low genetic retention from augmentation.

Participants

Cheyenne Acevedo
Nevada Department of Wildlife
cheyenne.acevedo@ndow.org

Cameron Aldridge
U.S. Geological Survey
aldridgec@usgs.gov

Robert Arkle
U.S. Geological Survey
rarkle@usgs.gov

Michael Atamian
Washington Department of Fish and Wildlife
michael.atamian@dfw.wa.gov

Joseph Atkinson
U.S. Geological Survey
jatkinson@usgs.gov

Erik Bartholomew
Idaho Department of Fish and Game
erik.bartholomew@idfg.idaho.gov

Jeremy Baumgardt
Idaho Department of Fish and Game
jeremy.baumgardt@idfg.idaho.gov

Jeffrey Beck
University of Wyoming
jlbeck@uwyo.edu

Tessa Behnke
Universal Engineering Sciences
tbehnke@teamues.com

Jennifer Boisvert
Powder Basin Watershed Council
pbwcsc@pbwsc.org

Eric Braaten
Washington Department of Fish and Wildlife
eric.braaten@dfw.wa.gov

Matt Brinkman
Washington Department of Fish and Wildlife
matthew.brinkman@dfw.wa.gov

Samantha Brown
Tetra Tech
samantha.brown@tetratech.com

Tara Callaway
U.S. Fish and Wildlife Service
tara_callaway@fws.gov

Ellie Carney
Conservation Northwest
keith@conservationnw.org

Ruger Carter
Utah State University
ruger.carter@usu.edu

Melissa Chelak
University of Lethbridge
melissa.chelak@uleth.ca

Renee Chi
Bureau of Land Management
rchi@blm.gov

Cara Christensen
Oregon State University
cara.christensen@oregonstate.edu

Mikal Cline
Oregon Department of Fish and Wildlife
sara.l.stilwell@odfw.oregon.gov

Millie Coleing
Wilder Institute/Calgary Zoo
milliec@calgaryzoo.com

Chris Collins
Bureau of Land Management
cmcollins@blm.com

Courtney Conway
U.S. Geological Survey
cconway@uidaho.edu

Sylvia Copeland
Bureau of Land Management
scopeland@blm.gov

Jacqueline Cupples
U.S. Fish and Wildlife Service
jacqueline_cupples@fws.gov

David Dahlgren
Utah State University
dave.dahlgren@usu.edu

Rachael Davee
SageCon Partnership
rachael.davee@sagesalix.com

Christine Davis
Washington Department of Fish and Wildlife
christine.davis@dfw.wa.gov

Lee Davis
The Nature Conservancy
lee.davis@tnc.org

Pat Deibert
Bureau of Land Management
pdeibert@blm.gov

Daniel Dewey
U.S. Fish and Wildlife Service
daniel_dewey@fws.gov

Jonathan Dinkins
Oregon State University
Jonathan.dinkins@oregonstate.edu

Lisa Dowling
Washington Department of Fish and Wildlife
lisa.dowling@dfw.wa.gov

Bryan Dupont
Washington Department of Fish and Wildlife
bryan.dupont@dfw.wa.gov

Kyle Ebenhoch
Western EcoSystems Technology
kebenhoch@west-inc.com

Johnna Eilers
Washington Department of Fish and Wildlife
johnna.eilers@dfw.wa.gov

Erik Ellis
Bureau of Land Management
edellis@blm.gov

Shawn Espinosa
Nevada Department of Wildlife
sespinosa@ndow.org

Mickey Fleming
Chelan-Douglas Land Trust
mickey@cdlandtrust.org

Katreeya Flood
U.S. Fish and Wildlife Service
katreeyaflood@gmail.com

Jennifer Forbey
Boise State University
jenniferforbey@boisestate.edu

Trevor Force
Washington Department of Fish and Wildlife
trevor.force@dfw.wa.gov

Haley Fowler
Great Basin Institute/U.S. Fish and Wildlife Service
haleyannfowler@gmail.com

John Gale
Bureau of Land Management
jgale@blm.gov

Stephanie Galla
Boise State University
stephaniegalla@boisestate.edu

Kathy Griffin
Colorado Parks and Wildlife
kathy.griffin@state.co.us

Christian Hagen
Oregon State University
christian.hagen@oregonstate.edu

Sophia Hara
Washington Department of Fish and Wildlife
sophia.hara@dfw.wa.gov

Kristina Harkins
Montana Fish, Wildlife and Parks
kristina.harkins@mt.gov

Heather Harris
Montana Fish, Wildlife and Parks
heharris@mt.gov

Becca Hebron
Foster Creek Conservation District
rhebron@fostercreekcd.org

Jeff Heinlen
Washington Department of Fish and Wildlife
Jeffrey.Heinlen@dfw.wa.gov

Mallory Hirschler
Washington Department of Fish and Wildlife
mallory.hirschler@dfw.wa.gov

Matt Holloran
Bureau of Land Management
mholloran@blm.gov

Emma Hoskins
Yakima Training Center
emma.hoskins@whitetail-env.com

Seth Hulett
Audubon Washington
seth.hulett@audubon.org

Danielle Husband
U.S. Fish and Wildlife Service
danielle_husband@fws.gov

Greg Jackle
Oregon Department of Fish and WIldlife
greg.s.jackle@odfw.oregon.gov

Elise Jackson
PacifiCorp
elise.jackson@pacificorp.com

Pat Jackson
Nevada Department of Wildlife
pjackson@ndow.org

Matthew Jeffress
Nevada Department of Wildlife
mjeffress@ndow.org

Emily Jeffreys
Washington Department of Fish and Wildlife
emily.jeffreys@dfw.wa.gov

Andrew Johnson
Bureau of Land Management
acjohnson@blm.gov

Marika Kearsley
Natural Resources Conservation Service
marika.kearsley@usda.gov

Chris Keefe
Bureau of Land Management
ckeefe@blm.gov

Jay Kehne
Conservation Northwest
jkehne@conservationnw.org

Rebecca Kelble
Oregon State University
rebecca.kelble@oregonstate.edu

Carly Kelly
Western EcoSystems Technology
ckelly@west-inc.com

Jesse Kolar
North Dakota Game and Fish Department
jessekolar@gmail.com

Jamie Lange
Bureau of Land Management
jllange@blm.gov

Jonathan Lautenbach
University of Wyoming
jlauten1@uwyo.edu

Nicole Lindenauer
U.S. Geological Survey/University of California, Davis
nlindenauer@usgs.gov

Sam Litschert
Bureau of Land Management
slitschert@blm.gov

Janyne Little
University of California, Cooperative Extension
janyne.little@gmail.com

Brad Lowe
Idaho Department of Fish and Game
brad.lowe@idfg.idaho.gov

Carrie Lowe
Washington Department of Fish and Wildlife
carrie.lowe@dfw.wa.gov

Jason Lowe
Bureau of Land Management
j3lowe@blm.gov

Kaitlin Lubetkin
Bureau of Land Management
klubetkin@blm.gov

Carl Lundblad
U.S. Geological Survey
clundblad@usgs.gov

Melissa MacKelvie
Washington Department of Fish and Wildlife
melissa.mackelvie@dfw.wa.gov

Belle Malley
University of California, Davis
bmalley@usgs.gov

Ellie Mangelinckx
Yakima Training Center
jmangelinckx@whitetail-env.com

Alan Marsh
Lotek Wireless
amarsh@lotek.com

Mary Marsh
Volunteer
pintler@hotmail.com

Marcus McClung
Colville Tribes, Fish and Wildlife Department
marcus.mcclung.fnw@colvilletribes.com

Jessica McDermott
Bureau of Land Management
jmcdermott@blm.gov

Kurt Merg
Washington Department of Fish and Wildlife
kurt.merg@dfw.wa.gov

Megan Milligan
U.S. Geological Survey
mmilligan@usgs.gov

Adrian Monroe
U.S. Geological Survey
amonroe@usgs.gov

David Morgan
The Nature Conservancy
david.morgan@tnc.org

Austin Nash
U.S. Geological Survey
anash@usgs.gov

Mikel Newberg
Montana Fish, Wildlife and Parks
mikel.newberg@mt.gov

Cammi Norville
U.S. Geological Survey
cammi.norville@gmail.com

Peter Olsoy
U.S. Dep. of Agriculture/Agricultural Research Service
peter.olsoy@usda.gov

Terrah Owens
Idaho National Laboratory
terrah.owens@inl.gov

Sara Oyler-McCance
U.S. Geological Survey
sara_oyler-mccance@usgs.gov

Nate Pamplin
Washington Department of Fish and Wildlife
nathan.pamplin@dfw.wa.gov

Lindsey Perry
Oregon State University
lindsey.perry@oregonstate.edu

Daniel Peterson
Washington Department of Fish and Wildlife
daniel.peterson@dfw.wa.gov

Aaron Pratt
George Miksch Sutton Avian Research Center
aaroncpratt@yahoo.com

Jared Reese
Bureau of Land Management
jreese@blm.com

Alex Repp
Washington Department of Fish and Wildlife
alex.repp@dfw.wa.gov

Alexandra Reyes
Natural Resources Conservation Service
alexandra.reyes@usda.gov

Richard Rich
Oregon State University
richr@oregonstate.edu

Jared Rohr
U.S. Fish and Wildlife Service
rohrj185@cobleskill.edu

Elianna Rosenthal
Washington Department of Fish and Wildlife
elianna.rosenthal@dfw.wa.gov

Jay Ruebens
U.S. Fish and Wildlife Service
jay_ruebens@fws.gov

Kayla Ruth
Oregon State University
kayla.ruth@oregonstate.edu

Becky Ruzicka
Colorado State University
beckyruz13@gmail.com

Jordan Ryckman
Conservation Northwest
jordan@conservationnw.org

Lauren Samaniego
Natural Resources Conservation Service
lauren.samaniego@usda.gov

Charles Sandford
U.S. Fish and Wildlife Service
charles_sandford@fws.gov

Jason Schilling
Douglas County P.U.D.
jason.schilling@dcpud.org

Nate Schmidt
Washington Department of Fish and Wildlife
nate.schmidt@dfw.wa.gov

Bruce Schoeberl
Bureau of Land Management
bschoeberl@blm.gov

Michael Schroeder
Washington Department of Fish and Wildlife
michael.schroeder@dfw.wa.gov

Vanessa Schroeder
Oregon State University
vanessa.schroeder@oregonstate.edu

Scott Scroggie
Natural Resources Conservation Service
scott.scroggie@usda.gov

John Severson
U.S. Geological Survey
jpseverson@usgs.gov

Landon Shaffer
Washington Department of Fish and Wildlife
landon.shaffer@dfw.wa.gov

Kelly Singer
Confederated Tribes of the Colville
kelly.singer@colvilletribes.com

Justin Small
Nevada Department of Wildlife
justin.small@ndow.org

Evan Standifer
Bureau of Land Management
estandifer@blm.gov

Justin Stanley
Okanogan Conservation District
justin@okanogancd.org

San Stiver
Consultant
san.stiver@gmail.com

Jennifer Struthers
Idaho Department of Fish and Game
jennifer.struthers@idfg.idaho.gov

Shawn Szabo
Oregon State University
shawn.szabo@oregonstate.edu

Heather Talley
Utah Division of Wildlife Resources
heathertalley@utah.gov

Eric Thacker
Utah State University
eric.thacker@usu.edu

Kim Thorburn
Washington Department of Fish and Wildlife
kthorburn@msn.com

Keifer Titus
Oregon State University
tituske@oregonstate.edu

John Tull
U.S. Fish and Wildlife Service
john_tull@fws.gov

Ben Turnock
Washington Department of Fish and Wildlife
benjamin.turnock@dfw.wa.gov

Megan Turnock
Washington Department of Fish and Wildlife
megan.turnock@dfw.wa.gov

Emily Tyrrell
U.S. Fish and Wildlife Service
emily_tyrrell@fws.gov

Julie Unfried
U.S. Fish and Wildlife Service
julie_unfried@fws.gov

Kelli Van Norman
Bureau of Land Management
kvannorm@blm.gov

Joe Veverka
The Nature Conservancy
joe.veverka@tnc.org

Kim Veverka
U.S. Fish and Wildlife Service
kim_veverka@fws.gov

Nate Vigdor
Foster Creek Conservation District
nvigdor@fostercreekcd.org

Skyler Vold
Oregon Department of Fish and Wildlife
skyler.t.vold@odfw.oregon.gov

Leah Waldner
Bureau of Land Management
lwaldner@blm.gov

Brett Walker
Colorado Parks and Wildlife
brett.walker@state.co.us

Caitlyn Wanner
University of Wyoming
cait92lyn@gmail.com

Sarah Webster
U.S. Geological Survey
swebster@usgs.gov

Andrew Wehausen
Bureau of Land Management
awehausen@blm.gov

Emily Weidner
U.S. Fish and Wildlife Service
emily_weidner@fws.gov

Cali Weise
U.S. Geological Survey
croth@usgs.gov

Michael Whitcomb
Retired
whitcombmj@gmail.com

Nyssa Whitford
Wyoming Game and Fish Department
nyssa.whitford@wyo.gov

Lief Wiechman
U.S. Geological Survey
lwiechman@usgs.gov

Brian Wilk
U.S. Fish and Wildlife Service
brian_wilk@fws.gov

Sam Williams
Idaho National Laboratory
samuel.williams@inl.gov

Clarinda Wilson
Bureau of Land Management
crwilson35@gmail.com

Dan Wilson
Backcountry Hunters and Anglers
washington@backcountryhunters.org

Aaron Wold
Okanogan Conservation District
aaron@okanogancd.org

David Wood
Bureau of Land Management
djwood@blm.gov

Shawna Zimmerman
U.S. Geological Survey
szimmerman@usgs.gov

Dr. Stephanie Galla