WESTERN AGENCIES SAGE AND COLUMBIAN SHARP-TAILED GROUSE

31st BIENNIAL WORKSHOP ★ BILLINGS, MONTANA ★ JUNE 18-21, 2018

PHOTO: JOHN CARLSON

In Memoriam

Thomas L. Maechtle

December 8, 1958 - December 25, 2016

Sage-grouse conservation, especially in Montana and Wyoming, suffered a blow on Christmas Day 2016 with the premature death of Tom Maechtle. Through his wildlife consulting business, Tom earned great respect from both resource developers and wildlife conservationists because of his interpersonal skills and reliance on science. Tom volunteered much of his own time to sage-grouse conservation efforts and was also an internationally recognized peregrine falcon expert.

Tom, a largely self-taught naturalist, was engaged in higher learning that included not just the natural sciences, but also political science and the social sciences. Tom believed the integration of these fields was necessary to truly understand the world. Tom endeavored to build bridges between disparate groups tasked with resource planning for the goal of finding sustainable solutions for the environment, as he understood that social and political ideals drive environmental policy. And it was Tom's life-long passion to support and promote the natural world.

Tom was husband to Kathy, father to Ireland and friend to many. He died too early after a brief battle with pancreatic cancer. We dedicate this workshop to Tom’s memory.

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A list of workshop attendees will be emailed to all participants after the workshop.

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ACKNOWLEDGMENTS

Thank you to all of you for participating in this workshop!

Special thanks to all workshop presenters, session moderators, and field trip speakers.

2018 Workshop Planning Team

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Patterson Student Poster Award Committee

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Field Tour Service Providers

The Northern Hotel, Backporch BBQ, Currant Creek Angus Ranch, Clint Pedrazzi, Jefferson Lines, Future Farmers of America – Roundup Chapter

Workshop Logo and Program Cover

Luke Duran

Images from Montana slide show

John Carlson

PROGRAM

MONDAY, JUNE 18, 2018

8:00 am – 12:00 pm	Joint Sage and Columbian Sharp-tailed Grouse Technical Committee and Rangewide Interagency Sage-grouse Conservation Team (RISCT) Meeting The Northern Hotel conference room – *Invitation Only*
12:00 – 1:00 pm	Lunch – *Invitation Only*
1:00 – 5:00 pm	Tech Committee and RISCT meeting continued
4:00 – 7:00 pm	Registration Opens for ***All Attendees***
5:30 – 7:30 pm	Welcome Reception (light refreshments) – ***All Attendees***

WAFWA Sage and CSTG Technical Committee Members

Catherine Wightman – Montana (Chair)
Lee Foster and Mikal Cline – Oregon (Incoming Chair)
Tom Christiansen – Wyoming (Past Chair)
Joel Nicholson – Alberta
Alicia Goddard – British Columbia
Katherine Miller – California
Kathy Griffin – Colorado
Ann Moser and Jeff Knetter – Idaho
Shawn Espinosa – Nevada
Jesse Kolar – North Dakota
Jessus Karst and Beatriz Prieto – Saskatchewan
Travis Runia – South Dakota
Jason Robinson and Avery Cook – Utah
Mike Schroeder – Washington
Robin Sell – BLM
Rema Sadak and Deborah Finch – USFS
Patricia Deibert – USFWS

RISCT (includes the above plus…)

Thad Heater and Jeremy Maestas – NRCS
Steve Hanser – USGS
Rod Hamilton – Farm Service Agency
San Stiver – WAFWA Sagebrush Coordinator
Virgil Moore – WAFWA Sagebrush Executive Oversight Committee Chair
Ken Mayer – WAFWA Fire and Invasives Coordinator
Tom Remington – WAFWA Sagebrush Science Coordinator

PROGRAM

TUESDAY JUNE 19, 2018

8:00 am **Welcome** Catherine Wightman, Wildlife Habitat Coordinator
Montana Fish, Wildlife and Parks

8:10 am **Opening Remarks** Paul Sihler, Deputy Director
Montana Fish, Wildlife and Parks

Tuesday symposium begins promptly at 8:30

Session #1	Time	Title	Presenter
Habitat Associations *Moderator: Kathy Griffin*	8:30	Thermal environment of greater sage-grouse nest sites following wildfire	Christopher Anthony
	8:50	Ascertaining the ecological impacts of a changing landscape: developing Gunnison sage grouse habitat selection indices	Douglas Ouren
	9:10	Conserving the longest ever migration for sage grouse and pronghorn in Montana's Hi-Line	Jason Tack
	9:30	Killing conifer to benefit grouse: an integrated approach to assessing population response	Andrew Olsen
	9:50	Reconstructing greater sage-grouse chick diets: selection, body condition, and availability at brood-rearing and altered habitats	Kurt Smith
	10:10*	Assessing adequacy of South Dakota's core sage-grouse area	Lindsey Parsons

*10-minute presentation

10:20 – 10:40 am **Morning Break**

Session #2	Time	Title	Presenter
Columbian Sharp-tailed Grouse *Moderator: Mike Schroeder*	10:40	Survival of Columbian sharp-tailed grouse females in restored grassland habitats in northwestern Colorado	Rachel Barker
	11:00	Effects of habitat and wind energy on Columbian sharp-tailed grouse reproduction in a CRP-dominated landscape	Shane Roberts
	11:20	Washington's Columbian sharp-tailed grouse recovery management and policy	Kim Thorburn
	11:40	Sharp-tailed grouse population restoration through translocation: lessons from Nevada	Steven Mathews

12:00 pm – 1 pm **Lunch (provided)**

Session #3	Time	Title	Presenter
Population Monitoring and Analysis *Moderator: Shawn Espinosa*	1:00*	Assessing lek attendance of male greater sage-grouse using fine-resolution GPS data	Gregory Wann
	1:10*	Refining estimates of lekking sage-grouse detection probabilities by integrating error from simultaneous ground-based and aerial infrared counts	Mark Ricca
	1:20	Modeling lek trends with N-mixture models: do we still need repeated counts?	Adrian Monroe
	1:40*	How many leks does it take? Evaluating management effects at local scales	Christian Hagen
	1:50*	Informing long-term monitoring of greater sage-grouse populations using a multi-scaled clustering framework	Michael O'Donnell
	2:00	Greater sage-grouse population viability analysis: management areas and lek clusters across hierarchical scales	David Edmunds
	2:20	High stakes and high variability: sage-grouse population monitoring framework within a stochastic environment	Peter Coates
	2:40*	Streamlining workflows for sage-grouse population analyses in PopR	Paul Lukacs
	2:50*	Questions and discussion	

*10-minute presentations

3:00 – 3:20 pm Afternoon Break

Session #4	Time	Title	Presenter
Grazing *Moderator: Ann Moser*	3:20	Maladaptive nest-site selection by greater sage-grouse in a grazing-modified landscape	Kyle Cutting
	3:40	Greater sage-grouse habitat and demographic response to grazing by non-native ungulates	Phillip Street
	4:00*	Physiological responses to grazing pressure: investigating feather corticosterone as a measure of stress response in greater sage-grouse	Tessa Behnke
	4:10	The impacts of grazing on greater sage-grouse population dynamics and habitat in central Montana	Lorelle Berkeley
		Effects of livestock grazing on sage-grouse nesting ecology in central Montana	Joe Smith
	4:40*	Native pollinators: the effects of livestock grazing on rangelands in Montana	Gabrielle Blanchette
	4:50*	Relationships between songbird populations and productivity in sagebrush-steppe of Montana	Kayla Ruth

*10-minute presentations

5:30 – 7:30 pm **Poster Session and Evening Social (light refreshments)**

Images from Montana – photography by John Carlson

Poster Session Chair: Lorelle Berkeley

Authors are expected to present their poster between 5:30 – 6:30 pm.

No.	Title	Presenter
1	SAGEWEST: Advancing a radical center agenda in the sagebrush ecosystem through collaborative communications	Matt Kales
2	SageDAT: Data and tools to support collaborative sagebrush ecosystem conservation and management	Steve Hanser
3	Conservation efforts database v2.0: conservation planning and effectiveness monitoring	Lief Wiechman
4	A retrospective of early sage-grouse research, highlighting the contributions of Dwayne Pyrah and others (1950's – 1970's)	Renee Chi
5	Physiological condition of greater sage-grouse as a function of conifer encroachment	Jordan Rabon
6	Effects of wildfire, invasive grasses, and avian predator densities on greater sage-grouse in Oregon	Terrah Owens
7	Comparison of avian and mammalian predators in sage-grouse core and non-core areas: assessing predator abundance and response to anthropogenic features	Claire Revekant
8	Implementing DOI Secretarial Order 3353: greater sage-grouse conservation and cooperation with western states	Vicki Herren
9	Implementation of a Candidate Conservation Agreement for greater sage-grouse on lands closed to the general public in Idaho	Quinn Shurtliff
10	Counting sage-grouse: Can Survey123 make our lives easier?	Colin Dovichin
11	Beneficial rump-mount harness alterations	Alyssa Kircher
12	Monitoring success of sage-grouse translocated from Montana to Alberta: An international conservation effort	Joel Nicholson
13	Land cover change and habitat monitoring of Columbian sharp-tailed grouse	Tom Calton
14	Sharp-tailed grouse reintroduction in western Montana	Chris Hammond
15	Soft release techniques for translocated Columbian sharp-tailed grouse from southeast Idaho to northeast Nevada	Matt Jeffress

YELLOW WATER TRIANGLE FIELD TOUR SCHEDULE

WEDNESDAY JUNE 20, 2018

Schedule times are approximate except the morning departure
Sack lunch, water, and some sodas provided

07:30 Gather at The Northern Hotel

08:00 Buses depart - ***Plan to be prompt as the buses will not wait for late arrivals***
Rotating speakers on buses:
Ashley Taylor, FWP biologist, Roundup
Levi Morgan, USFWS Partners for Fish and Wildlife Program, Lewistown
Dan Casey, Coordinator, Northern Great Plains Joint Venture

10:00 Stop 1 – Overlook of Devil's Basin
TOPIC: *Conversion of native range to cropland, range management*
Austin Shero, District Conservationist, NRCS Roundup Field Office
Joe Smith, Post-doc, University of Montana, Missoula

11:00 Depart Stop 1

12:00 LUNCH at Stop 2

Stop 2 – Yellow Water Triangle area and War Horse National Wildlife Refuge
TOPIC: *Historical perspectives, range management*
Rick Wallestad, retired Wildlife Biologist
Matt Comer, BLM Wildlife Biologist, Lewistown Field Office
Nikki Rife, Range Conservationist, NRCS Bozeman Area Office

13:30 Depart Stop 2

14:30 Stop 3 – BLM Overlook
TOPIC: *Research, management, and landowner perspectives*
Diane Ahlgren, landowner
Mark Szczypinski, Conservation Technician, Montana Fish, Wildlife and Parks
Lorelle Berkeley, Wildlife Research Biologist, Montana Fish, Wildlife and Parks
Sam Milodragovich, Wildlife Biologist, Northwestern Energy

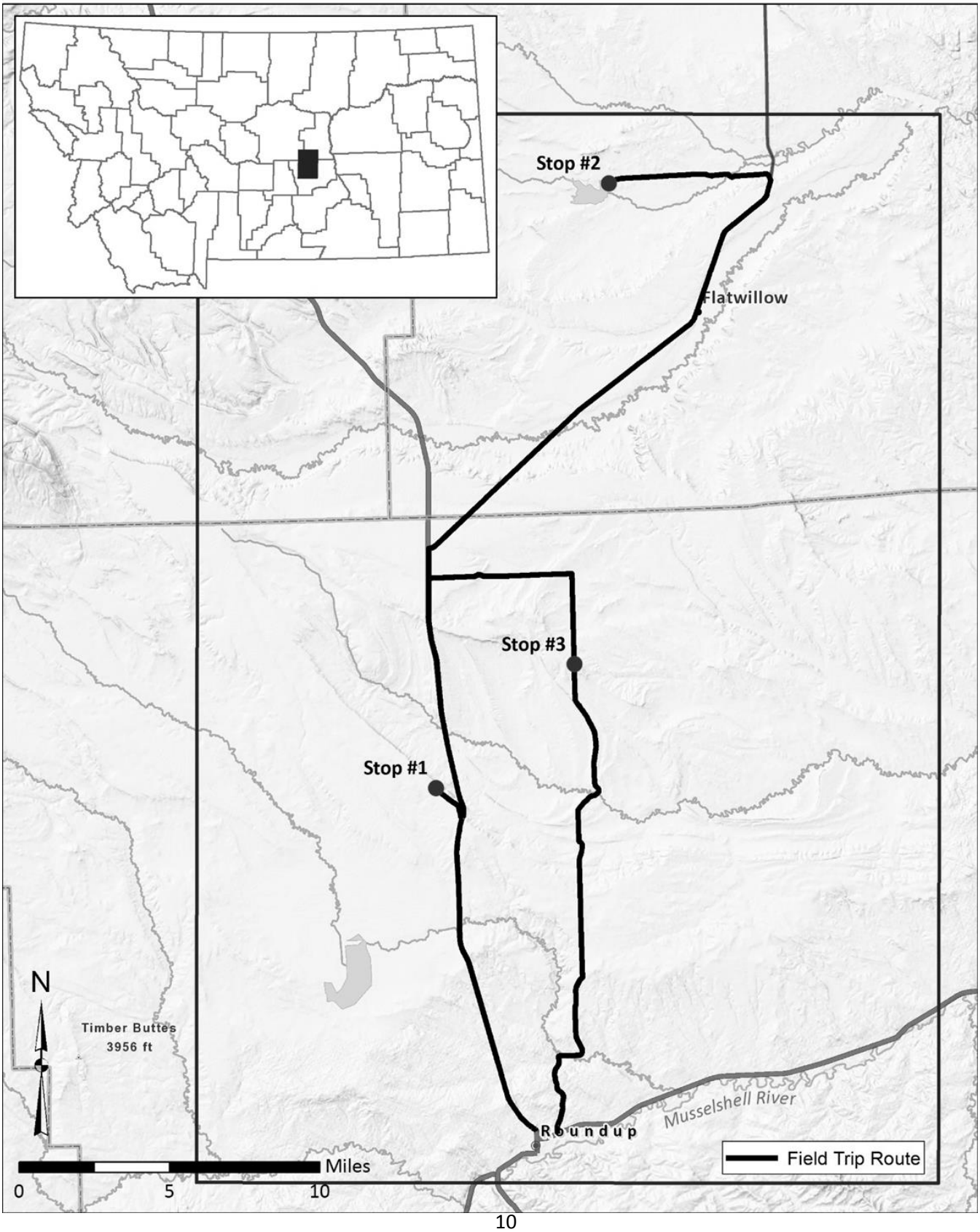
16:00 Depart Stop 3

17:00 Cookout at Currant Creek Angus Ranch in Roundup, catered by Backporch BBQ

19:00 Depart for Billings

20:30 Return to The Northern Hotel

Field Tour Overview



PROGRAM

THURSDAY JUNE 21, 2018

Thursday symposium begins promptly at 8:00.

Session #5	Time	Title	Presenter
Anthropogenic Influences *Moderator: Tom Christiansen*	8:00	Sound levels in sagebrush habitats in Wyoming and the influence of anthropogenic sounds on greater sage-grouse	Skip Ambrose
	8:20	Energy development and climate change in southwest Wyoming: simulating consequences for sage-grouse	Cameron Aldridge
	8:40	Greater sage-grouse response to bentonite mining in the Bighorn Basin of Montana and Wyoming	Aaron Pratt
	9:00	Greater sage-grouse response to two 230-kV transmission lines	Chad LeBeau
	9:20	Factors driving greater sage-grouse trends in the eastern portion of their range	Jonathan Dinkins
	9:40	Broad-scale occurrence of a subsidized avian predator: implications for reducing impacts of ravens on sage-grouse	Shawn O'Neil

10:00 – 10:20 am **Morning Break**

Session #6	Time	Title	Presenter
Lightning round #1 *Moderator: Pat Deibert*	10:20*	Identifying ecological traps for targeted pinyon-juniper removal in greater sage-grouse habitat	Cali Roth
	10:30*	The response of greater sage-grouse to the reclamation of an oil and gas development landscape	Chris Kirol
	10:40*	Behavior of female grouse: are we missing something important?	Mike Schroeder
	10:50*	Greater sage-grouse reproduction and mountain big sagebrush management in eastern Idaho	Shane Roberts
	11:00*	Global positioning system tracking devices can decrease greater sage-grouse survival	John Severson
	11:10*	Establishing a third sage grouse population in Washington State: what we've learned and where we are at	Michael Atamian
	11:20*	Addressing the management need for coordinated and collaborative strategic conservation and restoration investments in the sagebrush biome	Kenneth Mayer
	11:30*	Questions and discussion	

*10-minute presentation

11:40 am – 12:40 pm Lunch (provided)

Session #7	Time	Title	Presenter
Genetics *Moderator: Jason Robinson*	12:40	Delineation of genetic populations and connectivity in greater sage-grouse	Sara Oyler-McCance
	1:00	Quantifying functional connectivity: the role of breeding habitat, abundance, and landscape features on range-wide gene flow in sage-grouse	Bradley Fedy
	1:20	The genetic network of greater sage-grouse: range-wide identification of keystone hubs of connectivity	Todd Cross
	1:40	Genomic insights into neutral and adaptive variation in sage-grouse: implications for ecology and conservation	Sara Oyler-McCance
	2:00	Genes associated with signatures of adaptive differentiation in Gunnison sage-grouse	Shawna Zimmerman

2:20 – 2:40 pm Afternoon Break

Session #8	Time	Title	Presenter
Lightning round #2 *Moderator: Lee Foster*	2:40	Implementing the sage-grouse habitat assessment framework within the Bureau of Land Management	Megan McLachlan Chris Domschke
	3:00*	Threat-based land management and collaboration in southeast Oregon	Matt Cahill
	3:10*	If we build it will they come?: linking plant community ecology with sage-grouse habitat preference	Angela Sitz
	3:20*	Decision support tools: finding the right tool in the toolbox	John Tull
	3:30*	An introduction to the land treatment planning tool	David Pilliod
	3:40*	A decision support tool for conifer removal: maximizing benefits to sagebrush and woodland-obligate species	Jason Tack
	3:50*	Questions and discussion	

*10-minute presentation

Evening Banquet and Awards Ceremony begins at 6:00 pm

Banquet Speaker: Noppadol Paothong

Banquet Speaker: Noppadol Paothong

Noppadol Paothong is an award-winning nature and conservation photographer. His focus has been on rare and endangered species, primarily on grassland grouse and their fragile habitat. He is a staff wildlife photographer with the Missouri Department of Conservation publication, *Missouri Conservationist* since 2006 with a circulation of over 500,000, is one of the nation's largest state conservation magazines.

He is an award-winning nature photographer and author of the 2012 book *Save the Last Dance*, which beatifically captured the dance and displays of seven grouse species. It was well received by the public and conservation experts around the country. His new book *Sage Grouse, Icon of the Wes*t published in 2017 has received many praised from top magazine editors around the country including the Audubon magazine.

He was also a finalist for the BBC Wildlife Photographer of the Year and his photographs from *Save the Last Dance* were finalists for prizes from the Audubon Photo Contest and the Outdoor Writer Association of America. He also has received many more numerous prestigious awards, including Picture of the Year International, National Wildlife Photo Contest, Nature's Best, Audubon Photo Contest, Outdoor Writers Association of America Photo Contest, and Missouri Photojournalist of the Year.

He is also a board member with George Miksch Sutton Avian Research Center in Oklahoma, an organization that leads effort to save Attwater's prairie-chicken recovery with captive rearing program. He also had served as a board member with Society of *Tympanuchus Cupido Pinnatus* in Wisconsin.

His photography is celebrated and in-demand because of his ability to capture the life, movement and vibrancy of species and natural settings that people connect with.

His images appear regularly on many national publications such as Audubon, Nature Conservancy, National Wildlife Magazine, Ranger Rick, Sierra Club, Discovery Magazine, American Birds Conservancy, International Union for Conservation of Nature, WildEarth Guardians, Missouri Conservationist, Xplor, US Fish & Wildlife Service, Nature's Best Photography, Birding Magazine, Bird Watching , Feld & Stream, Washington Post, Field & Stream, High Country News, Kansas City Star, Spokesman-Review, Montana Magazine, Montana Outdoors, Colorado Outdoors, New Jersey Outdoors, Brown Trout Publishers, Willow Creek Press, The Journal of Wildlife Management, Landscape Architecture Magazine and many more.

For more information about his works please visit www.npnaturephotography.com

The Robert L. Patterson Award

The Robert L. Patterson Award was established in 2008 by the Western Agencies Sage and Columbian Sharp-tailed Grouse Technical Committee to recognize outstanding resource professionals who have contributed significant efforts to the conservation and management of these species. The award honors Patterson's pioneering work, captured in his 1952 seminal publication, *The Sage Grouse in Wyoming*, and is given to one or two recipients at the biennial Sage and Columbian Sharp-tailed Grouse Workshop. Nominations are made by peers, and award recipients are selected on their significant contributions, and outstanding commitment, to the long-term conservation of these species. They may be engaged research, management, or policy, and need to demonstrate a long-term commitment to these species.

Award Recipients

YEAR	MEETING LOCATION	RECEIPENT
2008	Mammoth, California	Clait E. Braun
2010	Twin Falls, Idaho	Randall B. Smith
2010	Twin Falls, Idaho	John W. Connelly, Jr.
2012	Steamboat Springs, Colorado	Michael Schroeder
2012	Steamboat Springs, Colorado	San Juan Stiver
2014	Elko, Nevada	Kerry P. Reese
2014	Elko, Nevada	Clinton McCarthy
2016	Lander, Wyoming	Steven T. Knick
2016	Lander, Wyoming	Patricia A. Deibert
2018	Billings, Montana	

CONTRIBUTED PRESENTATIONS ABSTRACTS

THERMAL ENVIRONMENT OF GREATER SAGE-GROUSE NEST SITES FOLLOWING WILDFIRE

Christopher R. Anthony[1], Christian Hagen[2], Dwayne Elmore[3], Katie M. Dugger[4]

[1]Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR 97331.
[2]Department of Fisheries and Wildlife, Oregon State University, Bend, OR 97702
[3]Department of Natural Resource Ecology and Management, Oklahoma State University, Stillwater, OK 94078
[4]U.S. Geological Survey, Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR 97331

Abstract. Thermal refuge may be important for nest site selection and nest survival by Greater Sage-grouse (*Centrocercus urophasianus,* hereafter sage-grouse) as specific microclimates can protect embryos from extreme temperatures and reduce thermal stress of incubating females. At fine spatial scales, thermal environments are influenced by vegetation structure/composition and abiotic factors. Thus, changes to vegetation due to wildfire could influence thermal environments for sage-grouse females that nest within the post-fire landscape. Our objective was to describe the thermal environments at unburned and burned sage-grouse nest sites and to quantify thermal differences among three spatial scales: nest-bowl, nest microsites, and adjacent landscape in the Trout Creek Mountains, Oregon. We modeled the thermal environments at each spatial scale based on the relationship between operative temperature and ambient temperature. Both burned and unburned nest bowls had lower thermal variability and moderated temperature more than both microsites and the landscape. However, temperature at the nest bowl does appear to influence nest fate. Specifically, when ambient temperatures were >15° C, successful nest bowls were cooler than failed nests. Therefore, sagebrush communities provide thermal refuge for nesting sage-grouse that are cooler than both the microsite and the landscape, and differences in thermal environments are associated with nest success.

ASCERTAINING THE ECOLOGICAL IMPACTS OF A CHANGING LANDSCAPE: DEVELOPING GUNNISON SAGE GROUSE HABITAT SELECTION INDICES

Douglas S. Ouren[1], Brian S. Cade[1], Melissa S. Siders[2], Kenneth W. Holsinger[2]

[1]United States Geological Survey, Fort Collins Science Center, 2150 Centre Ave, Bldg C, Fort Collins Colorado 80526
[2]United States Bureau of Land Management, 2465 S. Townsend Ave., Montrose Colorado 81401

Abstract. For the past 17-plus years, the shrub steppe ecosystems of the Colorado River basin have been under drought-like conditions. Simultaneously, Gunnison Sage Grouse (GUSG) populations, whose habitat is found within the Colorado River basin, have struggled with sustainability. To better understand this relationship, we collected GPS locations from 12 female GUSG in the Crawford population spanning a four-year period. With data representing seasonal individual use, we developed a variant of resource selection modeling to evaluate selection by season by bird-year. Relative selection ratios for individual bird-years provided seasonal resource use ranking representing concentration of bird use, yielding a range of resource use that can be utilized to focus management actions for conservation of GUSG habitat. Results from our spatially explicit modeling illustrated that concentrated habitat selection by GUSG was relatively spatially confined. We learned their habitat selection was directly tied to places on the landscape where the flora and fauna that make up highly selected habitat by GUSG were supported by mesic conditions. Finally, we demonstrated our modeling approach provided a new method of assessing GPS location data by developing relative selection indices based on individual bird use and relating that use to the availability of similar landscape characteristics.

CONSERVING THE LONGEST EVER MIGRATION FOR SAGE GROUSE AND PRONGHORN IN MONTANA'S HI-LINE

Jason D. Tack[1], Andrew F. Jakes[2], Mark Hebblewhite[3], Paul Jones[4], Joseph T. Smith[3], Rebecca E. Newton[5], Brian Martin[6], Ronald Pritchert[1], and David E. Naugle[3].

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[3]University of Montana, W.A. Franke College of Forestry and Conservation, 32 Campus Drive, Missoula, MT 59812
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[6]Nature Conservancy, Montana Grasslands Conservation Program, 32 S Ewing Street, Helena, MT 59601

Abstract. Conserving wildlife migration poses one a great challenge to land managers, as the scale of migration can eclipse the area encompassed by seasonal habitat requirements while transcending state and international boundaries. Though sage-grouse do not typically invoke images of large-scale migration, we documented obligate two-stage (autumn and spring) migration >120km one way between Saskatchewan and Montana at the northeastern edge of their range. We tracked this population during migration using GPS technology, and found that individuals used a 'stepping-stone' behavior analogous to that of migratory big game. We fit resource selection models and Brownian Bridge Movement Models (BBMM) to identify key migratory pathways. During our study, similar tracking efforts were underway for pronghorn near Glasgow, MT, which defines the northeastern distribution for North America's sole endemic ungulate. This population of pronghorn also exhibit the longest-ever documented migration for their species, up to 800km between Alberta, Saskatchewan and Montana. We used pronghorn data to assess migratory overlap between these two species, while measuring protections afforded to pronghorn by sage grouse Core Area policy. As cultivation poses the greatest threat to migration in this landscape, we developed a prioritization tool to identify the most critical intact private-lands for maintaining migration across taxa.

KILLING CONIFER TO BENEFIT GROUSE: AN INTEGRATED APPROACH TO ASSESSING POPULATION RESPONSE

Andrew Olsen[1], John Severson[2], Jeremy Maestas[3], Todd Forbes[4], Dave Naugle[5], Christian Hagen[1]

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[2]Department of Fish and Wildlife Sciences, University of Idaho, 975 W. 6th Street, Moscow, ID 83844
[3]Natural Resources Conservation Service, 625 SE. Salmon Avenue, Suite 4, Redmond, OR 97756
[4]Lakeview District, Bureau of Land Management, 1301 S. G Street, Lakeview, OR 97630
[5]Wildlife Biology Program, University of Montana, Forestry 108, Missoula, MT 59812

Abstract. Encroachment of conifers in sagebrush (*Artemisia* spp.) ecosystems is considered a primary threat to greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse) habitat in the Great Basin. However, little is known about the population level response of sage-grouse to management actions that reduce conifer cover. Using a "before-after-control-impact" study design, sage-grouse marked with VHF and GPS transmitters were monitored at a treatment site with conifer removal and a control site without conifer removal in Lake County, Oregon from 2010–2017. Conifer removal began in the treatment area in 2012 and approximately 13,134 ha were removed on public and private lands by 2017. Over the course of the study, 417 radio- marked females, 378 nests, and 223 broods were monitored. Our hierarchical integrated population model combined vital rate (from telemetry) and lek count data for more informative estimates of abundance and population growth rates and were developed for both the treatment and control areas. Additionally, sensitivity analysis and life table response experiments were used to quantify the effect of changes in vital rates on population growth rates as a result of conifer removal. A robust understanding of the population-level effects of conifer removal is critical to effective management of the sage-grouse.

RECONSTRUCTING GREATER SAGE-GROUSE CHICK DIETS: SELECTION, BODY CONDITION, AND AVAILABILITY AT BROOD-REARING AND ALTERED HABITATS

Kurt T. Smith[1], Aaron C. Pratt[1], Jason R. LeVan[1], and Jeffrey L. Beck[1]

[1]Department of Ecosystem Science and Management, University of Wyoming, Laramie, WY 82071

Abstract. Growth and survival of juvenile greater sage-grouse (*Centrocercus urophasianus*) is nutritionally demanding, making the availability of major foods critical to population productivity. We coupled stable isotope analysis of feathers and field measurements to quantify diet selection and then correlated that with measures of chick body condition. Our objectives were to: 1) evaluate diet availability and consumption at brood-rearing locations, and 2) assess the relationship between dietary consumption and body condition. Females with broods selected habitats in areas where diet resources occurred in proportion to their availability, with the exception that brooding females selected areas with greater forb abundance 4 weeks after hatch. Diet consumption of chicks at brood-rearing locations was unrelated to the availability of forbs and insects, but consumption of plant diets increased with chick age. Chicks that consumed proportionally greater amounts of plant diets during their first week of life tended to weigh more and have longer wing chords. Habitat management aimed at improving habitats for juvenile sage-grouse should focus on increasing the abundance and availability of dietary forbs. We relate our findings to mowing and application of tebuthiuron, two commonly implemented sagebrush (*Artemisia* spp.) treatments that are intended to improve forage quality and availability for sage- grouse.

ASSESSING ADEQUACY OF SOUTH DAKOTA'S CORE SAGE- GROUSE AREA

Lindsey A. Parsons[1], Travis Runia[2], Jonathan A. Jenks[1], Andrew Gregory[3]

[1]Department of Natural Resource Management, South Dakota State University, Box 2140 SNP 138, Brookings, SD 57007
[2]South Dakota Game, Fish and Parks, 895 3rd Street SW, Huron, SD 57350
[3]Department of the Environment and Sustainability, Bowling Green State University, 190 Overman Hall, Bowling Green, OH 43403

Abstract. To obtain conservation targets and maintain connectivity among populations, South Dakota Department of Game, Fish and Parks delineated a Core Sage-Grouse (*Centrocercus urophasianus)* Area within the state using 6.4 km buffers around active leks, which included high use areas and connectivity corridors. The area encompasses 3,977 km². To assess the adequacy of the Core Sage-Grouse Area, 73 female sage-grouse were fitted with VHF radio- collars in 2016 and 2017. We collected >2,300 breeding season and >200 winter locations. We detected a total of 71 nests, 65 (92%) of which were within the Core Sage-Grouse Area. We calculated 95% breeding season home ranges using the fixed kernel method for all individuals with ≥24 locations (n=55). Of the 55 home ranges, 26 (47%) were entirely within, 26 (47%) were partially within, and 3 (5%) were entirely outside the Core Sage-Grouse Area. During winter, 26% of locations were in Montana; however, over 99% of winter locations in South Dakota were inside the Core Sage-Grouse Area. Although the Core Sage-Grouse Area currently encompasses >90% of sage-grouse nests, management recommendations include updating the area to include new leks and their respective buffers and extending the area to include newly found high use areas.

SURVIVAL OF COLUMBIAN SHARP-TAILED GROUSE FEMALES IN RESTORED GRASSLAND HABITATS IN NORTHWESTERN COLORADO

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Abstract. We investigated the survival of Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*; CSTG) females on two landscapes (reclaimed mineland and Conservation Reserve Program (CRP)), driven by the need for baseline data in a proposed habitat improvement study on existing CRP lands. We radio-marked 258 CSTG females in April - May of 2015 – 2017 and monitored females via ground telemetry 2-3 times per week from April through September to compare their survival among differing habitats. Six-month Kaplan-Meier estimates of female survival in mineland reclamation averaged 62.7% (58.5 – 67.0%), while females in CRP averaged 61.7% (53.3 – 75.9%), suggesting no difference among years or study sites. We estimated nest survival (n=275) with Program MARK ($\hat{S}$= 33.9% (22.5 – 49.9%)), but found no influence of year or study site. This contrasts previous research findings that CSTG in mineland reclamation have higher survival and nest success than those in CRP and native shrub- steppe habitats. These results could suggest that mineland reclamation habitat degrades with age, like CRP, as management practices and ownership change. Both habitats may require active management to remain productive for CSTG. The findings of this research will serve as baseline data for planned habitat modifications aimed at enhancing existing CRP landsfor CSTG.

EFFECTS OF HABITAT AND WIND ENERGY ON COLUMBIAN SHARP-TAILED GROUSE REPRODUCTION IN A CRP-DOMINATED LANDSCAPE

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Abstract. To assess potential effects of Conservation Reserve Program (CRP) vegetation composition and wind energy development on Columbian sharp-tailed grouse (CSTG) nest selection and reproductive demographics, during 2014-2015 we monitored 135 females at leks 0.1-13.8 km from wind turbines in an eastern Idaho landscape dominated by CRP grasslands. We used 147 nests to assess the effects of wind energy and multi-scale habitat features on nest site selection and daily nest survival. Females selected nest sites, and experienced higher daily nest survival, in habitat patches that contained a higher proportion of restored grassland habitat containing >30% forb cover. Wind turbines had no effect on nest site selection or success. We also used 68 broods to examine the effects of wind energy, habitat, and other variables on brood success (success = 1 live chick) and chick survival (number of surviving chicks). There was no effect of wind energy on brood success but chick survival was negatively influenced by increased wind turbine density. Our results suggest that habitat conditions typically found in successful CRP-SAFE plantings can positively influence CSTG demographics, wind energy development may negatively impact CSTG chick survival, and measures of brood success and chick survival can produce different conclusions about CSTG recruitment.

WASHINGTON'S COLUMBIAN SHARP-TAILED GROUSE RECOVERY MANAGEMENT AND POLICY

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Abstract. The Columbian sharp-tailed grouse was classified as threatened by Washington State in 1998 after years of population decline. Historically the most abundant game bird in Eastern Washington, the population started dropping in the early 20th century due primarily to agricultural conversion of prairie and steppe habitats. By the time of listing, approximately 1,000 birds remained among eight discrete populations. Recovery work began with a 1995 management plan prior to listing. An official recovery plan was adopted in 2012. Activities included land acquisition, public and private habitat restoration, population augmentation, hazard management, and population monitoring. As recovery management intensified, the population initially stabilized. Recent declines to the lowest counts ever appeared to result from catastrophic wildfires. The Washington Administrative Code provides for the fish and wildlife commission to classify native species as sensitive, threatened or endangered based solely on biologic status. Once listed, the commission receives periodic status reports to review the classification determination. Following the Columbian sharp-tailed grouse status report in December 2017, the commission guided the agency to commence rule-making to consider a decision to up-list from threatened to endangered. This paper will discuss the factors influencing the commission guidance and the objectives that could be achieved by reclassification.

SHARP-TAILED GROUSE POPULATION RESTORATION THROUGH TRANSLOCATION: LESSONS FROM NEVADA

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Abstract. Prairie grouse translocations have shown variable success in recent decades. Studies investigating how translocation influences post-release performance across different life history stages of translocated grouse will likely help guide actions that enhance post-release reproduction and survival. We carried out two Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*) reintroduction projects in Nevada from 1996 – 2017 and identified methodology that could improve success rates of future translocations. We found the best candidates for translocation are yearling grouse and females that were inseminated at the source population prior to translocation. Furthermore, a relatively few established males found at established leks at the release sites were responsible for the majority of egg fertilizations in nests of translocated females. These results highlight the potential of success by augmenting small populations compared with reintroduction following extirpation. Lastly, we found evidence that offspring from marked translocated individuals outperformed their parents. After accounting for this effect, predictions of population growth from demographic rates corresponded with modeled predictions using observed lek counts while accounting for detection probability. We identified underlying mechanisms of population recovery despite poor measured vital rates derived solely from translocated individuals. Our findings are preliminary and provided to meet the need for timely best science.

ASSESSING LEK ATTENDANCE OF MALE GREATER SAGE-GROUSE USING FINE-RESOLUTION GPS DATA

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Abstract. Counts of males displaying on breeding grounds are the primary data used to assess population trends in lekking grouse species. Despite the importance of male lek attendance (i.e., the proportion of males on leks available for detection) influencing counts, patterns of interannual and intraseasonal variability in attendance rates are not well understood. We used GPS telemetry data from male greater sage-grouse (*Centrocercus urophasianus;* n = 67) over 5 lekking seasons (2013–2017) at 8 study sites in Nevada to estimate lek attendance rates. Average timing of peak attendance occurred on 16 April but varied from 16 March (2014) to 21 April (2016) throughout the study period. Overall, adult males attended leks at higher rates (0.683 at peak) and earlier in the season (19 March) than subadults (0.421 at peak on 19 April). Peak attendance probability increased with increasing winter precipitation. Daily probabilities of lek switching differed between adults (0.019 at peak on 3 March) and subadults (0.046 at peak on 22 March), and lek switching was negatively related to distance to nearest lek. Although attendance rates vary within season and among years, they may be predictable and useful for correcting counts. Findings are preliminary and provided for timely best science.

REFINING ESTIMATES OF LEKKING SAGE-GROUSE DETECTION PROBABILITIES BY INTEGRATING ERROR FROM SIMULTANEOUS GROUND- BASED AND AERIAL INFRARED COUNTS

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Abstract. Counts of males attending leks form the basis for long-term monitoring of greater sage-grouse abundance trends. Sage-grouse lek counts are imperfect, however, and subject to two primary forms of error in population estimation: 1) variation in the observed count from males that attend a lek and are available to count; and 2) variation in proportion of males attending leks. Here, we focus on the former (detection probability) through a sampling design that estimated differences in lek counts in Idaho, northeastern Nevada, and northeastern California obtained by: 1) double-blind ground observers versus an aerial-mounted integrated infrared imaging system (IRIS); and 2) IRIS versus known numbers of farmed game-birds physically tethered to 'pseudo-leks' that acted as a surrogate for true lek size. We found low error in both ground and IRIS derived counts that increased with the proportion of sagebrush cover on leks, and report an estimate of detection probability based on expected error propagation between ground and IRIS counts and IRIS and pseudo-lek counts. When combined with error arising from variable attendance, our estimates of detection can help correct naïve estimates of maximum lek counts. Findings are preliminary and provided for timely best science.

MODELING LEK TRENDS WITH N-MIXTURE MODELS: DO WE STILL NEED REPEATED COUNTS?

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Abstract. Lek counts are important for monitoring greater sage-grouse (*Centrocercus urophasianus*) populations, and *N*-mixture models may account for detectability (*p*) when estimating population size (*N*) and trends (λ). However, simulations evaluating efficacy of *N*- mixture models and informing survey effort (i.e., number of repeated counts) typically do not consider scenarios with systematic trends in detectability. We used global positioning system (GPS) data from greater sage-grouse (*Centrocercus urophasianus*) to inform simulations of the detection process for lek counts, and we created scenarios where *p* either varied randomly or declined linearly across years. Peak count models consistently underestimated *N* by >40%. *N*- mixture models without auxiliary data underestimated *N* to a lesser degree due to unmodeled effects of age and availability for detection. Nevertheless, estimates of λ from both models were unbiased and similar when *p* varied randomly each year. When *p* systematically declined across years, *N*-mixture models estimated λ with little bias whereas peak count models underestimated λ. However, bias in λ from *N*-mixture models increased as count frequency decreased. Additionally, we obtained accurate estimates of *N* and λ when correcting counts with auxiliary data. Evaluating population trend models with systematic trends in *p* may better reveal potential biases and inform survey design.

HOW MANY LEKS DOES IT TAKE? EVALUATING MANAGEMENT EFFECTS AT LOCAL SCALES

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Abstract. Concern over declines of greater sage-grouse (*Centrocercus urophasianus*) has resulted in unprecedented conservation efforts. One important and unresolved issue is how to efficiently monitor populations at spatial scales that are typically targeted for habitat management. Most research has addressed grouse responses to management using individually-marked birds, however these are resource-intensive and are impractical to replicate in many circumstances. Lek counts have traditionally been used to monitor grouse populations, but at large spatial- and temporal-scales. We evaluated the ability of count data to assess population trend at scales typical of habitat projects. We used N-mixture modelling combined with simulations to evaluate sample sizes required to detect a range of management effects (change in population growth rate, λ) under a control-impact study design. All simulations were informed by Oregon lek count data, and included random variation in both annual abundance and detection. We found that a minimum of 7 control and 7 treatment leks were sufficient to detect a 0.05 increase in λ; smaller effect sizes were not detected with < 20 leks. N-mixture models produced a marginal improvement over Poisson regressions (max of 3 lek counts), but were markedly more precise than regressions based on an annual single randomly-selected lek count.

INFORMING LONG-TERM MONITORING OF GREATER SAGE-GROUSE POPULATIONS USING A MULT-SCALED CLUSTERING FRAMEWORK

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Abstract. Greater sage-grouse populations cycle, and declines have been observed for several decades. Population monitoring is important for managers, but few tools exist to improve detection of persistent non-cyclic declines, both locally and regionally. We developed hierarchical, regionalized polygons of clustered leks by capturing similar habitat conditions. This multi-scaled, hierarchical framework provides a systematic and statistically repeatable approach to support long-term monitoring of sage-grouse via counts of males on leks. Our study areas included Nevada and Wyoming, which have disparate habitat conditions. We clustered sage- grouse leks and partitioned the landscape using multiple spatial scales of biologically relevant landscape characteristics, habitat connectivity, inter-lek movement distances (i.e., isolation-by- distance), and barriers to movement. We used these components to inform the Spatial "K"luster Analysis by Tree Edge Removal (SKATER) graph theory approach. In Nevada, the finest-scaled clusters captured 90% of sage-grouse movements when we linked a single "home" cluster polygon to individual sage-grouse home ranges, while mid-level scales captured 97% - 99% of movements within home clusters. Hierarchical clusters will support management and research needs relying on scale-dependent questions, including population monitoring and habitat modeling. As a result, we are expanding this framework across the sage-grouse range to provide new and consistent management tools.

GREATER SAGE-GROUSE POPULATION VIABILITY ANALYSIS: MANAGEMENT AREAS AND LEK CLUSTERS ACROSS HIERARCHICAL SCALES

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Abstract. Management area-based population trends are relevant to conservation as these boundaries are used to implement management plans; conversely, biologically-assigned population trends are likely to be more similar and yield more precise trend estimates. We investigated trends for Wyoming Greater Sage-grouse populations at multiple scales using population viability analysis to determine local- and meta-population dynamics. Our objective was to use lek count data to determine population growth rates (λ) by management boundaries (local Working Group Areas, Core Areas, and Core Areas by Working Group Areas) and biologically-defined sub-populations (hierarchical lek clusters). We used average peak male counts per lek annually (1993-2015) to test density-independent and density-dependent models to determine λ for each population. We found that when Core Area status was investigated within Working Group Areas, the two populations trended similarly and agreed with the overall trend of the Working Group Area. However, at the local scale (individual Core Areas), Core Areas within the same Working Group Area often trended differently, with a few large Core Areas driving the overall trend. Our approach will allow managers to identify local populations that are driving meta-population trends and may inform prioritization of areas for management efforts.

HIGH STAKES AND HIGH VARIABILITY: SAGE-GROUSE POPULATION MONITORING FRAMEWORK WITIN A STOCHASTIC ENVIRONMENT

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Abstract. Identifying drivers responsible for temporal variation in population abundance is a fundamental goal of population ecologists. For effective conservation, understanding whether variation is associated with natural environmental stochasticity or anthropogenic disturbances is crucial, yet difficult to achieve. We describe a novel, hierarchical monitoring framework for greater sage-grouse (*Centrocercus urophasianus*) that utilizes information from lek counts across nested spatial scales to identify when local declining populations fall out of synchrony with larger population aggregations. Importantly, the framework provides signals for managers to identify populations in need of conservation actions aimed at halting local declines and avoids implementing ineffective actions in areas where population decline is the result of drivers operating at larger spatial scales, such as drought. We provide two clear examples of early warning signals associated with disturbances that operate at two different spatial scales (i.e., wildfire and energy development). We also demonstrate the potential to evaluate restoration effectiveness by signaling when local populations fall back into trend synchrony with those at larger spatial scales. Although this framework was developed for Nevada and California, with modifications it can be applied to sage-grouse populations in other areas of their range with heterogeneous disturbance and climatic regimes.

STREAMLINING WORKFLOWS FOR SAGE-GROUSE POPULATION ANALYSES IN POPR

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Abstract. Sage-grouse population analyses require complex data structures and methods. Organizing data and performing the analyses can be substantial annual task. Yet, there are many common themes across different types of analyses and agency data sources. It may also be useful for multiple states or agencies to provide results from analyses across a common framework with common end points. We present a website driven workflow management tool for managing sage-grouse data and performing analyses. We intend to provide the website as a tool for analyses regularly used in sage-grouse monitoring. The website performs several types of analyses such as N-mixture models, high count analyses, and integrated population models. But more importantly, the website can be expanded as the breath of research provides additional alternatives for analysis. Finally, results of analyses are displayed in tables and graphs for easy use in reports and publications.

MALADAPTIVE NEST-SITE SELECTION BY GREATER SAGE-GROUSE IN A GRAZING-MODIFIED LANDSCAPE

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Abstract. Animals are expected to choose habitats that maximize their fitness. Yet in human-modified landscapes, habitat choices might not always lead to increased fitness because animals select low-quality habitats when high-quality ones exist. We (1) evaluated how greater sage-grouse females selected nesting habitats based on sagebrush type, along with grazing related linear and point features, and other biotic, abiotic mechanisms, (2) compared habitat selection information with results for habitat-specific nest survival estimates, and (3) used our results to evaluate how best to conserve this species in a grazing- dominated landscape. Nest-site selection appears to be maladaptive: nest survival was three times lower in the most-preferred sagebrush type than it was in the least-preferred sagebrush type. Nest survival for nests placed >100 m away from the nearest fence was five times higher than the rate for nests 1 m from a fence. Nest survival was negatively related to the density of cow defecation piles near nest sites. Biotic vegetation variables had contrasting effects on selection and survival. Our results provide evidence that basin big sagebrush acts as an ecological trap while mountain big sagebrush is underutilized. Results also inform mitigation strategies seeking to reduce predation levels on nests through fence modifications.

GREATER SAGE-GROUSE HABITAT AND DEMOGRAPHIC RESPONSE TO GRAZING BY NON-NATIVE UNGULATES

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Abstract. Management discussions regarding impacts of grazing by livestock and feral horses on Greater Sage-grouse often focus on negative impacts to habitat. While the linkage between sage-grouse demographics and habitat is well documented, quantifying direct impacts of non-native grazing on sage-grouse has been fraught with difficulties. These struggles include the logistical constraints and cost associated with monitoring multiple sage grouse populations across large landscapes and an adequate temporal span to detect responses. Building on 20 years of previous research we collected data that began 1 year prior and 4 years post a large removal of feral horses. We investigated the response of sage-grouse demographics, movements, and habitat to grazing. We found little evidence that sage-grouse are avoiding areas with high intensities of grazing by either horses or livestock. Likewise, there was little support for an effect of grazing on nest survival. We observed lower chick survival rates in areas that had higher grazing intensities of horses, livestock, and combinations of both. We also documented negative effects of grazing on the habitat. These results suggest that high intensities of grazing are negatively impacting grouse populations, and could assist land managers issuing grazing permits or managing feral horses.

PHYSIOLOGICAL RESPONSES TO GRAZING PRESSURE: INVESTIGATING FEATHER CORTICOSTERONE AS A MEASURE OF STRESS RESPONSE IN GREATER SAGE-GROUSE

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Abstract. Glucocorticoid hormones are used to assess stress response to environmental changes is captive and wild animals. For birds, corticosterone is deposited in feathers during growth. We measured feather corticosterone (fCORT) levels in over 280 Greater Sage-grouse from three areas in Northern Nevada and Southern Oregon from 2013-2017. These sites allow for comparison of different grazing regimes of cattle and feral horses. We sampled breast feathers of female sage-grouse at the time of capture, in March each year. These feathers were grown during November-December, thus, fCORT is an index of stress during this time. The majority of sage- grouse research takes place in the breeding season, leaving other parts of their annual cycle under-studied. We found site and year specific mean temperature for November-December explained over half of the spatial-temporal variation in fCORT. This is consistent with work in other species, where this hormone is temperature sensitive. After controlling for this weather effect, we observed peaks in fCORT associated with high grazing pressure. These results help fill in gaps about the physiological response of sage-grouse to grazing pressure and other environmental variables. Using fCORT as an index gives us insight into times of the year that are the most difficult to study.

THE IMPACTS OF GRAZING ON GREATER SAGE-GROUSE POPULATION DYNAMICS AND HABITAT IN CENTRAL MONTANA

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Abstract. In September 2015, the US Fish and Wildlife Service (USFWS) determined that the greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse) did not need to be listed for protection under the Endangered Species Act because of the collaborative conservation efforts among agencies and private landowners. These conservation efforts must be maintained to minimize future declines in populations; the status of greater sage- grouse will be re-evaluated by USFWS in 2020. State and federal agencies implement rotational livestock grazing systems under the assumption that they benefit wildlife and their habitat. Alternatively, livestock grazing is assumed to negatively impact wildlife habitat by others. We are testing these assumptions for sage-grouse in central Montana using a 10-year, large-scale observational study in which we investigate the impacts of rotational grazing systems on sage-grouse population dynamics and habitat. Partnerships with private landowners and agencies have been the key to conservation success as well as to our research efforts. In this presentation, we give an overview of this study, describe the partnerships that make this work possible, and show some preliminary results. This information will help inform future conservation efforts for this species.

EFFECTS OF LIVESTOCK GRAZING ON SAGE-GROUSE NESTING ECOLOGY IN CENTRAL MONTANA

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Abstract. Widespread, long-term population declines in greater sage-grouse (*Centrocercus urophasianus*) have elicited concern about negative effects of livestock grazing on sage-grouse populations. We tested predictions arising from several commonly hypothesized mechanisms by which livestock may affect nesting sage-grouse and evaluated how recently implemented rotational grazing systems affected nesting habitat quality as part of a large-scale, replicated, natural experiment in central Montana. In spite of some evidence nest survival was positively associated with residual vegetation height, evidence for effects of livestock presence and indices of local livestock use on nest site selection and survival was equivocal at best. In contrast, we found strong evidence for negative effects of major roads and extended periods of heavy precipitation. Though nests on rotationally grazed ranches displayed a trend toward greater survival rates, the evidence for an effect was weak and there was no evidence that rest from grazing (≥12 months) increased nest success. Furthermore, grazing management had negligible effects on herbaceous vegetation height and cover relative to annual variation induced by precipitation. Management of sage-grouse nesting habitat in this region should focus on conserving areas of adequate shrub cover and preventing further fragmentation by roads.

NATIVE POLLINATORS: THE EFFECTS OF LIVESTOCK GRAZING ON RANGELANDS IN MONTANA

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Abstract: Although native pollinators on rangelands serve, in part, as food at higher trophic levels, their primary ecosystem function is pollination. A large portion of the forbs and shrubs found in grouse diets rely on native pollinators to maintain their populations. With 70% of western U.S. rangelands grazed by livestock, understanding how this grazing affects native pollinators is a key component to managing for productive grouse habitats, yet this interaction is not well understood. In this study, we are investigating how rest-rotation cattle grazing influences both diversity and abundance of pollinators, including bees and wasps, syrphid flies, butterflies, and moths. We deployed colored pan traps at two research sites for seven to 10 weeks during the spring of 2016 and 2017. To date, we have collected 25,563 specimens from 32 *Genera*, documented one range expansion, and report that bee abundance is neutral to positively associated with areas moderately grazed by livestock. We will be collecting again during the 2018 field season to produce a three years novel data set to begin better understanding the relationship between livestock grazing and pollinators.

RELATIONSHIPS BETWEEN SONGBIRD POPULATIONS AND PRODUCTIVITY IN SAGEBRUSH-STEPPE OF MONTANA

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Abstract. A large portion of sagebrush-steppe across the west is used for grazing of domestic livestock. Rest-rotation grazing systems have been used as a conservation management tool, most recently, by the Natural Resource Conservation Service - Sage Grouse Initiative (SGI). The goal of SGI is to encourage private landowners to graze livestock more sustainably in order to maintain or improve habitat for greater sage-grouse (*Centrocercus urophasianus*), as well as to improve rangeland productivity. Songbirds are often used as biological indicators including the assessment of the health of sagebrush environments. However, often only adult songbird abundance or density is considered, without examination of other aspects of population dynamics, specifically breeding status. We measured adult density and nest density of Brewer's and vesper sparrows in central Montana across five breeding seasons to determine if adult density reflects songbird breeding status on the landscape. We also compare these parameters between lands enrolled in SGI versus those that were not enrolled to further evaluate conservation managed grazing regimes.

SOUND LEVELS IN SAGEBRUSH HABITATS IN WYOMING AND THE INFLUENCE OF ANTHROPOGENIC SOUNDS ON GREATER SAGE-GROUSE

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Abstract. We measured sound levels at 26 locations in WY from 2013–2017, six in rural, undeveloped areas and 20 in an active natural gas field. All sites were in sagebrush habitats. Our measurements in undeveloped areas revealed a very quiet acoustic environment. Mean sound levels at six rural sites were: L_{90} = 15 dBA (background sound level), L_{50} = 20 dBA (median sound level), and L_{eq} = 26 dBA (energy average sound level). In the gas field, mean sound levels were L_{90} = 23 dBA, L_{50} = 26 dBA, and L_{eq} = 30 dBA. Sound levels in the gas field were strongly correlated with distance to gas field activity. Significant relationships between elevated sound levels and declines in counts of male sage-grouse at leks were documented in the gas field. At leks where L_{50} >25 dBA, mean trend was -0.255 (92% were declining), and at leks where L_{50} <25 dBA, mean trend was +0.020 (90% were stable or increasing). Current management practices rely on a "not-to-exceed 10 dBA over background" approach, and our analysis suggests that this approach is appropriate. However, it is essential that accurate background levels be used, and establishing such is often difficult or impossible due to ongoing activities.

ENERGY DEVELOPMENT AND CLIMATE CHANGE IN SOUTHWEST WYOMING: SIMULATING CONSEQUENCES FOR SAGE-GROUSE

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Abstract. Multiple environmental stressors impact wildlife populations, but we know little about their cumulative and combined influences on future population outcomes. Further, we have a limited understanding of the indirect influences of avoidance, habitat selection, and demography on future wildlife distribution and abundance. For Greater Sage-grouse in southwest Wyoming, we projected oil and gas development footprints, and climate-induced vegetation changes ~50 years into the future. We re-calculated Sage-grouse habitat selection maps to dynamically modify future habitat quantity, quality, and configuration. We allowed simulated grouse to respond to changing habitat conditions through demographic consequences, limited avoidance of poor quality habitat, and an ability to track higher selection habitat through time. The inclusion of indirect responses to oil and gas infrastructure resulted in substantive changes in distribution and abundance, when accumulated through the regional population and over several decades. Incremental losses due to individual stressors accumulated over ~50 years and reduced the population by up to ~40%, although average annual population declines were not large. When combined, development and climate-induced vegetation changes additively reduced abundance by up to half of the original size. Cumulative impacts need to be broadly considered through space and time to understand the potential implications of incremental landscape change.

GREATER SAGE-GROUSE RESPONSE TO BENTONITE MINING IN THE BIGHORN BASIN OF MONTANA AND WYOMING

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Abstract. The greater sage-grouse has undergone range contractions and population decline because of anthropogenic disturbances; yet, there is little information on the impacts of mining. In the Bighorn Basin, bentonite mining is a growing source of disturbance contributing to loss of habitat. We evaluated sage-grouse response to active and reclaimed bentonite mining, relative to nesting, brood-rearing, adult breeding, and adult winter habitat, through resource selection and survival analyses, based from females (*n* = 321) monitored from 2011–2015. A greater proportion of our monitored sample was exposed to mining disturbance during the winter (65%) than during other seasons (range = 25%–34%). We observed avoidance of all mining disturbance for selection of nesting habitat (*n* = 378 nests), avoidance of active mining for brood-rearing habitat (*n* = 754 locations), avoidance of all mining for adult breeding habitat (*n* = 1,978 locations), and avoidance of all mining for adult winter habitat (*n* = 1,365 locations). We also observed increased brood failure (*n* = 48 events) and adult breeding season mortality (*n* = 62 events) associated with active mining disturbance but did not have evidence for effects on nest success (*n* = 207 events) and adult winter survival (*n* = 31 events).

GREATER SAGE-GROUSE RESPONSE TO TWO 230-kV TRANSMISSION LINES

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Abstract. Greater sage-grouse are a landscape-level species that require large tracts of intact sagebrush habitats. The increase in demand for energy generation, transmission, and distribution within sage-grouse habitats in the western U.S. has the potential to affect this species. We monitored 346 female sage-grouse from 2009 to 2014 to evaluate the potential effects of two 230-kilovolt H-frame transmission lines on sage-grouse habitat selection and demography. We had a unique opportunity to model the effect of the two transmission lines in two different study areas simultaneously using consistent habitat data. We determined the effect of transmission lines on habitat selection was confounded by other habitat features at the landscape scale. However, at the local scale, sage-grouse selected against habitats in close proximity to transmission lines during the brood-rearing and summer periods, although nest site selection was not influenced by the presence of transmission lines. In addition, nest and female survival were reduced within habitats in close proximity to transmission lines. We combined the habitat selection and demography results to evaluate habitat function within 2 km of the two transmission lines and found evidence to suggest that habitats within 0.5 km of a transmission line were associated with lower survival and lower relative probability of use. We suggest future power line placement consider potential impacts to sage-grouse habitat selection and survival parameters. We recommend systematic comparisons among power line voltages; structure type; and structure height to further elucidate potential effect distances from power line rights-of-way to greater sage-grouse use areas.

FACTORS DRIVING GREATER SAGE-GROUSE TRENDS IN THE EASTERN PORTION OF THEIR RANGE

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Abstract. Degradation of sagebrush (*Artemisia* spp.) habitat has occurred throughout the range of Greater Sage-grouse (*Centrocercus urophasianus*; hereafter "sage-grouse"). Areas with greater loss of sagebrush habitat are avoided by sage-grouse and congruent with lower demographic rates and lek extirpation. Non-habitat factors, such as hunting seasons, West Nile virus (WNv), and Common Ravens (*Corvus corax*; hereafter "raven"), may also influence sage- grouse populations. We evaluated the effects of habitat and non-habitat factors on lek counts of sage-grouse populations in the Powder River and Wyoming Basins from 1995–2014. Instantaneous growth rate (r) was positively associated with precipitation and negatively with WNv prevalence in both populations and negatively with raven numbers in the Wyoming Basin population. Anthropogenic features were negatively associated with initial lek counts (Λ) and time-varying carrying capacity (K) for both populations. The Wyoming Basin population had negative associations with tree proportion on Λ and fire proportion on K. We did not include both WNv and hunting season variables in any model, because both were only quantifiable at the spatial scale of the population annually. Hunting season variables were not informative for the Wyoming Basin, and prevalence of WNv fit the data better than hunting season variables in the Powder River Basin.

BROAD-SCALE OCCURRENCE OF A SUBSIDIZED AVIAN PREDATOR: IMPLICATIONS FOR REDUCING IMPACTS OF RAVENS ON SAGE-GROUSE

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Abstract. Common ravens (*Corvus corax*) are a predator of eggs and chicks of numerous species including greater sage-grouse (*Centrocercus urophasianus*). Raven abundance and distribution is increasing within sagebrush ecosystems as a result of anthropogenic resource subsidies. Despite concerns about subsequent predation pressure on sage-grouse, broad-scale information about raven populations remains lacking. We used hierarchical occupancy models to map raven distribution in response to natural and anthropogenic landscape covariates using >15,000 point count surveys occurring within the Great Basin region, 2007–2016. Anthropogenic factors contributing to greater raven occurrence included increased road density, presence of transmission lines, agricultural activity, and presence of roadside rest areas. Natural landscape characteristics included lower elevations with greener vegetation (NDVI), greater stream and habitat edge densities, and lower percentages of big sagebrush (*A. tridentate spp.*). Interactions between anthropogenic sources of nesting substrate and food subsidies suggested that raven occurrence increased multiplicatively when resource subsidies co-occurred. Average raven occurrence within the study area was ~0.83. We mapped predictions of raven occurrence across the Great Basin, and we show how model outputs can be used to guide management decisions where raven distributions overlap with breeding sage-grouse concentration areas. Findings are preliminary and provided for timely best science.

IDENTIFYING ECOLOGICAL TRAPS FOR TARGETED PINYON-JUNIPER REMOVAL IN GREATER SAGE-GROUSE HABITAT

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Abstract. Pinyon (*Pinus* sp.) and juniper (*Juniperus* sp.) expansion into sagebrush ecosystems represents a threat to greater sage-grouse (*Centrocercus urophasianus*) populations. Sparse pinyon-juniper cover within areas dominated by sagebrush with relatively high primary plant productivity leads to ecological traps as sage-grouse select these areas regardless of fitness consequences. We mapped ecological traps in Nevada and northeastern California and found these areas accounted for 14% of available high productivity habitat within 5-km of leks. On average, leks contained 1,217 ha of conifers (15% total area), with 543 ha (7%) classified as phase 1 encroachment and 51 ha (1%) ecological trap. We report impacts of proximity to and total amount of surrounding ecological trap area on lek size and lek persistence. Leks with a ten- year mean attendance of <20 males (n = 401) contained an average of 63 ha of ecological trap areas while those with >20 males (n = 170) consisted of 23 ha. We also mapped ecological traps in relation to modeled predictions of high-use areas by sage-grouse to provide managers with a decision support tool for planning pinyon-juniper treatments aimed at ameliorating risk of sage- grouse mortality. Findings are preliminary and provided for timely best science.

THE RESPONSE OF GREATER SAGE-GROUSE TO THE RECLAMATION OF AN OIL AND GAS DEVELOPMENT LANDSCAPE

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Abstract. Assumed benefits of reclamation of sagebrush (*Artemesia* spp.) habitat for greater sage-grouse (*Centrocercus urophasianus*) populations following oil and gas development remains an unproven hypothesis. To improve outcomes, we need to understand how sage-grouse respond to reclamation of habitats altered by oil and gas extraction. In 2017, we initiated research on sage-grouse in a landscape-scale natural gas (NG) reclamation area. We selected a study area in the Northeast, Wyoming that has undergone large-scale reclamation of NG features. Our study area includes a gradient of disturbance types, representing different stages of energy development; non-impacted sites (Control), reclaimed sites (Treatment 1), and active energy development sites (Treatment 2). Our study area overlaps with previous research that focused on impacts of NG development on sage-grouse populations. Our primary objectives are to 1) assess female habitat use of reclaimed areas during the reproductive season, compared to adjacent active development and non-impacted habitats, 2) assess movements of sage-grouse in reclaimed areas compared to movements in active development and non-impacted area, and 3) and compare fitness responses (e.g., nest success) across these gradients of development. We currently have 45 solar GPS-UHF transmitters deployed on sage-grouse. We will present preliminary data and other details of our on-going research.

BEHAVIOR OF FEMALE GROUSE: ARE WE MISSING SOMETHING IMPORTANT?

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Abstract. Most breeding season observations of intraspecific interactions in grouse are male- male (territoriality and/or dominance) or male-female (mate selection and/or breeding behavior). However, female sooty grouse (*Dendragapus fuliginosus*), dusky grouse (*D. obscurus*), and spruce grouse (*Falcipennis canadensis*) utter vocalizations which appear to aid in female-female spacing and/or territorial interactions around their nesting sites. Although this type of behavior is poorly documented for sage-grouse (*Centrocercus* spp.) and prairie grouse (*Tympanuchus* spp.), it has been suggested that dominant females may delay or prevent subordinate females from copulating on leks. I have observed female greater prairie-chickens (*T. cupido*) in Colorado and sharp-tailed grouse (*T. phasianellus*) in Washington uttering calls on what appeared to be their nesting areas. In spring 2018 I recorded calls of female greater sage-grouse (*C. urophasianus*) in north-central Washington in a similar context and was able to elicit apparent 'aggressive' responses from females with playbacks of the call. Though anecdotal, my observations suggest that female greater sage-grouse may exhibit spacing behavior during the nesting season. If this is the case, there could be numerous ramifications.

GREATER SAGE-GROUSE REPRODUCTION AND MOUNTAIN BIG SAGEBRUSH MANAGEMENT IN EASTERN IDAHO

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Abstract. Resource managers and users in eastern Idaho want to better understand how brush management actions affect sage-grouse populations. Therefore, we are investigating 1) which habitats sage-grouse select and succeed in for reproduction, 2) how the shrub structure of those habitats relates to that of stands with various shrub management histories, and 3) how those results fit with the habitat management guidelines in several high-elevation sagebrush landscapes across eastern Idaho. For this talk, we will focus on relating selection and demographics to brush reductions with fire (wild and prescribed) on the Sand Creek desert, a high-elevation, mountain big sagebrush landscape north of Idaho Falls. Nesting hens selected habitat patches with higher total shrub ($\bar{x}$ = 48% cover) and sagebrush ($\bar{x}$ = 27% cover) canopy cover than was available at random. Apparent nest success was relatively high ($\bar{x}$ = 59%) and increased as total shrub canopy cover increased (successful nests $\bar{x}$ = 50% cover, failed nests $\bar{x}$ = 43% cover). When we compared modeled nest site selection and success to shrub cover in burns of various ages, we found that nesting was most likely to be successful in stands with brush that had recovered to pre-fire conditions (≥20 years since burn).

GLOBAL POSITIONING SYSTEM TRACKING DEVICES CAN DECREASE GREATER SAGE-GROUSE SURVIVAL

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Abstract: Wildlife researchers assume that tracking devices do not alter behavior or demographics, yet violations can bias population inference and misinform conservation actions. GPS tracking units have greatly improved our understanding of space use compared to VHF transmitters, but information gaps remain regarding effects on demographic estimates. We evaluated survival using VHF and GPS units on >1,200 Greater Sage-Grouse (*Centrocercus urophasianus*), across multiple populations within the Great Basin. We also assessed unit weight as a percent of body mass (PBM). Survival was generally lower for GPS compared to VHF marked grouse, and relative differences varied among sexes, age classes, and seasons. We attributed decreased survival to specific features of GPS units that might increase susceptibility to predation such as greater unit weight, unit placement, and a reflective solar panel. PBM was negatively associated with survival of GPS-marked birds, which likely stemmed from altered flight dynamics. Model predictions indicated that rump-mounted GPS units >2% body mass negatively affected survival, which might be a useful threshold for field applications. Our results indicate that demographic parameters derived from GPS should be interpreted with caution, and design modifications aimed at reducing survival impacts would be beneficial. Findings are preliminary and provided for timely best science.

ESTABLISHING A THIRD SAGE GROUSE POPULATION IN WASHINGTON STATE; WHAT WE'VE LEARNED AND WHERE WE ARE AT

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Abstract. Washington's sage-grouse population declined in distribution and population size due to conversion of shrub-steppe to cropland, and degradation and fragmentation of the remaining habitat. Sage-grouse were listed as threatened by the state of Washington in 1998, at which time the population was estimated at 1,011 and occupying only 8% of its historic range. With only two relatively isolated endemic populations remaining, a key recovery task is expansion of the population into non-occupied recovery units. From 2008 through 2015 WDFW, in coordination with ODFW, BLM, and Spokane Audubon, translocated 280 sage-grouse (145 males and 135 females) from southern Oregon to public land in the Crab Creek recovery unit. All females and subset of males were fitted with transmitters to assess movement, habitat use, productivity, and survival. Signs of success were not observed until 2010 when onsite breeding was confirm with five nests from previously released hens. Additionally, in 2010 three males were observed strutting post translocation. In 2011 a lek formed north of the 2010 site; in 2012 it shifted to a nearby restored agricultural field where it remains. Though there have been setbacks and this population is not secure, the first phase of this re-introduction project has been relatively successful.

ADDRESSING THE MANAGEMENT NEED FOR COORDINATED AND COLLABORATIVE STRATEGIC CONSERVATION AND RESTORATION INVESTMENTS IN THE SAGEBRUSH BIOME.

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Abstract. Spanning 13 western states and two provinces, sagebrush has been referred to as one of the most imperiled biomes. Loss and degradation of sagebrush has caused declines in distribution and abundance of sagebrush dependent wildlife. Numerous petitions to list species under the federal ESA have resulted. If current habitat trends are not reversed, additional petitions are anticipated. This species-by-species approach is not sustainable. Thus, a more proactive and holistic approach that links local actions to biome-wide planning and objectives is needed. In this approach, human relationships, organizations, and social networks are needed to address ecologically meaningful problems at appropriate spatial and temporal scales. Success will require a shared understanding of biome conditions, threats, and opportunities. Additionally, the ability to link biome-wide science and data to local science and data is requisite. This presentation will describe a new approach to managing the sagebrush biome that incorporates these ideas. Developed by a multi-partner team, the Science Framework for Conservation and Restoration of the Sagebrush Biome" presents a strategic, multi-scale science framework to target locations for management activities and determine effective management strategies. This new approach is a paradigm shift in sagebrush management across the biome and is leading to new conservation partnerships.

DELINEATION OF GENETIC POPULATIONS AND CONNECTIVITY IN GREATER SAGE-GROUSE

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Abstract. Conservation objectives for Greater Sage-grouse (*Centrocercus urophasianus*) and their sagebrush (*Artemisia* spp.) habitats require identifying and designing strategies to maintain a set of viable and connected populations. Therefore, it is important to (1) define boundaries of biologically meaningful breeding populations, and (2) quantify how those populations are interconnected across regions of lower densities and less suitable habitat. To conduct our genetic analysis, we collected feather samples from leks across the species range and genotyped them using 15 microsatellite loci. Our analysis included 7005 unique individuals from 1417 leks providing us with a fine-scale comprehensive genetic data set. We have employed numerous genetic clustering clustering algorithms (e.g., STRUCTURE, TESS, sPCA, DAPC) and discuss the similarities and differences in outcomes. In general, we found that the Washington and Bi-State populations represent unique and divergent populations, with the remaining populations showing significant patterns of isolation-by-distance. Though still in preliminary stages, we will present our attempts to delineate biologically meaningful populations based on multiple analytical approaches.

QUANTIFYING FUNCTIONAL CONNECTIVITY: THE ROLE OF BREEDING HABITAT, ABUNDANCE, AND LANDSCAPE FEATURES ON RANGE-WIDE GENE FLOW IN SAGE-GROUSE.

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Abstract. Functional connectivity, quantified using landscape genetics, can inform conservation through the identification of factors linking genetic structure to landscape mechanisms. We used breeding habitat metrics, landscape attributes and indices of grouse abundance, to compare fit between structural connectivity and genetic differentiation within five sage-grouse Management Zones (MZ) using microsatellite genotypes from 6,844 Greater Sage-Grouse (*Centrocercus urophasianus*) collected across their 10.7 million-km^2 range. We estimated structural connectivity using a circuit theory based approach where we built resistance surfaces using thresholds dividing the landscape into 'habitat' and 'non-habitat'. Nodes were clusters of sage-grouse leks. As hypothesized, MZ-specific habitat metrics were the best predictors of differentiation. Interestingly, inclusion of grouse abundance indices did not greatly improve model fit in most MZs. Functional connectivity of breeding habitat was reduced when probability of lek occurrence dropped below 0.25 and 0.5, thresholds lower than those previously identified as required for the formation of breeding leks, which suggests that individuals are willing to travel through undesirable habitat. Model validations confirmed predictive ability across MZs. We produced resistance maps that spatially depict the strength of range-wide gene flow and can help direct conservation actions to maintain and restore functional connectivity for sage-grouse.

THE GENETIC NETWORK OF GREATER SAGE-GROUSE: RANGE-WIDE IDENTIFICATION OF KEYSTONE HUBS OF CONNECTIVITY

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Abstract. Genetic networks can characterize complex genetic relationships among groups of individuals. Network centrality indices can be used to identify nodes most important to the overall genetic connectivity of the network, toward which scarce resources can be guided. Greater sage-grouse (*Centrocercus urophasianus*) leks must remain connected by genetic exchange for population persistence. We genotyped 5,950 individuals, from 1,200 leks distributed across the entire species' contiguous range. We found a small-world network composed of 458 nodes, some of which were hubs—i.e., nodes facilitating gene flow across the network—and others of which were spokes—i.e., nodes where connectivity is served by hubs. Hubs contained the greatest genetic diversity. Using network centrality indices, we identified hub nodes of greatest conservation importance and keystone nodes with high centrality despite low lek counts. Hub and keystone nodes were located across the range, with concentrations found central to the range: especially in northeastern, central, and southwestern Wyoming as well as eastern Idaho. The loss of hub or keystone nodes could lead to the disintegration of the network into smaller, isolated sub- networks. Conserving hub and keystone nodes should conserve genetic diversity and maintain network connections that ensure a resilient and viable population.

GENOMIC INSIGHTS INTO NEUTRAL AND ADAPTIVE VARIATION IN SAGE- GROUSE: IMPLICATIONS FOR ECOLOGY AND CONSERVATION

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Abstract. Identifying and preserving unique genetic adaptations is an important consideration for conservation and management strategies, particularly for species with geographic distributions that span diverse ecological conditions. Contemporary sequencing technology has now made it possible to probe the genome for potential genetic adaptations with unprecedented resolution in species of conservation concern. We recently completed sequencing the genomes of both Gunnison Sage-grouse (*Centrocercus minimus*) and Greater Sage-grouse (*C. urophasianus*). We are leveraging these new genomic resources to investigate differentiation of satellite populations, as well as metabolic adaptations to different types of sagebrush diets within and among both sage-grouse species. Using whole-genome resequencing from birds sampled across the West, we have identified several promising candidate genes underlying sage-grouse dietary adaptations. We also present results of whole-genome scans to examine regions within the genome with elevated divergence between populations and species. We discuss potential implications of these analyses for common management practices including translocation of birds, and sagebrush restoration efforts.

GENES ASSOCIATED WITH SIGNATURES OF ADAPTIVE DIFFERENTIATION IN GUNNISON SAGE-GROUSE

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Abstract. The genetic underpinning of functional diversity is an important but often overlooked component of conserving populations. Gunnison Sage-grouse is a sagebrush obligate species whose range consists of seven populations, each with variable habitat and climatic conditions.
Though geographically close, populations have low levels of natural gene flow resulting in relatively high levels of differentiation. Here, we use 15,033 SNP genotypes in genomic outlier analyses and gene ontology (GO) enrichment tests across six of the seven populations to examine patterns of putatively functional genetic differentiation. We found seven genes which were enriched for GO terms and co-located with regions of chromosomes with high densities of loci displaying outlier behavior. Genes identified could play a role in metabolism of plant secondary metabolites, an important consideration for a sagebrush obligate, and pigmentation pattern variation, an important consideration for sexual selection. Our results provide evidence of local functional divergence in multiple genes and in multiple pathways, for isolated populations of a single species. In addition to providing insight into population uniqueness, this information can be useful in managing species of conservation concern, e.g., to avoid translocations or releases of individuals that may swamp locally adapted genetic diversity or guide habitat restoration efforts.

IMPLEMENTING THE SAGE-GROUSE HABITAT ASSESSMENT FRAMEWORK WITHIN THE BUREAU OF LAND MANAGEMENT

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Abstract. The Sage-Grouse Habitat Assessment Framework (HAF), developed by the Bureau of Land Management (BLM) and Western Association of Fish and Wildlife Agencies (WAFWA), establishes a suite of indicators to rate the suitability of sage- grouse habitat at multiple spatial scales. These scales represent hierarchical orders of sage-grouse habitat selection occurring within (sub)populations (mid-scale), home ranges (fine-scale) and seasonal use areas (site-scale). Mid-scale and fine-scale assessments primarily leverage remotely sensed landcover data, such as LANDFIRE, and site-scale assessments use field-collected vegetation structure and composition data to rate seasonal habitat suitability. This presentation will review the results of a HAF assessment recently completed by BLM, in cooperation with state and federal partners, in Beatys Butte, located in southeastern Oregon. All scales were rated suitable for sage-grouse habitat. At the site-scale, weighted areal estimates indicated that 74.1% (80% CI [63.7, 84.5]), 88.1% (80% CI [75.5, 100]), and 93.9% (80% CI [89.3, 98.5]) of BLM-managed breeding, summer, and winter habitat, respectively, within the analysis area are in suitable condition. These results provide one line of evidence for meeting the Oregon BLM Land Health Standard for native, threatened and endangered, and locally important species.

THREAT-BASED LAND MANAGEMENT AND COLLABORATION IN SOUTHEAST OREGON

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Abstract. Successful conservation of sage-steppe ecosystems must balance science-based prioritization and management with diverse stakeholder participation and implementation. In southeast Oregon, a collaboration of federal, state and private partners approached this issue with mental models to distill complex ecology into simplified bins. These bins form the foundation of "Threat-based Land Management", framing distinct ecological problems – woodland expansion and annual grass invasion – that threaten ecosystem function, wildlife habitat and rural grazing economies alike. In Oregon, this successful compromise between complexity and communication is now foundational to the State Sage-grouse Action Plan, to private landowner conservation programs and to federal agencies' cross-boundary conservation efforts. Though this approach greatly simplifies a complex ecological system, several projects demonstrate landscape-level links between these simple mental models, wildlife habitat needs and important ecosystem services. These efforts underscore the need for decision-support systems operating at spatial scales relevant to land managers and the systems they manage. Created in 2014 during the scramble of the potential sage-grouse Endangered Species Act listing, this approach shows how collaboratives can address conservation issues with responsive, adaptive and science-based frameworks that strike an innovative balance between complexity and communication. The reward in Oregon has been stakeholders leaning in to obtain large-scale conservation.

IF WE BUILD IT WILL THEY COME?: LINKING PLANT COMMUNITY ECOLOGY WITH SAGE-GROUSE HABITAT PREFERENCE

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Abstract: A recent collaboration between multiple partners in southeast Oregon developed mental models to distill complex ecology into simplified bins that address landscape level threats to the sagebrush ecosystem. These bins form the foundation of "Threat-based Land Management" (TBLM). In this paper we quantitatively linked sage-grouse lek occurrence to a landscape level habitat classification based upon the TBLM framework. We built spatially predictive models using both traditional land cover variables, such as sagebrush landcover, and models that placed the TBLM into landscape level habitat classes, such as landcover of Habitat Bin A (i.e. Sagebrush cover with a perennial grass understory). When the TBLM habitat classification bins were placed into a landscape context, we showed the TBLM framework was able to predict the locations of sage-grouse with similar accuracy to a model built with traditional land cover variables. These results provide a direct quantifiable and biological link to understand outcomes of transitioning habitats from various threat states to sagebrush and perennial bunchgrass dominated landscapes at a scale relevant to sage-grouse. Sage-grouse are well known to respond to landscape level amounts of habitat and exhibit low tolerance to threats. We documented similar responses between threats such as the % Juniper within 560-m compared to the conifer threat modules in the TBLM at 560-m. Our work also quantifies the importance of having a healthy perennial grass understory in conjunction with sagebrush cover across large landscapes, and suggests that understory grass conditions may be limiting grouse occurrence in certain parts of Oregon.

DECISION SUPPORT TOOLS: FINDING THE RIGHT TOOL IN THE TOOLBOX

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Abstract. Decision support tools (DSTs), particularly geospatially focused tools to aid conservation-based land management decisions, have proliferated in the resource conservation fields. Successful DSTs have several key components: 1) a clear need exists for the tool; 2) they are co-produced with meaningful engagement with the target audience (i.e., planners and decision-makers); 3) they are usable and intuitive; and 4) they are accessible. A large investment has been made in the development and deployment of DSTs across the Great Basin, and the Great Basin Landscape Conservation Cooperative saw a need to organize and help link managers to DSTs within this region. To accomplish this, we created a Conservation Planning Atlas (CPA) with a Decision Support Library using the DataBasin web platform developed by Conservation Biology Institute. Our CPA groups a curated set of regional DSTs and support materials (e.g., webinar tutorials) by theme and provides links to those resources in an effort to facilitate selection and access to DSTs. We have received positive feedback that the CPA is a useful resource connecting resource planners, managers, and scientists to helpful tools that enhance strategic habitat conservation in the Great Basin.

AN INTRODUCTION TO THE LAND TREATMENT PLANNING TOOL

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Abstract. Resource managers for public lands plan and implement vegetation manipulations known as land treatments across a wide variety of ecological and climatological conditions. To aid in this planning process, the U.S. Geological Survey partnered with the Bureau of Land Management to create the Land Treatment Planning Tool. This geospatial, online tool is designed to help natural resource managers identify and access information about past treatments that are similar to their planned treatment. The tool taps into information on >40,000 land treatments that are stored in the Land Treatment Digital Library (LTDL). We demonstrate how users can upload or digitize planned treatment areas, extract biophysical attributes about the proposed treatment, and compare those attributes to historical treatments in the LTDL. The resulting information can be mapped, tabulated, and exported for inclusion in planning and reporting documentation.

A DECISION SUPPORT TOOL FOR CONIFER REMOVAL: MAXIMIZING BENEFITS TO SAGEBRUSH- AND WOODLAND-OBLIGATE SPECIES

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Abstract. Conifers encroaching into sagebrush steppe landscapes have resulted in detrimental impacts to sage grouse and other sagebrush-dependent wildlife such as migratory songbirds. Highly-targeted removal of conifers among sagebrush has been an effective tool for restoring habitats for sagebrush-obligate wildlife, as well as providing ecosystem benefits including improved carbon capture and water storage. However, successes in large-scale conifer removal begets an investigation of potential impacts to species that rely on pinyon and juniper habitats. Understanding patterns of abundance for sagebrush-dependent wildlife and declining woodland obligates can help practitioners target conifer removal projects in the right places to provide multi-species benefits. We used Breeding Bird Survey data from across the sagebrush ecosystem to develop habitat-based relative abundance maps for nine sagebrush and woodland-dependent species, including declining Brewer's sparrow, sage thrasher, green-tailed towhee, and pinyon jay. We overlaid data from past conifer removal projects with predicted abundance for each species and found that cuts had largely targeted the highest predicted abundance for sagebrush- obligates, while avoiding important pinyon jay habitats. We made spatial layers available online such that practitioners can use an interactive web-based tool to help inform local decisions when targeting conifer removal projects.

CONTRIBUTED POSTER ABSTRACTS

SAGEWEST: ADVANCING A RADICAL CENTER AGENDA IN THE SAGEBRUSH ECOSYSTEM THROUGH COLLABORATIVE COMMUNICATIONS

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Abstract. Collaboration between conservation entities in the sagebrush ecosystem is a hallmark of the current rangewide effort to conserve sagebrush-dependent wildlife species and sagebrush habitat. Communications, frequently a follow-on function for conservation actions, is emerging as an increasingly integrated component of this rangewide effort and as a means for collaboration by diverse conservation entities. Communications also hold promise for advancing a "radical center" agenda in sagebrush ecosystem conservation, one that seeks to identify and pursue common interests among a majority of sagebrush stakeholders. In this presentation, we trace the inception and evolution of SageWest, a collaborative communications network "operated by many and owned by none", and explore the potential utility of this network – the largest of its kind in the United States – as a tool to support communications planning and delivery; and, as a vehicle to promote cohesion among stakeholders across large landscapes. Lastly, we discuss current approaches to SageWest governance issues in light of the rapid growth of the network and associated complexities.

SageDAT: DATA AND TOOLS TO SUPPORT COLLATERATIVE SAGEBRUSH ECOSYSTEM CONSERVATION AND MANAGEMENT

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Abstract. Collaborative and science-informed management has been at the heart of the large-scale efforts to conserve the sagebrush ecosystem for greater sage-grouse and over 350 other species that rely on the sagebrush ecosystem. The development and use of geospatial data and decision support tools to inform management of rangeland fire, restoration of sagebrush habitats, and conservation of sage-grouse has resulted in exciting new opportunities, but the volume of data and tools has resulted in challenges for providers and users of this information. SageDAT is a web-based system that uses the latest technology to reduce barriers to data sharing and increase access to information through the development of a multi-agency data catalog. For data providers, this effort will increase communication and coordination on data management and provide tools to help protect sensitive/proprietary locations and information, which can alleviate past impediments to participation in previous large-scale planning efforts. For users, SageDAT will provide access to a comprehensive list of datasets and decision support tools via a web interface and improve mechanisms for increased communications and cooperation between federal, state, and local agencies, tribes, non-governmental organizations, universities, and industry across 11 western States to enhance long-term stewardship of the sagebrush ecosystem.

CONSERVATION EFFORTS DATABASE V2.0: CONSERVATION PLANNING AND EFFECTIVENESS MONITORING

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Abstract: The Conservation Efforts Database (CED) is a secure, on-line, spatially explicit conservation planning tool and database. Natural and anthropogenic disturbances that are detrimental to fish, wildlife, plants, and ecosystems are often the focus of conservation. While the intensity and extent of these impacts, in many instances, are well documented, the conservation actions applied by resource management agencies and organizations and their effectiveness to address environmental impacts are often poorly and inconsistently documented. Even when conservation actions are documented, it can be difficult to determine the short- and long-term effects on targeted species or habitats because of poor record organization and lack of post-action monitoring. The CED enables partners to document and record conservation actions and post-action effectiveness across the landscape at multiple scales. The CED is an important tool, along with scientifically-rigorous post-conservation monitoring, for implementing landscape-scale adaptive management. The CED provides an opportunity to compile, comprehensively across all jurisdictions, the sum of all conservation planning and effort and evaluate the resources that receive conservation benefit as a result of conservation and/or restoration efforts. Spatial data displayed in the CED provides useful context to planning and siting of future conservation efforts, fostering collaborative conservation across the biome.

A RETROSPECTIVE OF EARLY SAGE-GROUSE RESEARCH, HIGHLIGHTING THE CONTRIBUTIONS OF DWAYNE PYRAH AND OTHERS (1950's - 1970's)

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Abstract. Understanding sage-grouse and the habitats they require has been pursued since the early 1900's. All sage-grouse researchers are familiar with the work of Robert L. Patterson with his seminal book, "Sage Grouse of Wyoming". At that time, there was a tremendous effort to better understand the sage-grouse with respect to their distribution, seasonal movements, and responses to range management activities. With the career-long documentation that fell into my possession, it seemed an opportune time to look back and remember the early contributions of researchers from the 1950-1970's timeframe and the foundation they created for today's research. In particular, a tribute to one of many researchers, Duane Pyrah, who worked on sage-grouse in Idaho, Montana, and Wyoming with R. O. Wallestad, P. D. Dalke, E. F. Schlatterer, and J. E. Crawford.

PHYSIOLOGICAL CONDITION OF GREATER SAGE-GROUSE AS A FUNCTION OF CONIFER ENCROACHMENT

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Abstract. Conifer encroachment into sagebrush steppe may influence physiological condition in greater sage-grouse (*Centrocercus urophasianus*) by increasing predation risk, altering foraging behavior, or reducing food abundance. We evaluated the relationship between conifer cover and physiological condition of sage-grouse in southwestern Idaho. We used body condition and plasma protein as indicators of physiological condition at two study sites (high conifer and low conifer cover). In spring and summer of 2017, we collected blood from hens, attached VHF radio-collars, and evaluated conifer stem density at known-use locations. Average plasma protein was 4.99 g/dl (± 1.73; *n*=12) and 5.41 g/dl (± 1.47; *n*=4) for hens in high conifer and low conifer sites, respectively. High conifer known-use locations were characterized by average stem densities of 1.00 stem/0.03 ha (± .25, *n* = 47) and 13.28 stems /0.4ha (± 2.44, *n* =47). Low conifer known-use locations had no conifers within .03 and .4 ha. We will also determine if conifer cover influences body condition or fecal corticosterone at multiple spatial scales. Results from this work may help elucidate specific mechanisms responsible for observed patterns of demography for grouse that occupy encroached landscapes and inform conifer removal efforts for greater sage-grouse.

EFFECTS OF WILDFIRE, INVASIVE GRASSES, AND AVIAN PREDATOR DENSITIES ON GREATER SAGE-GROUSE IN OREGON

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Abstract. Wildfire is a primary threat to Greater Sage-grouse (hereafter, sage-grouse) in Oregon, which is exacerbated by the positive feedback cycle created by invasive annual grasses. Loss or degradation of seasonal sage-grouse habitats from wildfire have lasting effects due to long sagebrush recovery intervals. In addition, fire can increase edge habitat leaving sage-grouse more vulnerable to predation. Our study areas are located in five Priority Areas of Conservation (PACs) in Baker and Malheur counties, Oregon. These study areas include variability in fire variables, invasive annual grass cover, and avian predator density. Sage-grouse habitat use and demographics will be documented using ground and aerial telemetry. Burned areas will be quantified through existing federal and state databases. Invasive annual grass cover will be quantified through satellite imagery and field data collection. Avian predator densities will be estimated at sage-grouse use and random locations using distance sampling. For 2018, we started the breeding season with 91 marked hens and we will conduct point count surveys at 156 random locations and all weekly sage-grouse locations. We will evaluate individual and interactive effects of fire variables, invasive annual grass cover, and avian predator density on hen survival, reproductive success, and seasonal habitat use.

COMPARISON OF AVIAN AND MAMMALIAN PREDATORS IN SAGE-GROUSE CORE AND NON-CORE AREAS: ASSESSING PREDATOR ABUNDANCE AND RESPONSES TO ANTHROPOGENIC FEATURES

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Abstract: Greater sage-grouse (*Centrocercus urophasianus*: hereafter sage-grouse) abundance and distribution in western North America has declined over the last century. Many factors have contributed to this decline, including habitat loss and fragmentation from human development with an associated potential for increased predation rates from avian and/or mammalian predators. In addition, sage-grouse avoid areas with higher avian predator densities. While human development influences sage-grouse demographic rates and habitat selection, development also provides an increased number of perch and nesting structures used by avian predators—including ravens that can negatively influence sage-grouse nest success. Wyoming's Sage-grouse Core Areas were developed to add protections to important habitat for sage-grouse by reducing human development within Core Areas. Core Areas have maintained higher sage-grouse trends compared to Non-Core Areas, which could be explained by reduced predation rates. However, we lack a study comparing predator abundance within and outside Core Areas. We performed avian point counts along 5-mi transects throughout the Wyoming Basin during the 2017 summer. Transects were stratified between sage-grouse Core and Non-Core Areas. Human structures were noted at each point count location. This information will be added to BBS data and human disturbance data previously calculated. We plan to survey coyotes, badgers, and other mammalian predators during the 2018 summer by performing line transect surveys with fixed-wing flights or other survey techniques. Our study will determine (1) what habitat or structural factors are associated with higher predator abundance and (2) if avian and mammalian predator abundance differs between Core and Non-Core Areas.

IMPLEMENTING DOI SECRETARIAL ORDER 3353: GREATER SAGE-GROUSE CONSERVATION AND COOPERATION WITH WESTERN STATES

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Abstract. The purpose of Secretarial Order 3353 is to 1) enhance cooperation between the Department of Interior and sage-grouse states in the management and conservation of GRSG and its habitat; 2) support a partnership with clearly defines objectives and roles for federal and state entities responsible for SG management and conservation to sustain healthy populations of the species; and 3) establish a team to review the federal land management agencies' Sage-Grouse plan amendments and revisions completed on or before September 2015. This poster will review the steps taken to implement SO 3353, including the status of potential land use plan amendments.

IMPLEMENTATION OF A CANDIDATE CONSERVATION AGREEMENT FOR GREATER SAGE-GROUSE ON LANDS CLOSED TO THE GENERAL PUBLIC IN IDAHO

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Abstract. The Idaho National Laboratory (INL) Site encompasses 890 mi^2 in southeastern Idaho, the majority of which likely provides breeding and wintering habitat for greater sage-grouse (*Centrocercus urophasianus*). The site is unique among western landscapes because it is administered by the U.S. Department of Energy (DOE), and access to the land is closed to the general public. Livestock grazing occurs on up to 60% of the INL Site, but other areas have not had grazing pressure since the 1940s. In 2014, the DOE entered into a Candidate Conservation Agreement (CCA) with the U.S. Fish and Wildlife Service to benefit greater sage-grouse on the INL Site. The agreement has become the primary regulatory mechanism for addressing threats to greater sage-grouse and implementing conservation actions on the INL Site. The CCA was intended, and has proven to be a flexible and adaptive framework for addressing conservation requirements of greater sage-grouse and its seasonal habitats, while avoiding or minimizing conflicts with the mission of DOE. In our presentation, we report on actions DOE has taken to address wildfire, annual grasslands, infrastructure development, human disturbance, and common raven (*Corvus corax*) nesting on the INL Site. We conclude that a close working relationship among stakeholders and management flexibility have been among the key ingredients to the successful implementation of the CCA thus far.

COUNTING SAGE-GROUSE: CAN Survey123 MAKE OUR LIVES EASIER?

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Abstract. Good data collection and management practices are paramount to the accuracy and utility of data. Historically, the Federal and State agencies collecting Sage Grouse lek count data across the West have had varying data needs, formats, and timelines. Continued research questions and analysis, and the development of management decisions reliant on data associated with lek locations and lek counts has made the implementation of consistent and timely collection methods a necessity. Unfortunately, our current data collection systems are simply unable to efficiently provide consistent and accurate lek data to researchers and managers. We used Survey123 to build an efficient and effective Sage Grouse lek data collection and delivery system capable of meeting data needs for research and management now and into the future. Our application is user-friendly, enabling data collected over large geographic areas to be summarized and made available quickly. We believe the use of this methodology will help State agencies better coordinate and communicate the collection and use of lek data in a way that meets evolving needs for the agencies and their partners.

BENEFICIAL RUMP-MOUNT HARNESS ALTERATIONS

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Abstract. Rump-mounted VHF and/or GPS PTT transmitters deployed on greater sage-grouse (*Centrocercus urophasianus*) have become ubiquitous throughout the West over the past 5-10 years. Since that time, several hundred units have been deployed primarily using GPS-PTT technology. Harness material generally consists of Teflon ribbon, elastic cord, metal crimps, and super glue. Following protocol and materials used in other western states and within Colorado, we deployed 23, 22 g VHF transmitters on male greater sage-grouse in a pilot study in northwestern Colorado in 2017. We recaptured 5 marked birds. Upon capture, we discovered all marked birds had moderate to severe abrasions and lacerations where the harness contacted the underside of the leg. We removed the harnesses and developed a less impactful design. Our modification uses the same harness material, but we added clear plastic tubing over the Teflon ribbon and heat shrink tubing to keep the clear tubing in place to lessen contact of the Teflon ribbon against the skin. Subsequently, we have used the modified design on 82 birds and recaptured 4 birds and observed only minor to no abrasions. Thus, we suggest that individuals deploying GPS PTT or VHF rump-mount transmitters strongly consider modifying the harness design we present.

MONITORING SUCCESS OF SAGE-GROUSE TRANSLOCATED FROM MONTANA TO ALBERTA: AN INTERNATIONAL CONSERVATION EFFORT

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Abstract. In 2008, a collaborative project was initiated between Montana Fish, Wildlife and Parks (MFWP) and Alberta Environment and Parks (AEP) under the Northern Sage Brush Steppe Initiative (NSSI). Over a two year period (2011-2012), 41 Greater sage-grouse (*Centrocercus urophasianus*) were captured in Montana and translocated to Alberta. A further 38 sage-grouse hens were translocated in 2016. These birds were monitored remotely using solar powered GPS PTTs to assess survival, nest success and recruitment to the local population. Recent monitoring data demonstrates population growth from historical lows. In addition to the translocation, conservation actions continue under guidance from the *Alberta Greater sage-grouse recovery plan 2013-2018*. These efforts aim to enhance survival and nesting success rates of resident and translocated sage-grouse. Actions include; implementation of a predator management strategy focused on key sage-grouse predators, anthropogenic structure removal, oil and gas reclamation activities, habitat enhancement and land securement in sage-grouse range. Analysis of data from the translocations also helped agencies better understand translocation as a management tool. This research focused on post-release movements and habitat selection in relation to anthropogenic features.

LAND COVER CHANGE AND HABITAT MONITORING OF COLUMBIAN SHARP-TAILED GROUSE

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Abstract: Columbian Sharp-tailed Grouse (*Tympanuchus phasianellus columbianus,* CSTG) populations have declined in western North America, now occupying <5% of their historical range. Idaho supports approximately 60-65% of the remaining CSTG in the U.S, and is home to one of three populations that make up 95% of remaining breeding populations. Satellite imagery captured since the early 90's will facilitate the classification and quantification of the rate and amount of rangeland conversion to agricultural production within critical habitat areas in Southeast Idaho. In combination with historical CSTG lek counts from Idaho Fish and Game, this study examines the relationship between increasing agricultural cover to fluctuations in counts at a regional scale. In addition, this study will evaluate the applicability of using unmanned aerial systems (UAS) for the acquisition of hyperspectral imagery with high spatial resolution, to classify vegetation composition of nesting and brood habitat at the field level. Understanding the impact of land use conversion on CTSG is paramount to supporting management decisions and the application of future rehabilitation efforts. This innovative approach will lead to a greater understanding of CSTG habitat change at a regional level, as well as supporting management and assessment of habitat restoration at the field level using UAS data.

SHARP-TAILED GROUSE REINTRODUCTION IN WESTERN MONTANA

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Abstract. In Montana, sharp-tailed grouse (STGR) west of the Continental Divide are a species of concern and have been a priority for Fish, Wildlife & Parks (FWP) for 32 years dating back to the Libby Mitigation Plan that quantified habitat and wildlife losses after Koocanusa Reservoir was created. Previous efforts to sustain populations with translocations of Columbian sharp-tailed grouse were unsuccessful with populations in western Montana extirpated by the early 2000s. After a genetic analysis determined that STGR in western Montana were actually of the plains subspecies, FWP and its collaborators completed a GIS-based and ground-truthed habitat suitability assessment that compared occupied habitats in eastern Montana to habitats west of the divide. The results identified large blocks of high quality habitat west of the divide which would be suitable for a reintroduction. In 2017, FWP worked with Dr. Lance McNew of Montana State University to complete a Restoration Plan for Sharp-tailed Grouse Recovery in western Montana. FWP is currently completing an environmental assessment evaluating potential reintroductions. We will share with you the history of the project and our plans moving forward.

SOFT RELEASE TECHNIQUES FOR TRANSLOCATED COLUMBIAN SHARP-TAILED GROUSE FROM SOUTHEAST IDAHO TO NORTHEAST NEVADA

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Abstract. Reducing dispersal of newly translocated grouse species has been a challenge for upland game bird managers for decades. Prior to the start of trapping on the second year of a five year Columbian Sharp-tailed grouse (CSTG) translocation effort we redesigned our release boxes in an effort to reduce stress of newly translocated birds that were moved from trap sites in Idaho to our release site in Bull Run Basin, Nevada and to reduce dispersal rates. Our design reduced handling time and minimized injuries to birds. We believe our release method, including placing release boxes in heavy cover (both natural and artificial), allowing birds several hours of no human interaction/ movement of the box at the release site prior to opening the front door, releasing birds at nautical twilight and minimizing the opening of the release box to the approximate width of an adult CSTG all led to greatly reduced dispersal rates.

History of WAFWA's Technical Team

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, WY. 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. WAFWA has expanded the group to include the Columbian sharp-tailed grouse as well as Canadian provinces.

Number	Year	Location
1	1959	Farson, WY
2	1961	Elko, NV
3	1963	Lima, MT
4	1965	Walden, CO
5	1967	Boise, ID
6	1969	Rock Springs, WY
7	1971	Salt Lake City, UT
8	1973	Lewistown, MT
9	1975	Reno, NV
10	1977	Grand Junction, CO
11	1979	Twin Falls, ID
12	1981	Bowman, ND
13	1983	Ontario, OR
14	1985	Alturas, CA
15	1987	Midway, UT
16	1989	Moses Lake, WA
17	1991	Pocatello, ID
18	1993	Fort Collins, CO
19	1994	Reno, NV
20	1996	Gillette, WY
21	1998	Billings, MT
22	2000	Redmond, OR
23	2002	Bicknell, UT
24	2004	Wenatchee, WA
25	2006	Spearfish, SD
26	2008	Mammoth, CA
27	2010	Twin Falls, ID
28	2012	Steamboat Springs, CO
29	2014	Elko, NV
30	2016	Lander, WY
31	2018	Billings, MT

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