GREATER SAGE-GROUSE RESEARCH CONDUCTED IN WYOMING IN 2019

Presented to State of Wyoming and Wyoming Game and Fish Department

Compiled by:

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Research studies are listed alphabetically by last name of lab or principal investigator. Please feel free to contact labs or principal investigators with specific questions.

Male Greater Sage-Grouse on a Lek in Central, Wyoming, Spring 2019
Photo by Ella Bishop-Heil

1. EVALUATING BIODIVERSITY OF SAGEBRUSH-DEPENDENT SPECIES WITHIN SAGE-GROUSE HABITAT: AN EXAMPLE FROM THE WYOMING BASINS

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Sagebrush (*Artemisia* spp.) steppe ecosystems have experienced drastic changes resulting in loss, fragmentation, and degradation of remaining habitat. As a result, sagebrush-dependent fauna have experienced population declines. Threats to list the Greater Sage-grouse (*Centrocercus urophasianus*) under the Endangered Species Act have resulted in west-wide conservation efforts to protect sage-grouse habitats, actions presumed to also benefit other sagebrush fauna. To evaluate the effectiveness of using Sage-grouse to conserve biodiversity of sagebrush-dependent species, we first developed and compared data-driven spatial occupancy and abundance models for seven sagebrush obligate/associated species across the greater Wyoming Basins Ecoregional Assessment (WBEA) area (345,300 km^2). Our models predicted 63,784 km^2 of optimal Sage-grouse habitat. Protection of these areas for conservation may provide added benefits for some species, such as Sage-Thrashers (*Oreoscoptes montanus*), where 73% of predicted breeding habitat was captured across the range of Sage-grouse in the WBEA area. However, Brewer's sparrows (*Spizella breweri*) may not be as well protected by the Sage-grouse umbrella, with only 39% of predicted breeding habitat captured across the range of Sage-grouse within the WBEA. Mapping biodiversity hotspots using models of four songbirds (Brewer's Sparrow, Sage Thrasher, Sagebrush Sparrow (*Artemisiospiza nevadensis*), Green-tailed Towhee (*Pipilo chlorurus*)), pronghorn (*Antilocarpa Americana*), and Greater short-horned lizard (*Phrynosoma hernandesi*), Sage-grouse habitat will capture an estimated 40-60% of biodiverse areas containing ≥4 (of 6) species of conservation concern. If Sage-grouse are to be an effective umbrella for sagebrush ecosystems, biodiversity of other sagebrush species should be considered in conservation efforts. We will submit a peer-reviewed manuscript summarizing this work in early 2020.

Funding provided by: Western Association of Fish and Wildlife Agencies Sagebrush Science Initiative, and U.S. Geological Survey

2. MULTI-SCALE STATEWIDE WYOMING GREATER SAGE-GROUSE TRENDS DETERMINED BY POPULATION VIABILITY ANALYSIS

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We are investigating trends for Wyoming Greater Sage-grouse populations at multiple scales and management boundaries using population viability analysis (PVA) to determine local- and meta-population dynamics. Our objective was to use lek count data provided by the WGFD to determine the population growth rate (λ) state-wide, by local Working Group Areas, Core Areas, Core Areas by Working Group Areas, and at nine nested spatial scales based on lek clusters. See "Hierarchical Clustering of Greater Sage-Grouse Leks to Improve upon the Detection of Population Persistence, Sinks, and Sources" by O'Donnell et al. (2019) for cluster development specifics. We used average peak male counts per lek annually (1993-2015) in a PVA to evaluate density-independent (DI) and density-dependent (DD) models to estimate λ for each management area-based population. Population trends determined by management areas are relevant as these boundaries are used to implement management plans and limit development disturbances at leks. Clusters are defined by fine- and broad-scale habitat and climate attributes relevant to sage-grouse biology; therefore, trends within these clusters are more likely to be correlated and yield more precise trend estimates than other population demarcations. We developed our suite of models and applied them by Working Group and Core Areas; we finalized the development of lek clusters and applied the PVA across cluster scales using lek count data (1993-2017). We published our management areas-based PVA and a correction to our publication in 2018 and we submitted a manuscript for peer-review assessing sage-grouse population viability by clusters in late 2019.

Funding provided by: U.S. Geological Survey and Wyoming Landscape Conservation Initiative through USGS.

Publications:

Edmunds, D.R., C.L. Aldridge, M.S. O'Donnell, A.P. Monroe, P.S. Coates, and B.S. Cade. *In Review.* Greater sage-grouse trends across nested hierarchical spatial scales in Wyoming. *Journal of Wildlife Management*.

Edmunds, D.R., C.L. Aldridge, M.S. O'Donnell, and A.P. Monroe. 2018. Erratum: Greater sage-grouse population trends across Wyoming. *Journal of Wildlife Management* 82(8):1808-1808. doi:10.1002/jwmg.21560.

Edmunds, D.R., C.L. Aldridge, M.S. O'Donnell, and A.P. Monroe. 2018. Greater sage-grouse population trends across Wyoming. *Journal of Wildlife Management* 82(2):397-412. doi:10.1002/jwmg.21386.

3. GREATER SAGE-GROUSE RESPONSES TO FUTURE CUMULATIVE AND INTERACTING CLIMATE AND ENERGY DEVELOPMENT IN WYOMING

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The abundance and distribution of Greater Sage-grouse in Wyoming depends on future habitat changes, including oil and gas development and climate-induced changes in habitat. Yet, we have a poor understanding of the potential magnitude of these effects and how these stressors may shape future sage-grouse habitats and populations. We developed a series of future landscape maps for the Wyoming Landscape Conservation Initiative (WLCI) area of southwestern Wyoming. We simulated future loss and fragmentation of sagebrush habitats resulting from oil and gas development and associated roads infrastructure. Models were parameterized using realistic oil and gas development scenarios, using algorithms previously developed in southwestern Wyoming. Future climate scenarios were incorporated as climate-induced changes in vegetation. Future landscape maps were used to update seasonal habitat selection maps and influence future Sage-grouse habitat use. In oil and gas scenarios, avoidance of infrastructure and fitness consequences were enacted for some life stages within a spatially explicit individual-based model. We quantified a possible range of impacts of climate and development stressors on sage-grouse distribution, abundance, and persistence. Results indicate that long-term changes in climate or development could substantively re-shape existing Sage-grouse populations. Consideration of only one stressor could underestimate expected population changes. The findings of this project are now published.

Funding provided by: U.S. Geological Survey and Wyoming Landscape Conservation Initiative through USGS

Publication: Heinrichs, J.A, M.S. O'Donnell, C.L. Aldridge, S.L. Garman, and C.G. Homer. 2019. Influences of potential oil and gas development and future climate on sage-grouse declines and redistribution. *Ecological Applications* 29(6): 116-1131. doi:10.1002/eap.1912.

4. HIERARCHICAL CLUSTERING OF GREATER SAGE-GROUSE LEKS TO IMPROVE UPON THE DETECTION OF POPULATION PERSISTENCE, SINKS, AND SOURCES

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Population monitoring is vital to conservation and management of wildlife; yet, population survey data are commonly limited to single geographic extents and rarely account for processes occurring across spatial and temporal scales. To support a statistically repeatable and hierarchical framework for long-term monitoring, we developed a method to construct hierarchically nested groupings of similar habitats represented as spatial boundaries of population structures. Our approach relied on a clustering algorithm (Spatial "K"luster Analysis by Tree Edge Removal), where we explicitly included habitat selection at multiple scales surrounding leks (breeding grounds), and we modified the process to include constraint-based rules of connectivity between habitat. We applied this framework to Greater sage-grouse (*Centrocercus urophasianus*) in two disparate ecological contexts (Nevada and Wyoming). The connectivity rules consisted of inter-lek movement distances (isolation-by-distance; 15 km) and resistance to movements (barriers) between leks, increasing the biological realism of connectedness. The selection of habitat type and habitat scales varied across the geographic extents as well as across cluster levels. In Nevada, the finest-scaled cluster level captured ~90% of sage-grouse movements, where each bird was assigned to a home cluster, while mid-level scales captured ~97%–99% of movements. This approach can support scale-dependent management and research needs including population and habitat monitoring to inform conservation and adaptive management practices. We completed the pilot study (2019 publication below) for Nevada and Wyoming, and we are working with all 11 western state wildlife agencies to finalize a range-wide Greater sage-grouse population monitoring framework.

Funding provided by: U.S. Geological Survey and the Bureau of Land Management
Publication:

O'Donnell, M. S., D. R. Edmunds, C. L. Aldridge, J. A. Heinrichs, P. S. Coates, B. G. Prochazka, and S. E. Hanser. 2019. Designing multi-scale hierarchical monitoring frameworks for wildlife to support management: a sage-grouse case study. *Ecosphere* https://doi.org/10.1002/ecs2.2872.

5. THE COMPLEXITIES OF SAGE-GROUSE LONG-TERM MONITORING DATABASE SYSTEMS

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The Wyoming Game and Fish Department (WGFD) maintains a database of Greater sage-grouse lek locations and annual lek counts. Because of the importance of these data and repetitive use by researchers and managers for population trend monitoring, we developed program R code to use these data for long-term monitoring based on policies defined in the WGFD Handbook of Biological Techniques (Chapter 12; Christiansen 2012; p. 12-8). Although these standards did not apply to data collected prior to the mid-1990s, we apply them across all years for the trend analyses. The impetus for these efforts was threefold: 1) provide results and tools to WGFD, 2) standardize workflows, and 3) support ongoing sage-grouse research (e.g., see Edmunds et al. (2019) and O'Donnell et al. (2019) [Clusters]). Our code extracts observations meeting the four main criteria for counts as defined in the handbook: 1) ground counts, 2) time constraints of 30 minutes before and 90 minutes post sunrise (modified from 60 minutes based on Monroe et al. 2016), 3) no precipitation, and 4) wind speeds ≤10 mph. Due to similar efforts for compiling a national range-wide Greater Sage-grouse lek database that could support the development of a range-wide hierarchical population monitoring framework (see O'Donnell et al. (2019) and "Hierarchical Clustering…" abstract), we employed similar methods to clean up data entry errors and standardize definitions for all 11 state lek databases. We migrated the code to open-source Python libraries, and we incorporated many quality control measures for verifying data integrity. We will release the software (some obfuscation of hardcoded pieces will exist), and states can adjust code based on their definitions or geographic region of interest (lek data not included).

Funding provided by: U.S. Geological Survey and Wyoming Landscape Conservation Initiative through USGS

6. PREDICTING POST-DISTURBANCE RECOVERY OF SAGEBRUSH ECOSYSTEMS USING REMOTE SENSING PRODUCTS

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The historic loss of vegetation and subsequent recovery trajectories after disturbances in sagebrush ecosystems are not well understood at broad spatial and temporal scales. Establishing rates of sagebrush recovery and estimating time to recovery will aid in characterizing restoration and management efforts and inform effective sagebrush restoration strategies. Recently, we have assembled spatial datasets characterizing disturbance-specific information from energy development, fire, mechanical, and chemical treatments within Wyoming. By pairing these spatial datasets with historic sagebrush habitat maps (SBMap; percent cover by 30-m pixels; every 2−5 years from 1985– 2015, see publications by Homer and others) within the Wyoming Landscape Conservation Initiative region (WLCI), we can evaluate the rate of 'ecological recovery' as well as the time to recovery (relative to current sagebrush cover). We demonstrate this approach by examining variation in recovery rates among 375 former well pads in WLCI, evaluating the contribution of weather, soils, and other factors on sagebrush recovery rates. We then used model estimates to predict recovery rates and times across the WLCI. The resulting prediction surfaces will aid in identifying sagebrush and habitat recovery expectations and directly inform management efforts outlined within the Secretarial Order 3336 and within the recently revised BLM and USFS resource management plans. Our peer-reviewed manuscript was published in the fall of 2019. We received support to extend this approach to a suite of other disturbance types and vegetation treatments across Wyoming, and to evaluate recovery trends under different future climate scenarios and examine economic implications.

Funding provided by: U.S. Geological Survey, the Bureau of Land Management, and the Wyoming Landscape Conservation Initiative through USGS

Publication:

Monroe, A.P., C.L. Aldridge, M.S. O'Donnell, D.J. Manier, C.G. Homer, and P.J. Anderson. 2020. Using remote sensing products to predict recovery of vegetation across space and time following energy development. *Ecological Indicators* 110:105872. https://doi.org/10.1016/j.ecolind.2019.105872

7. PRIORITIZING LANDSCAPES FOR BIRD-FRIENDLY RANCHING

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Widespread declines of bird populations breeding in North American rangelands are well-documented, and implementing approaches that sustain the livelihoods of ranchers while offering opportunities for wildlife has potential to attenuate or reverse these trends. In the Powder River – Thunder Basin of Wyoming, Audubon Rockies is working to establish their Conservation Ranching program, a market-based approach connecting conservation-conscious consumers to ranchers employing bird-friendly management practices. To increase efficiency of this effort, we are developing a landscape prioritization framework that identifies areas for bird conservation and establishes a monitoring program to evaluate outcomes. Using bird surveys conducted with the Integrated Monitoring in Bird Conservation Regions (IMBCR) protocol from 140 survey locations (2009−2018) across the Powder River – Thunder Basin, we built hierarchical community models to estimate passerine distribution and abundance across multiple scales while accounting for variation in detectability. We are then creating spatially-explicit predictions for each species as well as community-level metrics over the study area. These maps will identify areas with potential for high bird abundances, where the Conservation Ranching program could be prioritized. We also evaluated relationships with more fine-scale habitat components, which could inform pasture-level management for each species. Additionally, our framework establishes a baseline for continued monitoring as the Conservation Ranching program is implemented across the landscape, clarifying the link between consumers and on-the-ground conservation.

Funding provided by: Audubon Rockies, Margaret A. Cargill Foundation, and U.S. Geological Survey

8. SOUND LEVELS AT GREATER SAGE-GROUSE LEKS IN THE PINEDALE ANTICLINE PROJECT AREA, WYOMING, APRIL, 2013–2019

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The Bureau of Land Management's Pinedale Anticline Project Area Supplemental EIS developed a "Wildlife Monitoring and Mitigation Matrix" that identified species to be monitored and criteria to be monitored. Greater Sage-grouse were identified as a species to be monitored, and one criterion for this species was sound levels at leks. The objective of this project was to monitor sound levels at Greater Sage-grouse leks in the Pinedale Anticline Project Area (PAPA) south of Pinedale, WY, and determine if sound levels exceeded 10 dB over background ambient sound levels. The background ambient sound level (L_{A90}) in sagebrush habitats in rural, undeveloped Wyoming is 14.0 dB. A total of 2,938 hours of acoustic data were collected at 20 leks in the PAPA in 2019; 2,046 hours (70%) had L_{A50} levels > 24 dB. Of the 20 leks in the PAPA, 13 had L_{A50} >24 dB (11 of these had declining trends), and 7 had L_{A50} <24 dB (1 of these had declining trends). From 2013–2019, 17,407 hours of acoustic data were collected at 20 leks in the PAPA. Average sound levels for all hours for all leks were L_{Aeq} = 30.2 dB, L_{A50} = 25.9 dB, and L_{A90} = 25.9 dB. Available evidence suggests that when gas field sound levels (L_{A50}) exceed 24 dB (10 dB over background levels of 14 dB), grouse populations decline.

Funding: Pinedale Anticline Project Office, Bureau of Land Management, Pinedale, WY.

9. IDENTIFICATION OF WINTER CONCENTRATION AREAS IN SOUTH-CENTRAL WYOMING

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Availability and use of winter habitat by greater sage-grouse (*Centrocercus urophasianus*) has the potential to influence viability of sage-grouse populations and should receive considerable attention when prioritizing areas for sage-grouse habitat conservation. The Wyoming Sage-grouse Executive Order outlines the need to identify Winter Concentration Areas (WCAs), defined as winter habitats where sage-grouse consistently aggregate in groups of 50 or more individuals. Unfortunately, documentation of WCAs lags behind our knowledge of sage-grouse winter habitat requirements and space use during other critical periods. Our study was designed to detect locations of unknown WCAs while assessing abundance and resource selection to refine our understanding of winter habitats and critical use areas for sage-grouse. We used aerial infrared videography in winter 2017 to identify potential WCAs in south-central and southwest Wyoming to evaluate abundance and winter habitat selection as influenced by biological attributes, environmental, and anthropogenic features across the region. We located 4,859 individuals comprising 132 flocks across our study area. Flocks occurred in Core Areas more than expected, but a biologically meaningful number of sage-grouse flocks were located outside of Core Areas. Our results and survey technique provide a potential framework for identifying sage-grouse WCAs with implications for improving protection of all seasonal habitats for sage-grouse conservation.

Funding provided by: Wyoming Game and Fish Department, Wyoming Sage-grouse Conservation Fund; South-Central and Southwest Local Sage-grouse Work Groups.

Publication:

Smith, K. T., J. B. Dinkins, and J. L. Beck. 2019. Approaches to delineate greater sage-grouse winter concentration areas. *Journal of Wildlife Management* 83:1495–1507.

10. MANAGEMENT GUIDELINES FOR GREATER SAGE-GROUSE WINTER CONCENTRATION AREAS

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During 2018, we initiated a project with an overall goal to generate management recommendation guidelines for greater sage-grouse winter concentration areas in Wyoming using a 2-phase approach. Phase 1 will utilize currently-available data from sage-grouse equipped with GPS transmitters throughout Wyoming to address 3 main objectives: 1) identify the timing of sage-grouse presence on winter range, 2) identifying the interaction between snow cover/depth and sagebrush cover/height relative to sage-grouse winter habitat selection, and 3) identify thresholds of sage-grouse response to anthropogenic disturbance in winter. During 2018, we acquired existing datasets from multiple sage-grouse research projects across Wyoming that utilized GPS transmitters to obtain location data. We also began digitizing anthropogenic surface disturbance and started acquiring snow data for these study areas. The study areas contained a range of anthropogenic infrastructure and surface disturbance. Results from Phase 1 will form the basis from which disturbance management guidelines can be developed. Phase 2 will assess the effectiveness of these guidelines applied to a novel area located in the southern Red Desert and Sierra Madre region of Wyoming. This novel area is ideal because it contains areas of heavy disturbance, areas of little disturbance, and areas of proposed new disturbance. This area also has documented sage-grouse winter concentration areas outside Core Areas used by grouse that breed inside Core Areas. For Phase 2, during 2018 and 2019, we captured and equipped 58 adult female sage-grouse with GPS transmitters with plans to maintain a sample of 50 individuals for the duration of our study.

Funding provided by: Wyoming State Office of the Bureau of Land Management; Sublette County Conservation District; Wyoming Game and Fish Department; and South-Central, Southwest, and Wind River/Sweetwater River Local Sage-grouse Working Groups.

11. RESPONSE OF GREATER SAGE-GROUSE TO HUMAN ACTIVITY AND DEVELOPMENT IN THE NORMALLY PRESSURED LANCE AREA

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Our proposed research focuses on quantifying changes in the mortality risk, physiological stress, seasonal movements, and avoidance of wintering greater sage-grouse (*Centrocercus urophasianus*) to the Normally Pressured Lance (NPL) Project in Sublette County, Wyoming. The NPL encompasses 140,859 acres (96% of which is public land administered by the Bureau of Land Management [BLM]) south and west of the existing Jonah Field. Here, long-term development potential includes a maximum of 3,500 directionally drilled wells over 10 years that will produce oil and natural gas. A total of 35,000 acres of the Alkali Creek and Alkali Draw winter sage-grouse concentration areas overlay the NPL where upwards of 1,500 grouse aggregate during many winters, indicating the need for better information to guide grouse conservation efforts in the project area. We began field work by deploying 28 GPS transmitters during February 2019 within the winter concentration areas that occur in the NPL. During 2019, 21,630 grouse locations were collected from these transmitters. Our study design calls for 100 GPS transmitters to be deployed equally split between the NPL treatment area and nearby control areas outside the NPL where development will not occur. So far, we have deployed half of these transmitters during December 2019. Field work is planned to continue through winter 2022–2023.

Funding provided by: Jonah Energy, LLC, Wyoming Game and Fish Department

12. RESPONSE OF GREATER SAGE-GROUSE TO TREATMENTS IN WYOMING BIG SAGEBRUSH

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Wyoming big sagebrush (*Artemisia tridentata wyomingensis*) has been treated through chemical application, mechanical treatments, and prescribed burning to increase herbaceous forage species released from competition with sagebrush overstory. Originally intended to provide more forage for livestock, these techniques have been applied to improve habitat for sagebrush wildlife species including greater sage-grouse (*Centrocercus urophasianus*). Treatments are intended to rejuvenate sagebrush plants and increase herbaceous production. Studies evaluating habitat treatments have reported varied results and generally lack the replication necessary for evaluation of demographic rates and fine-scale habitat use of sage-grouse in response to treatments. Our study, centered near Jeffrey City, Wyoming is designed as a Before-After Control-Impact study with 3 years of pre-treatment and 6 years of post-treatment data comparing demographic rates and habitat selection patterns within treated and non-treated sites. We initiated our study in spring 2011 by capturing female sage-grouse and affixing VHF necklace-mounted or GPS rump-mounted transmitters to measure nest and brood-rearing success, and adult female survival. During winter 2014, we mowed 489 ha (1,208 acres) of sagebrush habitats across 2 mowing treatment areas and applied tebuthiuron to 607 ha (~1,500 acres) across 2 herbicide treatment areas in May 2014. We have monitored demographic parameters from n = 625 marked females. Identifying sage-grouse demographic and habitat use responses will aid in determining the efficacy of habitat treatments intended to enhance habitat for sage-grouse and other species associated with the sagebrush biome. Our field study was funded through summer 2019; we will perform final analyses during 2020.

Funding provided by: Wyoming Game and Fish Department, Wyoming Sage-grouse Conservation fund; Bates Hole/Shirley Basin, Bighorn Basin, South-Central, Southwest, Upper Green River, Upper Snake River and Wind River/Sweetwater River Local Sage-grouse Work Groups; Wyoming Reclamation and Restoration Center; Wyoming Wildlife and Natural Resource Trust; Land Field Office-Bureau of Land Management; and Margaret and Sam Kelly Ornithological Research Fund.

Publications:

Smith, K. T., J. R., LeVan, and J. L. Beck. 2019. Forb and invertebrate response to treatments for greater sage-grouse in Wyoming big sagebrush. *Rangeland Ecology and Management* 72:791–795.

Smith, K. T., A. C. Pratt, J. L. LeVan, A. M. Rhea, and J. L. Beck. 2019. Reconstructing greater sage-grouse chick diets: diet selection, body condition, and food availability at brood-rearing sites. *The Condor: Ornithological Applications* 121: 1–12.

Pratt, A. C., K. T. Smith, and J. L. Beck. Prioritizing seasonal habitats for comprehensive conservation of a partially migratory species. *Global Ecology and Conservation* 17:e00594.

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13. FREE-ROAMING HORSE IMPACTS ON SAGE-GROUSE NEST SITE SELECTION AND SUCCESS

Contact: Dr. Jeff Beck; Email: jlbeck@uwyo.edu; Phone: (307) 766-6863

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Feral horses have been cited as potential threats to greater sage-grouse (*Centrocercus urophasianus*) populations. Direct impacts can include disturbance of leks and trampling of nests or chicks. Potential indirect impacts primarily involve habitat alteration through decreased native grass and shrub cover, and overall vegetation height, along with increases in exotic grass cover and dominance of unpalatable forbs. Though feral horses are thought to negatively impact sage-grouse, quantitative investigation is lacking. Our project objectives include evaluating: 1) the impact that free-roaming horses have on greater sage-grouse nest site selection and success measured from marked female sage-grouse, and 2) the relative degree in which horse utilization, modeled from horse dung transects, compares to utilization distributions modeled from locations acquired from GPS-equipped feral mares. During August 2019 we recorded the density of horse dung along 225, 1-km transects across two study areas. We have marked sage-grouse in the Jeffrey City study area in central Wyoming and marked sage-grouse and feral mares in the Red Desert in south central Wyoming. In conjunction with other habitat features, we will use transects to generate a spatial prediction of relative horse density to evaluate the relationship between horse density and nest and brood site selection and success. We have a unique opportunity to validate predictive layers created by horse dung transects in the Red Desert study area with the probability surface modeled from locations of free-roaming horses equipped with GPS collars. This information will assist grouse scientists and managers in better understanding the potential impacts of free-roaming horses on sage-grouse populations.

Funding provided by: Wyoming Sage-grouse Conservation fund; Bighorn Basin, South-Central, Southwest and Wind River/Sweetwater River Local Sage-grouse Work Groups.

14. RESOURCE SELECTION OVERLAP BETWEEN GREATER SAGE-GROUSE AND CO-OCCURRING SPECIES

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Our project aims to address how resource selection and space use of greater sage-grouse compares with three co-occurring species: feral horses (*Equus ferus caballus*), pronghorn (*Antilocapra americana*), and sharp-tailed grouse (*Tympanuchus phasianellus*) in southern Wyoming. This information will elucidate how these species partition resources and identify potential areas of conservation concern for sage-grouse populations. Our sage-grouse, feral horse, and pronghorn investigation is focused around the BLM-administered Wild Horse Adobe Town Herd Management Area in Carbon and Sweetwater counties. Our sage-grouse and sharp-tailed grouse investigation is focused along the western slope of the Sierra Madre Range in Carbon County. During 2017, we captured and equipped 37 adult female feral horses and 35 adult female pronghorn with GPS transmitters. Between 2017 and 2019, we captured and equipped 213 adult female and 57 male sharp-tailed grouse with VHF transmitters. During 2018 and 2019, we captured and equipped 58 adult female sage-grouse with GPS transmitters. Our project will help clarify whether management actions for these other important species will benefit or adversely impact sage-grouse conservation, and vice-versa. Our study is in collaboration with other research projects investigating the ecology and management of feral horses; genetic relationships, demography, and resource selection of sharp-tailed grouse; and the winter ecology of sage-grouse.

Funding provided by: Bureau of Land Management; University of Wyoming–Agricultural Experiment Station; Wyoming Game and Fish Department; South-Central, Southwest, and Wind River/Sweetwater River Local Sage-Grouse Working Groups; Wyoming Governor's Big Game License Coalition; Wyoming Wildlife Federation; and U.S. Forest Service.

15. LANDSCAPE MANAGEMENT FOR SAGEBRUSH AND GRASSLAND BIRD GUILDS IN THUNDER BASIN, WYOMING

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The Thunder Basin National Grasslands (TBNG) of northeastern Wyoming are composed of a heterogeneous mosaic of sagebrush (*Artemisia spp.*), short-grass and mixed-grass plant communities. Portions of TBNG have been designated as core area for greater sage-grouse (*Centrocercus urophasianus*), and are also important for other sagebrush bird species. However, the grassland also contains some of the largest complexes of black-tailed prairie dogs (*Cynomys ludovicianus*) in North America; these colonies provide important habitat for shortgrass bird species (e.g. mountain plover [*Charadrius montanus*]), and are also prioritized as a reintroduction zone for the endangered black-footed ferret (*Mustela nigripes*). Because conservation of diverse species in the same landscape requires spatial optimization of management approaches, we initiated a study in 2015 to determine how shortgrass and sagebrush bird species are influenced by the composition and spatial configuration of habitat patches in the Thunder Basin landscape. From 2015-2017 we surveyed birds on transects placed across sage grouse leks ("sagebrush," n=10), prairie dog colonies ("shortgrass," n = 10), and also across edges between colonies and adjacent habitat ("edge," n = 41). In 2018, we collected data on a subset of these transects to track avian response to plague (*Yersina pestis*) in prairie dogs. We have published one paper examining the effect of disturbance on birds (Duchardt et al. 2018), but will continue to use these data to generate models of single species density as a function of local and landscape habitat variables. We are especially interested in how the size and configuration of prairie dog colonies influences sagebrush species in this landscape. However, because sage grouse have low detectability on point counts, we will use lek data to examine sage grouse response to colony abundance and configuration in the landscape, and compare these responses with sagebrush passerines including Brewer's sparrow (*Spizella breweri*) and sage thrasher (*Oreoscoptes montanus*).

Publications – Peer-reviewed:

Duchardt, C.J., Augustine, D.M., and Beck, J.L. Sagebrush bird responses to natural and anthropogenic disturbance at the eastern edge of the sagebrush steppe. (*In prep, Journal of Wildlife Management*).

Duchardt, C.J., Beck, J.L., and Augustine, D.M. 2020. Drivers of mountain plover habitat selection and nest survival on large prairie dog colonies. *The Condor: Ornithological Applications* 122:In press.

Duchardt, C.J., Augustine, D.M., and Beck, J.L. 2019. Threshold responses of grassland and sagebrush birds to disturbance by an ecosystem engineer. *Landscape Ecology* 34:895–909

Duchardt, C. J., L. M. Porensky, D. J. Augustine, and J. L. Beck. 2018. Disturbance shapes avian communities on a grassland–sagebrush ecotone. *Ecosphere* 9(10):e02483.

Publications – Extension

Duchardt, C.J. and Connell, L.C. 2018. Sharing Fences. Western Confluences Magazine (in press)

Duchardt, C.J. and Scasta, J. D. 2017. Welcome to Thunder Basin. Thunder Basin Ecology Factsheet Series. University of Wyoming Extension. B-1288.1.

Duchardt, C.J. and Scasta, J. D. 2017. Birds of Thunder Basin: Sagebrush specialists. Thunder Basin Ecology Factsheet Series. University of Wyoming Extension. B-1288.2.

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  - Program in Ecology Travel Grant ($500)
  - University of Wyoming College of Ag. and Natural Resources Grant ($2,500)
  - Prairie Biotic Inc ($1,500)

16. GREATER SAGE-GROUSE MIGRATION ECOLOGY AND RESPONSE TO BENTONITE MINING IN THE BIGHORN BASIN, WYOMING

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Wyoming contains 70% of the world's bentonite clay deposits, and mines in the Bighorn Basin produce >50% of Wyoming's annual supply. Bentonite is extracted by open-pit mining that leads to disturbance, fragmentation, and loss of sagebrush habitat. Plans call for mining to increase in sagebrush communities; therefore, our primary study objective was to monitor (for 4 years; 2011–2015) the demographic rates and habitat selection patterns of greater sage-grouse in areas with greater (Shell) and lesser (Hyattville) amounts of bentonite mining activity. We monitored female survival, nest success, and brood survival with radio telemetry. To help guide reclamation we sampled vegetation in microhabitat plots at nests, early-brood locations, and at paired random locations. Our second study objective was to describe the migration behavior of these populations using GPS-marked grouse. Observations have indicated a wide variety of migratory behavior including differences in the proportion of each population that was migratory, timing, distance, duration, destination, and differences among seasons. We have finished analyses and manuscript writing relative to our research objectives.

Funding provided by: American Colloid Company, Big Horn Basin Local Sage-Grouse Working Group, and the Margaret and Sam Kelly Ornithological Research Fund.

Publications:

Pratt, A.C., and J.L. Beck. *In review*. Do greater sage-grouse exhibit maladaptive habitat selection?

Pratt, A.C., and J.L. Beck. 2019. Greater sage-grouse response to bentonite mining. *Journal of Wildlife Management* 83:866–878.

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17. EXPLORING DISTURBANCE THRESHOLDS: GREATER SAGE-GROUSE REPRODUCTIVE RATES AND PATTERNS OF HABITAT USE RELATED TO THE PHYSICAL FOOTPRINT OF ENERGY DEVELOPMENT

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Energy infrastructure and associated habitat loss, can lead to reduce reproductive rates across a variety of species including the greater sage-grouse (*Centrocercus urophasianus*). Our goal was to refine our understanding of how the physical footprint of energy development relates to sage-grouse nest and brood survival. Because our survival analyses were conditional upon the amount of surface disturbance female sage-grouse were exposed to during these reproductive stages, we quantified levels of exposure and compared them to the surface disturbance levels of the surrounding habitats. We utilized data from 6 study areas in Wyoming containing 4 primary types of renewable and nonrenewable energy development. Our research focused on press disturbance which is disturbance sustained after initial disturbance and associated with existing energy infrastructure and human activity. Our results suggest exposure to press disturbance during nesting and brood-rearing was related to lower nest and brood survival, which manifested at different spatial scales. Our analysis of nest survival suggested that the likelihood of failure was positively associated with the proportion of press disturbance within an 8.0-km² area. Broods exposed to any press disturbance within a 1-km^2 area were less likely to survive compared to broods not exposed to press disturbance. The exposure of nesting and brood-rearing sage-grouse to press disturbance suggested females consistently used habitats with lower disturbance levels during these reproductive periods. Greater than 90% of nest and brood-rearing locations were in habitats with less than 3% press disturbance within a 2.7-km^2 (1 mi^2) area. Our research informs better understanding of biological tradeoffs related to the physical footprint of energy development and regulations designed to conserve impacted sage-grouse populations in the sagebrush (*Artemisia* spp.) biome.

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Publication:

Kirol, C, P., K. T. Smith, N. E. Graf, J. B. Dinkins, C. W. LeBeau, T. L. Maechtle, A. L. Sutphin, and J. L. Beck. Greater sage-grouse response to the physical footprint of energy development. *Journal of Wildlife Management* (revised and in review).

18. GREATER SAGE-GROUSE TRANSLOCATION FROM WYOMING TO NORTH DAKOTA

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Wildlife translocations and population augmentations continue to occur and are an important management option for wildlife managers. Many grouse populations are imperiled and managers have used translocation techniques for various species and populations. Past efforts have often lacked monitoring of the translocated individuals and we are often left with little information to understand how or why the management action was a success or failure. The majority of grouse translocation efforts with monitoring have often failed in the short term, or if some immediate success, then in the long-term. There is no information currently concerning impacts to the source population or the comparison of population dynamics between the source and translocated birds. We translocated 40 female and 20 male sage-grouse during the spring of 2017. In 2018, we translocated 20 females and 20 males in the spring and captured, translocated, and released 6 additional brood hens with their chicks in the augmented population. In 2019, we translocated 20 males in the spring, 10 brood hens with their chicks and 10 non-brood hens during the brooding period (i.e., early June to mid-July). All translocated birds were from the Stewart Creek area, north of Rawlins, WY to southwest North Dakota, where sage-grouse numbers have been declining for several years. All translocated birds were radio-marked and monitored for survival and reproductive rates. In addition to birds that were translocated or were released at the capture site with the potential to be translocated as brood hens, we also maintained a sample of 20 radio-marked female sage-grouse within the source population and monitored survival and reproduction. For spring translocated females in 2017 and 2018, we used artificial insemination (AI) techniques on a treatment group, with sham and control samples as well, to see if AI influences reproductive rates of females. These same techniques are being used in the Bi-State population in California and a population in west-central Utah. During June and July of 2018 we translocated 6 brood hens and 26 chicks. All captured and translocated brood hens and chicks were radio-marked in 2018 and 2019. We used a soft-release method by containing the chicks and brood hen in a specially designed brood box, which separated the hen from the chicks with a removable divider, but allowed vocalizations to occur. Once in North Dakota, the brood box was put in a release pen approximately 8 x 6 feet and 20 inches tall and the divider was removed and a door opened on the chick's side of the brood box into the release pen. To go into the release pen the brood hen was forced to move through her chicks. To release the brood into their new natural environment, one entire 8-foot side of the release pen was raised once the hen and chicks had acclimated to each

other again within the release pen. We constructed drift fences in a V-shape using chicken wire to guide the brood into sagebrush cover at the release site and reduce the risk of separation occurring between the chicks and hen. In 2018, 3 broods with 7 chicks total between all broods, successfully fledged with at least one chick surviving to 50 days. However, for one of these broods the adult female was found positive for Avian TB and we were required to dispatch the brood hen and her 3 chicks at 48 days post-hatch. In 2019, of the 40 chicks translocated in 10 broods, 23 chicks survived ≥ 50 days post-hatch. Of the 23 chicks that survived, 12 of them were recaptured in August and marked with adult necklace style VHF transmitters. We are currently processing data and preparing analyses to compare techniques and develop translocation protocols based on the comparison of translocated and source populations. We also plan on publishing a thesis and submitting a couple publications for peer-review based on this research.

Funding provided by: North Dakota Game and Fish Department and Wyoming Game and Fish Department

19. GREATER SAGE-GROUSE GEOPHAGY DURING THE WINTER

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Greater sage-grouse have been documented eating soil during the winter near Pinedale, WY. Our objectives included 1) understand why this behavior is happening, including what nutrient the birds are seeking, 2) how this behavior affects winter habitat selection, and 3) if this behavior influences survival and reproductive rates the following spring and summer. We are trapping and radio-marked up to 30 individual grouse each year for the winters of 2017-18 and 2018-19. We will monitor their movements and habitat selection. We are also collecting soil samples at geophagy sites and at random sites across the study area to assess differences. We will collect sagebrush leaf samples at feeding sites from plants that are fed on and plants in the area that are not selected to evaluate any differences in nutrient content. We will also collect sage-grouse fecal pellets from flocks with radio-marked birds to see if we can detect any differences in micro nutrients based on time since visiting a geophagy site. Samples of calcium, salt, and phosphorous will be placed at geophagy sites to see if visiting sage-grouse will select for one or more of these nutrients. During the following spring and summer we will follow radio-marked females to monitor their reproductive rates and assess whether geophagy behavior can be related to reproductive rates. In December 2017 we radio-marked 20 sage-grouse with store-on-board GPS radios. We also had an additional 10 or more VHF radio-marked grouse. As of January 1, 2018 16 of the 20 GPS radios had a software glitch that caused the GPS units to fail. We were not able to replace this sample of birds until late February 2018. All GPS units had a paired VHF radio, and we attempted to use VHF data loggers at known geophagy sites to record visitation rates. We receive funding to order 18 additional GPS-PTT ARGOS enabled units for the 2018-19 winter field season. This sample of GPS radios, combined with our existing sample from February 2018, should provide a large amount of location and movement data for this upcoming field season. We collected ~ 20 samples of vegetation and pellets last field season, and will continue this effort this coming winter. At the end of the 2018-19 field season all known geophagy sites had soil samples recorded. The current graduate student, Scott Fox, is currently developing his thesis. Another graduate student, Chuck Carpenter III, has begun work on this project during the 2019 spring and summer field season. Chuck's objectives are to monitor the reproductive activities and survival of female sage-grouse (in 2019, the females that were monitored during the 2018-2019 winter) which have location data from the previous winter. We want to evaluate the impacts of geophagy behavior on survival and reproduction the following breeding and brooding seasons. Chuck is currently capturing female sage-grouse to gather GPS location data from them this 2019-2020 winter and then monitor them

during the 2020 field season. We plan on 2 or more peer-reviewed publications concerning this research following the publication of theses.

Funding provided by: Bureau of Land Management Pinedale Field Office, Southwest Wyoming Sage-Grouse Local Working Group

20. 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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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 partially explained by reduced predation rates. However, we lack a study comparing predator abundance within and outside Core Areas. We performed avian point counts along 8.05-km transects during summers 2017 and 2018. This information will be added to BBS data and human disturbance data previously calculated. We deployed trail cameras at scent stations and performed 500-m scat/badger burrow transects to survey for mammals during the 2018 summer. Scent stations and transects (avian, scat, burrow) were stratified between Core and Non-Core Areas in the Wyoming Basin. Preliminary results and analyses are currently being generated to determine (1) what habitat or structural factors are associated with higher predator and songbird abundance, and (2) if avian and mammalian predator abundance differs between Core and Non-Core Areas.

Funding provided by: Bates Hole/Shirley Basin, Big Horn Basin, South Central, Wind River/Sweetwater River, and Southwest Wyoming Sage-Grouse Local Working Groups; and Oregon State University

Table 1. Sample sizes of completed data collection as of 2018.

Avian Predator Transects/Point Counts	400 transects/2,293 point counts
Deployed Scent Stations	117
Scat and Badger Burrow Transects	176 (98 repeated)

21. INTERACTIVE EFFECTS OF HABITAT, LIVESTOCK PRESENCE, AND PREDATORS ON GREATER SAGE-GROUSE DEMOGRAPHY AND SEASONAL HABITAT

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Greater sage-grouse (*Centrocercus urophasianus*: hereafter "sage-grouse") distribution and abundance in western North America has declined over the last century, which has prompted multiple petitions to the U.S. Fish and Wildlife Service to list sage-grouse throughout its range. Habitat loss and degradation are the predominant factors attributed to these declines, but predation in some contexts may also contribute to declines. Livestock grazing has been identified as one of the potential threats to sage-grouse habitat and populations, which has been based on vegetation changes associated with grazing. From a community ecology perspective, very little is known about potential benefits or threats of livestock management interactions with other ecosystem processes on sage-grouse habitat and populations. This study aims to evaluate the variation in predator communities and interactions with livestock presence on sage-grouse demographic rates and habitat use through the use of camera traps on the landscape and data collected from GPS units on livestock in the Bighorn Basin. Our objectives for this study include evaluating the influence of predators relative to habitat and livestock on sage-grouse habitat use and adult hen, nest, or brood survival, evaluating the difference in predator abundance and community composition relative to cattle presence, and monitoring and quantifying seasonal habitat use and adult survival (including winter) of sage-grouse related to habitat characteristics and weather. The primary assessments will include relationships of sage-grouse habitat use and demographic rates in areas with different livestock presence and timing of use, in addition to the predator composition in relation to livestock presence.

Funding Sources: Bureau of Land Management, Big Horn Basin Sage-Grouse Local Working Group

22. IMPROVING SUCCESS IN HABITAT RESTORATION FOR SAGEBRUSH OBLIGATE WILDLIFE: ASSESSMENT OF AVIAN HABITAT USE AND VEGETATION COMPOSITION IN SAGEBRUSH STEPPE RECLAMATION ACTIVITIES

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Bradley C. Fedy[1], Christopher P. Kirol[1] and Natasha L. Barlow[1]

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To improve outcomes of habitat restoration for sage-grouse (*Centrocercus urophasianus*) and other sagebrush dependent birds, we need to understand relationships between distribution and composition of plant communities on reclaimed sites in relation to habitat use and population fitness of sagebrush species. Generally speaking, how can we best restore birds when restoring sagebrush habitat? We initiated research in the summer of 2016 to assess the influence of reclamation activities on habitat use, movements and population fitness of sagebrush-obligate/associate birds. Our study is in the Powder River Basin in an area that has undergone large-scale reclamation of coal bed natural gas infrastructure. Our focal species include sage-grouse and passerines using sagebrush habitats during the breeding season. This study area is ideal because it contains a gradient of disturbance types, representing different stages of energy development, from non-impacted sites, reclaimed sites, and active energy development sites. Our primary objectives are to assess the response of these species across the gradient of energy development, reclaimed, and control areas. We have completed three field seasons (2016 - 2019) and published two manuscripts associated with this research.

Funding provided by: BLM-Buffalo Field Office, Northeast Sage-Grouse Working Group, the Wyoming BLM-State Office, Canadian Foundation for Innovation, Natural Sciences and Engineering Research Council of Canada.

Publications:

Barlow, N.L, C.P. Kirol, K.E. Doherty, and **B.C. Fedy.** *In press*. Does the umbrella-species concept work at fine spatial scales? Journal of Wildlife Management.

A.L. Sutphin, T.L. Maechtle, C.P. Kirol, and **B.C. Fedy**. 2018. A mobile tool for capturing greater sage-grouse. Wildlife Society Bulletin. DOI: 10.1002/wsb.899

23. STATE-WIDE GENETIC CONNECTIVITY FOR GREATER SAGE-GROUSE IN WYOMING

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Greater sage-grouse population connectivity has been identified as a priority management issue by multiple state and federal management agencies. We are working on a large-scale project to assess levels of population connectivity using genetic approaches. This project assisted in the delineation of related populations and described possible sub-population boundaries. The research also identified likely barriers to the movement of individuals among populations. One objective of the State's Game and Fish Agency is to maintain connectivity. To accomplish this, we must understand more about the genetic diversity and the likelihood and nature of impacts from any inbreeding that is identified and the association between the seasonal habitats of the species and the subpopulations that use them. We have published 4 peer-reviewed manuscripts associated with this research.

Funding provided by: U.S. Bureau of Land Management, Wyoming Game and Fish Department, U.S. Geological Survey.

Publications:

Row, J.R., S.T. Knick, S.J. Oyler-McCance, S.C. Lougheed, and B.C. Fedy. 2017. Developing approaches for linear mixed modeling in landscape genetics through landscape-directed dispersal simulations. Ecology and Evolution. DOI: 10.1002/ece3.2825

Fedy, B.C., J.R. Row, and S.J. Oyler-McCance. 2016. Integration of genetic and demographic data to assess population risk in a continuously distributed species. Conservation Genetics doi:10.1007/s10592-016-0885-7.

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24. GREATER SAGE-GROUSE MOVEMENT PATTERNS NEAR AN EXISTING WIND FARM

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Existing peer-reviewed research on the potential effects of wind energy on greater sage-grouse is fairly limited. Currently there is little to no information on site fidelity, recruitment or dispersal of sage-grouse in relation to energy development, specifically wind energy. Adult sage-grouse are known to have a high site fidelity, which can limit their ability to adapt to changes in their environment. But no information exists for sage-grouse movement from natal to initial breeding areas. For our research project, the specific objectives were to: (1) quantify multi-scale resource selection/avoidance in sage-grouse within the wind farm, (2) generate data-driven high-resolution maps of seasonal habitat (nesting, late brood-rearing/summer, and winter) at the landscape scale, and (3) investigate natal dispersal while also examining brood-rearing habitat use, fecundity, survival, and second year use by chicks in wind farm areas.

Female sage-grouse were captured by nocturnal spot-lighting in spring 2019. We equipped female greater sage-grouse with solar-powered ARGOS/GPS transmitters in and around the wind farm near Hanna, Wyoming. Following successful hatching and chicks surviving to 75 days, a total of 10 chicks/juveniles were outfitted with a 6g ARGOS/GPS transmitter. The project is currently ongoing and we hope future funding will allow us to create several peer-reviewed publications from the research work.

Funding provided by: Bureau of Land Management

25. USGS UPDATED SHRUBLAND COMPONENTS IN WYOMING

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The USGS in collaboration with the BLM produced a remote sensing-based quantification of Wyoming shrub lands in 2015. Some mountain geographies including the Wind River and Yellowstone Park areas were excluded. These areas have now been mapped, which means all of Wyoming is now represented in the latest release of these products. Nine individual products are available with values representing the proportion (fractional vegetation) of each target component for every 30 m pixel. Component products include percent shrub, percent sagebrush, percent big sagebrush, percent herbaceous, percent annual herbaceous, percent litter, percent bare ground, shrub height and sagebrush height. A modeling process has been developed to take the 2015 database of mapped components back in time to 1984, and forward in time to 2018 using the Landsat archive, creating a 34-year record of component change across Wyoming. These new back in time products are being analyzed to understand trend analysis, especially in regard to climate change. Newly filled base component products are now available for download from www.mrlc.gov. Back in time change products for Wyoming, will also soon be available on www.mrlc.gov.

Funding provided by: U.S. Geological Survey, BLM

Publication: Pending

26. SAGE-GROUSE HABITAT RESTORATION IN NORTHEASTERN WYOMING: EVALUATING REVEGETATION OUTCOMES

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Greater sage-grouse conservation measures in Wyoming include large revegetation programs to restore landscapes disturbed by energy extraction. If we are to understand the effectiveness of current conservation practices, studies are needed of reclamation seeding outcomes. Few studies examine differences in the seed mix and established vegetation at reclamation sites. We compared reclamation seed mixes with reclamation outcomes for vegetation in the Powder River Basin. Over two years, we surveyed vegetation on 16 reclaimed coalbed methane (CBM) well pads and 10 active (interim reclaimed) well pads using the Assessment, Inventory and Monitoring (AIM) protocol. Each reclaimed site was paired with nearby, undisturbed rangeland site to contrast reclaimed vegetation with intact plant communities. Preliminary findings for the first 16 well pads indicate that reclaimed vegetation does not resemble nearby, undisturbed vegetation. Reclaimed well pads had higher cover of introduced plant species and lower cover of native species relative to undisturbed sites. The difference in vegetation outcomes was underpinned by 23 species, nine of which are introduced, invasive species. The absence of sagebrush in the seed mix had the greatest impact on dissimilarity between reclaimed and undisturbed sites. Of the seven species in the seed mix, 54% were found on average in reclaimed sites in 2017 and 69% were present in 2018. These species represented an average of 38% cover on the well pads (with a range of 15 – 79%). We found no significant difference in cover between observation years. Early conclusions are that seeding does improve establishment of native species, but establishment success varies for species included in the seed mix. Future analyses aim to identify factors that influence successful establishment of planted species and the quality of resulting habitat.

Funding provided by: Wyoming Game and Fish Department, Bureau of Land Management, and Wyoming Wildlife and Natural Resources Trust

27. EVALUATION OF THE RESPONSE OF GREATER SAGE-GROUSE TO WIND DEVELOPMENT ACTIVITIES ASSOCIATED WITH THE CHOKECHERRY AND SIERRA MADRE WIND ENERGY PROJECT, CARBON COUNTY, WYOMING

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Jon Kehmeier and Nate Wojcik, SWCA Environmental Consultants

Power Company of Wyoming (PCW) has proposed to construct the Chokecherry and Sierra Madre Wind Energy Project (CCSM Project) south of Rawlins in Carbon County, Wyoming. A before-after-control-impact (BACI) design is being used to evaluate the impacts of wind energy development on greater sage-grouse. The research area consists of two treatment areas where wind energy development will occur and three control areas without any wind energy development. Generally, the research effort will evaluate pre-, during, and post-construction habitat selection, population demographics, general movement and distribution patterns, and lek attendance trends and dynamics. Our current design calls for maintaining between 40 and 50 females tagged with GPS PTTs. Approximately 6 years of pre-construction data were collected prior to the initiation of construction. Construction activities for the project began in fall 2016 and are ongoing. Currently we are analyzing and characterizing pre-construction demographics, space use, and habitat selection. Data are continuously being collected during construction activities. Subsequent years of research will begin to evaluate the response of sage-grouse to the construction and operations of the CCSM Project.

Funding provided by: Power Company of Wyoming

28. SPATIAL VARIABILITY OF SOIL CLIMATE AND MOISTURE BUDGETS WITHIN SAGEBRUSH ECOSYSTEMS: AN ENHANCEMENT OF RESISTANCE AND RESILIENCE TO IMPROVE CONSERVATION

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Understanding the drivers defining sagebrush ecosystem distributions and dynamics is important for habitat management, restoration and mitigation. Resistance and resilience concepts (R&R) provide a useful framework for understanding these drivers, which advantageously have been related to soil temperature and moisture classifications. Attribution of soil climate regimes within the Natural Resources Conservation Service soils data have therefore been used to define spatially explicit R&R classifications. Our objective was to improve the spatial discrimination of the R&R and enhance the information available for management of sagebrush habitats. Within the Wyoming Landscape Conservation Initiative (WLCI) area, we developed a spatially explicit model of soil conditions using the Newhall Simulation Model (NSM). We used the NSM for evaluating the interactions of temperature and moisture conditions with soils by simulating evapotranspiration and movement of water in surface soils. We incorporated probabilistic soil data to define available water capacity and gridded climate data to represent spatial variability in drivers of ecosystem conditions. We also adjusted monthly climate data to account for temporal lags of water release via snow depletion rates. This approach resulted in detailed spatial discrimination of variability in temperature and moisture regimes and estimation of seasonal soil moisture budgets. These results improve our understanding of growing conditions related to the distribution and dynamics of sagebrush, disturbance effects and recovery rates, distribution of invasive plants and invasion risk, site potential for state-and-transition simulations, climate effects, and site quality for landscape mitigation. We are expanding these efforts range-wide with 30-year average and forecasted climate conditions. We will release all data products and related software, as well as produce two journal publications (expected in 2020; 1) Wyoming NSM application without climate change; 2) range-wide NSM application with climate forecasts).

Funding provided by: U.S. Geological Survey, Ecosystems Program, science support for the Wyoming Landscape Conservation Initiative and the North Central Climate Adaptation Science Center

29. PROBING THE SAGE-GROUSE GENOME FOR SIGNATURES OF ADAPTIVE GENETIC VARIATION

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Identifying and maintaining genetic adaptations to environmental variation is key for developing sound conservation and management strategies. Genomics can greatly augment our ability to precisely characterize the genetic basis of important adaptations within extant populations. We have generated the first high-quality genome assemblies for both Gunnison and greater sage-grouse. We assembled a reference genome and performed whole-genome sequencing across sage-grouse from both species and six populations, including Jackson Hole, WY. Our recent work on adaptive genetic variation has identified a suite of single-nucleotide polymorphisms (SNPs) to demonstrated elevated rates of divergence among sage-grouse populations at the range-wide level. Some of these are present in biochemical pathways that may be important as counter-adaptations to toxic plant secondary metabolites (PSM) produced by sagebrush (*Artemisia* spp.) as a defense against herbivory. We have also accumulated additional tissue samples and conducted a restriction associated DNA sequencing study (RAD-Seq) of additional samples including a group from southwestern WY to evaluate variation in these candidate genes across the range. We work is summarized in peer-reviewed manuscript published in 2019.

Funding provide by: U.S. Geological Survey

Publication:

Oh, K.P., C.L. Aldridge, J.S. Forbey, C.Y. Dadabay, and S.J. Oyler-McCance. 2019. Conservation genomics in the sagebrush sea: population divergence and adaptive metabolic variation in sage-grouse (*Centrocercus* spp.). Genome Biology and Evolution 11(7): 2023-2034. doi: 10.1093/gbe/evz112

30. MAPPING SAGE-GROUSE LEKS TO LINK DIET, HABITAT STRUCTURE, AND BEHAVIOR

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Dr. Jennifer Forbey and Chelsea Merriman, Boise State University

The goal of this project is to understand how sage-grouse use their microhabitats on and off the lek and how those choices may affect health and reproductive success. During the 2017 mating season, we conducted multi-point TLS (a ground-based Terrestrial LiDAR Scanning) for 5 study leks in the Government Draw area near Hudson, Wyoming (Fremont County). These scans are being queried for the cover, horizontal concealment, and other relevant metrics to measure ecologically important features of the lek microhabitat. We also collected videos of the sage-grouse space use on the lek in experimental interactions with robotic female sage-grouse. We have analyzed these videos and we are now connecting behavioral observations to TLS scans to determine which microhabitat features are important for both male and female sage-grouse on leks. We are also examining sage-grouse dietary preferences off the lek. From 2014-2017 we used radio telemetry tags to find foraging and roost sites, and we conducted transects around leks. At these sites, and random sites, we collect samples of browsed and unbrowsed sagebrush and habitat measures. This will help us to assess preferred habitat and forage at the chemical level. Fecal samples collected from leks are being analyzed for a byproduct of detoxification (glucuronic acid) and metabolites of stress-associated hormones (corticosterone); this will allow us to link dietary toxin intake to lek position and behavior. In 2018-2019, we did the same at leks in the Bi-State population (Mono County, California). Samples from WY and CA are currently being analyzed in the Forbey lab.

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