AVIAN PROGRAM
2015
WILDLIFE RESEARCH SUMMARIES

OCTOBER 2014 – SEPTEMBER 2015

AVIAN RESEARCH PROGRAM

COLORADO DIVISION OF PARKS AND WILDLIFE
Research Center, 317 W. Prospect, Fort Collins, CO 80526

Executive Summary

This Wildlife Research Report contains summaries of wildlife research projects conducted by the Avian Research Section of Colorado Parks and Wildlife (CPW) from October 2014 through September 2015. These research projects are long-term projects (2 – 10 years) in various stages of completion, each of which addresses applied questions to benefit the management of various bird species and wildlife habitats in Colorado. More technical and detailed reports of most of these projects can be accessed on the CPW website at http://cpw.state.co.us/learn/Pages/ResearchBirds.aspx or from the project principal investigators listed at the beginning of each summary. Also included in this report is a listing of publications, presentations, workshops and participation on various committees and working groups by Avian Research staff from October 2014 through September 2015.

Current research projects in the Section address various aspects of the ecology and management of wildlife populations and the habitats that support them, human-wildlife interactions, and new approaches to field methods in wildlife management. This report includes summaries of a new study designed to understand how Columbian sharp-tailed grouse respond to habitat treatments, development of techniques to maintain and breed Gunnison sage-grouse in captivity, new seasonal resource selection models for Gunnison sage-grouse in the Gunnison Basin, several continuing studies on greater sage-grouse, experiments to evaluate techniques on restoring native plant communities for wildlife, and a long-term study to understand how avian communities associated with prairie dog colonies respond to plague management.

Also included in this report is a listing of publications, presentations, workshops and participation on various committees and working groups by Avian Research staff from October 2014 through September 2015. Communicating research results and using their subject matter expertise to inform management and policy issues is a priority for CPW scientists.

We are grateful for the numerous collaborations that support these projects and the opportunity to work with and train graduate students and technicians that will serve wildlife management in the future. Research collaborators include the CPW Commission, statewide CPW personnel, Colorado State University, Bureau of Land Management, City of Fort Collins, EnCana Corp, ExxonMobil/XTO Energy, Marathon Oil, WPX Energy, Rocky Mountain Bird Observatory, and the private landowners who have provided access for research projects.

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Colorado Division of Parks and Wildlife
October 2014 – September 2015

TABLE OF CONTENTS
AVIAN WILDLIFE RESEARCH REPORTS

Colorado Parks and Wildlife

WILIDLIFE RESEARCH PROJECT SUMMARY

Columbian sharp-tailed grouse demographic response to habitat treatments

Period Covered: October 1, 2014 – September 30, 2015

Principal Investigator: Anthony D. Apa, tony.apa@state.co.us

Project Collaborators: Jim Haskins and Bill deVergie, Area Wildlife Managers; Brad Petch, Senior Terrestrial Biologist; Trevor Balzer Sagebrush Habitat Coordinator; Kathy Griffin, Grouse Coordinator; Liza Rossi, Brian Holmes, and Jeff Yost, Terrestrial Biologists, Michael Warren, Energy Liaison; Becky Jones, Biologist-RMBO/NRCS/CPW

All information in this report is preliminary and subject to further evaluation. Information MAY NOT BE PUBLISHED OR QUOTED without permission of the principal invetsigator. Manipulation of these data beyond that contained in this report is discouraged.

The Columbian sharp-tailed grouse (CSTG, *Tympanuchus phasianellus columbianus*) is one of 6 subspecies of sharp-tailed grouse in North America. Historically its distribution ranged from the northwest in British Columbia to the southwest in Colorado. Isolated populations exist (or formally existed) in Washington, Idaho, Wyoming, Colorado, Montana (extirpated), Utah, Nevada (reintroduced) and Oregon (reintroduced) occupying 10% of its former range. Habitat loss and degradation from anthropogenic activities are cited as the primary reasons for its decline with the conversion of native shrub plant communities to agricultural production being the most prevalent. The United States Fish and Wildlife Service (USFWS) has been petitioned twice to list the CSTG for protections under the Endangered Species Act, and concluded that the CSTG was not warranted for listing following both petitions. The ESA listing decision was, in part, not warranted because of CSTG range expansion facilitated by Conservation Reserve Program (CRP) in 1985 and subsequent reauthorizations.

In Colorado a preponderance of CRP plantings were seeded to intermediate wheatgrass (*Agropyron intermedium*), smooth brome (*Bromus inermis*), and occasionally included alfalfa (*Meticago sativa*). These mixes resulted in mature herbaceous stands of grass that provide marginal benefits to CSTG. In contrast, mineland reclamation sites in northwest Colorado have been shown to be beneficial to CSTG and provide high quality spring-summer-fall habitat to CSTG when compared to CRP or native rangeland. Mineland reclamation provides sufficient habitat quality to support favorable demographic rates for females when compared to CRP. Thus, based on past observational research, and that some existing CRP habitats are not occupied by CSTG, there is building evidence that habitat treatments could improve existing or expired CRP. As a result, improvement of CRP habitat is recommended as a management action for CSTG.

Ecological theory supporting habitat improvements (quality) through wildlife habitat enhancement and/or management has been a long established tenet of wildlife management, but the wildlife-habitat relationship is complex. CSTG provide an opportunity to evaluate demographic rates and population growth to assess changes in habitat quality. CSTG are a highly productive, generalist species that have centralized breeding locations, limited movements during the breeding season, and relatively small home ranges. My overall research objective is to ascertain the short- and long-term demographic and population response of CSTG to improvements in habitat quality by increasing floristic horizontal and vertical structure and species richness in monotypic stands of non-native grasses. Specific objectives are to 1) ascertain the current baseline (before impact) and short-term (2 years) demographic and spatial parameters in existing non-native grass dominated communities and compare with treated sites, and 2) ascertain the long-term (5-7 year) post-habitat enhancement, demographic and spatial parameters in non-native grass dominated communities and compare with treated sites. As part of this research treatments (habitat improvements) will be conducted in two CSTG lek (dancing ground) complexes (T1 and T2). The actual location and placement of the habitat enhancement will depend upon landowner permission and agency funding. Treatments will be in collaboration with NW Regional management staff and the Northwest Region Habitat Coordinator. A Before-After Control-Impact (BACI) design with paired controls will be employed. My study area is located in northwestern Colorado, in southwestern Routt and southeast Moffat counties. The study area is predominantly (70%) privately owned by individuals or mining companies and is interspersed with Bureau of Land Management and State Land Board properties (Fig. 1).

Female CSTG were captured in the spring using walk-in funnel traps in the morning on dancing grounds. Trapping occurred on dancing grounds in three study sites in Moffat County (T1, T2, C3) that range in size from 10 – 45 males. Trapping also occurred on dancing grounds in two study sites in Routt County (C1, C2) that ranged in size from 6 – 24 males. I fitted females with 12 g elastic necklace-mounted radio transmitter equipped with a 12-hour mortality circuit having an 8.5 month nominal battery life. I monitored movements every 1-3 days with hand-held Yagi antennas attached to a receiver. When monitoring revealed a successful hatch, I attempted to capture all chicks in the brood within 24 hours. I randomly selected 4 chicks/brood and fit a 0.65 g backpack style transmitter using sutures along the dorsal midline between the wings (Fig. 2). I captured juveniles when they reached 20-23 days-of-age at approximately two hours before sunrise while juveniles are brooding with the female. I removed chick transmitters and replaced them with a 3.9 g back-pack style juvenile transmitter (Fig. 3). I sampled vegetation at all nest and a sample of brood locations.

I captured 109 female CSTG (49 adults: 58 yearlings: 2 unknown) from 1-28 April 2015 on 11 dancing grounds in 5 study areas. Adult and yearling female mass ($\bar{x}$ ± SE) was 694.0 ± 5.6 g (*n* = 58) and 680.2 ± 6.9 g (*n* = 49), respectively. From April through September 2015, I documented 23 and 17 adult and yearling female mortalities resulting in a 6-month adult female survival rate of 0.61 ± 0.01 (*n* = 59; 95% CI 0.48 - 0.74) and a yearling survival rate of 0.64 ± 0.01 (*n* = 48; 95% CI 0.48 - 0.79). I pooled female survival yielding a female survival rate of 0.62 ± 0.01 (*n* = 107; 95% CI 0.52 - 0.72) (Fig. 4). Female survival was similar among study areas. I documented an overall nest initiation rate of 82% (*n* = 40/49) and 91% (*n* = 40/44) for adult and yearling females, respectively. I documented 60% (*n* = 24/40) and 61% (n = 25/41) apparent nest success for adult and yearling females, respectively. Only one yearling female initiated a renest and it was unsuccessful. Female movement from the lek of capture to nest averaged 2.01 ± 0.32 km (*n* = 81; range 0.29 - 24.48 km). The median distance moved was 1.3 km (25% quartile = 0.83 km; 75% quartile = 2.0 km) (Fig. 5). Seventy-four percent (*n* = 61/82) of the nests were located within 2 km of the lek of capture. A slightly different scenario presented itself among study areas. Female movements in the West Axial study appeared to move further with only 31% (*n* = 5/16) of females nesting within 2 km of the lek of capture while 92% (*n* = 23/25), 91% (*n* = 19/21) and 70% (*n* = 14/20) of females nesting within 2 km of the lek of capture at the Iles Dome, Trapper, and Hayden study areas, respectively. I captured 355, chicks from 49 broods with an overall mean mass of 13.8 ± 0.8 g (range 8.0 – 30.4) that ranged in age from 1-8 days. A majority of chicks (91%, n=324/355) were 1-3 days-of-age and included 86% (*n* = 42/49) of the broods. Thus, the mean mass for chicks from 1-3 days-of-age was 13.2 ± 0.2 g (range 8.0 – 21.6). Chick mean mass by study area was 12.3 ± 1.5 g (*n* = 63; range 9.2 – 17.0; 95% CI 11.6-12.8), 12.5 ± 1.2 g (*n* = 102; range 8.0 – 21.2; 95% CI 11.9-13.1), 14.1 ± 0.5 g (*n* = 75; range 9.0 – 21.6; 95% CI 13.1-15.1), and 13.9 ± 0.3 g (*n* = 84; range 9.4 – 18.7;95% CI 13.2-14.5) at West Axial, Iles Dome, Trapper, and Hayden, respectively. Seventy-five percent (*n* = 243/324) of chicks captured were ≤16 g and 41% weighed 10-11 g (Fig. 6). Thus, the percentage of body mass for transmitters was as high as 8% for chicks weighing 8 g (only 1 was that small), but 41% (*n* = 134/324) would have had a transmitter mass of 6.5%. I radio-marked 179 chicks resulting in an average number of chicks marked/brood of 3.7 chicks. Total average brood size was 7.5 chicks (range 2 - 13). I recaptured and marked 76 juveniles at approximately 18 - 21 days-of-age. At the time of this report I have not estimated survival for chicks or juveniles. I conducted vegetation sampling at 66 nest sites and 69 random sites. Due to logistical issues, I did not conduct vegetation sampling at brood sites. Six-month female survival (0.61) was slightly higher than previous reports (2004;0.41 - 0.58) for birds in mineland reclamation, but lower (0.70 - 0.79) than females in shrub steppe habitat at 150 days exposure post-capture. In contrast, survival in this study was higher than other reports (2002; 0.50). I documented a similar, but slightly lower, nest initiation rates than in 2004 (97%) and 2002 (97%) which could be explained by the larger number of yearlings females in my sample. Apparent nest success was higher than one previous report (2004;42%) but similar to another (2002;63%). Transmitter size was higher than the recommended ≤5% of body mass which is a concern and was an unexpected result based on data from a pilot study. In previous studies chick mass ranged from 15 - 19 g, which is similar to chick mass reported for plains sharp-tailed grouse. As chicks age, and become flight capable, transmitter mass will decline to < 1% as chick mass (85- 130 g) increases. Although some transmitter:chick mass ratios

exceeded 5%, this percentage is typically recommended for flight capable birds and may be more important when considering power requirements for flight. Regardless, these results strongly suggest that the day-old chick transmitter size (0.65 g) needs to be reconsidered. Other transmitter sizes are available that range in size from 0.2-0.55 g. The 0.2, 0.3, and 0.5 g transmitters are of a glue-on style and to be retrofit for suture style will require an increase of 0.05 g/transmitter. A decrease in transmitter weight will have a concomitant decrease in battery life from 36 days for 0.65 g to 12 days for 0.20 g with a pulse rate of 30 ppm. This is the first of four planned field seasons; two before treatment and two following treatment.

Figure 1. Study area location of treatment (T) and control (C) sites and the number of males on 2 or more dancing grounds in Moffat and Routt counties, Colorado.

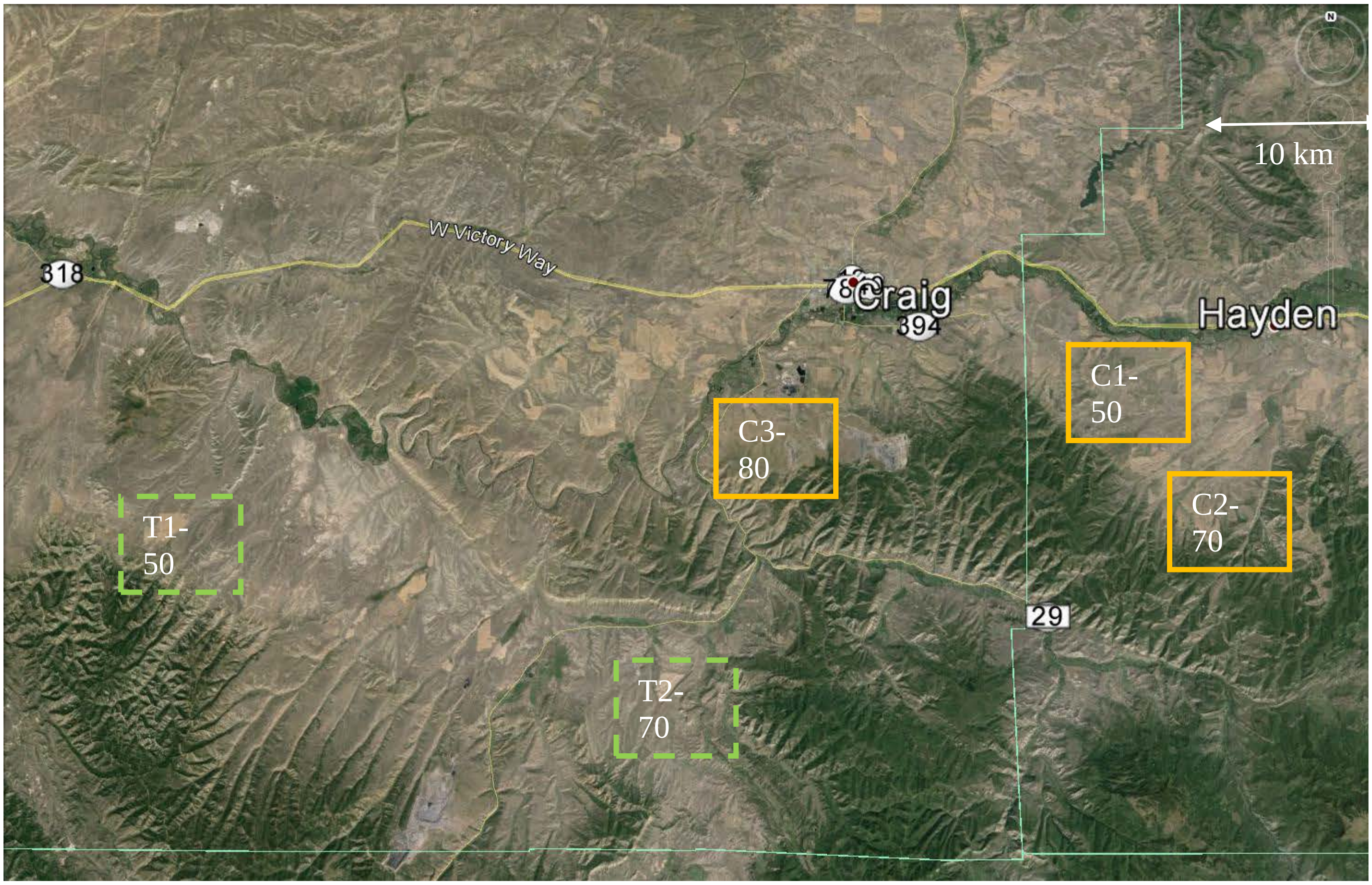


Figure 2. One day-old Columbian sharp-tailed grouse chick after being fitted with a 0.65 g VHF micro-transmitter.

Figure 3. Twenty day-old Columbian sharp-tailed grouse juvenile fitted with a 3.9 g VHF micro-transmitter that replaces the chick transmitter seen in Figure 2.

Figure 4. Kaplan-Meier product-limit monthly survival (± 95% CI) with staggered entry of female Columbian sharp-tailed grouse (n = 107) from April - September in northwest Colorado, 2015.

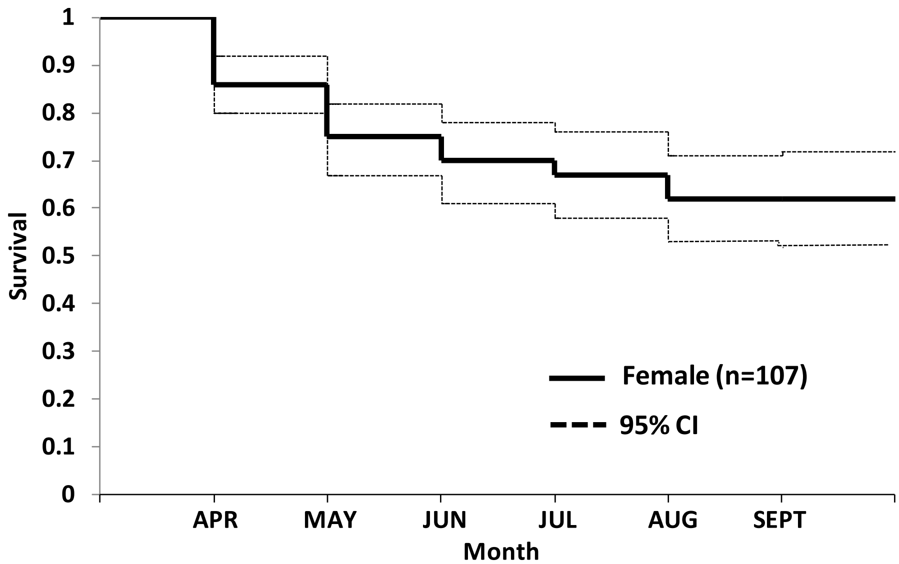


Figure 5. The median distance moved by female Columbian sharp-tailed grouse to nest from the lek of capture at four study areas in northwestern Colorado, 2015.

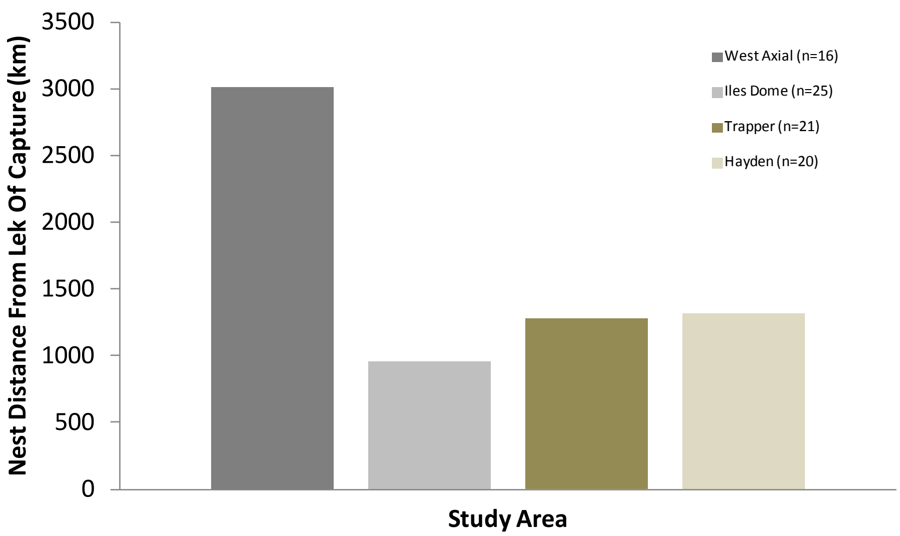
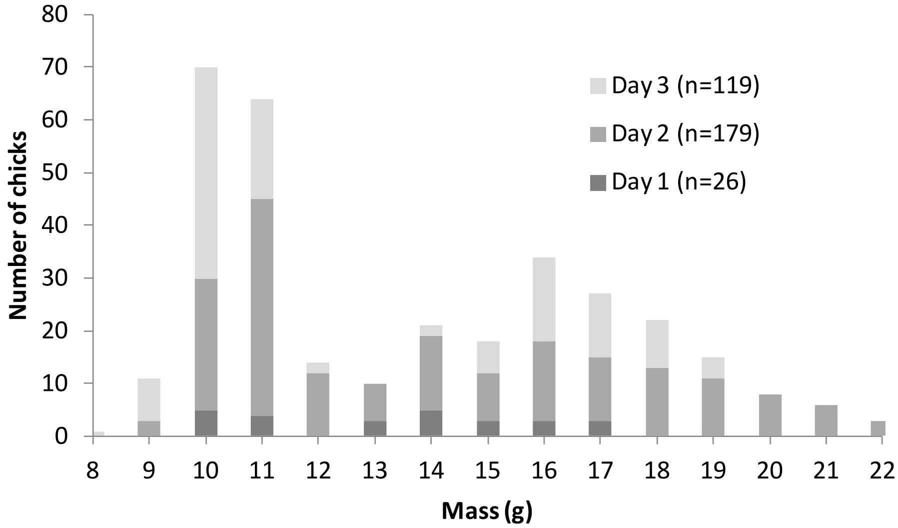


Figure 6. Frequency distribution of the number of 1, 2, and 3 day-old Columbian sharp-tailed grouse chicks by mass in northwestern Colorado, 2015.



Colorado Parks and Wildlife

WILIDLIFE RESEARCH PROJECT SUMMARY

Gunnison Sage-grouse Captive-Rearing

Period Covered: October 1, 2014 – September 30, 2015

Principal Investigator: Anthony D. Apa, tony.apa@state.co.us Michael Phillips, and Lief Wiechman

Project Collaborators: Karen Fox, Colorado State University; Alan B. Franklin, NWRC/APHIS; John V. Azua, Jr., Denver Zoo; Preston Alden, Chris Binschus, Caitlin Davis, Michelle Downey, Kyle LeDoux, Clare Mix, Sarah Ogden, Rob Sadowski, Ben Sedinger, Lisa Stoorza, Sarah Vincent, Clarinda Wilson, Lisa Wolfe, CPW.

Gunnison sage-grouse (*Centrocercus minimus*, hereafter GUSG) is a species of concern in Colorado. Two conservation issues addressed in the Gunnison Sage-grouse Rangewide Plan (RCP) are the population persistence of GUSG (especially the small populations) and the relatively low genetic diversity among GUSG. Augmenting small GUSG populations is a potentially useful management tool to address these conservation concerns. Five alternative techniques to transplanting yearling or adult individuals are discussed in the RCP, including use of captive-reared GUSG. Researchers at the U.S.D.A. National Wildlife Research Center (NWRC) in Fort Collins, CO were able to maintain 18 yearling greater sage-grouse (*C. urophasianus*, hereafter GRSG) in captivity for 8 months. Recent Colorado Parks and Wildlife (CPW) research on GRSG has evaluated different aspects of captive-rearing techniques. The objectives for this project were to: 1) collect 70 GUSG eggs, 2) artificially incubate and hatch eggs, 3) develop captive breeding techniques for GUSG,4) determine if captive GUSG can initiate incubation and rear a brood in captivity, 5) augment wild surrogate broods with domestically-reared chicks at 1-, 3-, 5-, and 7- weeks of age. Female GUSG were captured using spot-lighting techniques. Females were radio-marked and monitored to assist in locating nesting females. Eggs were collected from laying and incubating females. Eggs were transported from the Gunnison Basin to the CPW Foothills Wildlife Research Facility (FWRF) in Fort Collins and placed in an incubator in a newly constructed building until an external pip was observed (25-26 days) and then they were moved to a hatcher.

Objectives 1, 2, and 4:

Gunnison sage-grouse (*Centrocercus minimus*) are distributed across southwestern Colorado and southeastern Utah, United States. Their distribution has decreased over the past century and the species has been listed as threatened by the U.S. Fish and Wildlife Service. Reduced genetic diversity, small population size, and isolation may affect Gunnison sage-grouse population persistence. Population augmentation can be used to counteract or mitigate these issues, but traditional translocation efforts have yielded mixed, and mostly unsuccessful, results. Captive-rearing is a viable, although much debated, conservation approach to bolster wild conservation-reliant species. Although there have been captive-rearing efforts with greater sage-grouse (*C. urophasianus*), to date, no information exists about captive-rearing methods for Gunnison sage-grouse. Therefore, we investigated techniques for egg collection, artificial incubation, hatch, and captive-rearing of chicks, juveniles, subadults, and adults for Gunnison sage-grouse to develop captive-rearing protocol early in conservation. In 2009 we established a captive flock that produced viable eggs. From 2009-2011, we collected and artificially incubated 206 Gunnison sage-grouse eggs from 23 wild and 14 captive females. Our hatchability was 90%. Wild-produced eggs were heavier than captive-produced eggs and lost mass similarly during incubation. We produced 148 chicks in captivity and fed them a variety of food sources (e.g. invertebrates to commercial chow). Bacterial infections were the primary cause of chick mortality, but we successfully reduced the overall mortality rate during the course of our study. Conservationists and managers should consider the utility in developing a captive-rearing program or creating a captive population as part of a proactive conservation effort for the conservation-reliant Gunnison sage-grouse.

Publication

Apa, A. D., and L. A. Wiechman LA. 2015. Captive-rearing of Gunnison sage-grouse for egg collection to adulthood to foster proactive conservation and recovery of a conservation-reliant species. Zoo Biology 34:438-452.

Objective 3:

Gunnison sage-grouse (*Centrocercus minimus*) distribution in North America has decreased over historical accounts and has received federal protection under the Endangered Species Act. We investigated captive-breeding of a captive-flock of Gunnison sage-grouse created from individuals reared in captivity from wild-collected eggs we artificially incubated. We also introduced wild-reared individuals into captivity. Our captive-flock successfully bred and produced fertile eggs. We controlled the timing and duration of male-female breeding interactions and facilitated a semi-natural mating regime. Males established a strutting ground in captivity that females attended for mate selection. In 2010, we allowed females to establish 8 nests, incubate, and hatch eggs. Incubation of nests in captivity was more successful than brood-rearing. Although there are many technical, financial, and logistic issues associated with captive-breeding, we recommend that federal biologists and managers work collaboratively with state wildlife agencies and consider developing a captive-flock as part of a comprehensive conservation strategy for a conservation-reliant species like the Gunnison sage-grouse. The progeny produced from a captive-rearing program could assist in the recovery if innovative approaches to translocation are part of a comprehensive proactive conservation program.

Publication:

Apa, A. D., and L. A. Wiechman LA. In Press. Captive-breeding of captive and wild-reared Gunnison sage-grouse. Zoo Biology.

Objective 5:

Gunnison sage-grouse (*Centrocercus minimus*, hereafter GUSG) is a species of concern in Colorado. Two conservation issues addressed in the Gunnison Sage-grouse Rangewide Plan (RCP) are the population persistence of GUSG (especially the small populations) and the relatively low genetic diversity among GUSG. Augmenting small GUSG populations is a potentially useful management tool to address these conservation concerns. Five alternative techniques to transplanting yearling or adult individuals are discussed in the RCP, including use of captive-reared GUSG. Fifteen wild broods were augmented with 51 captive-reared chicks over 19 separate introductions. Overall adoption success (defined as successful if the chick is with the surrogate brood 24-36 hours post-introduction) was 35.3% (*n* = 18/51). Within Treatment I (7-days), our adoption success was 60% (15/25), although 1 chick was lost due to exposure, and 2 surrogate broods, including 7 domestic chicks were depredated within 24 hours of release, accounting for most of our failed adoptions. Apparent survival of the domestically reared chicks was 0% (0/39). Four of the 51 chicks were censored from the analysis after the transmitters fell off. Eight of the remaining 47 were missing and their fate is unknown. Data collection and analysis for this project is completed and the publication process is in progress and some are completed.

Publication

Wiechman, L. A. and A. D. Apa. In Prep. Production, brood augmentation and chick survival of Gunnison sage-grouse. Wildlife Society Bulletin.

Colorado Parks and Wildlife

WILIDLIFE RESEARCH PROJECT SUMMARY

Development of landscape scale resource selection models for the management of Gunnison sage-grouse in the Gunnison Basin population

Period Covered: October 1, 2014 – September 30, 2015

Principal Investigator: Mindy B. Rice, mindy.rice@state.co.us, and Anthony D. Apa, tony.apa@state.co.us

Project Collaborators: Michael Phillips, J Wenum

All information in this report is preliminary and subject to further evaluation. Information MAY NOT BE PUBLISHED OR QUOTED without permission of the principal invetsigator. Manipulation of these data beyond that contained in this report is discouraged.

Gunnison sage-grouse (*Centrocercus minimus,* GUSG) have declined substantially from their historical range and were listed as threatened by the U. S. Fish and Wildlife Service (USFWS) in November of 2014. GUSG are distributed into seven isolated populations in Colorado and one population, Gunnison Basin (GB) comprises 85-09% of all GUSG in the state. Concern over the small population size and isolated and fragmented nature of many of the smaller populations has led to interest in the habitat use of GUSG. Much of the information that has been used on GUSG habitat selection has come from studies pertaining to Greater Sage-grouse (*Centrocercus urophasianus*). Currently the USFWS have designated most of the GB as critical habitat, but there may be some variability to the quality and use of that critical habitat which could refine those maps for better management of the species. To successfully manage and understand the GUSG, we must identify the habitat that is most important to the birds using data driven models. Colorado Parks and Wildlife has collected radio-telemetry data from almost 200 birds from 2004-2010 which could be used to model habitat selection with a robust dataset specific to the GUSG in the GB.

We used radio-telemetry data from individual GUSG caught during the spring and fall periods 2004-2010. Following release, radiotelemetry locations of radio-marked individuals were estimated on the ground using hand-held Yagi antennas once every 1-3 days (from date of capture through September) to monitor status (dead or alive) and movement patterns. We were able to estimate resource selection models for the breeding (April to July 15) and summer seasons (July 16 to September). We used 3,936 locations from 188 GUSG for the breeding season model and 3,721 locations from 171 GUSG for the summer model. We buffered each use location by the average daily movements of 180.5 m in the breeding period and 223 m in the summer period. We generated 9,000 "available" locations across the entire GB and used the same seasonal buffers. Vegetation, topographical, and development variables were extracted for each buffer to be used in the analysis. Development variables included roads, subdivisions, trails, easements, and address points collected by Gunnison County. We used a generalized mixed linear model with a logistic link and a random effect for individual birds to model habitat use. We used all linear combinations of variables and model averaged over the 95% model set. We utilized an average prediction surface in ArcMap 10.1.

The breeding model indicated that GUSG were 2.24 times as likely to be located in sagebrush and 1.5 times as likely to be located in high densities of trails (Table 1). Being closer to subdivisions and easements and further from wetlands were also important predictors. Finally, GUSG are 1.49 more likely to not be located in forest. There were also smaller effects including being located in grassland, slightly higher elevations, in areas with higher water density, in areas with high road density and further from class 1 and 2 roads and further from address points (Table 1). The resulting prediction surface indicated that large swaths of sagebrush had a higher relative probability of GUSG presence and many of the drainages were avoided (Figure 1).

The summer model indicated that GUSG were 3.64 times as likely to be located in sagebrush, 2.41 times as likely to be located in irrigated agriculture, 1.41 times as likely to be in grassland, and 1.8 times as likely to be in alpine (Table 2). Being closer to subdivisions and easements and further from house address points were also important predictors. Finally, GUSG are 1.49 more likely to NOT be located in forest. GUSG are more likely to be in areas with high trail densities, low road densities, and high water densities. GUSG are also more likely to be closer to roads and slightly further from wetlands. They are also going to be located in higher elevations (Table 2). The resulting prediction surface indicated that GUSG used a more diverse set of habitats and tended to move into higher areas within the GB (Fig. 2).

Overall GUSG are dependent on large swaths of sagebrush although they tend to have more diverse selection during the summer when they utilize numerous habitats including grassland, irrigated agriculture, and alpine. They tend to be close to subdivisions and easements and in areas with high levels of trail density in both seasons. Overall, not all the human related variables were negatively impacting GUSG although it was dependent on the season. These models can be used to further refine the estimated critical habitat currently being used by USFWS as they reduce the amount of critical habitat in both seasons. In addition, these models provide information regarding two seasons in the GUSG life cycle and can be used to manage the population on the ground.

Table 1. Model averaged model coefficients, confidence intervals, and odds ratios for Gunnison sage-grouse during the breeding season in the Gunnison Basin of Colorado.

Variable	**β**	**SE**	**LCI**	**UCI**	**Odds ratio**
Intercept	- 1.671				
Sagebrush	0.805	0.065	0.712	0.899	2.24
Grassland	0.184	0.037	0.131	0.238	1.2
forest	- 0.396	0.081	- 0.513	- 0.279	0.67
elevation	0.095	0.039	0.039	0.151	1.10
distance to wetlands	0.517	0.029	0.479	0.554	1.68
water density	0.230	0.029	0.189	0.271	1.26
Road density	0.139	0.032	0.093	0.185	1.15
Distance to roads	0.103	0.032	0.056	0.149	1.11
Trail density	0.463	0.029	0.421	0.504	1.59
Distance to address points	0.309	0.034	0.260	0.358	1.36
Distance to subdivisions	- 0.536	0.049	- 0.607	- 0.495	0.58
Distance to easements	- 0.458	0.039	- 0.514	- 0.402	0.64

Table 2. Model averaged model coefficients, confidence intervals, and odds ratios for Gunnison sage-grouse during the summer season in the Gunnison Basin of Colorado.

Variable	β	SE	LCI	UCI	Odds ratio
Intercept	- 1.580				
Sagebrush	1.292	0.058	1.209	1.376	3.64
Grassland	0.342	0.033	0.294	0.389	1.41
Irrigated agriculture	0.881	0.042	0.821	0.941	2.41
Alpine	0.592	0.032	0.547	0.638	1.81
elevation	0.238	0.039	0.182	0.295	1.27
distance to wetlands	0.072	0.026	0.035	0.110	1.07
water density	0.161	0.027	0.123	0.199	1.17
Road density	- 0.356	0.040	- 0.413	- 0.299	0.70
Distance to roads	- 0.294	0.032	- 0.340	- 0.249	0.75
Trail density	0.339	0.028	0.299	0.379	1.40
Distance to address points	0.377	0.034	0.328	0.427	1.46
Distance to subdivisions	- 0.655	0.040	- 0.713	- 0.597	0.52
Distance to easements	- 0.453	0.037	- 0.506	- 0.399	0.64

Figure 1. Relatively probability of Gunnison sage-grouse presence during the breeding season across the Gunnison basin using data from radio-telemetry data collected from 2004 until 2010.

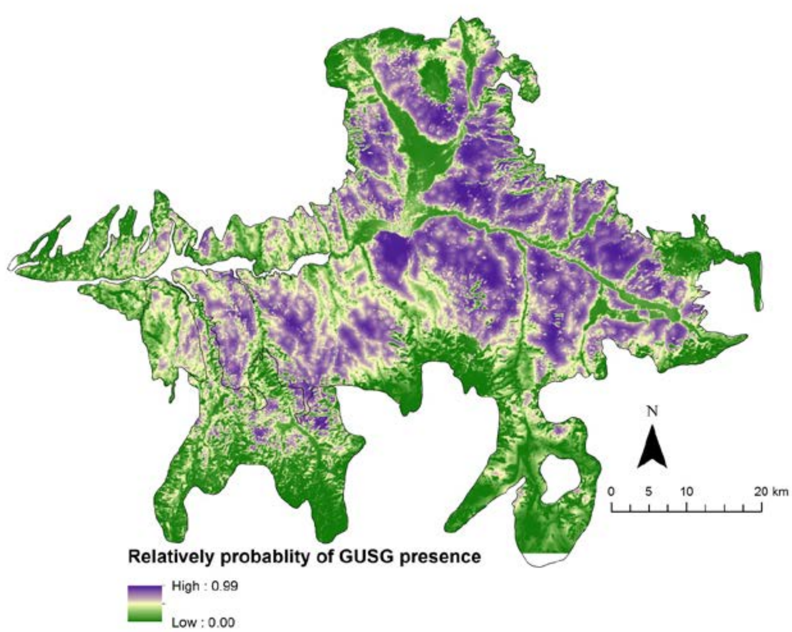
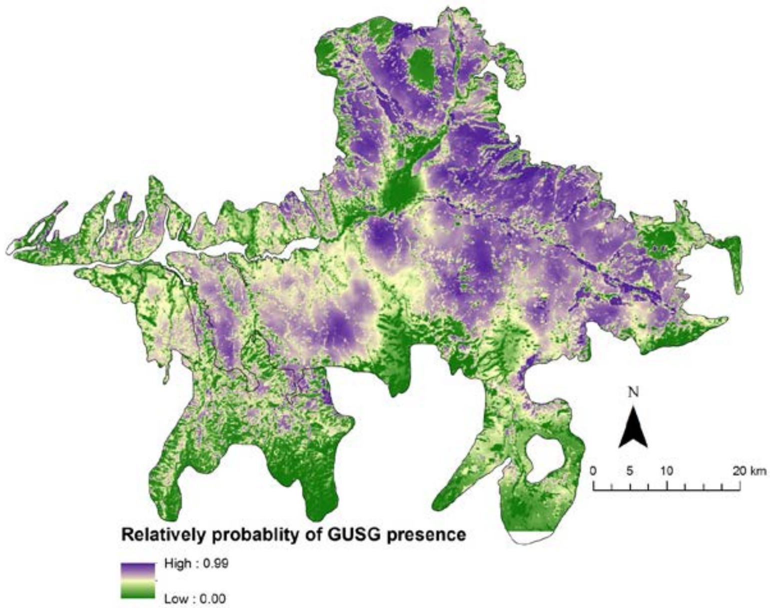


Figure 2. Relatively probability of Gunnison sage-grouse presence during the summer season across the Gunnison basin using data from radio-telemetry data collected from 2004 until 2010.



Colorado Parks and Wildlife

WILIDLIFE RESEARCH PROJECT SUMMARY

Greater Sage-grouse Natal Dispersal and Brood Augmentation with Captive-reared Chicks

Period Covered: March 1, 2005 – November 1, 2015

Principal Investigator: Anthony D. Apa, tony.apa@state.co.us

Project Collaborators: T. R. Thompson and K. P. Reese, University of Idaho, Moscow, ID

All information in this report is preliminary and subject to further evaluation. Information MAY NOT BE PUBLISHED OR QUOTED without permission of the principal invetsigator. Manipulation of these data beyond that contained in this report is discouraged.

In response to population declines, recent research on greater sage-grouse (*Centrocercus urophasianus*) has focused on the population ecology, habitat relationships, and response to management practices by this species. However, the mechanisms, patterns, and consequences of movements between seasonal habitats, especially by juveniles during natal dispersal, and the effects of this movement on survival, recruitment, the redistribution of individuals, as well as the population dynamics within and between populations remains largely unknown. Quantifiable data and information on juvenile dispersal and survival in the greater sage-grouse is one of the least understood aspects of this species' life history. Dispersal patterns and recruitment processes of juvenile sage-grouse, as well the landscape characteristics that influence and contribute to these movements remain lacking. Knowledge of the dispersal ecology (timing, distances moved, frequency and rate of movement, immigration and emigration rates within and between populations, and juvenile survivorship) will provide better information on how to manage this species at the landscape level, as well as within and between populations. This information will be useful in attempting to improve and plan for the conservation and management of this species as its habitat becomes more fragmented and altered. The objectives of our study were to 1) determine the sex-specific movement patterns of juvenile sage-grouse during natal dispersal including timing, duration, rate of movement, distances moved and recruitment rate, 2) determine the effects of these dispersal patterns on survival rates and causes of mortality, 3) determine how landscape structure influences both the movement patterns and survival of juveniles during this period, 4) verify and evaluate the mechanisms and conditions of adoption in wild broods through the introduction of domestically-hatched chicks and observation of natural adoption rates, 5) assess the movement patterns and survivorship of successfully adopted domestically-hatched 2 and 7 day-old chicks from the natal area of the surrogate brood to chick independence and brood break-up (approximately 10 weeks of age), and 6) compare the movement patterns and survivorship of domestically-hatched chicks with the movement patterns and survivorship of wild-hatched chicks in mixed and unmixed broods from the natal area of the surrogate brood to chick independence and brood break-up. The study areas were located in the Axial Basin and Cold Springs Mountain in northwestern Colorado from 2005 – 2007. The project field research and final report is complete and we continue in the publication phase of this research project.

Objectives 4, 5, and 6

Captive rearing sage-grouse for augmentation of surrogate wild broods: evidence for success

Both species of North American sage-grouse (Centrocercus spp.) have experienced declines in distribution and abundance. Translocation of adult birds from a stable population to a small or declining population has been a management tool used by wildlife managers to support population persistence in these areas. Captive rearing chicks and releasing them into wild surrogate broods is an untested alternative to augment declining populations of sage-grouse. We developed techniques to successfully rear sage-grouse chicks in captivity, evaluated explanatory variables that could influence hatch and captive-rearing success, and estimated the survival of domestically hatched (DH) chicks to 28 days of age following introduction to a surrogate wild brood.We collected 304 eggs from radiomarked female greater sage-grouse (C. urophasianus) during 2004–2007 in 3 study areas in northwestern Colorado. Estimated hatching success of collected eggs was 0.745 (SE¼0.022, 95% CI¼0.700–0.786) and was negatively influenced by the number of days an egg was stored and the percent egg weight loss that occurred during storage and incubation. We monitored 175 DH chicks in captivity for 1–10 days before introduction and adoption into surrogate wild broods. Model-averaged captive-rearing success was 0.792 (SE¼0.045, 95% CI¼0.686–0.865) across years, and was positively influenced by initial chick mass at hatch and daily weight gain in captivity but negatively influenced by the number of days the egg was stored and advancing hatch date. We were able to radiomark and monitor 133 DH chicks adopted into surrogate wild broods until 28 days of age. Eighty-eight percent of DH chicks were successfully adopted within 24 hours. Our overall estimate of DH chick survival to 28 days (0.423; 95% CI¼0.257–0.587) was comparable to published wild-hatched chick survival. Predation and exposure-related deaths accounted for 26.3% and 25.6% of the known fates, respectively. Our captive-rearing protocols and techniques were successful for collecting greater sage-grouse eggs, hatching and rearing chicks in captivity, and releasing chicks into wild surrogate broods. This success further implies that captive rearing and release can be a potential management strategy to demographically and genetically reinforce or augment small populations of sage-grouse.

Publication:

Thompson, T. R., A. D. Apa, K. P. Reese, and K. M. Tadvick. 2015. Captive rearing sage-grouse for augmentation of surrogate wild broods; evidence for success. Journal of Wildlife Management 79:998-1013.

Objectives 1 & 2:

Survival of greater sage-grouse broods and chicks from hatch to brood independence in northwestern Colorado

Survival of chicks from hatch to brood independence and recruitment into fall populations is an important but poorly understood life history trait that can have important consequences on the dynamics and viability of greater sage-grouse (*Centrocercus urophasianus*) populations. Little is known about how the factors of gender, hatch date, hatch weight, distance traveled from nest, and brood size contribute both individually and ecologically to survival of chicks. We monitored survival and causes of mortality in wild-hatched (WH) chicks (n = 431) in wild broods (n = 115) from hatch to 16 weeks of age in the AB (Axial Basin) and CSM (Cold Springs Mountain) study areas in northwestern Colorado, 2005-2007 and evaluated potentially important predictors of brood and chick survival. In addition, we monitored survival from hatch to 16 weeks of age for a cohort of domestically-hatched (DH) chicks raised to 1-10 days of age in captivity (n = 116) and introduced into a subset of wild broods during this same time period. Overall brood survival from 2005-2007 (both wild and wild broods augmented with DH chicks) to 16 weeks of age was 0.381 (95% CI: 0.264 – 0.514) at CSM compared to 0.533 (0.405 – 0.657) in the AB. Within the AB, we observed higher model-averaged survival rates among broods with DH chicks (0.631, SE = 0.088) compared to broods without (0.430, SE = 0.104), while at CSM the pattern was reversed (0.205, SE = 0.102 and 0.573, SE = 0.080). When we included broods that were depredated 1-3 days post-hatch and before radiomarking of chicks our overall apparent brood survival decreased from

47.8% (55/115) to 43.7% (55/126). The main cause of chick death was from predation, although exposure accounted for 27% of mortalities among DH chicks. Model averaged estimates of brood and chick survival indicated that survival varied both temporally and spatially. Brood and chick survival were higher in the AB compared to CSM, and WH chicks had higher survival in both areas compared to DH chicks. Similarly, DH and WH chicks at CSM in both augmented and wild broods had lower survival than DH and WH chicks in the AB with the largest differences occurring during weeks 1 – 3. Among the WH chicks survival rates among years in the AB ranged from 0.158 to 0.446 and at CSM from 0.088 to 0.339. Between study areas and among years survival was lowest during the first 3 – 4 weeks. We found evidence that chick survival increased with age and decreased with advancing hatch date, but found limited support for the influence of gender or distance traveled. We recommend that managers develop better understanding and knowledge of the relationship between nesting cover and brood habitat, as well as movement patterns between these areas within a landscape for each population. Managers need to consider prioritizing the protection and restoration of both early- and late brood-rearing habitat within specific landscapes, as our study demonstrates 2 bottlenecks through which chick survival significantly decrease at < 21-day post-hatch and during brood independence at > 10 weeks of age. We suggest that > 3 areas of each seasonal brood habitat type be dispersed within a breeding population to maintain traditional use patterns and to facilitate the use of new areas (i.e., restorations or plantings such as CRP), so as to help reduce predation risks and exposures due to concentration of broods in poor quality or limited critical habitat.

Publication:
Thompson, T. R., A. D. Apa, and K. P. Reese. In Prep. Survival of greater sage-grouse broods and chicks from hatch to brood independence in northwestern Colorado. Journal of Wildlife Management.

Objectives 1 & 2:
Survival, natal dispersal and recruitment of juvenile greater sage-grouse in northwest Colorado

Juvenile survival and recruitment has not been studied extensively in many grouse species, including greater sage-grouse (*Centrocercus urophasianus*). Since there is scant information on this vital rate, the implications of management actions on specific population demographics remains unknown. We captured, radio-marked, and monitored survival and recruitment of 183 transmitter-equipped juvenile sage-grouse from 1 September – 31 March at 2 study areas in northwest Colorado (AB: Axial Basin, CMS: Cold Springs Mountain). Juvenile grouse survival September through March varied by month, study area, and gender. Juvenile females had higher survival than juvenile males, and survival for each was higher in AB compared to CSM. Juvenile survival was lowest during September and October and coincided with brood independence and integration into winter flocks. Average survival from hatch to recruitment into the natal breeding population (March) varied between areas (AB: $\overline{x}$ = 0.287, SE = 0.039; CSM: $\overline{x}$ = 0.122, SE = 0.054). This information on survival and recruitment of juvenile sage-grouse has important implications for the management of this species at local, landscape, and regional levels.

Publication:
Apa, A. D., T. R. Thompson, and K. P. Reese. In Prep. Juvenile greater sage-grouse survival, fall movements, and recruitment in northwest Colorado. Journal of Wildlife Management.

Objectives 1 & 2:
Dispersal, gene flow, and population genetic structure in the greater sage-grouse: implications for connectivity and natural recolonization

Dispersal and gene flow have important consequences for the population dynamics and genetic structure of populations. However, for most species the degree to which dispersal and gene flow maintain population demographic and genetic connectivity remains unknown. Here, we compare the patterns of dispersal and genetic structure in Greater Sage-Grouse (*Centrocercus urophasianus*) at 15 leks in six population management zones (PMZs) in northwest Colorado by genotyping 275 individuals at 17 microsatellite loci. All leks showed high levels of genetic diversity, and low levels of genetic structure were observed between neighboring leks and PMZs. Multiple analyses revealed an isolation by distance pattern among leks and PMZs that followed a directional or two-dimensional stepping-stone pattern. Contrary to the traditional view of female-biased dispersal in avian and grouse species, we observed direct evidence of male-biased dispersal in our radio-telemetry data, but less evidence in our genetic methods. Our spatial autocorrelation analyses revealed significantly positive *r* values out to the 5 km distance class for males and 15 km distance class for females. Analyses of dispersal using direct and indirect methods indicated that dispersal distances above 20 km are rare. Our study demonstrates the importance of using both demographic and genetic methods to define and understand population characteristics and manage populations at appropriate scales.

Publication:
Apa, A. D. T. R. Thompson, S. Oyler-McCance, K. P. Reese, and L. P. Waits. In Revision. Comparing dispersal and gene flow in the greater sage-grouse: implications for connectivity and natural recolonizaton. Condor.

Objective 3:
Relationship of landscape characteristics to movement behaviors and settlement patterns of greater sage-grouse in northwest Colorado

Range-wide declines in greater sage-grouse (*Centrocercus urophasiansus*) populations have largely been attributed to loss, degradation, and fragmentation of sagebrush habitats and landscapes that are believed to negatively impact population vital rates, movements, and distribution patterns. Current understanding of these processes in sage-grouse is primarily limited to adult age individuals with little understanding of their influences on juvenile movement behaviors and settlement patterns. In this study we assessed how landscape composition (percent land cover) and edge density (m/ ha) within the dispersal range (winter and dispersal locations) and dispersal period landscapes (pre-dispersal, winter, and post-dispersal locations) differed between male and female juvenile sage-grouse in 2 study areas (Axial Basin and Cold Springs Mountain) in northwestern Colorado. During September – April, 2005 – 2008 we monitored 95 juveniles (74 female and 31 males). Before running landscape analyses we performed an accuracy assessment on 3 potential Landsat satellite imagery sources (Colorado Vegetation Classification Project, LANDFIRE, and Southwest Regional GAP) and used overall accuracy, and kappa coefficients to determine which data source would have the highest quality and less uncertainty in derived land cover maps. Using the LANDFIRE (2006) Existing Vegetation Map we compared proportion of land cover types and edge densities in 4 dominant land cover types (sagebrush dominated community (*Artemisia tridentata* spp), salt desert shrub dominated community (shadscale saltbush (*Atriplex confertifolia*); greasewood (*Sarcobatus vermiculatus*)), grassland/ rangeland/ perennial grass and forb, and deciduous shrub/ mountain-shrub dominated community (bitterbrush (*Purshia tridentate*); Gambel oak (*Quercus gambelii*); serviceberry (*Amelanchier spp*); snowberry (*Symphoricarpos spp.*), and tested for effect on genders, areas, dispersal ranges, and among dispersal period landscapes at 2 spatial extents (500- and 2,000-m). Dispersal ranges and dispersal period landscape metrics were not significantly different between genders at either buffer extent. Within dispersal ranges, percent cover in sagebrush did not significantly differ between study areas at the 500-m buffer extent; however at the 2,000-m buffer extent proportion of land cover in sagebrush was higher in the Axial Basin. Among dispersal period landscapes, measured metrics significantly differed between areas and among periods. At the 500-m buffer extent winter and post-dispersal landscapes in the Axial Basin had higher land cover in sagebrush, lower edge density in sagebrush, and lower cover in salt desert shrub compared to Cold Springs Mountain. At the 2,000-m buffer extent a similar pattern was observed, as well as higher land cover in sagebrush and shrub, as well as shrub edge density in the Axial Basin. The grassland cover type did not significantly differ at either buffer extent for dispersal range or dispersal period landscapes. We believe this suggests natal dispersal movement behaviors and settlement patterns within our study areas, where percent land cover in sagebrush are > 60%, are not directly influenced by landscape structure or composition in the dispersal range or period, but by individual and population pressures and demands (e.g., access to resources, inbreeding avoidance, traditional use) related to the breeding and production (brood-rearing) areas.

Publication:

Thompson, T. R., A. D. Apa, and K. P. Reese. In Prep. Relationship of landscape characteristics to movement behaviors and settlement patterns of greater sage-grouse in northwest Colorado. Journal of Wildlife Management.

Colorado Parks and Wildlife

WILIDLIFE RESEARCH PROJECT SUMMARY

Using GPS satellite transmitters to estimate survival, detectability on leks, lek attendance, inter-lek movements, and breeding season habitat use of male greater sage-grouse in northwestern Colorado

Period Covered: September 1, 2014 – August 31, 2015

Principal Investigator: Brett L. Walker, brett.walker@state.co.us

Project Collaborators: Brian Holmes, Brad Petch, Bill deVergie

All information in this report is preliminary and subject to further evaluation. Information MAY NOT BE PUBLISHED OR QUOTED without permission of the principal investigator. Manipulation of these data beyond that contained in this report is discouraged.

Implementing effective monitoring and mitigation strategies is crucial for conserving populations of sensitive wildlife species. Concern over the status of greater sage-grouse (*Centrocercus urophasianus*) populations has increased both range-wide and in Colorado due to historical population declines, range contraction, continued loss and degradation of sagebrush habitat, and the potential for listing the species under the Endangered Species Act. Despite untested assumptions, lek-count data continue to be widely used as an index of abundance by state and federal agencies to monitor sage-grouse populations. Lek locations are also commonly used to identify and protect important sage-grouse habitat. However, the use of lek counts and lek locations to monitor and manage sage-grouse populations is controversial because how closely lek-count data track actual changes in male abundance from year to year and how effective lek buffers are at reducing disturbance to male sage-grouse and the habitat they use during the breeding season are largely unknown. Colorado Parks and Wildlife deployed solar-powered GPS transmitters on male greater sage-grouse and conducted double-observer counts and resighting at leks to obtain data on male survival, lek attendance, inter-lek movements, detectability, and diurnal and nocturnal habitat use around leks during the breeding season in and near the Hiawatha Regional Energy Development project area in northwestern Colorado in spring from 2011-2014. These data will allow us to evaluate the reliability of current lek-based monitoring methods for providing information about sage-grouse population trends the performance of lek buffers for conserving greater sage-grouse habitat. Analyses for this project are in progress.

Figure 1. Attachment, placement, and camouflage of rump-mounted, solar-powered, GPS satellite PTT transmitters for male greater sage-grouse.

Colorado Parks and Wildlife

WILIDLIFE RESEARCH PROJECT SUMMARY

Evaluation of alternative population monitoring strategies for greater sage-grouse (*Centrocercus urophasianus*) in the Parachute-Piceance-Roan population of northwestern Colorado

Period Covered: September 1, 2014 – August 31, 2015

Principal Investigators: Brett L. Walker, brett.walker@state.co.us, and Jessica S. Brauch (Colorado State University)

Project Collaborators: Brian Holmes, Brad Petch, Bill deVergie, J. T. Romatzke

Robust estimates of population size and population trends provide the scientific basis for managers to make appropriate and defensible recommendations regarding land-use decisions, harvest regulations, and mitigation efforts for wildlife. When linked with environmental variables, robust monitoring programs also allow managers to examine wildlife responses to various stressors. However, many wildlife monitoring programs continue to use untested population indices that may not provide reliable information on population status or trends. For this reason, it is essential to evaluate alternative approaches to population monitoring in terms of estimator precision, cost, practicality, and level of disturbance. Lek counts are the primary index used by state wildlife agencies to monitor changes in greater sage-grouse (*Centrocercus urophasianus*) abundance, but current lek-count monitoring relies on untested assumptions about lek attendance, detectability, inter-lek movement, sex ratio, and proportion of leks counted. Given the availability of new methodological and statistical approaches to estimate wildlife populations, it is worth comparing the performance of current lek-count approaches against other monitoring methods. Dual-frame sampling of leks by helicopter and non-invasive genetic mark-recapture analyses based on winter pellet sampling are promising alternative for monitoring trends in sage-grouse populations. The purpose of this study is to evaluate and compare the reliability and efficiency of dual-frame sampling, genetic mark-recapture, and standard lek counts for estimating population size and trend and to estimate sex ratio in the Parachute-Piceance-Roan population in northwest Colorado. All field data collection for this project was completed in May 2014. We are using occupancy modeling to account for imperfect detectability of leks in each frame. The dual-frame analysis is in progress. All pellet samples have been analyzed to derive genetic data. Some pellet samples are currently being re-run because they had missing data for some alleles. We will analyze genetic data (including sex ratio) once final data are available using both traditional genetic mark-recapture and spatial genetic mark-recapture models to estimate sex-specific abundance in each of the two winters.

Colorado Parks and Wildlife

WILIDLIFE RESEARCH PROJECT SUMMARY

Evaluating lek-based monitoring and management strategies for greater sage-grouse in the Parachute-Piceance-Roan population of northwestern Colorado

Period Covered: September 1, 2014 – August 31, 2015

Principal Investigators: Brett L. Walker, brett.walker@state.co.us

Project Collaborators: Bill deVergie, Stephanie Duckett, Brian Holmes, Brad Petch, J.T. Romatzke

All information in this report is preliminary and subject to further evaluation. Information MAY NOT BE PUBLISHED OR QUOTED without permission of the author. Manipulation of these data beyond that contained in this report is discouraged.

Implementing effective monitoring and mitigation strategies is crucial for conserving populations of sensitive wildlife species. Concern over the status of greater sage-grouse populations has increased range-wide and in Colorado due to population declines, range contraction, loss and degradation of sagebrush habitat, and potential for listing the species under the Endangered Species Act. Despite untested assumptions, lek counts are widely used as an index of abundance by state agencies to monitor sage-grouse populations. Lek locations are also commonly used to identify and protect important sage-grouse habitat. However, the use of lek counts and locations to monitor and manage sage-grouse populations remains controversial because it is unknown how closely lek-count data track actual changes in male abundance from year to year or if lek buffers are effective at protecting habitat for male sage-grouse during the breeding season. Colorado Parks and Wildlife deployed solar-powered GPS satellite transmitters on male greater sage-grouse to obtain data on male survival, lek attendance, inter-lek movements, and diurnal and nocturnal habitat use around leks and conducted double-observer lek counts to estimate detectability of males on leks during the breeding season in the Parachute-Piceance-Roan population in northwestern Colorado in spring from 2012-2015. These data will allow us to evaluate whether current lek-based monitoring methods provide reliable information about sage-grouse population trends and whether current lek buffers are effective at protecting breeding males. Chevron did not provide access in spring 2015, so no additional GPS males were marked. We monitored 17 GPS males for part or all of the 1 September 2014 - 31 August 2015 period. Analyses for this project are in progress.

Colorado Parks and Wildlife

WILIDLIFE RESEARCH PROJECT SUMMARY

Assessment of greater sage-grouse response to pinyon-juniper removal in the Parachute-Piceance-Roan population of northwestern Colorado

Period Covered: September 1, 2014 – August 31, 2015

Principal Investigators: Brett L. Walker, brett.walker@state.co.us

Project Collaborators: Bill deVergie, Brian Holmes, T. Knowles, Brad Petch

All information in this report is preliminary and subject to further evaluation. Information MAY NOT BE PUBLISHED OR QUOTED without permission of the author. Manipulation of these data beyond that contained in this report is discouraged.

Greater sage-grouse (*Centrocercus urophasianus*) in the Parachute-Piceance-Roan (PPR) region of western Colorado face at least two major potential stressors: projected habitat loss from energy development and a long-term decline in habitat suitability associated with pinyon-juniper (PJ) encroachment. Pinyon-juniper removal may be a useful mitigation tool to offset potential habitat losses associated with energy development. Although pinyon-juniper removal is commonly used to improve habitat for greater sage-grouse, no studies to date have quantified the timing or magnitude of how birds respond to treatments. Since 2008, Colorado Parks and Wildlife (CPW) has cooperated with industry and landowner partners to investigate the effectiveness of pinyon-juniper removal for restoring sage-grouse habitat in the PPR. In fall 2008, I established nine "survey" study plots, arranged in three groups of three, with each group consisting of a Sagebrush-Control plot, an untreated PJ-Control plot, and a PJ-treatment plot. Treatments were completed on three survey plots in 2010 and 2011. Pellet surveys in summer from 2009-2015 indicated that the mean proportion of sample units containing pellets was consistently highest on sagebrush control plots (range 0.197-0.449 across years), consistently lowest on plots with encroaching pinyon-juniper (range 0.007-0.048), and increased on 2 of 3 treated survey plots (Ryan Gulch and Upper Galloway) within 1-2 years after treatment. Fourteen transect plots were established in fall 2010 and summer 2011, and two were established in summer 2014. Transect plots were surveyed for pellets in summer though 2015. As expected, estimated mean pellet piles/km were low on the four PJ-Control plots for the duration of the study (range across years = 0.00-0.58 pellets/km) and on PJ-Treatment plots prior to treatment (mean = 0.03 pellet piles/km). Mean pellet piles/km were consistently higher on all four Sagebrush-Control transect plots through 2014 (range across years = 11.10 - 27.14 pellet piles/km), but declined precipitously on 3 of 4 Sagebrush-Control plots in 2015 (Magnolia Control, Upper Barnes Control, and Wagonroad Control). Pellet piles/km were also high on the Lower Barnes transect plot 4-5 years post-treatment (13.78-25.71 piles/km), but declined 6-8 years post-treatment (0.00-3.91 pellet piles/km). Mean pellet piles/km has generally remained low on treated transect plots for four years after pinyon-juniper removal (range across years = 0.00 - 2.86 pellet piles/km) with the exception of Upper Bar D in 2014 (8.96 pellet piles/km). Estimates of proportion of sample units with pellets (from survey plots) and of pellet piles/km (from transect plots) also varied substantially among Sagebrush-Control plots within years and among years within plots, which suggests there is substantial variation in pellets deposited within suitable habitat (i.e., over and above variation in counts due to observer bias). We completed double-observer sampling on survey plots in 2013, 2014, and 2015 to estimate sample unit-level detectability, and we completed distance sampling on transect plots in 2014 and 2015 to generate distance-detection curves, and those analyses are in progress. We established and conducted pre- and post-treatment surveys on two additional transect plots (Lower Galloway and

Lower Ryan Gulch) in summer 2014 and 2015. To date, response to pinyon-juniper removal has been inconsistent, with pellet counts increasing on only two of eight plots within 4-5 years post-treatment. However, a recent experimental treatment suggests that sage-grouse may respond more strongly to combined pinyon-juniper and serviceberry removal. We are developing a proposal to expand the current pinyon-juniper removal project to include serviceberry treatments on existing study plots starting in fall 2017.

Colorado Parks and Wildlife

WILIDLIFE RESEARCH PROJECT SUMMARY

Development of landscape scale resource seletion models using interpolated layers from micro-scale vegetation measurements in North Park, Colorado

Period Covered: October 1, 2014 – September 30, 2015

Principal Investigator: Mindy B. Rice

All information in this report is preliminary and subject to further evaluation. Information MAY NOT BE PUBLISHED OR QUOTED without permission of the principal invetsigator. Manipulation of these data beyond that contained in this report is discouraged.

State agencies have long used micro-scale vegetation measurements to assess relationships between species and how they chose their habitat. Often species select habitat at small scales based on vegetation structure, the height and density of certain vegetation, and the availability of forage species. With the onset of remote sensing and the ability to predict species' distributions based on relatively easy and inexpensive methods, micro-scale measurements have had reduced value when describing a species' habitat selection. There is also the problem of how to translate micro-scale measurements at a small scale to landscape level resource selection models. There is a long history of using interpolation methods to predict vegetation characteristics across space, but these predictive surfaces have rarely been applied to spatial models of species habitat.

I tested the ability of micro-scale vegetation measurement predictive layers to be incorporated into landscape scale models related to the North Park population of greater sage-grouse (*Centrocercus urophasianus*) (GRSG) in Colorado. The GRSG is a species of conservation concern due to historical population declines and range contraction. For species that use large areas including GRSG, there is value in evaluating habitat selection at multiple spatial scales as species may respond differently at larger or smaller scales. Finer scale models based on detailed species and landscape information have shown great potential to detect crucial habitat not obvious at broader scales. How we incorporate this information may be critical to how we manage GRSG on the ground.

As part of a radio-telemetry study of GRSG conducted in 2010-2012, vegetation measurements were taken at all located nest sites as well as a sample of brood, broodless female, and winter sites. I created a grid layer of 1-km^2 cells across North Park (Fig. 1) and selected individual grid cells based on a spatially balanced random sample in which to determine GRSG use or non-use. The same vegetation measurements were taken at approximately the same number of non-use sites as use sites. At all vegetation measurement sites, two 20-m transects were placed in the cardinal directions with the 10-m mark of each transect intersecting at the nest bowl or UTM location for other use and non-use points. Canopy cover, shrub species intercept, percent of forbs, percent grass cover, percent soil cover, and percent litter cover, height of grass, forb plant height, and height of nearest sagebrush were measured at each location. At winter locations snow depth and height of nearest sagebrush above snow were also measured.

These original vegetation measurements will be used to create a kriging interpolation for canopy cover, sagebrush height, grass height, forb height, and percent cover across the North Park study area. In the summer of 2015, we selected additional points to sample within the same 1-km^2 grid created for the original project. These points would then be used to validate the original vegetation measurements by taking the same vegetation measurements. These locations were not based on any GRSG locations or nests. Figure 2 displays the locations of the original vegetation measurements and the validation locations along with the private and public land access across North Park.

I will compare the original vegetation measurements to remote sensing layers to determine if there is agreement between the two scales. In addition, we will validate the interpolated spatial layers using the validation vegetation measurements. If both of these comparisons prove to be in agreement and the error associated with the interpolation layers is low, we will re-do our resource selection seasonal models including these additional, more detailed vegetation variables to determine a) if they improve the habitat selection models based on lower AIC values and b) refine the amount of area considered high priority habitat within North Park. All models will follow the same methods as defined in the original North Park assessment.

Current status of the project is that all vegetation measurements have been measured including 232 original vegetation locations (2010-2012) and 169 validation locations (2015). The interpolation models and possible resource selection models are to be completed by the end of 2016 along with a final report and publication regardless of the success or lack thereof using interpolation models.

Figure 1. North Park study area and 1-km2 grid cells used to randomly select locations for vegetation measurements both in the original dataset and the validation dataset.

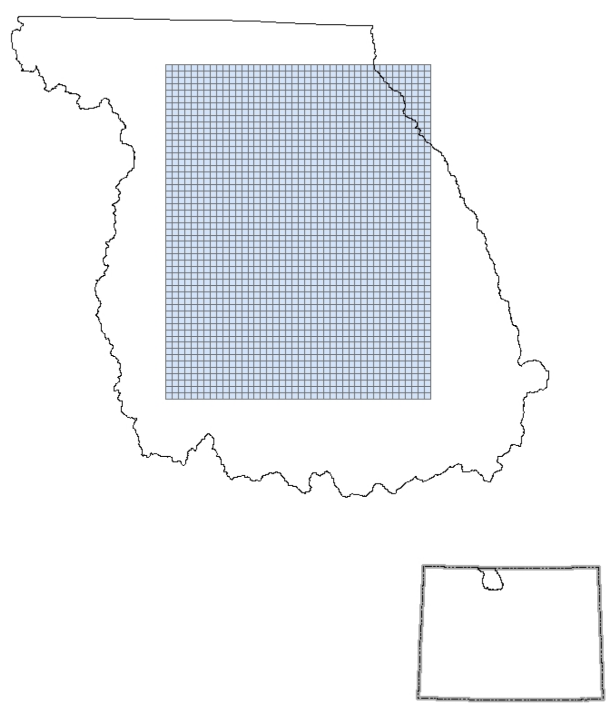
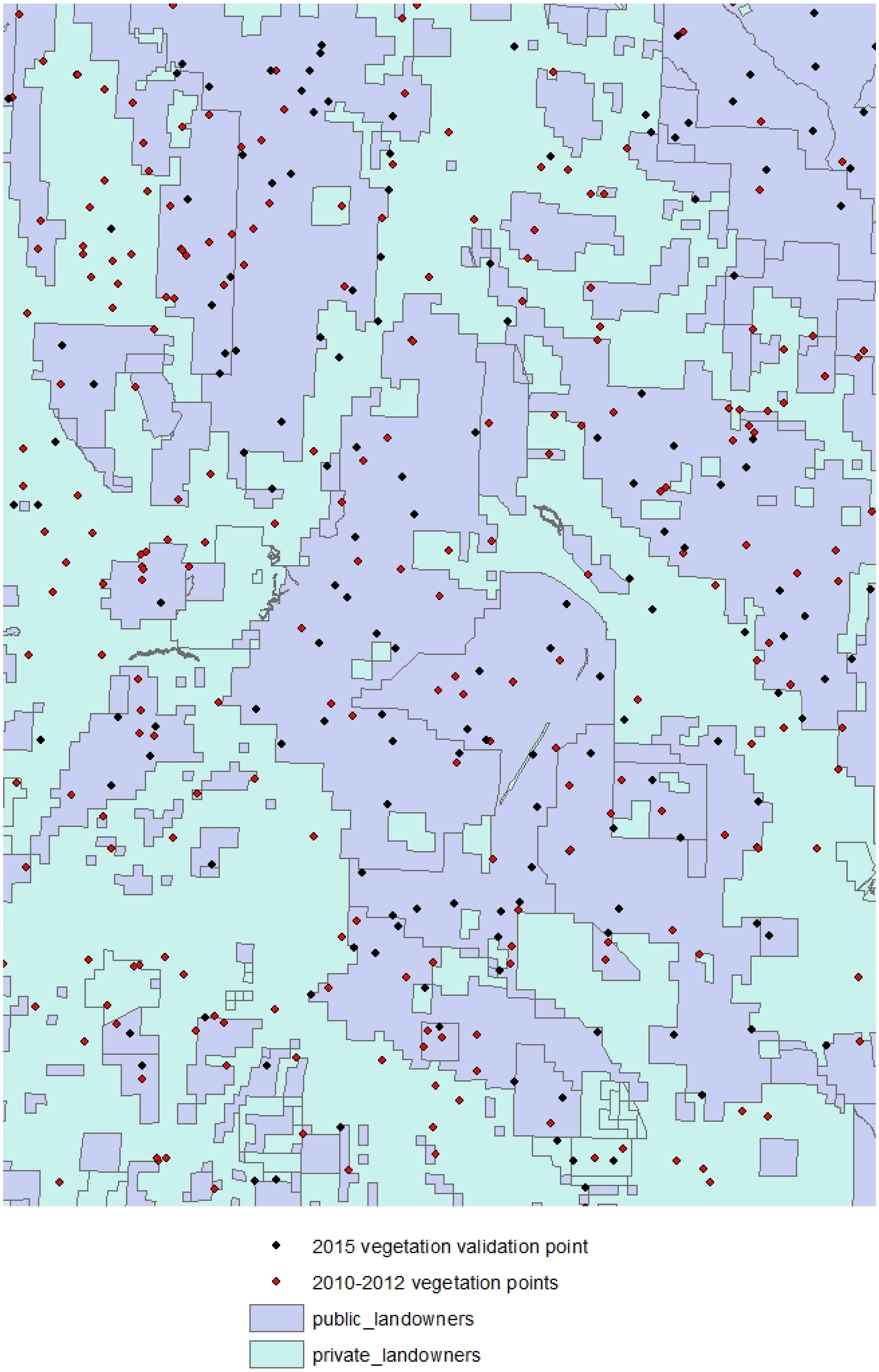


Figure 2. Sample locations in 2010-2012 and in 2015 in North Park used for interpolation or validation of interpolation layers to use in landscape resource selection models.



Colorado Parks and Wildlife

WILIDLIFE RESEARCH PROJECT SUMMARY

Restoring habitat with super-absorbent polymer

Period Covered: September 1, 2014 – August 31, 2015

Principal Investigators: Danielle Bilyeu Johnston, danielle.bilyeu@state.co.us

Project Collaborator: Cynthia Brown and Magda Garbowski, Colorado State University; Murphy Jacox

In the western United States, successful restoration of degraded habitat is often hindered by invasion of exotic species and unfavorable climatic conditions. Cheatgrass (*Bromus tectorum* L.) is an especially aggressive competitor on disturbed lands and poses threats to restoration, including outcompeting desirable species, altering soil nutrient cycles, reducing species diversity, and decreasing the quality of forage and wildlife habitat. In addition, uncertainties of future climate and precipitation changes make planning for and implementing restorations difficult. With their ability to absorb moisture when soils are wet and slowly release it over time, superabsorbent polymers (SAPs) may buffer seeded species against negative impacts of precipitation fluctuations. In a prior CPW study, incorporating SAPs into the soil at the time of seeding was found to reduce cheatgrass cover by up to 50%, possibly by shifting the timing of soil moisture availability in a way that favors perennial plants.

Because SAPs act on existing soil moisture, their effectiveness is likely to depend on precipitation factors, such as total annual precipitation, seasonal timing, and extent of precipitation events. In this study, we assess the repeatability of the prior study in two additional locations which have contrasting precipitation patterns: a Colorado front range site (Waverly Ranch, Larimer County), and a Colorado western slope site (Dry Creek Basin State Wildlife Area, San Miguel County; Figure 1). We quantify how SAPs influence soil moisture through time at these locations, and how drought, cheatgrass presence, and SAPs interact to influence plant community development. At the Dry Creek Basin site, we also contrast broadcast versus pelleted application methods. We implemented the experiment by preparing research areas, seeding a native seed mix, and applying drought, SAPs, and cheatgrass treatments in a factorial design. Drought was imposed via construction of rainfall diversion shelters, and treatments were completed in fall 2013 at Waverly and summer 2014 at Dry Creek (Figure 2). Additional activities for this reporting period include analyzing 2014 seedling density data from Waverly, and collecting 2015 data on: seedling density data at Dry Creek, plant cover data at Waverly, soil available nitrogen (NH_3^-, $NH4^+$) at Dry Creek, and water potential data of focal species at both sites.

First season results at Waverly include a negative effect of the drought treatment on native perennial density ($p = 0.002$), and a trend for higher native annual density with SAP application. 2016 activities will include analysis of 2015 Waverly plant cover and Dry Creek seedling density, analysis of nitrogen and plant water potential data, and continued collection of plant cover and water potential data at both sites.

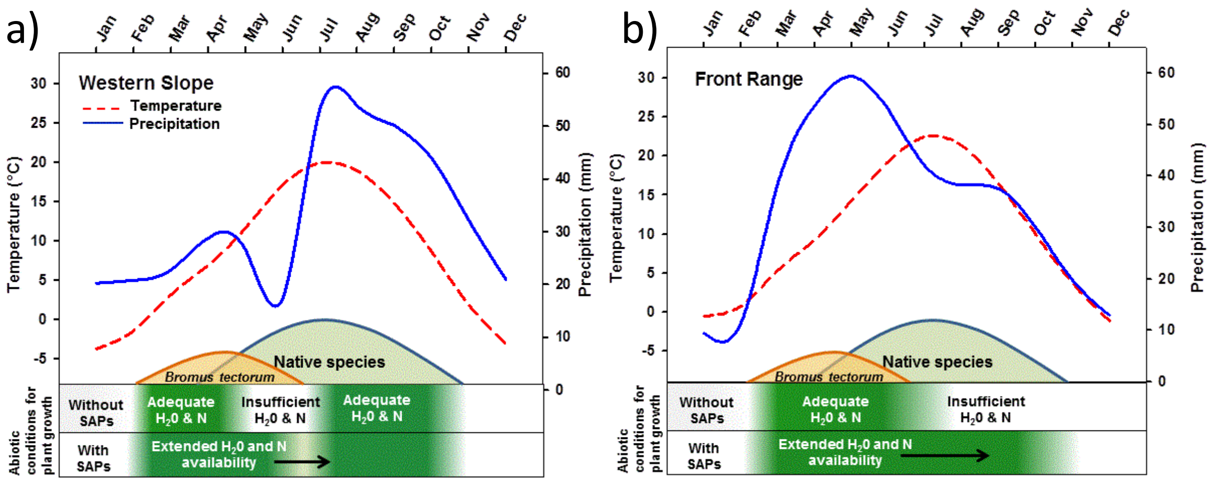


Figure 1. Thirty-year average temperature and precipitation for the Western Slope (Dry Creek State Wildlife Area, San Miguel County, CO) and Front Range (Waverly, CO) study sites. a) Western Slope. Water availability is suitable for plant growth in the early spring when soils are moist after snow melt, but the majority of precipitation falls in late summer and early fall as part of the North American Monsoon. Seedlings are especially vulnerable during the warmest and driest months of the growing season (April-July) when rainfall events are small and intermittent and evaporative demand is high. SAPs may ameliorate the negative impacts of periodic drought by extending water availability during this resource limited period until late summer monsoonal precipitation commences. b) Front Range. Water is most often sufficient for plant growth during the spring. Seedlings are most vulnerable in the summer (mid-June – mid-September), when rain events are small and intermittent and evaporative demand is high due to warm temperatures. SAPs may extend water and nutrient availability through these harsh months, promoting seedling survival.

Figure 2. One of 3 blocks at the Dry Creek Basin site.

Colorado Parks and Wildlife

WILIDLIFE RESEARCH PROJECT SUMMARY

Avian response to plague management on Colorado prairie dog colonies

Period Covered: September 1, 2014 – August 31, 2015

Principal Investigators: Reesa Yale Conrey, reesa.conrey@state.co.us

Project Collaborators: Dan Tripp, Jim Gammonley; E. Youngberg, Rocky Mountain Bird Observatory

All information in this report is preliminary and subject to further evaluation. Information MAY NOT BE PUBLISHED OR QUOTED without permission of the author. Manipulation of these data beyond that contained in this report is discouraged.

Range-wide declines in prairie dog (*Cynomys* sp.) populations have occurred, and the largest limiting factor in recent decades appears to be the high mortality and colony extirpation associated with plague (Antolin et al. 2002), caused by the bacterium *Yersinia pestis*. Prairie dog colonies support a diverse community of associated species, many of which are not susceptible to plague but may be indirectly affected. In order to conserve prairie dogs and species associated with their colonies, principally the black-footed ferret (*Mustela nigripes*), a plague vaccination program is being developed (Fig. 1a), which may also benefit a suite of species (Fig. 1b) listed in the Conservation Plan for Grassland Species in Colorado (Colorado Division of Wildlife 2003) and the Colorado Sagebrush Conservation Assessment and Strategy (Boyle and Reeder 2005). CPW is involved in a multi-state, multi-agency study of prairie dogs and associated small mammal species; the objective is to determine whether survival is enhanced by the experimental vaccine compared to use of placebo or insecticide to control fleas, an important vector of plague. They are also interested in how patterns of prairie dog abundance and occupancy change when plague epizootics occur in plots receiving different treatments. As an extension to this project, we initiated research in 2013 on the effects of plague management on avian species associated with prairie dog colonies, with particular focus on species of concern. Our main long-term objective is to determine whether areas treated to control plague differ from untreated areas in their avian communities. Shorter-term objectives are to 1) Determine how plague affects avian species and their predators associated with prairie dog colonies; 2) Determine whether avian species associations exist for colonies of Gunnison's prairie dogs (*C. gunnisoni*: GUPD); most evidence for associated species comes from black-tailed prairie dogs (*C. ludovicianus*: BTPD); 3) Determine whether insecticidal dusting influences bird density or nest survival; 4) Evaluate the importance of covariates such as weather and cattle grazing.

Study areas included BTPD colonies in north-central Colorado and GUPD colonies in west-central Colorado. BTPD study colonies were dominated by short and mid-grasses and located in Larimer and Weld Co. adjacent to the Wyoming border, managed by the City of Fort Collins. GUPD study colonies were dominated by sagebrush mixed with other shrubs and grasses and located in the Gunnison Basin (Gunnison, Saguache, and eastern Montrose Co.) and Woodland Park area (Teller Co.), managed by the Bureau of Land Management, U.S. Forest Service, National Park Service, and CPW. The 2015 season was the third of three study seasons associated with phase 1 of this avian research project, which coincided with Wildlife Health's 3-year efficacy trials for the plague vaccine (Fig. 1a). In Colorado, CPW Wildlife Health Program staff led by Dan Tripp surveyed colonies before and after bait distribution and conducted a mark-recapture study of prairie dogs and associated small mammal species. Treated areas were arranged in triplets with one vaccine, placebo, and dusted site per group; baited sites were assigned vaccine or placebo baits in a blind procedure. We have collected 1 year of pre-treatment avian data and 2 years of post-treatment data. We created a 250 m point grid to sample all treated and untreated prairie dog colonies on public land within the study region, and on GUPD colonies, we created a doughnut-shaped region that extended 500 – 1500 m from colony boundaries and randomly chose grids of nine points (3 x 3) to serve as off-colony study areas. Although breeding season data collection for phase 1 is complete, analyses are ongoing. Bird occupancy, density, and species composition will be estimated from point count data. Summer and winter counts of diurnal raptors and early season passive and call-playback surveys of mountain plover (*Charadrius montanus*) and burrowing owls (*Athene cunicularia*) were used to sample species that are rarely detected during point counts. On-colony nest survival rates will be estimated for passerines (Fig. 1d, e) and burrowing owls. Remote camera data will be used to estimate summer and winter on-colony occupancy rates for mammalian carnivores, including coyotes, badgers, and swift fox. Finally, we have quantified percent ground cover, visual obstruction (Fig. 1c), and species composition of vegetation at points, nests, and along randomly located transects.

Since fall 2013, plague epizootics have occurred on one GUPD colony and across ~70% of the BTPD study area. In September and October 2014 and 2015, black-footed ferrets were released in three BTPD study colonies. Precipitation (Fig. 2) has varied greatly over the three years of this study, particularly on BTPD sites, from slightly dry to very wet, compared to the 30-year average. At this point, data analyses are all preliminary, with detailed analysis to follow during 2015 – 2016. From 2013 – 2015, we detected 130 bird species during the breeding season. During BTPD colony surveys, at least three bird species (Brewer's blackbird *Euphagus cyanocephalus*, Brewer's sparrow *Spizella breweri*, and vesper sparrow *Pooecetes gramineus*) appeared to have higher detection rates on active prairie dog colonies, while two species (grasshopper sparrow *Ammodramus savannarum* and lark bunting *Calamospiza melanocorys*) appeared to have higher detection rates on colonies with extinct or severely reduced prairie dog populations following plague outbreaks (Table 1). During surveys on and off GUPD colonies, seven species (Brewer's sparrow, common raven *Corvus corax,* horned lark *Eremophila alpestris*, red-winged blackbird *Agelaius phoeniceus*, sage thrasher *Oreoscoptes montanus*, vesper sparrow, and western meadowlark *Sturnella neglecta*) appeared to show associations with colonies, while four species (dark-eyed junco *Junco hyemalis*, green-tailed towhee *Pipilo chlorurus*, mountain chickadee *Poecile gambeli*, and western wood-pewee *Contopus sordidulus*) had higher detection rates off colonies, and many others showed no pattern (Table 2). We documented 217 plant species over three years. Colonies contained a higher bare ground component with lower vegetation heights than off-colony sites, with shortgrasses dominant at BTPD sites and a more even distribution of grasses, forbs, and shrubs at GUPD sites. Vegetation species composition was highly variable at BTPD sites over time, with increasing grasses and forbs and decreasing bare ground during an El Niño event associated with high rainfall during the growing season (Table 3, Fig. 2). We detected 17 raptor species during on- and off-colony counts. Burrowing owls, northern harriers (*Circus cyaneus*), ferruginous hawks (*Buteo regalis*) (Fig. 1b), and rough-legged hawks (*Buteo lagopus*) were detected only on prairie dog colonies (ferruginous hawks, only on BTPD colonies). Apparent nest success varied between 50 and 57%, except that it was 40% on BTPD colonies and 69% at GUPD colonies in 2014. The decrease at BTPD colonies was likely attributable to hail storms and flooding during the peak nesting season in 2014, but prior to doing a thorough nest survival analysis, there was no obvious explanation for increased survival at GUPD colonies that year. The increase in nest numbers after 2013 was partly due to increased effort and partly to a huge influx of lark buntings during El Niño and following widespread plague events. In > 1 million remote camera photos, we have documented decreased coyote activity and increased swift fox activity over three years. Swift fox occurred only on BTPD colonies and badgers were more commonly detected there, while coyotes were equally common across all sites on BTPD and GUPD colonies.

This was the third year of data collection on this project, and it will likely take additional years of monitoring to detect potential changes in the avian community caused by different types of plague management, as treated colonies no longer experience extinction events. Regardless of the efficacy of plague vaccine versus insecticide in reducing plague impacts, the vaccine will continue to be an important tool due to cost/benefit of its use and increasing evidence that fleas are evolving resistance to deltamethrin. Preliminary data suggest that bird densities do vary according to the status of prairie dogs on a colony, with differences between active colonies and those with extirpated or severely reduced prairie dog populations following plague outbreaks. These data also suggest several species may be associated with GUPD, including Brewer's sparrow, vesper sparrow, and sage thrasher. Vegetation surveys have also identified differences between on- and off-colony areas. Raptor and camera data collection will continue through winter 2015/2016. Afterward, the field-based portion of phase 1 of this avian research project will be complete. We anticipate that phase 2 of this project will have a larger spatial scale, with the plague vaccine used more broadly as a management tool, but will focus on fewer data collection methods, species, and/or sites. Our study areas and the focus of data collection may shift, depending on availability of vaccine baits, management priorities, and results of avian data analysis from phase 1.

Table 1. Bird use rates for the most common species detected during avian point counts on BTPD prairie dog colonies with varying prairie dog activity status: Active (A), Reduced (R) after a plague event, and Extinct (E). Use rate was calculated by dividing the number of detections by the total number of points per colony per year. The first three species were more common on active colonies, those in the middle showed no preference, and the last two species were more common on reduced or extinct colonies. Data reported here do not yet account for probability of detection or the location of individual birds inside or outside of treatment area boundaries.

CODE	SPECIES	2013 Use Rate		2014 Use Rate		2015 Use Rate		TOTAL
		A	R + E	A	R + E	A	R + E	COUNT
BRBL	Brewer's Blackbird	0.067	0.053	0.115	0.035	0.815	0.045	223
BRSP	Brewer's Sparrow	0.116	0.063	0.107	0.018	0.095	0.111	116
VESP	Vesper Sparrow	0.371	0.116	0.202	0.029	0.481	0.177	298
BARS	Barn Swallow	0.156	0.200	0.074	0.194	0.143	0.075	157
BHCO	Brown-headed Cowbird	0.049	0.053	0.025	0.459	0.069	0.018	119
CORA	Common Raven	0.192	0.084	0.086	0.135	0.079	0.111	147
EUST	European Starling	0.000	0.021	0.206	0.088	0.011	0.192	133
HOLA	Horned Lark	6.656	7.505	3.864	3.253	3.709	3.562	5583
LASP	Lark Sparrow	0.045	0.084	0.045	0.006	0.116	0.168	108
MCLO	McCown's Longspur	2.509	1.947	1.099	0.812	0.762	1.453	1780
RWBL	Red-Winged Blackbird	0.138	0.253	0.329	0.312	0.640	0.279	402
WEME	Western Meadowlark	1.531	2.337	1.593	1.759	2.587	2.270	2496
GRSP	Grasshopper Sparrow	0.018	0.000	0.012	0.029	0.323	0.486	235
LARB	Lark Bunting	3.817	3.316	2.506	5.471	1.201	2.195	3667

Table 2. Bird use rates for the most common species detected during avian point counts on GUPD sites, comparing points located in prairie dog colonies to those 500 – 1500 m outside colony boundaries. Use rate was calculated by dividing the number of detections by the total number of points per colony per year. The first seven species were more common in colonies, those in the middle showed no preference, and the last four species were more common outside colonies. Data reported here do not yet account for probability of detection or the location of individual birds inside or outside of colony or off-colony grid boundaries.

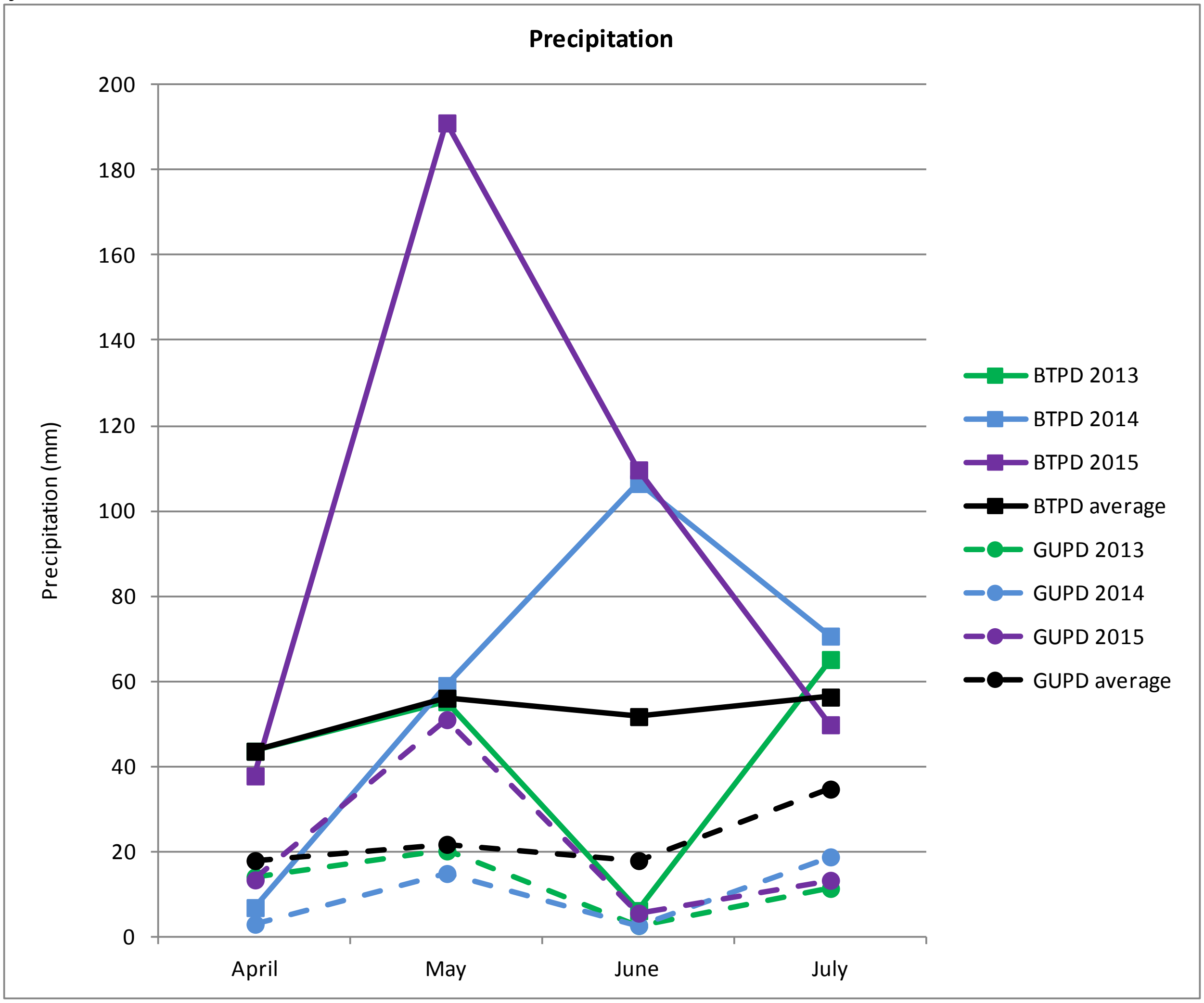
CODE	SPECIES	2013 Use Rate		2014 Use Rate		2015 Use Rate		TOTAL
		In	Out	In	Out	In	Out	COUNT
BRSP	Brewer's Sparrow	2.240	0.663	1.095	0.827	1.512	1.242	1155
CORA	Common Raven	0.700	0.143	0.514	0.189	0.518	0.527	406
HOLA	Horned Lark	0.880	0.367	0.333	0.438	0.619	0.329	435
RWBL	Red-Winged Blackbird	0.170	0.071	0.133	0.124	0.369	0.177	172
SATH	Sage Thrasher	1.350	0.133	0.486	0.249	0.494	0.404	440
VESP	Vesper Sparrow	3.030	0.888	0.838	0.492	1.048	0.430	864
WEME	Western Meadowlark	0.910	0.694	0.371	0.319	0.488	0.332	431
AMRO	American Robin	0.370	0.357	0.210	0.195	0.196	0.383	269
BBMA	Black-billed Magpie	0.260	0.102	0.086	0.054	0.107	0.123	107
BTLH	Broad-tailed Hummingbird	0.210	0.143	0.124	0.108	0.179	0.343	193
NOFL	Northern Flicker	0.240	0.286	0.114	0.059	0.095	0.137	129
ROWR	Rock Wren	0.240	0.214	0.019	0.130	0.125	0.137	130
DEJU	Dark-eyed Junco	0.110	0.184	0.019	0.086	0.071	0.162	104
GTTO	Green-tailed Towhee	0.640	0.969	0.333	0.341	0.345	0.549	467
MOCH	Mountain Chickadee	0.040	0.133	0.057	0.178	0.012	0.126	93
WEWP	Western Wood-pewee	0.200	0.347	0.057	0.173	0.196	0.141	164

Table 5. Ground cover percentages for dominant vegetation types from 2013 – 2015 for BTPD sites in north central Colorado.

% Cover	2013	2014	2015
Grass	36.7	55.9	55.7
Litter	27.2	8.7	14.3
Bare	22.8	19.4	13.3
Forb	3.9	8.3	9

Figure 1. Photos from BTPD and GUPD sites during 2013 – 2015. a) GUPD consuming experimental bait. b) Ferruginous hawk seen during a winter raptor count on a BTPD colony. c) Visual obstruction measurement at a GUPD site. d) Horned lark nest on a BTPD colony. e) Estimating age of a lark bunting nest by floating eggs on a BTPD colony.

Figure 2. Monthly precipitation at BTPD (Larimer and Weld Co.) and GUPD (Gunnison Co.) sites from 2013 – 2015, including the 30-year averages. Data were taken from the nearest weather station. BTPD data are shown with solid lines and square symbols. GUPD data are shown with dashed lines and round symbols.



Publications, presentations, workshops and committee involvement by Avian Research staff
October 2014 – September 2015

PUBLICATIONS

Apa, A. D., and L. A. Wiechman LA. 2015. Captive-rearing of Gunnison sage-grouse for egg collection to adulthood to foster proactive conservation and recovery of a conservation-reliant species. Zoo Biology 34:438-452.

Apa, A. D., and L. A. Wiechman. *In press*. Captive-breeding of captive and wild-reared Gunnison sage-grouse. Zoo Biology.

Conrey, R. Y., S. K. Skagen, and A. Panjabi. *In review.* Heat and precipitation extremes depress reproductive success in shortgrass prairie birds. Ibis.

Johnston D.B. 2015. Downy Brome (*Bromus tectorum*) control for pipeline restoration. Invasive Plant Science and Management 8:181-192.

Rice, M. B., L. G. Rossi, and **A. D. Apa.** *In review.* Refining scales of analysis for resource selection functions to better manage a greater sage-grouse population in North Park, Colorado. Wildlife Society Bulletin.

Searle, K. R., C. Anderson, C. Bishop, N. T. Hobbs, and **M. B. Rice.** *In press*. Asynchronous vegetation phenology enhances winter body condition of mule deer (*Odocoileus hemionus*) Oecologia.

Thompson, T. R., **A. D. Apa**, K. P. Reese, and K. M. Tadvick. 2015. Captive rearing sage-grouse for augmentation of surrogate wild broods; evidence for success. Journal of Wildlife Management 79:998-1013.

Walker, B. L., **A. D. Apa**, and K. Eichhoff. *In press*. Mapping and prioritizing seasonal habitats for the Parachute-Piceance-Roan greater sage-grouse population in northwestern Colorado. Journal of Wildlife Management.

PRESENTATIONS, WORKSHOPS, AND COMMITTEES

Apa, A. D. Biology and Habitat Requirements of Sage-Grouse in Colorado. Sagebrush Practitioners Meeting, Grand Junction, CO. Hosted by the U.S. Fish and Wildlife Service. February 3, 2015.

Apa, A. D. Greater Sage-grouse Biology and Habitat Requirements in Colorado. Ranching for Sage-Grouse Meeting, Steamboat Springs, CO. Hosted by Colorado Parks and Wildlife. February 9, 2015.

Apa, A. D. Greater Sage-grouse Biology and Habitat Requirements in Colorado. Ranching for Sage-Grouse Meeting, Craig, CO. Hosted by Colorado Parks and Wildlife. February 11, 2015.

Apa, A. D. Gunnison Sage-grouse Biology and Habitat Requirements in Colorado. Ranching for Sage-Grouse Meeting, Montrose, CO. Hosted by Colorado Parks and Wildlife. February 17, 2015.

Apa, A. D. Gunnison Sage-grouse Biology and Habitat Requirements in Colorado. Ranching for Sage-Grouse Meeting, Gunnison, CO. Hosted by Colorado Parks and Wildlife. February 19, 2015.

Apa, A. D. Columbian Sharp-tailed Grouse Demographic Response to Habitat Improvements. CPW Area 6 staff meeting, Rangely, CO, April 27, 2015.

Apa, A. D. Ecology and Habitat Use of Gunnison Sage-grouse in southwestern Colorado. Cortez Birding Festival, Cortez, CO, May 7, 2015.

Apa, A. D. Columbian Sharp-tailed Grouse Demographic Response to Habitat Improvements. CPW Area 9 and 10 staff meeting, Steamboat Springs, CO., June 4, 2015.

Apa, A. D. Upland Bird Hunting 101. CPW Northwest Region hunting workshop, Grand Junction, CO., August 20, 2015.

Conrey, R. Y. Great Plains Landscape Conservation Cooperative Science Committee meeting, Fort Collins, Co, December 2-3, 2014.

Conrey, R. Y., D. W. Tripp, E. N. Youngberg, and A. O. Panjabi. Avian response to plague management on prairie dog colonies. Wildlife Health Lab meeting, Fort Collins, CO, February 20, 2015.

Conrey, R. Y., D. W. Tripp, E. N. Youngberg, and A. O. Panjabi. Avian response to plague management on prairie dog colonies. CPW Southeast Region Biology Days, Pueblo, CO, June 9, 2015.

Conrey, R. Y., D. W. Tripp, E. N. Youngberg, and A. O. Panjabi. Managing plague in prairie dogs: effects on birds associated with colonies. Grassland Bird Symposium, Joint meeting of the American Ornithologists' Union & Cooper Ornithological Society, Norman, OK, July 31, 2015.

Skagen, S.K., V. Dreitz, **R. Conrey**, A.A. Yackel Adams, A.O. Panjabi, and D.J. Augustine. Vulnerability of shortgrass prairie birds to climate change. American Ornithologists Union/Cooper Ornithological Society annual meeting, Norman, OK, July 31, 2015.

Conrey, R. Y. CPW Animal Care and Use Committee meeting, Fort Collins, CO, September 16, 2015.

Conrey, R. Y. Burrowing Owl. Audubon Society of Greater Denver's HOOTenanny, Littleton, CO, September 26, 2015 (poster and activity table, 442+ attendees).

Conrey, R. Y., D. W. Tripp, M. F. Antolin, E. N. Youngberg, and A. O. Panjabi. Bird community response to plague management in prairie dog colonies. America's Grasslands Conference, Fort Collins, CO, September 30, 2015.

Skagen, S.K., V. Dreitz, **R. Conrey**, A.A. Yackel Adams, A.O. Panjabi. Vulnerability of shortgrass prairie bird assemblages to climate change. America's Grasslands Conference, Fort Collins, CO, September 30, 2015.

Gammonley, J. H. Human Dimensions Working Group meeting (representing the Central Flyway), Denver, CO, October 9-10, 2014.

Gammonley, J. H. Central Flyway Waterfowl Technical Committee meeting, Corpus Christi, TX, December 9-12, 2014.

Gammonley, J. H. Waterfowl and Upland Birds Hunter Education Instructor Workshop. Thornton, CO, January 24, 2015.

Gammonley, J. H. Class lecture: waterfowl management. Fish and Wildlife 375 (Paul Doherty, professor), Colorado State University, February 4, 2015.

Gammonley, J. H. Central Flyway wing bee, Hartford, KS, February 17-20, 2015.

Gammonley, J. H. Central Flyway Waterfowl, Webless Migratory Game Bird, and Central Management Unit Dove Technical Committee meetings, Bozeman, MT, February 27 – March 5, 2015.

Gammonley, J. H. Mid-Continent Mallard Adaptive Harvest Management Committee workshop, Kansas City, MO, June 2-4, 2015.

Gammonley, J. H. Central Flyway Waterfowl Technical Committee and Council meetings, Bozeman, MT, July 20-24, 2015.

Johnston, D. B. Habitat Research Update. Annual Piceance Basin Research Cooperator's Research Update Meeting. Grand Junction, CO. October 31, 2014.

Johnston D. B. Seeding, soil surface, and brush mulch effects on plant community development of disturbed mountain sagebrush sites. The Colorado Chapter of the Wildlife Society Annual Winter Meeting, Grand Junction, CO, February 6, 2015.

Johnston D. B., M. G. Garbowksi, and C. S. Brown. Restoring habitat with super-absorbent polymer. CPW Northeast Region Biology Days, Brighton, CO, February 17, 2015.

Johnston D. B. Seeding, soil surface, and brush mulch effects on plant community development of disturbed mountain sagebrush sites. High Altitude Revegetation conference, Fort Collins, CO, March 11, 2015.

Garbowski M. G. Brown C. S., and **Johnston, D. B.** Restoring arid lands with superabsorbent polymers. (poster presentation) High Altitude Revegetation conference, Fort Collins, CO, March 10, 2015.

Rice, M. B. Refining seasonal resource selection models for the management of greater sage-grouse in North Park, Colorado. The Wildlife Society national meeting, Pittsburgh, PA, October 28, 2014.

Rice, M. and **A. D. Apa.** Gunnison Sage-Grouse Distribution and Seasonal Habitat Mapping in the Gunnison Basin. Presented to the Gunnison Basin Strategic Committee, Gunnison, CO, November 2014.

Rice, M. B. Seasonal resource selection models for greater sage-grouse in North Park, Colorado. North Park Greater Sage-grouse Working Group meeting, Walden, CO, January 6, 2015.

Rice, M. B. Preliminary breeding season resource selection model for Gunnison sage-grouse. Gunnison Sage-grouse Strategic Committee, Gunnison, CO, January 21, 2015.

Rice, M. B. Refining seasonal resource selection models for the management of greater sage-grouse in North Park, Colorado. Colorado Chapter of The Wildlife Society meeting, Grand Junction, CO, February 6, 2015.

Walker, B. L. Parachute-Piceance-Roan Greater Sage-Grouse Research Update. CPW Area 6 staff meeting. Meeker, CO. October 27, 2014.

Walker, B. L. Parachute-Piceance-Roan Greater Sage-Grouse Research Update. Annual Piceance Basin Research Cooperator's Research Update Meeting. Grand Junction, CO. October 31, 2014.

Walker, B. L. Parachute-Piceance-Roan Greater Sage-Grouse Research Update. PPR Local Working Group Annual Meeting. Rifle, CO. January 15, 2015.

Walker, B. L. Parachute-Piceance-Roan Greater Sage-Grouse Research Update. Federal and State Land and Resource Manager's quarterly meeting. Rifle, CO. January 29, 2015.

Walker, B. L. Testing Lek-Based Management for Greater Sage-Grouse in northwestern Colorado. Colorado Chapter of The Wildlife Society. Grand Junction, CO. February 6, 2015.

Walker, B. L. CPW Animal Care and Use Committee meeting, Fort Collins, CO, September 16, 2015.