AVIAN PROGRAM
2017
WILDLIFE RESEARCH SUMMARIES

OCTOBER 2016 – DECEMBER 2017

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AVIAN RESEARCH PROGRAM

COLORADO DIVISION OF PARKS AND WILDLIFE
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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 2016 through December 2017. 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 from the project principal investigator listed at the beginning of each summary, or on the CPW website at http://cpw.state.co.us/learn/Pages/ResearchBirds.aspx and http://cpw.state.co.us/learn/Pages/ResearchHabitat.aspx.

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 study designed to understand how Columbian sharp-tailed grouse respond to habitat treatments, development of seasonal habitat selection models for populations of Gunnison sage-grouse, survival estimates for Gunnison sage-grouse translocated from the Gunnison Basin to other populations, a new study examining greater sage-grouse response to surface mining mitigation, several continuing studies on greater sage-grouse, evaluation of techniques for restoring native plant communities for wildlife, a pilot study to examine response of ring-necked pheasants and grassland passerines to management of Conservation Reserve Program fields, a long-term study to understand how avian communities associated with prairie dog colonies respond to plague management, development of spatial models for a variety of wildlife species, a new study evaluating data available to monitor and model raptor populations, an study of bobwhite quail response to grazing management, and a study examining waterbird food availability and foraging ecology on different wetland types. 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 2016 through December 2017. 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, Colowyo Coal Company L.P., 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 2016 – December 2017

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Colorado Parks and Wildlife

WILIDLIFE RESEARCH PROJECT SUMMARY

Columbian sharp-tailed grouse demographic response to habitat treatments

Period Covered: October 1, 2016 – December 31, 2017

Principal Investigator: Anthony D. Apa, tony.apa@state.co.us and R. E. Barker

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

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 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 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 improvements could improve existing or expired CRP. This has resulted in management recommendations to improve CRP. 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 and have limited movements during the breeding season with relatively small home ranges. Our 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. The goal of our research is to conduct treatments (habitat improvements) in two lek complexes (T1 and T2). We used a Before-After Control-Impact (BACI) design with paired controls. Our study area is located in northwestern Colorado, specifically in southwestern Routt and southeast Moffat counties. Our 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. 2). Working cooperatively with the Northwest Region Habitat Coordinator (NWRHC), we identified and finalized treatment areas working cooperatively with private landowners, the Natural Resources Conservation Service (NRCS), and the Farm Services Agency (FSA). Although we initially planne to conduct treatments in one year, FSA vegetation manipulation restrictions for mid-contract maintenance of the properties enrolled in CRP prevented such an approach. Maintenance requirements differ for enrolled fields that are at a 65 ha threshold. For enrolled fields < 65 ha, we could only treat 50% of the field in year 1 and the remaining in year 2. For fields > 65 ha, we could only treat 33% of a field in year 1, 33% in year 2, and 33% must remain untreated. Thus, in Treatment Area 1 (Fig. 2), we treated 140 ha in 2016 and 140 ha in 2017. In Treatment Area 2 (Fig. 2), we treated 202 ha in 2016 and 202 ha in 2017. Although there are numerous vegetation manipulation approaches to reduce non-native grass cover and increase plant species richness, we identified the following protocol to implement habitat treatments. First, during late summer (after nest hatch), we initiated treatments with mechanical tillage equipment (off-set disc) to reduce viable non-native perennial grass cover and assist with seed-bed preparation. Second, approximately 2 - 4 weeks after mechanical tillage, we treated sites with a chemical aerial application of Plateau® and glyphosate to reduce non-native perennial grass and limit annual and perennial grass seed germination. Lastly, in late-fall, we drilled a seed mixture of native and non-native grasses, forbs, and shrubs (Table 1) with a no-till drill.

We captured female CSTG 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) (Fig. 2). We did not trap at dancing grounds in Routt county (C2) in 2017 due to landowner access restrictions. We fitted females with 15 g elastic necklace-mounted radio transmitter equipped with a 12-hour mortality circuit having an 8.5 month nominal battery life. When monitoring revealed a successful hatch, we attempted to capture all chicks in the brood within 24 hours. We randomly selected 4 chicks/brood and fit a 0.55 g backpack style transmitter using sutures along the dorsal midline between the wings (Fig. A-3). We captured juveniles when they reached 20-23 days-of-age at approximately two hours before sunrise while juveniles are brooding with the female. We removed chick transmitters and replaced them with a 2.4 g back-pack style juvenile transmitter (Fig. A-4). We sampled vegetation at all nest and a sample of brood sites and random sites. We captured 60 female CSTG (55 adults: 5 yearlings). Our capture dates in 2017 were from 31 March – 30 April (Fig. 4). We trapped on 7 dancing grounds in 3 study areas (West Axial; Moffat County Road 53 and Temple; Iles Dome; Iles Dome 1, 3, and 4: Trapper; Trapper Mine 1, and 7). In 2017, adult and yearling female mass ($\bar{x}$ ± SE) was 675.1 ± 4.3 g (*n* = 61) and 652.3 ± 2.3 g (*n* = 4), respectively (Fig.5). Additionally, female mass appears to vary by study area (Fig. 6). Over the 3 years of our study (2015-2017), female mass also appears to vary by study area (Fig. 7) and within a study area by age (Fig. 8). From April through September 2017, we documented 30 adult and 1 yearling female mortalities resulting in a 6-month adult female apparent survival rate of 0.64 ± 0.00 (*n* = 93; 95% CI 0.54 - 0.75) and a yearling survival rate of 0.80 ± 0.19 (*n* = 5; 95% CI 0.40 - 1.00) (Fig. 9). We also documented female survival among study areas (Fig. 10). We also evaluated adult and yearling female apparent survival across 4 years (Figs 11 & 12). Similar patterns during the duration of our study were observed in Hayden (0.63 ± 0.00 (*n* = 128; 95% CI 0.54 - 0.71), Iles Dome (0.58 ± 0.01 [*n* = 92]; 95% CI 0.48 - 0.68), Trapper (0.62 ± 0.01 [*n* = 77]; 95% CI 0.51 - 0.73), and West Axial (0.66 ± 0.01 [*n* = 62]; 95% CI 0.53 - 0.78) (Fig. 13). In 2017, we documented an overall 66.7% (*n* = 52/78) and 78.8% (*n* = 52/66) apparent nest and female success, respectively. Nine females renested once yielding 88.9% (*n* = 8/9) nest success. Female movement in 2017 from the lek of capture to nest averaged 2.80 ± 0.66 km (*n* = 78; range 0.19 - 37.0 km) (Fig. 14). Eighty-one percent (*n* = 63/78) of the nests were located within 2 km of the lek of capture (Fig. 14). Female movements in the West Axial study area resulted in 67% (*n* = 12/18) of the females nesting within 2 km of the lek of capture and 88% (*n* = 31/35), and 80% (*n* = 20/25) of females nesting within 2 km of the lek of capture at the Iles Dome, and Trapper study areas, respectively (Fig. 14). Over the 3 years of our study (2 for Hayden) 74.8% (*n* = 190/254) of the females nested within 2 km of the lek of capture. By study area, 66.7% (*n* = 30/45), 88.1% (*n*=74/84), 77.1% (*n* = 54/70), and 71.1% (*n* = 32/45) nested within 2 km of the capture lek at West Axial, Iles Dome, Trapper, and Hayden study areas, respectively (Fig. 15).

We captured 449 chicks from 51 broods with an overall mean mass of 16.0 ± 0.7 g (range 11.7 – 21.6) and an average brood age of 2.2 ± 0.1 days (range 1 - 4 days). Chick mean mass by study area was 15.2 ± 0.1 g (*n* = 88; range 11.7 – 18.8), 16.3 ± 0.1 g (*n* = 219; range 12.5 – 21.6), and 16.2 ± 0.1 g (*n* = 142; range 12.5 – 19.9) at West Axial, Iles Dome, and Trapper, respectively (Fig. 16). Mass also appeared similar over the 3 years of our study (Fig. 17).

We radio-marked 235 chicks resulting in an average number of chicks marked/brood of 4.4 chicks. We also PIT tagged 217 chicks. The average brood size at marking was 8.4 chicks (range 2 - 14). We recaptured and/or marked 251 juveniles that averaged 22.9 days post-hatch (range 15 – 30 days post-hatch). Juvenile mean mass was 110.5 ± 1.7 g (range 56.0 - 197.0 g). Fifty-one of the juveniles were not previously marked. Juvenile mass by study area was (116.5 ± 3.4 (*n* = 71; range 72-197), (101.3 ± 3.6 (*n* = 34; range 60-141), (109.6 ± 2.1 (*n* = 124; range 56-190) at Trapper, West Axial, and Iles Dome.

We conducted vegetation sampling at 42 nest and 39 random sites and 24 brood and 28 random sites. Habitat improvements continued in the designated treatment areas of T1 and T2 (Fig. 2). Seeding followed application of glyphosate and mechanical treatment by disking. In T1 and T2, 146 ha and 265 ha were seeded with a predesigned seed mix (Table 1) during October – December 2017.

Our adult:yearling capture ratio (12.8:1) was very skewed and dramatically different than 2015 (0.84:1) (Apa 2015), 2016 (2.89:1) (Apa and Harris 2016) and reported by Collins (2004; 5.0:1) and Boisvert (2002; 3.6:1). Adult and yearling female mass was similar to earlier reports (Boivert 2002, Collins 2004), but appeared slightly lower than 2015 and 2016 (Apa 2015, Apa and Harris 2016). Our 2017 6-month female survival (A: 0.64; Y:0.80) was higher than reported by Collins (2004; 0.41 - 0.58) for birds in mineland reclamation, but similar (0.70 - 0.79) to females in shrub steppe habitat at 150 days exposure post-capture. Our survival was higher than reported by Boisvert (2002; 0.50). Our apparent nest success in 2017 was higher than nest success reported by Collins (2004; 42%) and Boisvert (2002; 63%). We reduced chick transmitter size from 0.65 to 0.55 g and juvenile transmitter size from 3.9 to 2.4 g in an attempt to reduce the overall percentage of transmitter:body mass ratio. The lowering of the transmitter:body mass ratio was partly a result of the smaller transmitter but also due to chick mass increasing from 13.8 g in 2015 to 15.5 in 2016 and 16.0 in 2017. In no case this year did our transmitter:chick mass ratios exceeded 5% (a recommended standard) which is typically recommended for flight capable birds and may be more important when considering power requirements for flight (Cochran 1980, Caccamise and Hedin 1985, Fair et al. 2010). The most significant change to our study was the loss of the C1 and C2 (Fig. 2) study areas due to landowner concerns and access denial. We attempted to substitute a similar study area, but were unsuccessful. Ultimately the loss of this study area affected overall study sample sizes and the resulting loss of data acquisition of previously marked females and juveniles. At the writing of this report, data entry and proofing is continuing.

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.

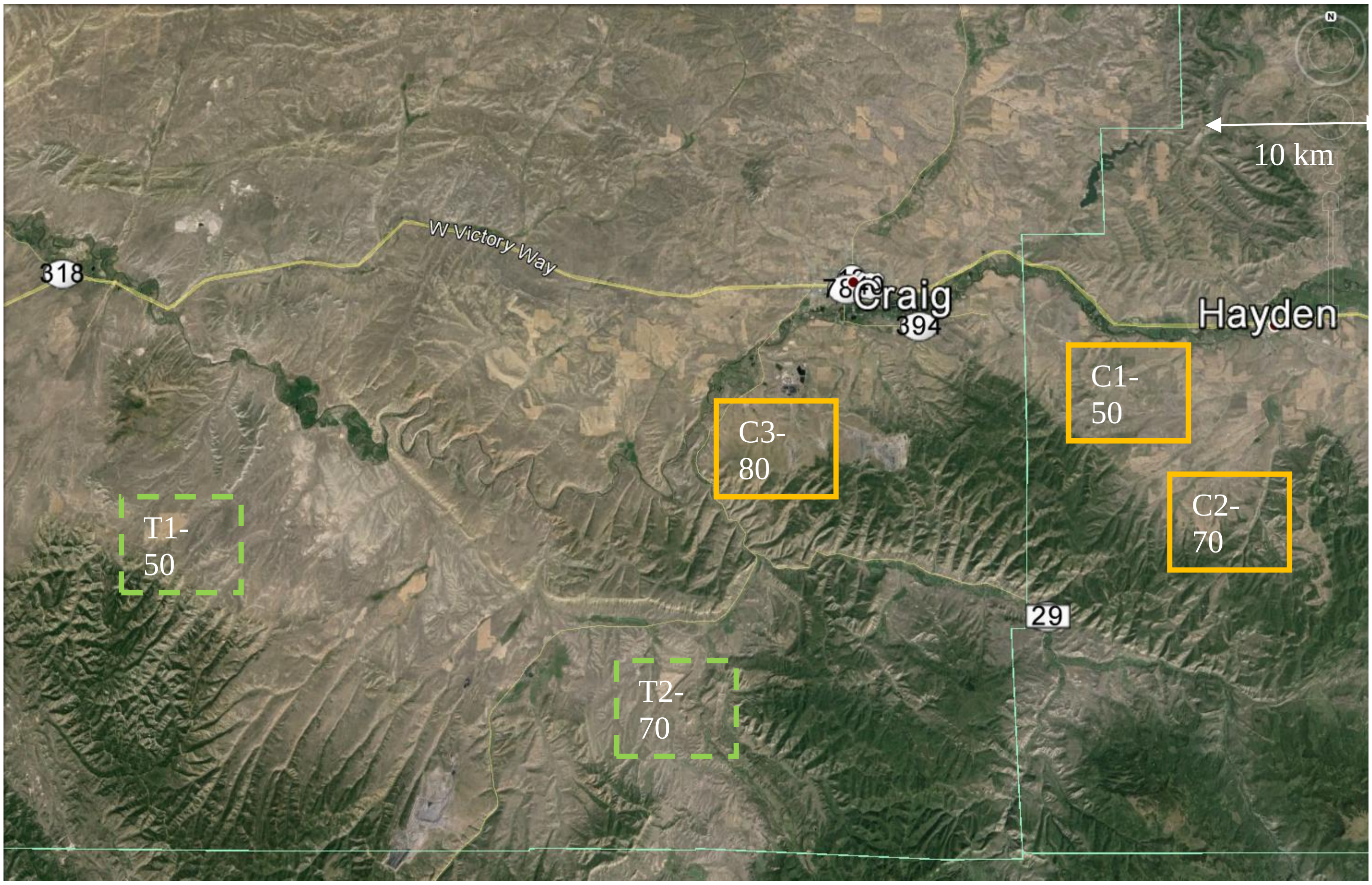


Figure 2. One-day-old Columbian sharp-tailed grouse chick after being fitted with a 0.65 g VHF micro-transmitter.

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.

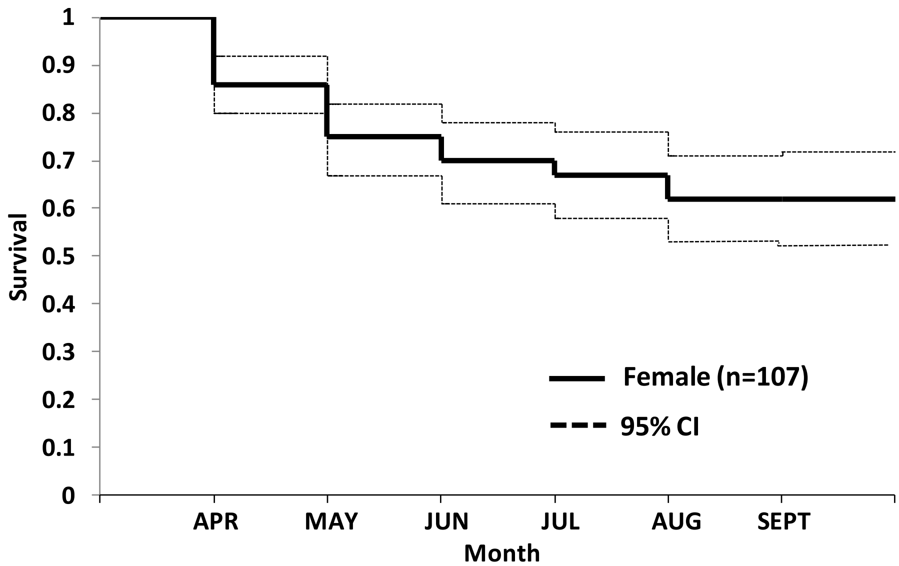


Figure 5. The median distance moved by female Columbian sharp-tailed grouse to nest from the lek of capture at four study areas in northwestern Colorado, 2015.

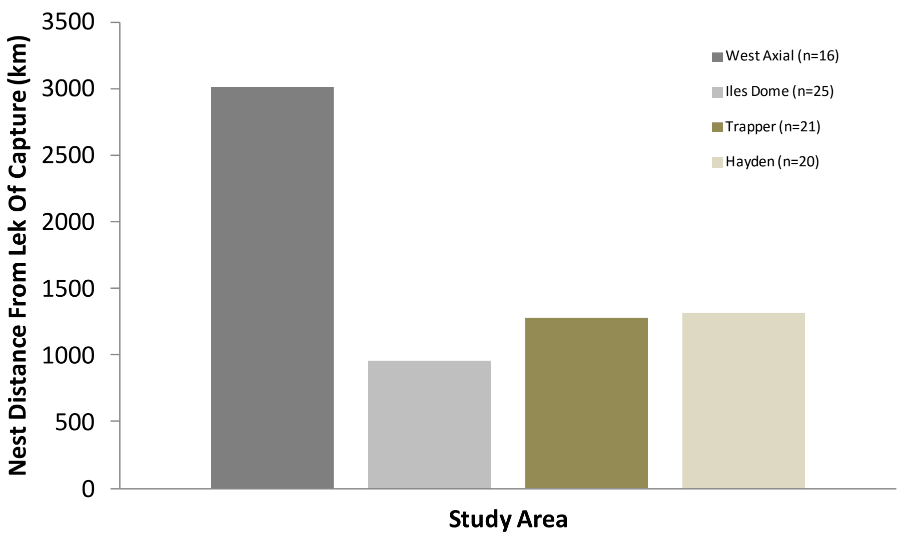
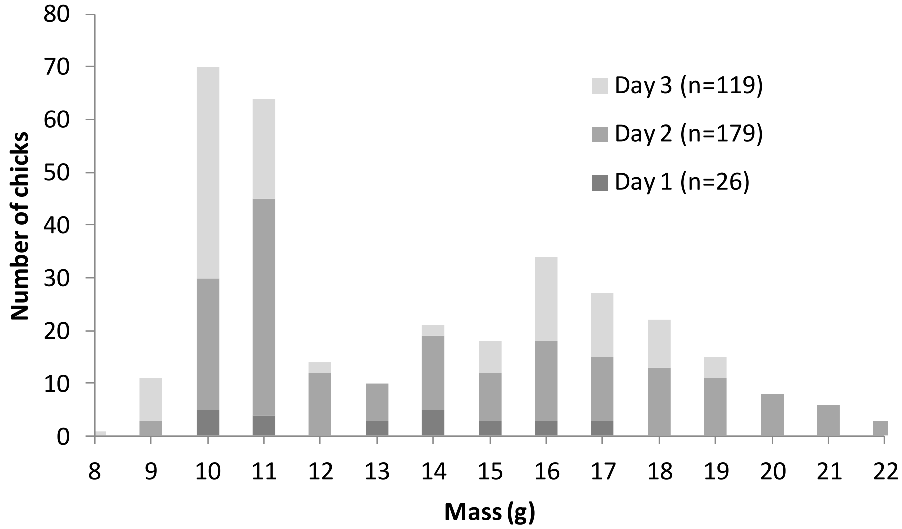


Figure 6. Frequency distribution of the number of 1, 2, and 3 day-old Columbian sharp-tailed grouse chicks by mass in northwestern Colorado, 2015.



Colorado Parks and Wildlife

WILIDLIFE RESEARCH PROJECT SUMMARY

Gunnison Sage-grouse Resource Selection Models

Period Covered: October 1, 2016 – December 31, 2017

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

Project Collaborators: Kevin Aagaard, CPW; Mindy B. Rice and Lief Wiechmann; U.S. Fish and Wildlife Service; Julie Heinrichs, Colorado State University; Michael O'Donnell and Cameron Aldridge, U.S. Geological Survey

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.

It is important to identify priority habitat for species of conservation concern. The designation of critical habitat under the U.S. Endangered Species Act 1973 identifies areas occupied by the species that are important for conservation and may need special management or protection. However, relatively few species' critical habitats designations incorporate habitat suitability models or seasonal specificity, even when that information exists. Gunnison sage-grouse (GUSG) have declined substantially from their historical range and were listed as threatened by the US Fish and Wildlife Service (USFWS) in November 2014. GUSG are distributed into eight isolated populations in Colorado and Utah, and one population, the Gunnison Basin (GB), has been the focus of research by Colorado Parks and Wildlife. Rice et al. (2017) provided seasonal habitat suitability models for the GB based on telemetry locations of GUSG, but similar models are lacking for the remaining 6 isolated populations in Colorado: Cerro/Cimarron/Sims, Crawford, Dove Creek, Glade Park/Pinyon Mesa, Poncha Pass, and San Miguel Basin.

The objective of our study is to provide season-specific (breeding, summer, and possibly fall/winter) resource selection models to assist wildlife managers, and other conservation efforts (i.e., the GUSG Collaborative Action Plan; CAP) in targeting conservation actions within the designated critical habitat in the 6 isolated populations.

We will use radio-telemetry data from GUSG captured and monitored from 1992 to 2016 in a variety of research, monitoring, and management efforts. These efforts include the capture and monitoring of resident and translocated birds. The translocated birds were captured within the GB and moved in the spring or fall to the isolated populations starting in 2000. We will attempt to estimate resource selection models for the breeding (approximately 1 April–15 July), summer (approximately 16 July–30 September), and fall/winter (1 October – 31 March) seasons in each isolated population. The specific modeling approach (including whether and how locations from translocated birds will be used) and how many seasons will be modeled (fall/winter may not be possible) is in development. The suite of variables to be used in the models is under discussion, but will include a variety of the best available spatial data in each isolated population using vegetation, topographical and anthropogenic variables. We will compare the seasonal models with the existing critical habitat to investigate whether the more specific seasonal models will help identify priority habitat for GUSG conservation. We will compare the overall habitat between the critical habitat designation and our combined models to investigate any patterns and configuration of the habitat.

A potential outcome is that our models will highlight areas with favorable environmental variables and spatial juxtaposition to establish priority habitat within the critical habitat designated by USFWS. More seasonally specific resource selection models can assist in identifying specific areas within the critical habitat designation to concentrate habitat improvements and conservation within the isolated populations.

Colorado Parks and Wildlife

WILIDLIFE RESEARCH PROJECT SUMMARY

Survival of Translocated Gunnison Sage-grouse

Period Covered: October 1, 2016 – December 31, 2017

Principal Investigators: James H. Gammonley jim.gammonley@state.co.us and Anthony D. Apa, tony.apa@state.co.us

Project Collaborators: Daniel Neubaum, Evan Phillips, Jonathan Runge, Nathan Seward, Scott Wait, Brad Weinmeister

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.

Translocations have been used frequently to manage North American grouse species (Baxter et al. 2008, Bell 2011, Bouzat et al. 1998, Gruber-Hadden et al. 2016, Hoffman et al. 2015, Mathews et al. 2016, Musil et al. 1993, Reese and Connelly 1997, Snyder et al. 1999, Stonehouse et al. 2015), with varied results. For sage-grouse (*Centrocercus*. spp), many translocations have failed or lacked enough data for an evaluation, with only three of the 56 efforts examined considered successful (Reese and Connelly, 1997). Baxter et al. (2008) recommended tracking several metrics to evaluate the success of sage-grouse translocation including annual survival rates, distance moved from release site, nesting propensity, nest survival, chick survival, flocking, and attendance at leks. Translocations are considered successful, according to Baxter et al. (2008), when translocated individuals were indistinguishable from resident birds in behavior and their demographic rates were comparable to or greater than resident birds.

The Gunnison sage-grouse (GUSG) is a sagebrush (*Artemisia spp*.) obligate whose range is limited to southwestern Colorado and southeastern Utah. Historically, the species is thought to have inhabited ~ 46,500 km^2 of sagebrush habitat in Colorado, Utah, New Mexico, and Arizona (Schroeder et al., 2004). Land-use changes in sagebrush habitat have reduced the species to just 8% of its historic range (Braun et al., 2014; Schroeder et al., 2004). A large (85-90% of the remaining birds) and stable population persisits the Gunnison Basin of Colorado, which is surrounded by seven much smaller satellite populations in Colorado and Utah: Poncha Pass, Cerro Summit-Cimarron-Sims Mesa, Crawford, Dove Creek, Monticello, Piñon Mesa, and San Miguel (U.S. Fish and Wildlife Service 2014). Natural migration between populations is low, resulting in significant genetic differentiation between populations (Oyler-McCance et al. 2005). Gunnison Sage-grouse is currently listed as threatened under the federal Endangered Species Act (U.S. Fish and Wildlife Service 2014).

In response to declining population sizes and low genetic diversity in satellite populations, Colorado Parks and Wildlife (CPW) began translocating individuals from the Gunnison Basin to satellite populations in 2000. Field crews used spot-lighting techniques (Giesen et al. 1982, Wakkinen et al. 1992) to trap GUSG. Spring trapping occurred during mid-March through early-May, and fall trapping occurred during early September through mid-October. In most cases, translocated birds were marked with transmitters and tracked following release. Plumage characteristics were used to determine sex and age (Dalke et al. 1963, Beck et al. 1975); each GUSG was classified as either an adult (second or later breeding season), yearling (first breeding season if captured in the spring), or juvenile. Although a preliminary summary indicated that 12-month survival rates of translocated GUSG can vary by population, ranging between 20 and 60% (U.S. Fish and Wildlife Service 2014), a detailed analysis of survival rates of translocated GUSG has not been conducted.

Several previous studies provide survival rate estimates of GUSG in their native population (i.e., not translocated). Apa (2004) examined survival in all seven Colorado populations; survival appeared to vary between the populations, however the sample sizes were too small to make definitive comparisons among the populations. Stiver et al. (2008) estimated one year survival in the San Miguel population. Survival estimates for GUSG ranged between 0.45–0.71 for females and 0.27–0.51 for males (Apa 2004, Stiver et al. 2008). Davis et al. (2015) estimated average annual survival for females was 0.61 (SE 0.06) and for males was 0.39 (SE 0.08). The effect of age was not a relatively strong effect on survival (cumulative wi = 0.34). Model averaged estimates of monthly survival were nearly identical for female adults and yearlings, and slightly higher, especially during the lekking period, for yearling males compared to adult males, although confidence intervals overlapped considerably. On average, males had a lower annual survival probability than females, which is consistent with many previous studies on greater sage-grouse (Zablan et al. 2003).

We compiled telemetry and observation data for GUSG translocated from the GB to the Crawford, Dove Creek, Pinyon Mesa, Poncha Pass, and San Miguel satellite populations. We are currently checking data and formatting the dataset for an analysis of survival one year following release of translocated birds. Our objectives are to 1) obtain estimates of period and annual survival of translocated GUSG, and 2) examine variation in survival in relation to timing of translocation (spring or fall), age-sex cohort (adult females, adult males, juveniles [fall translocations], yearlings [spring translocations]), and release population. We will use the nest survival module in Program MARK (White and Burnham 1999) to estimate survival. We will finalize models and develop a final report (manuscript) by 2019.

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Colorado Parks and Wildlife

WILIDLIFE RESEARCH PROJECT SUMMARY

Greater sage–grouse response to surface mine mitigation

Period Covered: October 1, 2016 – December 31, 2017

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

Project Collaborators: Bill deVergie, Area Wildlife Manager; Brad Petch, Senior Terrestrial Biologist; Trevor Balzer Sagebrush Habitat Coordinator; Kathy Griffin, Grouse Coordinator; Brian Holmes, Conservation Biologist, Michael Warren, Energy Liaison Colowyo Coal Company, L.P., Tri-State Energy; R. Scott Lutz, University of Wisconsin-Madison

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 greater sage–grouse (*Centrocercus urophasianus*) (GRSG) is a species of conservation concern because of historical population declines and range contraction (Schroeder et al. 2004, Connelly and Knick 2011). Intensive and extensive energy development within sagebrush (*Artemisia spp.*) communities in the western United States has raised specific concerns because of evidence linking demographic impacts to GRSG from active natural gas development (Lyon and Anderson 2003, Holloran 2005, Aldridge and Boyce 2007, Walker et al. 2007, Holloran et al. 2010, 2015). As such, significant financial resources have been allocated researching and mitigating the impact of fluid mineral development on GRSG. In contrast, there has been little attention towards investigating the response of GRSG to other forms of mineral extraction such as surface coal mine development (Manier et al. 2013). Most understanding about surface mine impacts has been gained from observational studies (Raphael and Maurer 1990) that rarely employ an impact study design (Green 1979, Buehler and Percy 2012).

Since most research assessing surface mining impacts to wildlife focus on reclamation and mitigation efforts, and there is significant potential for direct negative impacts (Buehler and Percy 2012), there has been considerable emphasis by industry and federal and state agencies to avoid, minimize, and mitigate impacts of energy development on GRSG (CDOW 2008). Therefore, the effectiveness of these costly mitigation efforts is largely unknown. As such, industry and management and regulatory agencies need a better understanding of the efficacy of mitigation efforts.

In June 2016, the Bureau of Land Management (BLM) and the Office of Surface Mining Reclamation and Enforcement (OSMRE) finalized the "Colowyo Coal Mine Collom Permit Expansion Area Project Federal Mining Plan and Lease Modification Final Environmental Assessment" (EA) (Little Collom Expansion EA; USDI 2016). The avoidance measures were primarily focused on one active GRSG strutting ground (SG–4) (CPW, unpublished data). Therefore, there is potential for negative consequences to the SG–4 strutting ground even with the implementation of significant avoidance measures. In contrast, it must be noted that the avoidance and minimization measures were based on a different type of energy development (e.g. more dispersed fluid minerals) because information is lacking on coal surface mine impacts and mitigation measures. Because of the potential impacts, minimization and mitigation requirements were implemented in an attempt to avoid and minimize impacts to SG–4 (USDI 2016).

Our research will evaluate the efficacy of GRSG mitigation (avoidance and minimization) efforts implemented in the Little Collom Mine Expansion EA (Alternative B). The results of our study will provide the first approach to assess the response of male GRSG to coal surface mining mitigation efforts and whether they effectively and successfully conserve the SG–4 strutting ground and breeding and summer habitat. The advanced notice and spatial containment of mining activities provide an opportunity to implement a BACI design (Table 1) that yields a higher level of management action certainty than traditional observational studies (Ratti and Garton 1994, Garton et al. 2005). With more management action certainty, managers will be better informed in making future disturbance specific mitigation recommendations in the face of disturbances associated with surface mine development or similar anthropogenic disturbance. The mitigation efficacy results from this research will help industry, state, and federal wildlife and habitat managers to conserve GRSG.

Our study area is located in Moffat County, Colorado (Fig. 1). The Axial Basin (AB) is approximately 736.7 km^2 consisting of rolling topography ranging from 1,800–2,350 m in elevation. The mine project area (MPA) is located in the largest (northwest) of 6 GRSG populations in northwestern Colorado (Fig. 1, 2).

For the purposes of this progress report, we include general methods for Phase I and Phase II and more specific methods and results for Phase I. This is important because the results of Phase I directly impact the future methods of Phase II.

We captured male and female GRSG for Phase I at night using spotlights and nets (Giesen et al. 1982, Wakkinen et al. 1992) on or near strutting grounds from mid–March through April. We fit females with an 18 g, 654–day VHF necklace–mounted transmitter (model A4050, Advanced Telemetry Systems, Inc., Isanti, MN). We also fit GRSG males with a 19 g, 654–day VHF rump–mount radio transmitter (model A1135, Advanced Telemetry Systems, Inc., Isanti, MN). All VHF transmitters have a 4–hour mortality sensor. In Phase II we will fit males with rump–mount harness 22 g PTT Solar Argos/GPS PTT (GeoTrak, Inc., Apex, NC) transmitters. We classify males and females as yearlings (<1 yr–old) or adults (≥ 2 yr–old) based on primary feather wear on #9 and 10 (Eng 1955, Cruden 1963) and fit all captured birds with an individually–numbered aluminum leg band (males #16, females #14; National Band & Tag Company, Newport, KY).

The purpose of Phase I of our research was to evaluate the success and applicability of using dataloggers for the Phase II research project. If the datalogger approach is successful, we will deploy dataloggers on strutting grounds in treatment (n = 5) and control (n = 4) areas. In addition to ground track the VHF marked males in Phase II, we will program PTT/GPS transmitters to acquire GPS fixes every 15–30 minutes from 0500–0900 and 2100–2400 from 1 March through 15 June. These times coincide with the morning strutting ground attendance period as well as the roosting period in the evening.

We encountered and observed unanticipated abrasion issues on males with the rump-mount harness deployment. The VHF transmitter harness attachment included a single metal loop in the anterior portion and two loops on the posterior portion of the transmitter to facilitate ribbon attachment. We added neoprene foam (0.64 cm thick) to the bottom of the transmitter to limit friction between the skin and transmitter. We used a 91.44 cm Teflon™ ribbon allowing for 20.32 cm of stretch in the middle of the ribbon. We tied a square knot to the middle loop to secure the harness to the transmitter. Each harness was then marked with five colors of metallic marker at every 1.27 cm mark from 24.13-29.21 cm.

We attempted three harness designs (Design I, II, and III). Design I is the aforementioned proposed approach. Generally, we fit all designs by centering the transmitter on the birds' rump and we then placing Teflon™ around the leg muscle trying to keep it flat against the skin. We threaded the ribbon through the back two loops on the transmitter that the straps are held in place with hemostats to ensure a good fit before the final crimping. The ends were crimped (0.64 cm brass crimps). We cut the end of the ribbon at a diagonal to limit fraying and applied super glue to the flat ribbon on the back of the bird.

Design I allowed approximately 2.54 cm of movement longitudinally up and down on the birds' back. Design II involved removing approximately 5 cm of the elastic from the center of the harness to increase the longitudinal movement. We further decreased the elastic length by crimping the harness material to limit excess stretch, and removed the excess elastic and super glued the crimp to the transmitter. For Design III we utilized 10.16 cm of air tubing (0.32 cm inner and 0.48 cm outer diameter) to create a smooth buffer between the bird's skin to limit or eliminate the Teflon™ ribbon abrasion. We added super glue to each end of the tube to fasten it to the ribbon. We also sealed each end of the tube with a piece of 0.48 cm heat shrink tubing approximately 1.91 cm long. Once the tube was secured, we added to the measurement lines as per Design I and II. The harnesses had approximately 3.8 cm of back and forth movement.

We captured 51 sage-grouse (29 M: 22 F). More specifically, we captured 22 adult and 2 yearling males and 19 adult and 3 yearling females. We radio-marked all captured females and 17 and 2 adult and yearling males, respectively. We recaptured 5 males to evaluate harness abrasions and removed transmitters from 3 due to unacceptable abrasions. We captured grouse from 13 March – 22 April 2017 with one male capture on 19 July 2017. We trapped on or near 6 strutting grounds in the Axial Basin ((CRP, Morgan Gulch 2, Juniper 1 & 2, Gossard) and Danforth Hills (SG-4)). Adult and yearling male greater sage-grouse mass ($\bar{x} \pm$ SE) was 2,914.91 ± 49.51 g (n = 21) and 2,365.50 ± 65.50 g (n = 2) and adult and yearling female was 1,573.16 ± 17.16 g (n = 19) and 1,449.67 ± 71.99 g (n = 3), respectively.

From March through September 2017, we documented 6 adult male, 2 yearling male, 7 adult female, and no yearling female mortalities. The mortalities resulted in a 7-month adult male apparent survival rate of 0.55 ± 0.00 (n = 21; 95% CI 0.30 - 0.81) and an adult female apparent survival rate of 0.69 ± 0.00 (n = 20; 95% CI 0.45 – 0.93). We did not estimate yearling survival because both yearling males died and three yearling females survived.

We deployed and initiated data collection with the datalogger data on 3 April 2017 and continued for 54 days through 26 May 2017 (datalogger was removed on 31 May 2017) (Figs. 3, 4). We discontinued datalogger use when there were five consecutive days with no transmitter detections. The datalogger sampled the lek for transmitters at 20 minute intervals. The beacon transmitter signal was sampled every 2 hours as a check on datalogger function.

Male sage-grouse attendance averaged 68.5% and ranged from 27.8-90.7% (Table 2). The datalogger receiver did not collect transmission data for 2 days (19 and 20 May 2017). Bird attendance also varied by the morning (2400-1200) and afternoon (1200-2400) (Fig. 5) time periods. Bird attendance varied after receiving snow (16.5 cm) on 18 May 2017.

We allocated 15 mornings to triangulation of marked males on four different strutting grounds. Triangulation was conducted on Morgan Gulch2 five times, SG-4 and Gossard four times, and CRP was monitored two times. All males heard on the lek were triangulated and all females were only documented as detected (alive/dead) and not triangulated.

We were successful in capturing a sample of males and female greater sage-grouse and deployed transmitters to evaluate monitoring approaches for Phase II of our research project. Rump-mount transmitters attachment issues dominated our focus following the discovery of moderate to severe abrasions on male greater sage-grouse from the harness. Once we encountered the issue, we contacted several researchers familiar with the rump-mount approach. They were modestly helpful since everyone we contacted had rarely (1-2 occurrences) recaptured birds with a rump-mount attachment (GPS transmitters rather than VHF have been the predominate approach and do not facilitate easy recaptures). We made modifications while consulting with other experts (B. Walker, personal communication).

Rump-mount Design I proved to be too tight and caused the moderate abrasions. The abrasions were magnified when the harness ribbon became folded over or twisted. Folding created a sharp edge facilitating cutting to the underside of the leg. Design II alleviated some of the cutting and abrasion issues, but the abrasion issues remained unacceptable. In addition to abrasions, when the Teflon™ ribbon was crimped to shorten the elastic length, the harness caused the transmitter to sit at an angle on the bird. We will solve this issue by adding two loops instead of one to the front of the transmitter while still allowing less stretch, but more stability. Design II also situated the harness ribbon slightly more vertically through the large patch of feathers behind the leg to help eliminate a sharper angle underneath the leg. This seemed to help limit friction under the leg. Design III included the addition of air tubing to cover the abrasive edges of the Teflon™ ribbon. This allowed for the harness to be smooth and limit abrasions. This method also helped maintain a flat surface of the harness. The approach allowed for approximately 3.18 cm longitudinal movement by placing the ribbon more vertically through the previously mentioned feathers. This design was the most successful causing minimal abrasion one week after deployment.

Even though our design modifications were ad hoc, and the abrasion issue resulted in smaller sample sizes than desired, we are confident that the adjustments solved the abrasion issues. Therefore, we will implement Design III for 2018 season. To further limit or mitigate abrasions, we have made additional modifications by shorting the elastic length on the harness and modifying the transmitters to match the GPS transmitter dimensions and shape. Lastly, as a final test of our modifications, we will capture a sample of VHF-marked males to evaluate the success of our attempts to alleviate abrasion issues.

We generally compared data acquisition with triangulation versus the datalogger. The datalogger is superior option primarily due to its efficiency and consistent data collection. Test beacons provide a measure of standardization and datalogger functionality redundancy. Triangulation was very time consuming. To access multiple leks and successfully acquire triangulation data was very difficult and an inefficient use of time. Although some acquisition stations were far enough apart to insure bearings intersection, they ultimately were too far apart to obtain consistent triangulation detections during the strutting period. The long distance between sampling stations, often resulted in only 1-2 stations (rather than three or more) being accessed before the birds flushed in the morning. Datalogger deployment will be implemented in the 2018 research season. Data collection on all leks can occur on all mornings during the strutting season. Once the desired gain is reached for each strutting ground area, distance from the datalogger can be calculated based on the frequency's signal strength recorded on the datalogger.

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Table 1. Proposed sample sizes for male and female greater sage-grouse marked in the control, treatment (impact) lek complexes and the impact lek (SG-4) before and after treatment (impact) and the number of males counted on leks in 2016 in Moffat county, Colorado, 2017-2019.

		BEFORE			**AFTER**	
		Pilot 2017[1]	**Year 2018[1]**	**Mine Development**	**Year 2019[1]**	**Total[1]**
	Females					
Control						
	Lek Complex	10/0	40/0		40/0	**90/0**
Treatment						
	Lek Complex	5/0	25/0		25/0	**55/0**
	Impact Lek	5/0	15/0		15/0	**35/0**
	Males					
Control						
	Lek Complex (254 males)	15/0	25/10		25/10	**65/20**
Treatment						
	Lek Complex (256 males)	5/0	15/5		15/5	**35/10**
	Impact Lek (42 males)	10/0	10/5		10/5	**30/10**

[1]VHF/GPS-PTT sample size

Table 2. Signal detection (attendance percentage) for 54 days of 4 male and beacon transmitter at the SG-4 greater sage-grouse strutting ground in the Danforth Hills of northwestern Colorado, 2017.

Bird	Percent A.M. Attendance	Percent P.M. Attendance	Percent Daily Attendance
1	27.8	14.8	27.8
2	64.8	50.0	72.2
3	77.8	74.1	83.3
4	83.3	68.5	90.7
Beacon	95.2	95.2	96.6

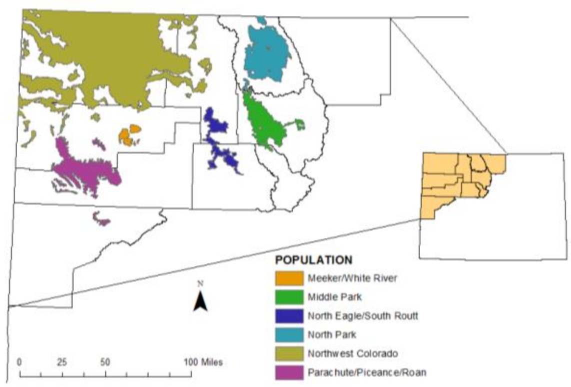


Figure 1. Greater sage-grouse populations identified by Colorado Parks and Wildlife (CDOW 2008) and county borders (black lines around populations) in northwestern Colorado.

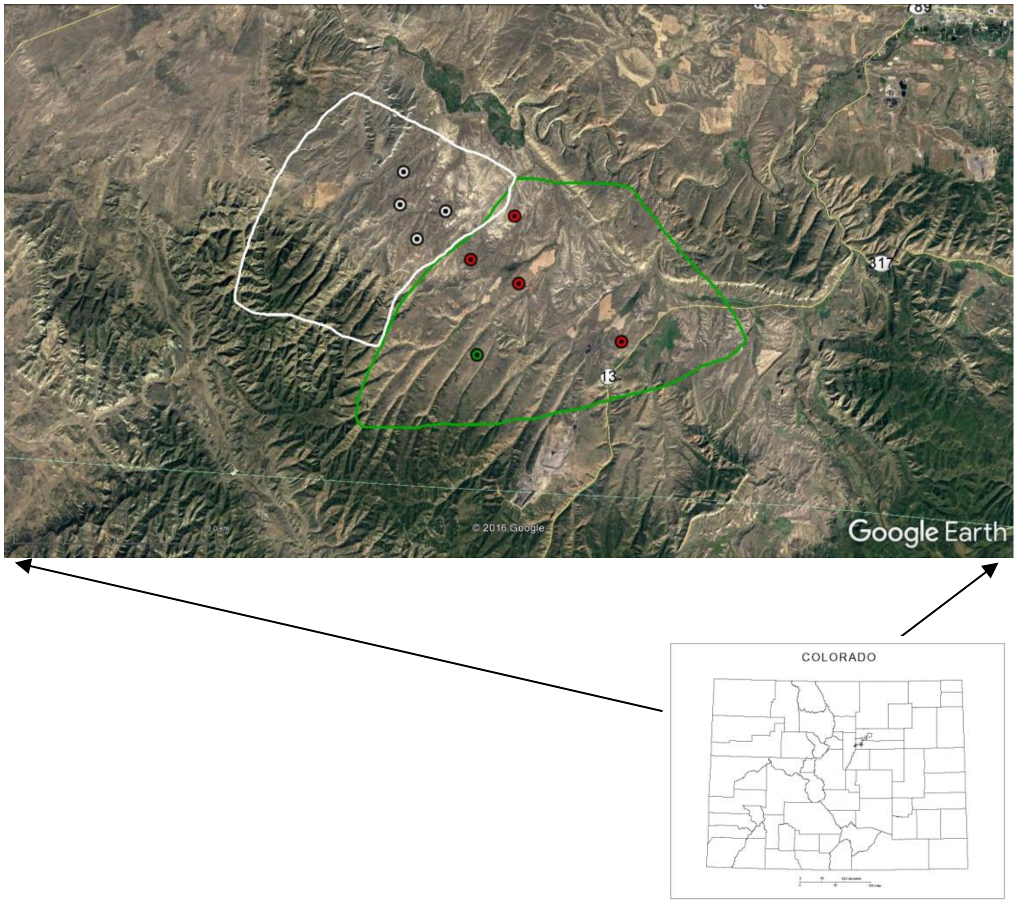
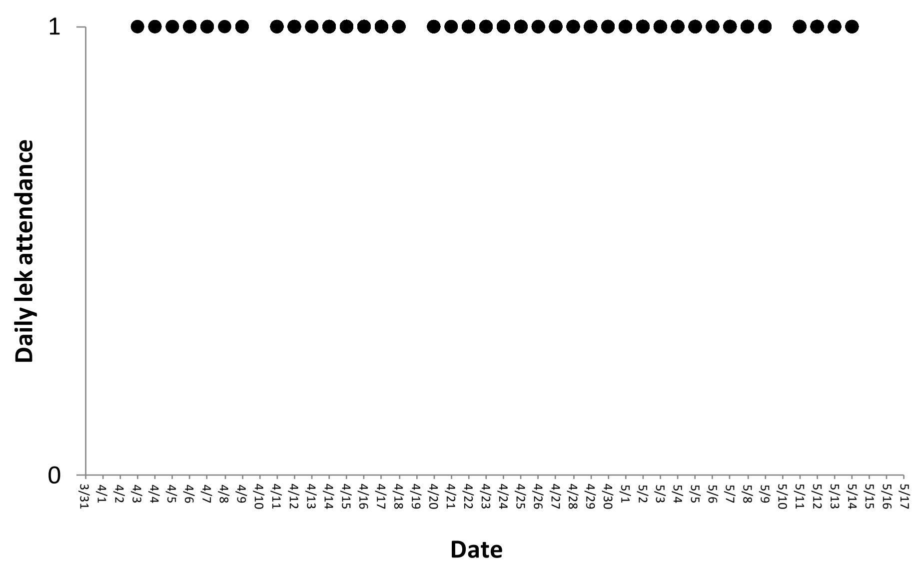


Figure 2. Study area location of treatment ( ) and control ( ) greater sage-grouse strutting grounds in the Axial Basin area of Moffat county, Colorado. Treatment area is outlined in green, and control is outlined in white. Also included is the SG-4 ( ) strutting ground that will be within the mine project area.

Figure 3. The ATS datalogger connected to the 12-volt battery inside the waterproof box on the SG4/Collom 2 lek in northwestern, Colorado.

Figure 4. The datalogger setup in the waterproof box with the lid closed and camouflaged with sage on SG4/Collom 2 lek in northwestern Colorado.

a)



b)

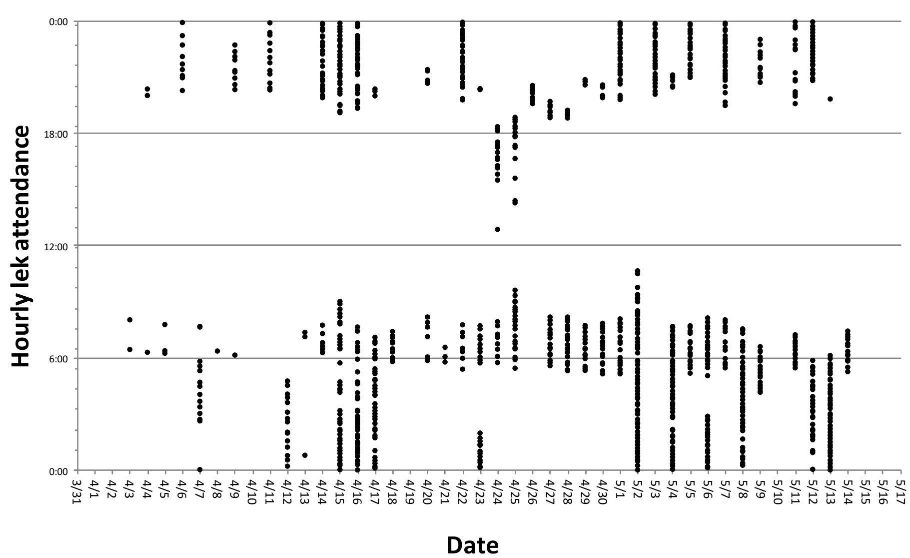


Figure 5. Greater sage-grouse adult male #2 a) daily (1= attending, 0= not attending) and b) hourly (0.00 = 2400 midnight) signal detection (SG-4 strutting ground attendance) from a datalogger in the Danforth Hills, Colorado 2017.

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: October 1, 2016 – December 31, 2017

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 as a surrogate 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. We 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 and around the Hiawatha Regional Energy Development project area in northwestern Colorado in spring from 2011-2014. I will use estimates of male survival, detectability of males on leks, lek attendance, inter-lek movement, and the proportion of leks known and counted during the breeding season to generate simulated lek-count data from simulated male populations to evaluate the reliability of current lek-based methods for monitoring population trends. I am using local convex hull (t-Locoh) and Brownian bridge movement models to identify space use in relation to known leks to evaluate the performance of lek buffers for conserving important greater sage-grouse seasonal habitats. Analyses for this project are ongoing. I anticipate submitting a publication on male space use in 2018 and papers on detectability, lek attendance, inter-lek movements, and lek-count reliability in 2019.

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: October 1, 2016 – December 31, 2017

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

Project Collaborators: Brian Holmes, Brad Petch, Bill deVergie, J. T. Romatzke, CPW; Barry Noon, Colorado State University

Robust estimates of population size and population trends provide the scientific basis for managers to make appropriate and defensible recommendations regarding land-use, 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 population indices that may or may not meet the assumptions required to accurately estimate population abundance 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 over time, but they rely 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 abundance, it is worth comparing the performance of current lek-count approaches against other potential monitoring methods. Dual-frame sampling of leks by helicopter and non-invasive genetic mark-recapture analyses based on winter pellet sampling are two promising alternatives for monitoring trends in sage-grouse populations. The purpose of this study was to evaluate and compare the reliability and efficiency of dual-frame sampling of leks, genetic mark-recapture, and standard lek counts for estimating population size, trend, and sex ratio in the Parachute-Piceance-Roan (PPR) population in northwest Colorado. All field data collection for this project finished in May 2014. Jessica Shyvers completed her dissertation in July 2017. We submitted a manuscript for the dual-frame lek surveys to the Journal of Wildlife Management in January 2018. Dual-frame survey results suggest that there are a substantial number of unknown active leks in the population and that different proportions of active leks are counted in each year. Annual variation in the proportion of active leks counted may bias estimates of population status, abundance, or trends and management decisions and habitat prioritization based on lek-count data. For the genetic mark-recapture (GMR) analysis, we completed genetic analysis of all feather and pellet samples, used microsatellite data for six loci plus one sex locus to generate capture histories for individual birds, and conducted GMR analysis with closed population models in Program MARK to obtain abundance and sex ratio estimates for the PPR population over two consecutive winter seasons (2012-2013 and 2013-2014). Preliminary results suggest a large between-year population increase that was similar in direction and magnitude to that reported in CPW lek-count data (summed maximum male count across leks) and in dual-frame lek survey estimates from spring 2013 to spring 2014. However, genetic data also indicated higher than expected variation in sex ratio between years, likely associated with high reproductive success and juvenile survival in 2013. Annual variation in sex ratio may be an additional source of bias for estimates of population abundance and trends based on lek-count data that rely on a constant sex ratio assumption. We are in the process of finalizing manuscripts on GMR and sex ratio results for submission to journals in 2018.

Shyvers, J. E., B. L. Walker, and B. R. Noon. In review. Assessment of dual-frame lek surveys for estimating sage-grouse populations. Journal of Wildlife Management.

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: October 1, 2016 – December 31, 2017

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

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

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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 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 as a surrogate to identify and protect important sage-grouse habitat. However, the use of lek counts and lek locations to monitor populations is controversial because how closely lek-count data track actual changes in male abundance from year to year has never been tested. It is also unknown how effective lek buffers are at reducing disturbance to male sage-grouse and the habitats they use in each season. We 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 2012-2016. I originally planned to use estimates of male survival, detectability of males on leks, lek attendance, inter-lek movement, and the proportion of leks known and counted during the breeding season to generate lek-count data from simulated male populations to evaluate the reliability of current lek-based methods for monitoring population trends. However, we were unable to capture sufficient number of males away from leks to obtain estimates of lek attendance representative of the entire male population. I anticipate submitting a publication on GPS male inter-lek movement and male detectability on leks in 2018. I also hope to use estimates of lek attendance, inter-lek movement, and detectability to assess impacts of these 3 factors on dual-frame lek survey estimates in a simulation paper in 2019. I am using local convex hull (t-Locoh) and Brownian bridge movement models to document space use in relation to the proportion of leks known and incorporated into management decisions to evaluate the performance of lek buffers for conserving important greater sage-grouse seasonal habitats. Male space use analyses are in progress, and I anticipate submitting a publication in 2018.

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: October 1, 2016 – December 31, 2017

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

Project Collaborators: B. Holmes, B. Petch, T. Knowles, B. deVergie; H. Sauls and E. Hollowed (BLM-WRFO)

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, until recently, few studies 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 use pellet surveys to investigate the effectiveness of pinyon-juniper removal for restoring sage-grouse habitat in the PPR. In fall 2008, I established nine area-based 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 of the 9 plots in 2010 and 2011. Pellet surveys in summer from 2009-2015 indicated that, as expected, the mean proportion of sample units containing pellets was consistently highest on sagebrush control plots and consistently lowest on plots with encroaching pinyon-juniper. The mean proportion of sample units containing pellets increased on 2 of 3 treated survey plots (Ryan Gulch and Upper Galloway) within 1-2 years after treatment. I established an additional 14 transect-based plots in fall 2010 and summer 2011, and two in summer 2014. We conducted pellet transects on these 16 plots each summer through 2015. As expected, the mean no. of pellet piles/km were low on the four PJ-Control plots for the duration of the study, low on PJ-Treatment plots prior to treatment, and higher on all four Sagebrush-Control transect plots (at least through 2014). However, the mean no. of pellet piles/km declined precipitously on 3 of 4 Sagebrush-Control transect plots in 2015. The mean no. of pellet piles/km was also high on the Lower Barnes transect plot 4-5 years post-treatment, but declined 6-8 years post-treatment. Mean no. of pellet piles/km remained low on treated transect plots for four years after pinyon-juniper removal with the exception of the Upper Bar D plot in 2014. 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. 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. Overall, estimates of the proportion of sample units with pellets (from survey plots) and the no. of pellet piles/km (from transect plots) varied substantially among Sagebrush-Control plots within years and among years within plots, which suggests substantial background variation in the no. of pellets deposited within suitable habitat. Sage-grouse response to pinyon-juniper removal (as measured by pellet surveys) also appeared to be inconsistent in the PPR, with pellet counts clearly increasing on only 2 of 8 treated plots within 4-5 years post-treatment. Final analyses for this project are still in progress. A recent experimental pilot project conducted by Conoco-Phillips, with assistance from CPW, suggests that sage-grouse may respond more strongly to both pinyon-juniper and serviceberry removal. However, a proposal to expand that pilot study into a large-scale research project investigating pinyon-juniper and/or serviceberry treatments is on hold until access issues are resolved.

Colorado Parks and Wildlife

WILIDLIFE RESEARCH PROJECT SUMMARY

Comparing survival of greater sage-grouse with VHF and GPS transmitters in northwestern Colorado and southwestern Wyoming

Period Covered: October 1, 2016 – December 31, 2017

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

Project Collaborators: B. Holmes, B. Petch, B. deVergie

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Large-scale changes to sagebrush habitats throughout western North America have led to growing concern for conservation of greater sage-grouse (*Centrocercus urophasianus*) and widespread efforts to better understand sage-grouse demographic rates, movements, habitat selection, and responses to habitat manipulation and disturbance. Almost all current research projects use very high frequency (VHF) transmitters attached to a neck collar to radio-track individual sage-grouse because previous attempts using backpack-style transmitters appeared to increase vulnerability of birds to predation. However, recent technological advances have led to commercial production of 22-30 g, solar-powered, global positioning system (GPS) satellite transmitters that appear suitable for use with sage-grouse. GPS transmitters have several advantages over traditional VHF collars. They collect multiple locations per day at pre-programmed times, problems with accessing locations on the ground are eliminated, data are gathered remotely without disturbing the bird or its flock mates, and they provide extremely high-resolution data on survival, movements, habitat use, and timing of nest initiation. However, it remains unknown whether rump-mounted GPS transmitters influence survival or rates of nest initiation or survival of sage-grouse compared to VHF transmitters. I conducted a 1-year pilot study to compare demographic rates between greater sage-grouse with traditional VHF neck collars and rump-mounted solar GPS PTT transmitters in the proposed Hiawatha Regional Energy Development Project (HREDP) area in NW Colorado and SW Wyoming. We captured and attached 30-g, rump-mounted solar-powered GPS PTT satellite transmitters and VHF necklace collars on adult female sage-grouse in spring 2009 in and around the proposed HREDP. Survival of females with VHF ($n = 42$) and ($n = 50$) GPS transmitters was similar from spring 2009 through October 2009, but lower for GPS-marked females from October 2009 - March 2010, resulting in lower annual survival for GPS-marked females (0.556 ± 0.073 SE for VHF vs. 0.406 ± 0.068 SE for GPS). This finding prompted us to improve transmitter camouflage and padding, increase harness flexibility, modify our leg-loop fitting techniques, and recommend caution in using rump-mounted GPS transmitters on females. Nest survival and transmitter performance analyses will be completed and a manuscript submitted in 2018.

Colorado Parks and Wildlife

WILIDLIFE RESEARCH PROJECT SUMMARY

Hiawatha Regional Energy Development Project and Greater Sage-grouse Conservation in Northwestern Colorado and Southwestern Wyoming Phase I: Conservation planning maps and habitat selection

Period Covered: October 1, 2016 – December 31, 2017

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

Project Collaborators: B. Holmes, B. Petch, B. deVergie

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Increasing energy development within sagebrush habitat has led to concern for conservation of greater sage-grouse (*Centrocercus urophasianus*) populations, and both industry and regulatory agencies need better information on when and where sage-grouse occur to reduce impacts. Managers also lack landscape-scale habitat guidelines that identify the size and configuration of seasonal habitats required to support sage-grouse use. It is also essential to understand how sage-grouse in local populations select habitat in terms of the relative importance of local (i.e., micro-site) vs. landscape-scale habitat features. Understanding their response to different components of energy infrastructure is also essential for understanding and predicting the effects of specific development proposals. Resource selection functions (RSF) can be combined with geographic information system data to model habitat selection by sage-grouse in response to natural and anthropogenic habitat features at multiple scales and to map key seasonal habitats at high resolution over large areas. Multi-scale habitat use models, landscape-scale habitat guidelines, and high-resolution seasonal habitat-use maps will help streamline planning and mitigation for industry and facilitate sage-grouse conservation in areas with energy development. The proposed Hiawatha Regional Energy Development Project (HREDP) overlaps much of the known winter habitat and a portion of the documented nesting and brood-rearing habitat for the sage-grouse population that breeds in northwestern Colorado. Colorado Parks and Wildlife conducted a field study project tracking VHF females from December 2007 through July 2010. Objectives were to: (1) create validated, high-resolution conservation planning maps based on RSF models that delineate important seasonal sage-grouse habitats within the proposed HREDP boundary, (2) identify landscape-scale seasonal habitat guidelines, (3) evaluate the relative importance of local versus landscape-level habitat features (including vegetation, topography, and energy infrastructure) on sage-grouse wintering and (if possible) nesting habitat selection, and (4) assess whether historical energy development in the Hiawatha area influences current habitat selection. Field data collection was completed in July 2010. Preliminary seasonal RSF maps were completed in March 2010 (Fig. 1), however analyses were limited by the extent of reliable classified land cover layers on either side of the Colorado-Wyoming state line. CPW's GIS section attempted to produce an improved classified land cover layer from 2010 -2014, however, that effort was unsuccessful. We completed mapping of annual energy infrastructure within 4 miles of the HREDP boundary from 2006-2016 in 2017 and will conduct final RSF analyses and submit maps to cooperating agencies and for publication in 2018 (to meet objectives 1-3, above). We found that historical and recent energy development within the HREDP were largely coincident (i.e., spatially correlated), so it would be difficult to distinguish the effects of historic vs. current development on habitat selection. So, to better assess the effect of historical well pads on likelihood of use by GRSG, we measured micro-site vegetation on abandoned and reclaimed well pads in summer 2010 for comparison against vegetation measured around well pads and around nests and wintering locations. The well-pad vegetation recovery analysis (objective 4, above) will be completed and submitted for publication by 2019.

Colorado Parks and Wildlife

WILIDLIFE RESEARCH PROJECT SUMMARY

Seasonal Habitat Mapping in the Parachute-Piceance-Roan Region of Western Colorado

Period Covered: October 1, 2016 – December 31, 2017

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

Project Collaborators: T. Apa, B. Holmes, D. Finley, S. Duckett, B. Petch, B. deVergie, J. T. Romatzke

Large-scale changes to sagebrush habitats throughout western North America have led to growing concern for conservation of greater sage-grouse (*Centrocercus urophasianus*) and repeated petitions to list the species under the Endangered Species Act. Greater sage-grouse in the Parachute-Piceance-Roan (PPR) region of western Colorado face two major conservation issues: a long-term decline in habitat suitability associated with pinyon-juniper (PJ) encroachment, and potential impacts from rapidly increasing energy development. In 2006, Colorado Parks and Wildlife (CPW) and industry partners initiated a 3-year study to obtain baseline data on greater sage-grouse in the PPR. Since then, CPW identified two key research needs: (1) generate high-resolution maps showing concentrated seasonal use areas to help industry and agencies avoid and mitigate impacts to sage-grouse habitat; and (2) assess the value of PJ removal to restore habitat as mitigation for habitat loss associated with energy development. The seasonal habitat mapping portion of this project was completed in 2016 with the publication of validated multi-scale, season-specific, resource selection function (RSF) models for the PPR (Walker et al. 2016; Figure 1). RSF models were based on VHF telemetry locations from 2006-2010 and validated with independent telemetry data from 1997-1998 (Hagen 1999) and 2013-2014. They have since been shown to also validate well against an additional independent dataset of seasonal locations collected in 2012-2016. VHF telemetry data and RSF models from this project were used to generate Random Forest models and in an ensemble map with priority and general habitat designations as part of the recent Associated Governments of Northwest Colorado statewide sage-grouse habitat remapping project. The Walker et al. (2016) paper did not consider the effects of different components of energy infrastructure on habitat selection. To meet that second objective, mapped annual changes in four major components of energy infrastructure (well pads, facilities, pipelines, and roads) as well as other landscape changes (e.g., habitat treatments, fires) over the duration of the study period (2006-2010). We completed final infrastructure and landscape change mapping in March 2017 and we received landscape metrics from the GIS section in November 2017. The analysis testing habitat selection in response to different components of energy infrastructure is in progress and will be completed and submitted for publication in 2018. Because of widespread interest in quantifying (and predicting) land cover changes associated with energy development for management agencies (Martinez and Preston 2018), I also anticipate submitting a paper in 2018 that describes mapped changes in different components of infrastructure with ongoing energy development within the PPR population between 2006-2016.

Walker, B. L., A. D. Apa, and K. Eichhoff. 2016. Mapping and prioritizing seasonal habitats for greater sage-grouse in northwestern Colorado. Journal of Wildlife Management 80:63-77.
doi: 10.1002/jwmg.962

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, CPW

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.

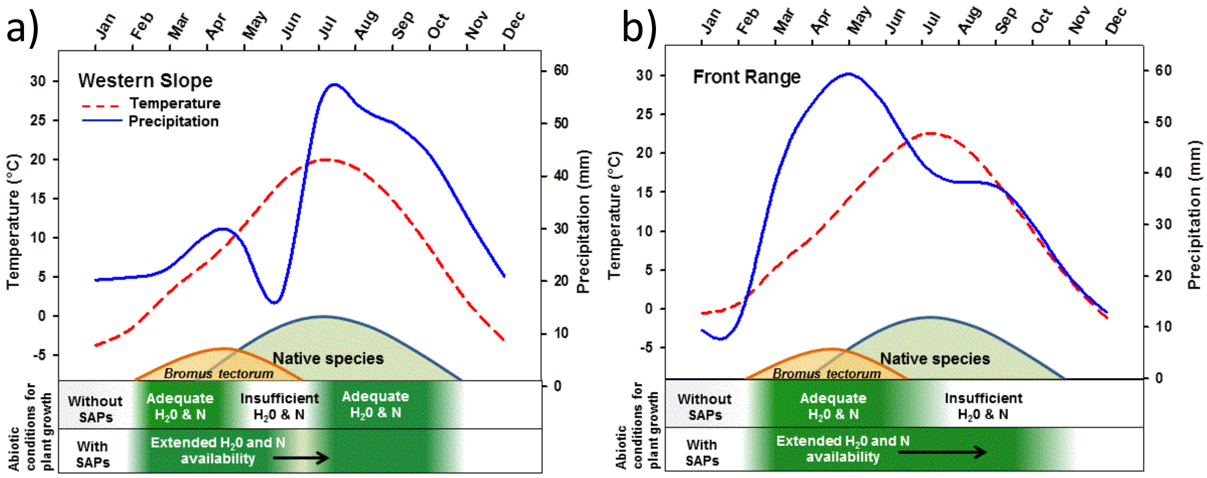

Figure 1. Thirty-year average temperature and precipitation for the Western Slope (Dry Creek State Wildlife Area, San Miguel County, CO) and Front Range (Waverly, CO) study sites. a) Western Slope. Water availability is suitable for plant growth in the early spring when soils are moist after snow melt, 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.

WILDLIFE RESEARCH FINAL REPORT

Rangeland restoration with super-absorbent polymer and potholed surface at Horsethief State Wildlife Area

Period Covered: September 1, 2012 – December 31, 2017

Period Covered: September 1, 2012 – September 31, 2017

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

Personnel: T. Stroh, Bureau of Reclamation; R. Velarde, J.T. Romatzke, I. Archer, D. Lovoi, Steve Ryan, CPW

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EXTENDED ABSTRACT

Rangeland restoration in western Colorado often fails due to inadequate moisture to support germination, overwhelming competition from non-native annuals, or both. Two techniques which have helped ameliorate these difficulties in a prior CPW study are seeding over a roughened, or pothole, surface, and addition of super-absorbent polymer (SAP) to the soil (Johnston 2016). Potholes may help control cheatgrass by limiting cheatgrass seed dispersal, trapping seeds in the bottoms of pits (Johnston 2011, Johnston and Chapman 2014). The pits are likely to have higher and more stable soil moisture, and cheatgrass seeds are known to be less competitive in such environments. SAPs may reduce the competitive ability of cheatgrass by extending the period of time soils are moist, as cheatgrass is more competitive when soil moisture is more variable (Chambers et al. 2007, Johnston 2016).

In this study, these two techniques are combined with a light application of imazapic (Plateau™) herbicide to restore a previously undisturbed rangeland which was heavily invaded by cheatgrass (*Bromus tectorum* L.). In addition, the mechanism by which pothole seeding may aid in cheatgrass control was explored with soil moisture measurements and a seed dispersal study.

We created a new implement, dubbed a 'pothole seeder' to create the pothole surface efficiently. This machine consisted of a broadcast seeder mounted over a gang of large notched discs. The notched discs produced a checkerboard pattern of mounds and 30-cm deep pits when dragged over the ground. With this implement, about 2 ac/hr of ground could be roughened and seeded.

The restoration study site was within Horsethief State Wildlife Area near Fruita, Colorado (Figure 1). To prepare the site, scattered sparse greasewood plants were cut with a brush hog and four polygons totaling 6.7 acres were sprayed with 70 g ai/ha (4 oz/acre) of imazapic herbicide in August 2012. The polygons were treated with the pothole seeder in November, 2012 using a diverse mixture of native grasses, forbs, and shrubs. Two of the four treated polygons were randomly assigned to receive granulated SAP, which was applied at 300 lbs/ac by mixing the SAP granules with the seed. The resulting vegetation community was monitored using seedling counts in 2013-4 and cover measurements 2015-16. Two control polygons were monitored 2014-2017. Soil moisture was monitored in mounds vs. pits in 2013.

The seed dispersal study was located within the city limits of Fruita, Colorado on private property owned by CPW engineer Steve Ryan. The site was an abandoned agricultural field, and 0.4 ac were prepared by scraping and hand-pulling perennial grasses in March 2017. Two of four plots 17.5 X 21.7 m in size were randomly assigned to receive the pothole treatment, which was produced using a mini-

excavator. One pothole plot and one flat plot received a brush mulch treatment consisting of scattered sagebrush skeletons. Fluorescently-marked, sterilized cheatgrass seeds were released on two occasions from pothole pits, pothole mounds, or flat soil surfaces in June 2017. The distance between each seed and its release point was measured 2d and 6-7d following release.

Initially, SAP doubled perennial grass seedling density. However, by the end of 2013, nearly all seedlings had died within study plots, and no further effect of SAP was detected on seedling density or cover of perennial grasses, forbs, shrubs, cheatgrass, or annual forbs. In contrast, the pothole-seeded versus control polygons were markedly different over the course of the study. Cheatgrass density in 2014 was 2-fold lower in treated polygons, and 2015-2017 perennial grass cover was about 4 times higher in treated versus control polygons. Perennial forb cover was much higher in treatment areas 2015-6, but declined sharply to a level similar to control plots in 2017 following a die-off of western yarrow (*Achillea millefolium*). The dominant shrub in treatment areas by 2017 was fourwing saltbush (*Atriplex canescens),* while the dominant shrub in control areas was greasewood.

In the seed dispersal study, seeds released from pits traveled only 21 cm on average, with a 95% quantile distance of only 39 cm. In contrast, seeds released from flat surfaces traveled 91 cm on average, with a 95% quantile distance of 245 cm. Seeds released from mounds traveled 43 cm on average, with a 95% quantile distance of 94 cm. The brush treatment only had an effect for seeds released from mounds, and the effect was slight.

The transient effect of SAP may not justify its cost, $600/ac in this study. For drill-seeded restoration seedings, applying SAP only within drill-seeded rows would dramatically reduce cost.

Prior work has suggested that pothole seeding combined with a light imazapic application may be an effective restoration strategy, and our restoration study corroborates this finding. The level of imazapic applied here is generally thought to be too light to permit native plant establishment and higher rates of imazapic aren't advisable due to unacceptable injury to desirable species. Nonetheless we witnessed outstanding native plant establishment using a light imazapic application when combined with pothole seeding (Figure 2).

The seed dispersal and restoration studies support the idea that potholing helps control cheatgrass through a combination of restricted seed dispersal and altered soil moisture. We found higher and more stable soil moisture within pits of the restoration study, and we noted a dramatic decrease in cheatgrass seed dispersal for both pits and mounds versus flat surfaces in the seed dispersal study. In addition, we observed a slow march of cheatgrass from the edge of treated polygons over the years 2014-2017. In 2014, cheatgrass was almost absent from treated areas, but dense along the plot edge. By 2015, cheatgrass was evident within the first few pits of the plot border, but had not progressed further (Figure 3). By 2017, cheatgrass was ubiquitous within pits of the treatment area.

Anything which can slow the spread of cheatgrass offers new possibilities for restoration. Research has shown that even a few weeks' head start can give native plants an edge over invasive species (Firn et al. 2010). Potholes have the potential to slow the spread of cheatgrass over a timecourse of years. Coupled with a light application of imazapic and a seeding of drought-tolerant, site-adapted native species, potholing may improve restoration outcomes for those sites where ground-disturbing machinery can be used.

The pothole seeder used in this study had durability issues, and it is no longer available. A second version is currently under construction by Ivan Archer and Derek Lovoi. This version will feature a drop seeder made from Truax drill seed boxes, mounted using air pillows over a single row of notched discs. These design features should improve on noted problems of wasted seed, buckling seeder mounts, and awkward balancing in the prior seeder.

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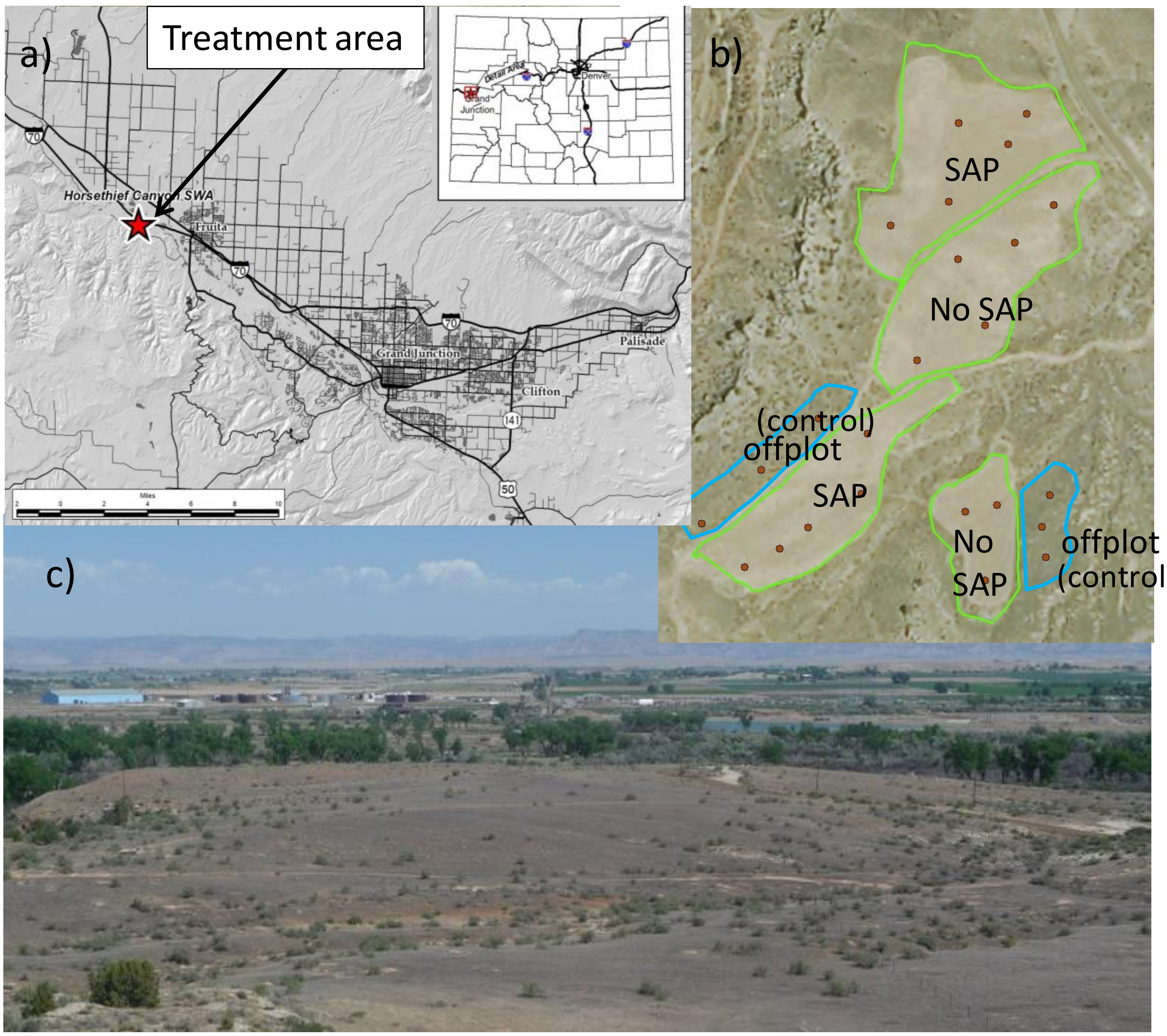

Figure 1. The restoration study was conducted at Horsethief State Wildlife Area near Fruita, CO (a). Two of four treatment polygons received super-absorbent polymer (SAP), while two polygons served as controls (b). Prior to treatment, the site was dominated by cheatgrass and greasewood (c).

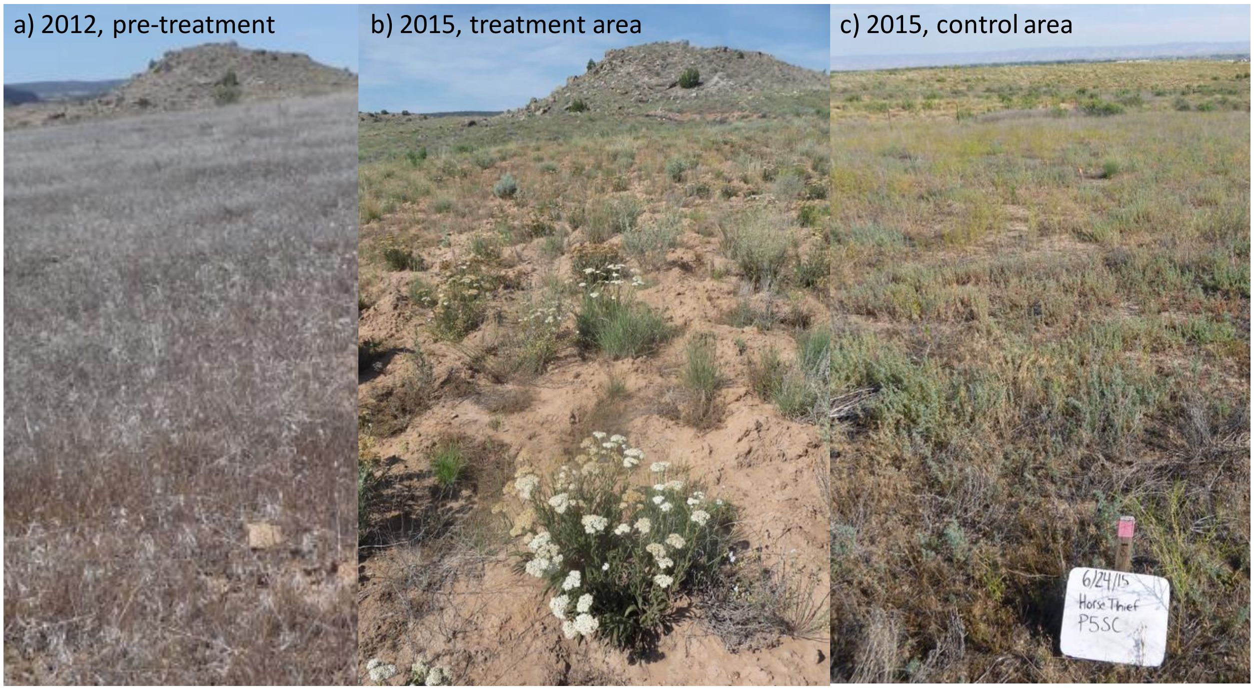

Figure 2. By 2015, areas which had been stands of cheatgrass prior to treatment (a), now had established perennial grasses, forbs, and shrubs (b). Treatment areas looked markedly different from control areas (c).


Figure 3. View into to polygon 4 from the upslope edge in June 2015. Cheatgrass had invaded the first few pits near the polygon edge but had not progressed further.

Colorado Parks and Wildlife

WILDLIFE RESEARCH PROJECT SUMMARY

Evaluating spatial patterns and processes of avian and mammalian wildlife populations

Period Covered: September 1, 2017 – December 31, 2017

Principal Investigator: Kevin Aagaard, kevin.aagaard@state.co.us

Project Collaborators: Dan Neubaum, Lance Carpenter, Reesa Conrey, Darby Finley, Trevor Balzer, Amy Seglund, Tony Apa, Mindy Rice [US FWS], Julie Heinrichs [USGS], Mike O’Donnell [USGS]

Evaluating wildlife location data provides substantial information for management. Location data reveal patterns of movement dynamics, species distribution (habitat suitability), and varying habitat use. Understanding these patterns and dynamics is critical for management of species of conservation concern and harvested species. Colorado Parks and Wildlife monitors myriad species of concern for conservation and hunting and thus needs to develop thorough and up-to-date assessments of the spatial patterns and processes of its target species. In collaboration with state wildlife biologists, avian researchers, big game managers, and federal counterparts, I have assisted in evaluating spatial data for several species and populations. Below, I list the active research projects I am associated with, and briefly detail the objectives and current status of each.

Colorado Bat Distribution Model (with D. Neubaum)

We compiled expected distribution models and range maps for 18 species of Colorado-resident bats species using location data of radio-tagged bats. A stated goal is to generate baseline expectations for bat distribution for comparative use in the event that white-nose syndrome (*Pseudogymnoascus destructans*) expands its range into Colorado. At present, we have created distribution models for each species (see Figure 1 for example, below). Future objectives include evaluating likely species movement corridors using landscape movement models.

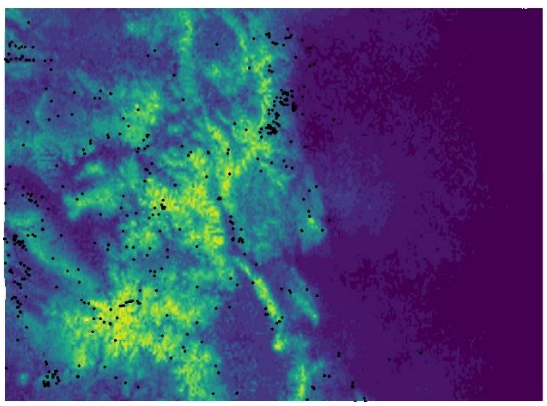

Figure 1. Example bat distribution model for long-legged myotis (*Myotis volans*). Warm (yellow) colors represent likely suitable habitat; cool (indigo) colors represent unlikely suitable habitat. Black dots represent observed locations.

Mountain Goat Distribution Model (with L. Carpenter)

Our focus is on mountain goat (*Oreamnos americanus*) populations in and around Mount Evans. The stated objective is to determine differences in winter and summer habitat use, and to compare contemporary to historical habitat use patterns. We have completed distribution models for summer and winter seasons (Figure 2 A and B). We are now working to compare results to historical distributions. We are using literature-derived location data for comparison. We are attempting to elicit the data from the author.

(A) **(B)**

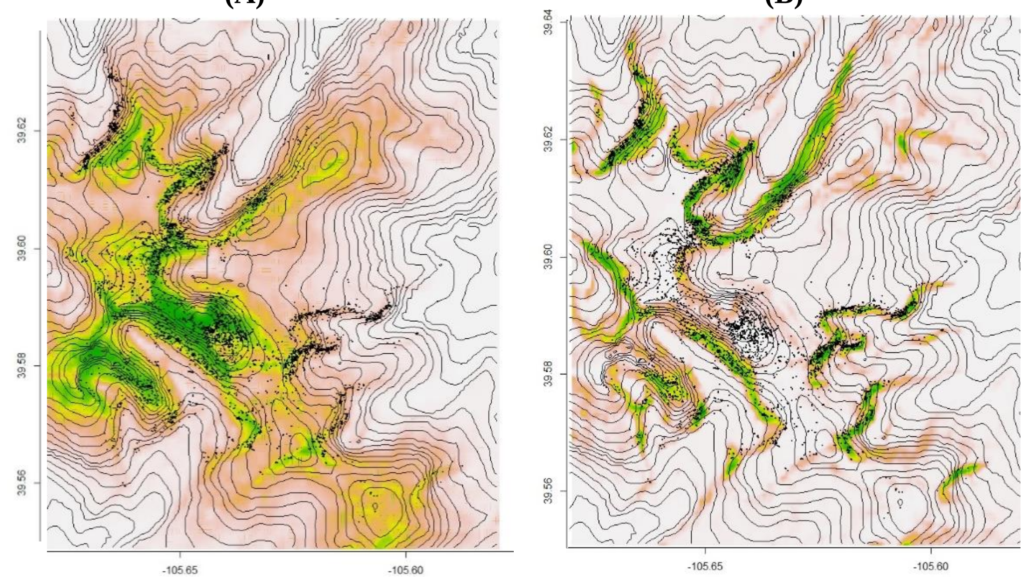

Figure 2. Expected summer (A) and winter (B) distribution models for Mt. Evans mountain goats. Elevation contours are provided for context. Green represents area of likely suitable habitat; white represents areas of unlikely suitable habitat. Black dots represent observed locations.

Raptor Nesting Distribution Model (with R. Conrey, see pages 51-55 for full project summary)

We developed models to identify areas that four raptor species of concern (bald eagle, *Haliaeetus leucocephalus*; golden eagle, *Aquila chrysaetos*; ferruginous hawk, *Buteo regalis*; prairie falcon, *Falco mexicanus*) are most likely to use for nesting habitat (See Figure 3, for example). These models are informed by data collected via GPS by on-the-ground observers.

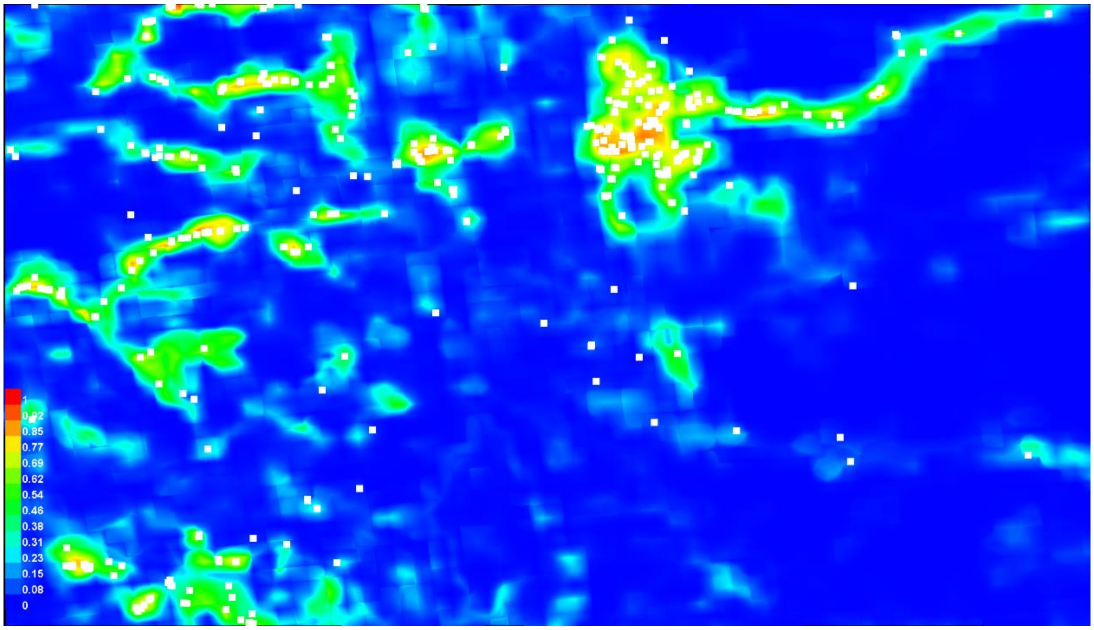

Figure 3. Expected suitable nesting habitat for bald eagles in Colorado. Warm (red) colors represent likely suitable habitat, cool (blue) colors represent unlikely suitable habitat. White squares represent observed nest locations.

Big-game Data Analysis (with D. Finley and T. Balzer)

This is an on-going effort to model movement patterns of some big-game species (e.g., mule deer, *Odocoileus hemionus*; elk, *Cervus canadensis*) within Colorado. We plan to use Brownian-bridge movement models to evaluate movement corridors for Colorado big-game species. Preliminary data analysis is underway to generate a work flow to create the models.

Gunnison Sage-grouse Habitat-use Model (with T. Apa, see pages 8-9 for full project summary)

We are working with members of the U.S. Fish and Wildlife Service and U.S. Geological Survey to develop management-focused habitat-use models (resource selection function, RSF) for Gunnison sage-grouse (*Centrocercus minimus*) populations. We have developed the landscape habitat covariate layers for use in the RSF and are actively working to develop the distributional models for plotting.

White-tailed Ptarmigan Habitat Use and Movement Models (with A. Seglund)

We are evaluating seasonal trends in habitat use and movement across the landscape of white-tailed ptarmigan (*Lagopus leucura*; WTPT) near Gunnison, CO. We have used presence-only data to inform "useable" habitat (Figure 5A). This serves as the input for a use-available resource selection function (RSF) to identify seasonally variable habitat use patterns for WTPT in the target region (Figure 5B). We will use the RSF to generate expected movement corridors using landscape movement models.

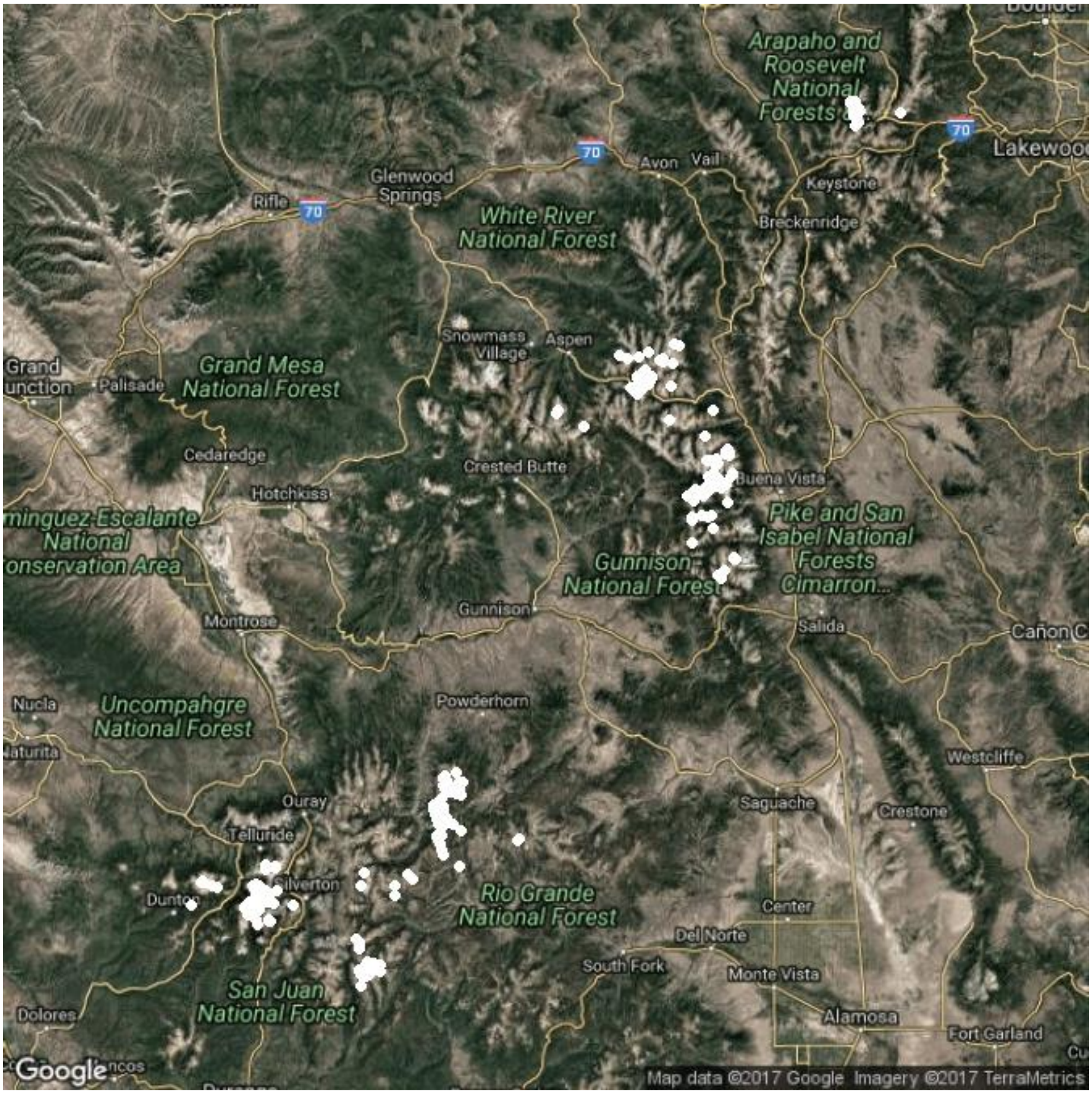

Figure 4. Observed locations (white points) of white-tailed ptarmigan near Gunnison, CO.

Figure 5. Expected summer (A) and winter (B) distribution models for white-tailed ptarmigan near Gunnison, CO. Warm (yellow) represents area of likely suitable habitat; cool (purple) represents areas of unlikely suitable habitat.

Colorado Parks and Wildlife

WILIDLIFE RESEARCH PROJECT SUMMARY

Avian response to Conservation Reserve Program management practices in northeastern Colorado

Period Covered: October 1, 2016 – December 31, 2017

Principal Investigator: Adam C. Behney, adam.behney@state.co.us

Project Personnel: Trent Verquer, Ed Gorman, Jim Gammonley

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.

EXTENDED ABSTRACT

The Conservation Reserve Program (CRP) is a government program in which landowners are paid to maintain grass cover on land that was, and would otherwise be, used for row-crop agriculture. Overall, the CRP has had many documented benefits to wildlife, specifically grassland birds, many of which are experiencing range-wide declines due to habitat loss and degradation. However, as CRP fields age with no disturbance, litter increases, bare ground decreases, vegetation density increases, and plant species and structural diversity decrease, which can reduce the value of CRP fields to certain bird species. Therefore, beginning in 2004, some type of "mid-contract management" was required on CRP fields. In northeastern Colorado this management typically consists of haying, disking, or disking and interseeding with forbs. Although there is some evidence that disking and interseeding can provide benefits to ring-necked pheasants in other regions, we lack a thorough understanding of how these various management practices affect pheasants and grassland dependent songbirds in northeastern Colorado. In an effort to provide guidance to managers and landowners regarding grassland management on CRP fields in northeastern Colorado, I monitored the response of pheasants and songbirds to the three most common CRP mid-contract management practices (haying, disking, disking & interseeding).

I randomly assigned treatments to halves of each study field so each treatment was paired with a control. Beginning in late winter, I captured pheasants on and around study fields using nightlighting techniques. All captured females were fitted with a necklace-style radio transmitter and released at the capture site. I located all marked birds three times per week and determined nest sites by locations occurring in the same spot on multiple occasions. For successful nests, I located broods three times per week and flush broods at days 10 and 21 post-hatch to estimate brood survival. I conducted vegetation samples at nest and brood flush sites as well as paired random points to assess factors affecting nest and brood survival and nest and brood site selection. I conducted two rounds of songbird point counts at six points within each study field throughout the summer.

I collected two years (2016 and 2017) of pre-treatment baseline data to gather demographic information on pheasants and songbirds in the study area. I captured and monitored 34 female pheasants in 2016 and 24 in 2017 and surveyed songbirds on two occasions in six fields both years. During 2016 adult pheasant survival during the breeding season (four months) was low (0.29 ± 0.09) and 76% of the mortality occurred during May and June. In 2017, survival was greater (six month = 0.71 ± 0.11). In 2016, nest survival was influenced by whether nests were located in wheat fields (0.43 ± 0.20) or CRP fields (0.33 ± 0.18). For nests in CRP fields, the amount of visual obstruction at the nest site positively influenced nest survival. In 2017, nest survival was most influenced by percent bare ground around nest sites. Overall nest survival was 0.36 ± 0.01. Pheasants selected nest sites with a greater percentage of

warm-season grasses (nest sites: 45.8 ± 8.3 %, random points: 27.3 ± 3.7 %). Brood survival to 21 days post-hatch was 0.07 in 2016 and 0.38 in 2017. Western meadowlarks were the most common bird detected during point counts, followed by grasshopper sparrows, dickcissels, lark buntings, and mourning doves.

Due to the decline in CRP acreage in northeastern Colorado, I will not be continuing with field work in 2018. In fall/winter 2018, I will reassess possibilities for initiating further work on this project.

Table 1. Grassland bird detection during point counts during summer 2017.

Species	**Number of detections**
Western Meadowlark	302
Grasshopper Sparrow	264
Dickcissel	166
Lark Bunting	161
Mourning Dove	148
Ring-necked Pheasant	81
Red-winged Blackbird	45
Barn Swallow	36
Brown-headed Cowbird	26
Common Grackle	24
Horned Lark	15
Brewer's Blackbird	13
Rock Pigeon	11
Killdeer	10
Western Kingbird	10
American Robin	8
Great-tailed Grackle	8
Unknown Bird	7
Eurasian Collared-Dove	5
European Starling	5
Mallard	5
House Finch	4
Burrowing Owl	2
Northern Harrier	2
Swainson's Hawk	2
American Goldfinch	1
Common Nighthawk	1
House Sparrow	1
Lark Sparrow	1
Red-tailed Hawk	1
Unknown Buteo	1

Colorado Parks and Wildlife

WILIDLIFE RESEARCH PROJECT SUMMARY

Avian response to plague management on Colorado prairie dog colonies

Period Covered: October 1, 2016 – December 31, 2017

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

Project Collaborators: Jim Gammonley, Miranda Middleton, Dan Tripp, CPW; Arvind Panjabi, Erin Youngberg, Bird Conservancy of the Rockies; City of Fort Collins Natural Areas and Utilities Programs; Bureau of Land Management (Gunnison and Cañon City offices); National Park Service Florissant Fossil Beds National Monument; and CPW wildlife managers, biologists, park rangers, and property technicians from Areas 1, 4, 14, and 16.

EXTENDED ABSTRACT

Prairie dogs (*Cynomys* sp., Fig. 1a) are highly susceptible to plague, a disease caused by the non-native bacterium *Yersinia pestis*, introduced to the Great Plains of North America in the 1940s–50s. Plague epizootics may have cascading effects on species associated with black-tailed prairie dog (*C. ludovicianus*: BTPD) colonies, such black-footed ferrets (*Mustela nigripes*), ferruginous hawks (*Buteo regalis*, Fig. 1b), and burrowing owls (*Athene cunicularia*, Fig. 1d). Colorado Parks and Wildlife (CPW) has completed a study of plague management in prairie dogs, in which oral vaccine (Fig. 1a) treatments were compared to placebo baits and insecticidal dusting of burrows (Tripp et al. 2017). Our objective is to quantify the effects of plague and plague management on avian species and mammalian carnivores associated with colonies of BTPD and Gunnison's prairie dogs (*C. gunnisoni*: GUPD). Working at sites receiving vaccine, placebo, insecticidal dust, and no treatment, we have sampled colonies before, during, and after plague epizootics. For preliminary analyses, colonies have been categorized as active or post-plague (extirpated or severely reduced prairie dog populations). Here we summarize research activities from 2013-2017 on both BTPD and GUPD sites, but we focus the presentation of results on active vs. plague-affected BTPD colonies. As 2017 was the first year our GUPD study colonies experienced much plague, we cannot yet make similar comparisons for GUPD colonies. Our 2015 annual report (Conrey 2015) summarized research comparing on- vs. off-colony avian communities at GUPD sites (to determine avian community composition and degree of association), and that presentation is not repeated in this report. Research is ongoing, so all results should be considered preliminary.

Data collection over five years has included: avian point counts, summer and winter raptor surveys, burrowing owl surveys and nest monitoring, monitoring of all raptor nests located opportunistically, remote camera data targeting mammalian carnivores (Fig. 1e), and percent ground cover, visual obstruction (Fig. 1c), and species composition of vegetation at points, nests, and along randomly located transects. In prior years, we also monitored passerine nests and surveyed for mountain plover (*Charadrius montanus*). Study areas include BTPD colonies in north-central Colorado and GUPD colonies in western and central Colorado. BTPD study colonies are dominated by short and mid-grasses and located in Larimer and Weld counties adjacent to the Wyoming border, managed by the City of Fort Collins. GUPD study colonies are dominated by sagebrush mixed with other shrubs and grasses and located in the Gunnison Basin (Gunnison County), northwest Saguache County, Woodland Park area (Teller County), South Park (Park County), and Baca National Wildlife Refuge (Saguache County).

GUPD sites are managed by the Bureau of Land Management, U.S. Forest Service, National Park Service, U.S. Fish and Wildlife Service, and CPW. Study sites were grazed by cattle (sheep in Baca NWR) and native grazers, especially prairie dogs, pronghorn (*Antilocapra americana*), jackrabbits (*Lepus* sp.), and cottontails (*Sylvilagus* sp.).

Over a 3-year period starting in fall 2013, plague epizootics occurred over ~75-80% of the BTPD study area. Some colonies, particularly those receiving dust or vaccine, have had increasing prairie dog numbers since initially declining during the peak of the epizootic, while others, especially untreated areas, have continued at severely reduced acreage (Tripp et al. 2017). Precipitation has varied greatly over the five years of this study, from slightly dry to very wet, compared to the 30-year average. This plague cycle began during a dry period but peaked during two wet years. In contrast, we observed very little plague activity (two small colonies) at GUPD sites until the 2017 field season, when an epizootic appeared to be in progress at two small and four medium-sized colonies. The upcoming 2018 season will be our first opportunity to collect data on post-plague communities on GUPD colonies.

Summed over five years, we detected more Brewer's blackbirds (*Euphagus cyanocephalus*), vesper sparrows (*Pooecetes gramineus*), Brewer's sparrows (*Spizella breweri),* and horned larks (*Eremophila alpestris*) during point counts in active BTPD colonies, and more grasshopper sparrows (*Ammodramus savannarum*), red-winged blackbirds (*Agelaius phoeniceus*), burrowing owls, and western meadowlarks (*Sturnella neglecta*) in colonies impacted by plague (which intersected with wet years). Grasses were taller and plant cover generally higher following epizootics, which likely contributed to higher densities of species that prefer taller vegetation structure and lower densities of those that prefer shorter stature vegetation. In both summer and winter raptor counts, during which we recorded time spent within colonies, ferruginous hawks showed the strongest preference for foraging on active versus post-plague colonies, with a use rate six times higher on active colonies. American kestrels (*Falco sparverius*) and golden eagles (*Aquila chrysaetos*) had use rates three times higher on active colonies. In contrast, burrowing owls, which are known to be associated with BTPD colonies (e.g., Butts and Lewis 1982, Tipton et al. 2008) and were by far the most commonly detected raptor in our summer surveys, had use rates ~2.5 times higher on post-plague colonies. Although seemingly counterintuitive, this confirms results from Conrey (2010), who found high densities of burrowing owls nesting on post-plague colonies where small numbers of BTPD occurred. Additional analyses of bird data are planned, with the inclusion of covariates related to colony characteristics, weather, vegetation, and for raptors, alternative prey such as lagomorphs.

Badgers and coyotes had 20-30% lower usage of BTPD colonies following plague events (Fig. 2). Swift fox showed the opposite pattern, but prairie dog activity had a weaker effect on fox occupancy, and this species may be responding more strongly to coyotes, which prey upon swift fox (Kamler et al. 2003, Karki et al. 2006). Occupancy models containing prairie dog activity had 99.9% of model weight for coyotes and badgers and 82.7% for swift fox. Detection rates for all three species were higher when more cameras were deployed and during August-April, compared to May-July. Coyotes and badgers appear to respond negatively to plague in prairie dogs, which dramatically reduces abundance of an important prey item. Future analyses of camera data will incorporate additional years of data and more covariates and may include multi-species models (allowing coyote-fox interaction) and relative abundance models.

Plague management via vaccine delivery and insecticidal dust can reduce the impact of plague on prairie dogs (Tripp et al. 2017) and their associates. Smaller scale applications within larger BTPD complexes did not eliminate plague but helped to maintain pockets of live prairie dogs and promote population recovery. This mosaic of active and plague-affected areas retains habitat for species associated with colonies. Not surprisingly, species that prey upon prairie dogs or preferentially forage in short stature grasslands are the most likely to benefit from plague management. 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 and over time diverge from untreated areas. During the 2018 breeding season, we will continue collecting data on GUPD colonies, which will be our first opportunity to collect extensive post-plague data at these sites. We are also exploring opportunities to continue building on the work of CPW and our collaborators at BTPD sites.

CPW is involved in several collaborations related to this research. Bird Conservancy of the Rockies began collecting data at our BTPD site in 2006 and is sharing these data, with a goal of analyzing point count data over two full plague and recovery cycles over 12+ years. We have collaborated on point count data collection since 2013. David Augustine (USDA Agricultural Research Service) has provided bird and vegetation transect data on and off GUPD and WTPD colonies that were collected by Bruce Baker (emeritus, USGS Fort Collins Science Center). These data may be useful in expanding inference of species associations with GUPD colonies. David Augustine, Ana Davidson (Colorado Natural Heritage Program), and possibly others in future may also collaborate on questions related to mesocarnivore use of prairie dog colonies using remote camera data. Tangential to this research, R. Conrey is serving on the graduate committee of M.S. student Tyler Michels at the University of Colorado Denver. He is working with Dr. Mike Wunder on habitat use (via GPS tags) of mountain plover breeding on the Pawnee National Grassland and a multi-species occupancy analysis of mountain plover, burrowing owl, and swift fox.

Expected products over the next several years include manuscripts related to avian and mammalian carnivore species associated with prairie dog colonies:

1) We will work with Bird Conservancy of the Rockies to analyze grassland bird densities at our BTPD site over two plague and recovery cycles (12+ years).
2) We have three years of avian point counts, raptor surveys, and vegetation transects on and off GUPD colonies that might be combined with B. Baker’s data to examine associations with GUPD colonies, which are less well-understood than those with BTPD.
3) We will estimate the relationship of grassland bird nest survival to plague, climate, and other variables.
4) We will run more complex occupancy models for mammalian carnivores associated with colonies, expanding upon the results for active and plague-affected colonies presented here.
5) We will examine raptor use of active and plague-affected BTPD and GUPD colonies.
6) Additional possibilities for analysis include comparisons of vegetation height and ground cover across active and plague-affected colonies, along with weather and land management variables. In addition, remote camera data contain information about the relationship of other species with prairie dogs, including lagomorphs and pronghorn, which could be explored.

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Figure 1. Photos from BTPD and GUPD sites during 2013–2017. a) GUPD consuming experimental bait. b) Ferruginous hawk seen during a winter raptor count. c) Visual obstruction measurement. d) Burrowing owl on BTPD site. e) Coyote and badger photographed by remote camera.

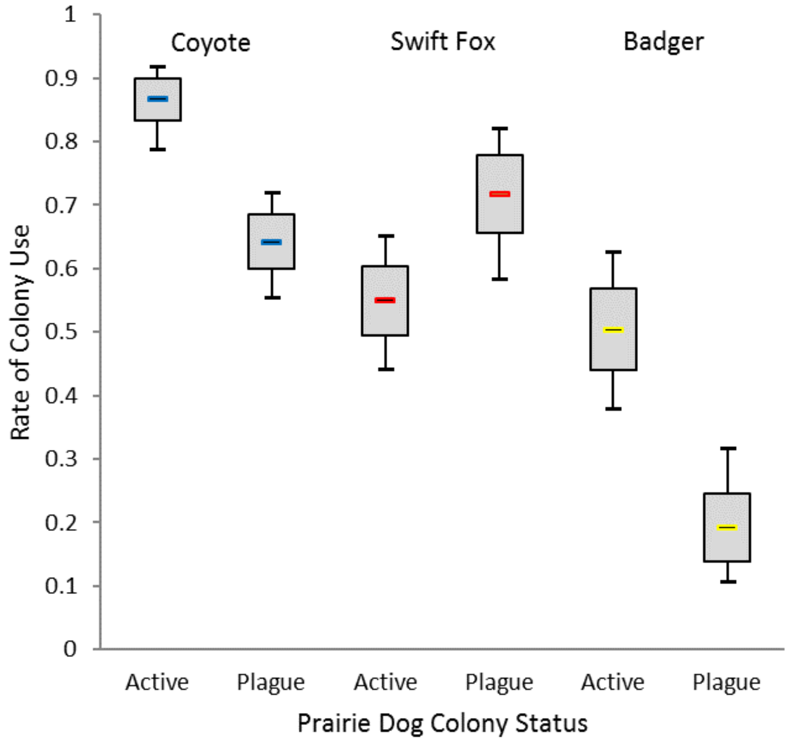


Figure 2. Rate of BTPD colony use by coyote, swift fox, and badger for active and post-plague colonies. Occupancy was estimated from remote camera data in northern Colorado from 2013–2016, with results shown for the top ranked (minimum AICc) model per species. Boxes are standard errors and bars are 95% confidence intervals around estimates.

Colorado Parks and Wildlife

WILIDLIFE RESEARCH PROJECT SUMMARY

Raptor data integration, species distribution, and suggestions for monitoring

Period Covered: October 1, 2016 – December 31, 2017

Author**:** Reesa Yale Conrey reesa.conrey@state.co.us

Principle Investigators: R. Yale Conrey, J. Gammonley, K. Aagaard, CPW; J. DeCoste*, W. Kendall, Colorado Cooperative Fish & Wildlife Research Unit (*currently, City of Boulder Parks and Recreation)

Collaborators: U.S. Fish and Wildlife Service; Bird Conservancy of the Rockies; U.S. Forest Service; Bureau of Land Management; National Park Service; Boulder County; other agencies who have submitted nest data; Cornell Lab of Ornithology

CPW biologists, GIS group, Species Conservation staff, and Parks staff: especially R. Sacco (GIS Unit); Senior Terrestrial Biologists, M. Sherman, A. Estep, M. Cowardin, N. Seward (Terrestrial); D. Klute, L. Rossi (Species Conservation); J. Thompson (Resource Stewardship).

EXTENDED ABSTRACT

Where they exist, raptor monitoring databases have generated important insights into various aspects of raptor ecology, and can provide a sound foundation for management of individual species or within the larger context of managing targeted habitats (Greenwood 2007). CPW has a statewide raptor nest database, developed by R. Sacco (GIS Unit), which currently contains records for > 9,000 nests of 30 species going back to the 1970s. Currently, the nest database is primarily being used by CPW at a site-specific scale in the oil and gas consultation process (Colorado House Bill 1298) and other local-scale land use input. The potential of this database to assess raptor populations at regional or statewide scales, and the field protocols used to provide records for this database, have not been thoroughly assessed. Other data sources have potential to contribute to our understanding of Colorado raptors, including eBird, Breeding Bird Survey, and Colorado Breeding Bird Atlas. We hope to generate a comprehensive picture of raptor distribution across the state and illustrate how a better structured statewide survey could provide a more concrete understanding of raptor population trends for management purposes.

We are focusing on breeding populations of four species: bald eagles (*Haliaeetus leucocephalus*: BAEA), golden eagles (*Aquila chrysaetos*: GOEA), prairie falcons (*Falco mexicanus*: PRFA), and ferruginous hawks (*Buteo regalis*: FEHA). GOEA are a Tier 1 Species of Greatest Conservation Need in Colorado, while the other three species are on the Tier 2 list and BAEA and FEHA are species of Special Concern. We focused first on BAEA, because we have higher quality data for this species, with repeat visits to many nests that made it possible to estimate nest survival. BAEA are a species of management concern due to the recent attention to nest take, contention over regulations, and their tendency to nest in areas with rapidly accelerating housing development. Consultation on these species is mandated by HB 1298.

Research objectives are to 1) Assess and improve the data available in CPW's raptor nest database; 2) Estimate nest survival for bald eagles, evaluating the importance of ecological and anthropogenic covariates, and offering a comparison of distribution vs. productivity objectives; 3) Build

distribution models for our highest priority raptor species, evaluating the importance of ecological and anthropogenic covariates and identifying priority areas for future surveys; 4) Evaluate the potential for integrating other data sources, such as eBird, Breeding Bird Survey, and Colorado Breeding Bird Atlas; 5) Make recommendations for a state-wide raptor monitoring protocol.

The first step in this research project was to assess the data available in CPW's raptor nest database. This database contains locations and nest site occupancy information for 30 species of raptors from 1975 to present. Most of the nest data have been collected opportunistically, and known nest sites are resurveyed at a higher rate than new areas are surveyed. For a nest site to be considered active during CPW consultation for HB 1298, it must be known to have been occupied sometime within the past 5 years. Although some sites are visited yearly, others are therefore visited only when they have reached the end of their 5-year window, and most nest sites have a listed status of undetermined or unknown, meaning that the site has not been visited in at least 5 years or that an observer was unable to determine the status of the nest. More detailed information (e.g., biweekly observations) is sometimes available for nests, but is typically summarized into annual records by GIS staff who enter and maintain the data.

The CPW raptor nest database contained nest records for 9308 locations of 30 raptor species, as of 28 February 2018 (Table 1). This included 1846 active nests known to be occupied within the past 5 years. The majority of nest locations (5947 nests, 64% of the total) have an unknown or undetermined status. In general, diurnal species are better represented than nocturnal species (owls), and those with nests in taller structures (e.g., trees, cliffs) are better represented than ground-nesters. There are 12 species with at least 100 nest records in the database: bald eagle, burrowing owl, Cooper's hawk, ferruginous hawk, golden eagle, great horned owl, northern goshawk, osprey, peregrine falcon, prairie falcon, red-tailed hawk, and Swainson's hawk. In contrast, there are eight species (American crow, boreal owl, Chihuahuan raven, eastern screech-owl, merlin, Mexican spotted owl, Mississippi kite, and northern pygmy-owl) with just 1 – 2 records in the database and one species (short-eared owl) known to breed in Colorado but with no records in the database. Twenty-six percent of records are nests occupied by an unknown species. We made an agency-wide and inter-agency request for additional nest data to maximize sample size prior to our analyses, which likely contributed to the 27% increase (2342 nests) over 3 years, with more active nests and fewer unknown or undetermined nests for most species over the past 15 months.

There has been a special effort to monitor BAEA through multiple visits per known nest location per year, making these data suitable for modeling of daily nest survival. Aside from estimating daily and annual nest survival rates, the goals of this model are to determine what ecological and anthropogenic covariates are important predictors of nest survival and to provide a comparison of the outputs, usefulness, and monitoring methods suitable for nest survival modeling versus distribution modeling. Our bald eagle nest survival model currently has an input file containing 163 nest attempts at 86 locations from 2012−2016; 54 nest sites are on the Front Range and 32 are on the Western Slope. An additional 179 nests were not included, and the most common reason for exclusion was that the observer did not visit enough times or at the appropriate time to confirm nest fate. Preliminary results suggest daily nest survival is best modeled by nest stage, maximum temperature in June, and time in season. Other covariates for land cover, roads, distance to water, monthly precipitation, location (Front Range vs. elsewhere), and year were not supported. We did not have enough data from nest observers to properly analyze the effects of nest substrate (live tree, dead tree, or other) or disturbance (traffic, recreation, etc.).

Results for BAEA will be finalized and nest success estimates available after we complete quality contol on the input data. Even without final results, we can note what extra effort is required in the field and in follow-up data management to get information that will produce productivity estimates versus distribution estimates. First, nest survival models require more intensive survey data than do distribution models, because at least two (but these estimates would have poor precision), and frequently more visits are required. One visit must occur during the incubation or nestling phases, in which nesting activity can be confirmed by sighting eggs or nestlings, or at least by sighting an adult on the nest who is presumably incubating or brooding. One visit must occur shortly before or after the presumed fledging date to confirm the fate of the nest, where successful nests have at least one fully feathered juvenile leaving the nest and failed nests have none. In addition, observers must note the presence of eggs, nestlings, or fledglings, or at least make careful observations of adult behavior that can reveal nest activity (e.g., incubation, bringing food to the nest, etc.). Instead of just one record per year, there are multiple records to enter and proof, and productivity observations may need to be added as a separate data type in the database.

The goal of distribution modeling is to determine what variables predict breeding locations and to map areas with high to low probability of use for mitigation planning and future survey design. Preliminary maps are available as proof-of-concept to jump-start discussions about survey methods (Fig. 1). These models were produced using MaxEnt (Maximum Entropy), a modeling program that estimates species distributions based on environmental conditions (covariates provided by the user) and occurrence locations ("presence-only" data). As an initial test, we used covariate layers developed for Wyoming Basin breeding models of GOEA by the U.S. Fish and Wildlife Service's Western Golden Eagle Team (WGET). These included landscape layers relating to land cover classes (alfalfa, pasture, cultivated crops, cottonwood, mixed forest, herbaceous grassland, sagebrush/piñon juniper, riparian, sagebrush, shrubland, and wetland), topography (cliffs, flat land, and sloped areas), developed areas, distance to water, and precipitation. These models used all nest locations in the database. During the next phase of modeling, we will use a more refined set of species-specific covariates, and we may restrict the sample of nests to only those active during a more recent time frame (perhaps the past 10 years). We are also exploring a hybrid approach to resource selection modeling that defines MaxEnt output with a relative probability of occurrence ≥ 0.5 as "available" habitat and occurrence locations as "used" habitat. None of the covariate layers were predictive of our raptor nest locations during a "test run", but we will reevaluate this approach once we have species-appropriate covariates and a refined sample of nests.

Although the CPW raptor nest database is the principal source of data for this project, other existing data sources such as eBird, Breeding Bird Survey (BBS), and Colorado Breeding Bird Atlas (BBA) may also be helpful. None of these data sources have nest locations as their sampling unit (instead using bird sightings), which limits their utility in this project. However, observers may sometimes record nest locations, and we are particularly interested in exploring this possibility in BBA data. eBird and BBS data may be useful in model verification, but eBird in particular may have utility in future as a way to recruit vetted volunteer birders in a targeted way to do raptor surveys and enter their data. We met with eBird staff to discuss this possibility and saw examples from other targeted surveys.

It is our objective to make recommendations for future monitoring guidelines that can be consistently applied state-wide. We plan to use the distribution maps that result from this research to stratify the state into appropriate survey regions. Ideally, monitoring guidelines will include a time of year for surveys, how often various regions will be visited, and a means to record survey effort and both presence (new and existing nests) and absence data. In addition, we hope to provide some guidance on the amount of effort that should be allocated to surveys for new nests versus return visits to known nest sites, and how to prioritize survey effort by species and spatial location. There are several ways surveys could be structured: by species, survey method (fixed-wing flights, ground surveys, etc.), area, modeled probability of occurrence, or some combination of these. We will work with all interested CPW staff and partners to find an approach that can be piloted in 2019. We then envision an iterative process of refining both our models and survey design over time. Initial internal meetings are scheduled for spring/summer 2018, and we have begun reviewing written protocols and reports from staff who survey raptors.

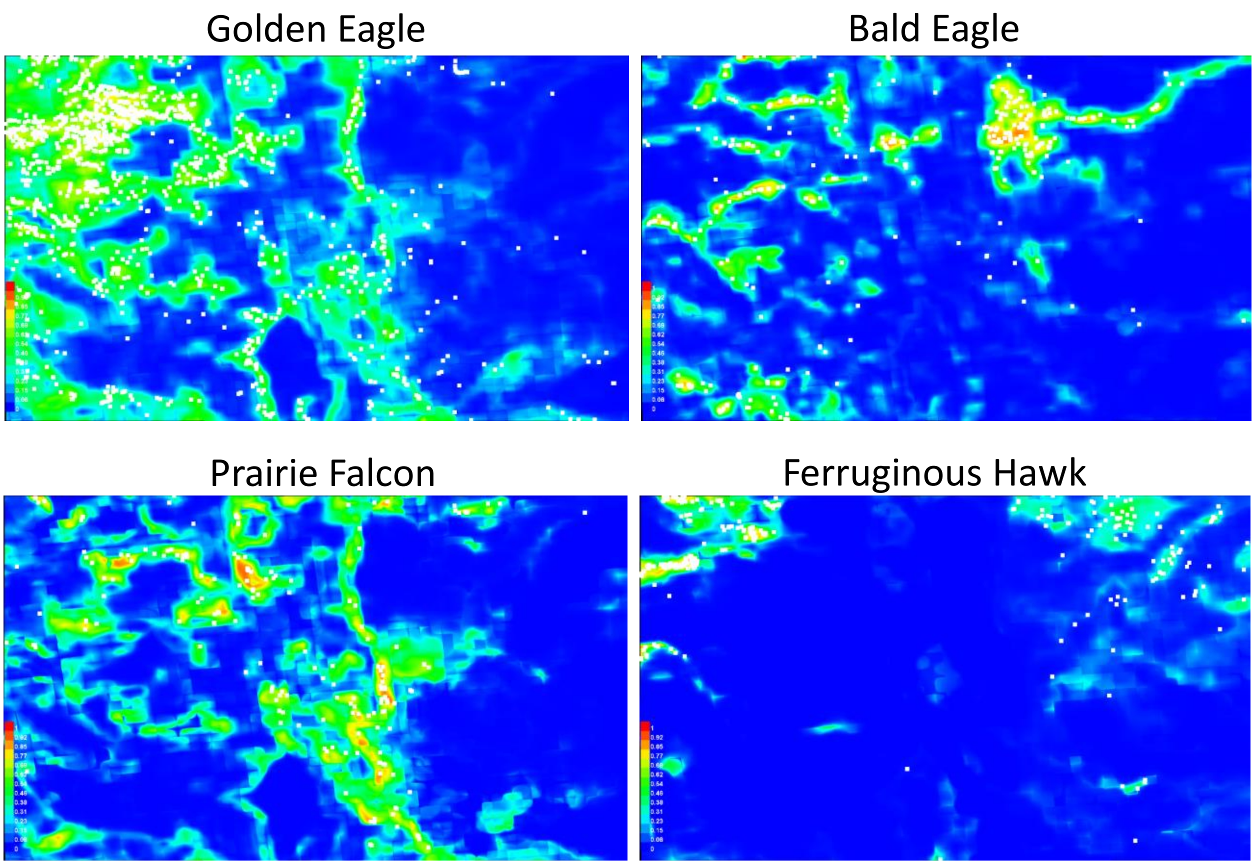
At this early stage in the planning process, we are able to make several recommendations, which we have begun sharing both internally and externally with partners. If only one survey of a given area is possible, it should occur during the typical egg-laying or incubation phase when adult activity can be confirmed and before nest failures cause adults to abandon their nests. Observers should reserve the value of zero to represent true zero, as opposed to a placeholder or indication of an unknown or inapplicable value. They should ensure that the nest substrate is recorded, at least at the level of live tree, dead tree, cliff, etc. Observers should also note the source of potential nest disturbances (development, recreation, tree breakage, etc.). Finally, 64% of nest locations in the database have a status of unknown or undetermined (Table 1). These sites have much less value for modeling or HB 1298 purposes than have nests with any of the other status designations, so some effort should be allocated to re-visiting these sites.

Table 1. Number of nest records for Colorado raptors included in the CPW raptor nest database as queried on 28 February 2018. Active nests are those known to be occupied within the past 5 years. Inactive nests are those known to be unoccupied within the past 5 years. Destroyed nests are those known to be no longer usable (e.g., tree or branch has fallen). Unknown nests are those that have not been visited within the past 5 years, excluding destroyed nests. Undetermined nests are those for which status could not be determined by an observer within the past 5 years. Counts of active, inactive, destroyed, unknown, and undetermined nests are for the last raptor species occupying a nest site. In the 15 months since the last assessment, there are more active nests and fewer unknown/undetermined nests for golden eagles, prairie falcons, and all species summed together and little change for bald eagles or ferruginous hawks.

SPECIES	NUMBER OF NESTS				
	Active	Inactive	Destroyed	Unk/Undeter	Total*
Bald Eagle	203	18	64	167	452
Golden Eagle	169	193	97	1557	2016
Ferruginous Hawk	62	2	30	332	426
Prairie Falcon	36	15	2	152	205
Total: 30 Species	1846	811	704	5947	9308

*Total does not count nests with missing data or those that were originally occupied by one species but have changed to a different species (counted as belonging to the "new" species only).

Figure 1. Preliminary distribution model results for golden eagle, bald eagle, prairie falcon, and ferruginous hawk. Blue areas have a modeled probability of occurrence = 0, red areas have probability = 1, and other shades have intermediate probability. This test run from MaxEnt used all nests in the CPW raptor nest database from 1975–2017 and covariate layers developed for golden eagle by the Western Golden Eagle Team.



Colorado Parks and Wildlife

WILIDLIFE RESEARCH PROJECT SUMMARY

Northern bobwhite response to short-duration intensive grazing on Tamarack State Wildlife Area

Period Covered: October 1, 2016 – December 31, 2017

Principal Investigator: Adam C. Behney, adam.behney@state.co.us

Project Personnel: Trent Verquer, Ed Gorman, Jim Gammonley

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.

EXTENDED ABSTRACT

Widespread suppression of historic disturbance regimes have reduced heterogeneity in vegetation communities on which many wildlife rely for various life events and stages. Northern bobwhites require areas of thicker grass cover for nesting within close proximity to more open areas with bare ground and abundant food producing forbs for brood rearing and feeding. Altered or eliminated vegetation disturbance has been implicated in the rangewide decline of northern bobwhite populations. Lack of disturbance on state wildlife areas in Northeast Colorado has caused the vegetation to become uniformly dense and tall which is likely not meeting the needs of all parts of the northern bobwhite life cycle. Some type of disturbance is required to reduce the vegetation biomass and create some of the open structure on which bobwhites rely. Grazing represents one of the only options for disturbance at Tamarack State Wildlife Area and other similar riparian areas in northeast Colorado. Whereas unmanaged continuous grazing has been linked to degradation of bobwhite habitat quality, short-duration intensive grazing holds promise to reduce the vegetation biomass and rejuvenate the habitat to become more attractive to bobwhites.

The objectives of this project are to assess the efficacy of using short-duration high-intensity grazing as a tool to improve northern bobwhite habitat. I used a randomized block design in which the study site was divided into groups of four plots, one of which is grazed each year over a three year period and one is a control (Fig. 1). Beginning in late winter, we captured bobwhites using walk-in traps and deployed 50 necklace-style VHF radio transmitters. We located each radio-marked bobwhite three times per week and determined nest sites by observing birds in the same location on subsequent days. When nests hatch we continued to monitor broods and on day 14 post-hatch we flushed the brood, and weekly thereafter to count chicks and assess brood status. To assess nest and brood site selection, we sampled vegetation at nest and brood sites and four associated random points to represent available habitat around the nest or brood site. The overall goals are to estimate adult, nest, and brood survival as well as nest and brood site selection in relation to grazing treatment and other general habitat characteristics.

In 2017, we were able to graze seven plots in late winter/early spring. Directly after grazing, there were substantial differences in vegetation characteristics between grazed and control plots (lower height, density, percent grass, and more bare ground). However, by late summer, there was little difference, if any, remaining between grazed and control plots (Fig. 2). We deployed 50 VHF radio transmitters on northern bobwhites and collected 2118 locations. Overall survival from April through September was 0.45 ± 0.09. Estimated nest survival was 0.35 ± 0.19 based on 11 monitored nests. Nest survival was positively affected by percent litter around the nest and weakly by visual obstruction. Bobwhite nest sites exhibited a greater percentage of grass cover and less bare ground than associated random sites (Fig. 3). We found one nest in a grazed plot and five in control plots. We monitored 13

broods and survival to 30 days post-hatch was 0.27. Broods selected sites with more woody vegetation than associated random points. We located three broods in grazed plots and two in control plots. Moving forward, we need to gather a larger sample of nests and broods and/or create greater differences between grazed and control plots in order to more concretely document any effects of grazing on bobwhite demographic parameters.

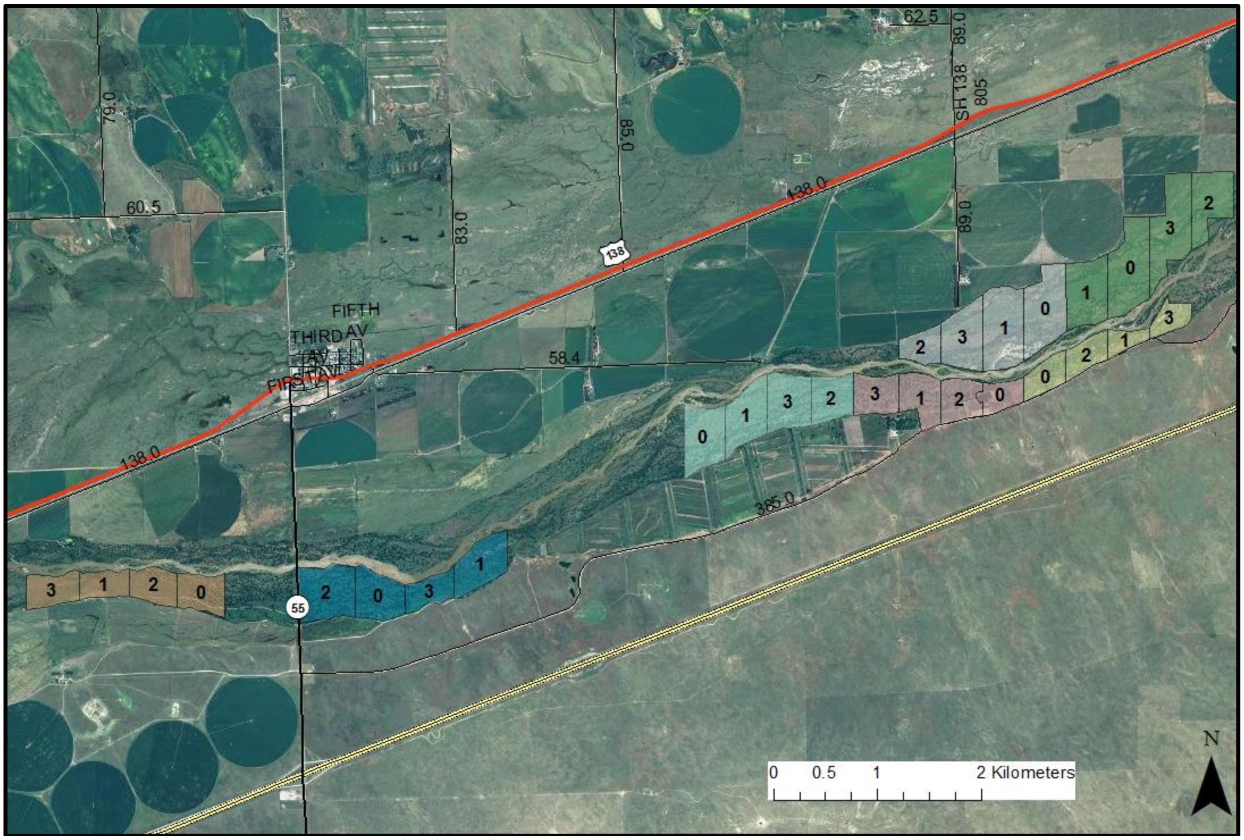


Figure 1. Grazing treatment plot layout for Tamarack State Wildlife Area. Numbers represent the year of treatment, zeros indicate control plots.

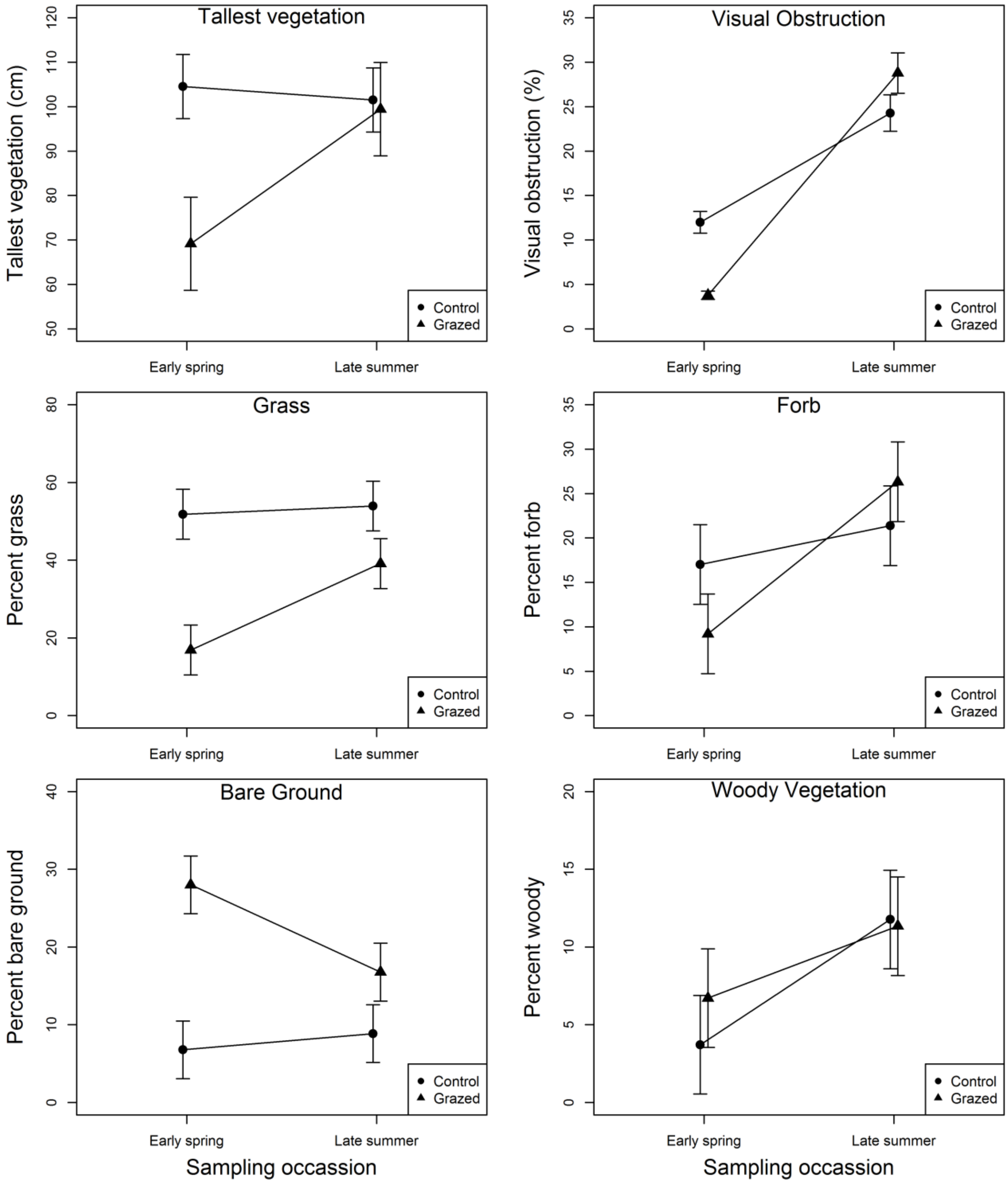


Figure 2. Vegetation characteristics at random points in grazed and control plots during two sampling occasions at Tamarack State Wildlife Area. Error bars represent one standard error.

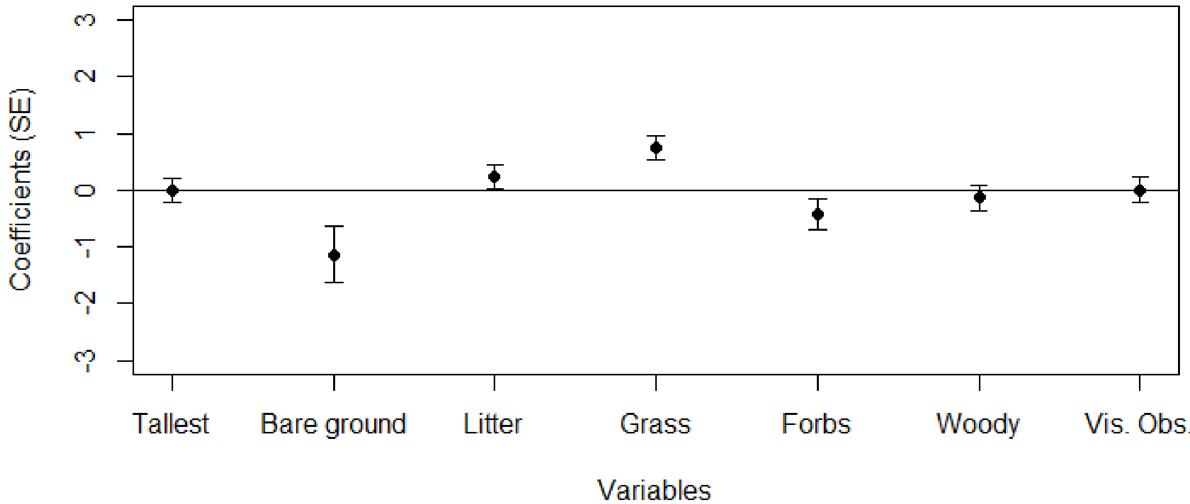


Figure 3. Standardized coefficients ± SE from discrete choice models predicting nest site selection of northern bobwhites at Tamarack State Wildlife Area in 2017. Positive values indicate selection for a variable and negative values indicate selection against a variable. All coefficients are taken from single variable models.

Colorado Parks and Wildlife

WILIDLIFE RESEARCH PROJECT SUMMARY

Foraging ecology of nonbreeding ducks and other waterbirds in the South Platte River Basin

Period Covered: October 1, 2016 – December 31, 2017

Principal Investigator: Adam C. Behney, adam.behney@state.co.us

Project Personnel: Brian Sullivan, Jim Gammonley

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EXTENDED ABSTRACT

Attracting and holding large populations of waterfowl are goals of habitat management for nonbreeding waterfowl (Soulliere et al. 2007). Currently, many habitat planners use bioenergetics approaches to guide habitat planning for nonbreeding waterfowl and shorebirds (Central Valley Joint Venture 2006, Soulliere et al. 2007, Playa Lakes Joint Venture 2008). In their simplest form, these bioenergetics models predict the amount of habitat needed to support a population goal based on the energy requirements of that goal and the productivity of the habitat. Many of these models assume that energy availability is the only factor affecting duck use of sites. However, recent evidence suggests that although energy availability is important for predicting wetland use by ducks, there are many other factors that influence duck use of sites and utility of those used sites (Brasher 2010, O'Shaughnessy 2014, Behney 2014). Therefore, more complex models have been developed (Sutherland and Allport 1994, Miller et al. 2014) but it is unclear how complex these models need to be and what specific factors should be incorporated into to accurately predict carrying capacity or habitat needs. Regardless of what form these models take, given the demonstrated importance of energy availability, estimates of food availability are necessary for the different wetland types in which nonbreeding ducks and shorebirds forage. Most dabbling and many diving ducks primarily consume benthic seeds during winter and migrations but transition to diets higher in invertebrates prior to nesting in spring (Hitchcock 2009, Tidwell et al. 2013) and shorebirds primarily consume invertebrates (Davis and Smith 1998).

The lower South Platte River corridor in northeastern Colorado (Fig. 1) is considered a waterfowl conservation priority area for migrating and wintering ducks (Colorado Parks and Wildlife 2011) and is important in terms of recreation (Runge and Gammonley 2012). However, relatively little research has been conducted to determine the effectiveness of habitat management actions or food availability in the region. My first objective is to estimate duck and shorebird food abundance in various wetland types in the South Platte River basin throughout the nonbreeding season. Depletion of energy in wetlands is most likely a result of consumption by ducks and other wildlife or decomposition (Hagy and Kaminski 2012*b*). Therefore, wetlands that exhibit the most depletion are also likely the most used during the nonbreeding season. Based on previous food availability research in other regions and the attractiveness of moist-soil units to ducks, I predict that moist soil units will produce the most energy and exhibit the greatest amount of energy depletion throughout the nonbreeding period. Secondly, I will assess the relationship between duck and shorebird use of wetlands, food abundance, and habitat structure characteristics in an effort to inform management treatments and better understand what form the energetic habitat planning models need to take. Sampling food availability for ducks and shorebirds in wetlands is very time-intensive. Therefore, my last objective is to evaluate a rapid visual assessment procedure to estimate duck habitat

quality (Ortega 2013) by comparing the calculated score with actual habitat quality metrics (i.e., food availability and duck use of sites).

Over two years, I sampled during September – October (fall), February – March (winter), and May (summer), collecting a total of 1265 core samples (avian food samples) at 44 sites (each site was not sampled during each occasion), and conducted rapid habitat visual assessments at each site. From February through March both years, I counted ducks at a subsample of wetlands to examine patterns of duck distribution. All field work has been completed and I am currently working on data analysis. Preliminary analysis shows that emergent and moist soil wetlands contained the greatest biomass of waterfowl food during all three sampling occasions (Fig. 2). Based on the subsample of water bodies that were sampled during both fall and winter sampling, depletion of food during fall was greatest in moist soil wetlands and sloughs (Fig. 3). The most parsimonious model of spring duck abundance included a quadratic effect of week and a positive effect of food during fall sampling (Fig. 4). Rapid assessments were carried out at every sampling site during fall, winter, and spring. During fall and winter, moist soil units and emergent wetlands had the greatest habitat quality score. The rapid assessment procedures explained about 45% of the variability in energy availability of sites (Fig. 5) and about 68% of the variability in mean duck density on sites during spring (Fig. 6).

These estimates of food abundance can be directly incorporated into bioenergetic planning models for northeastern Colorado. Avian food sampling in wetlands is a very time intensive process and we demonstrate that a simple rapid assessment procedure is positively related to food biomass and duck use. However, depending on the desired accuracy of food availability estimates, the rapid visual assessment procedure we tested may not be sufficient.

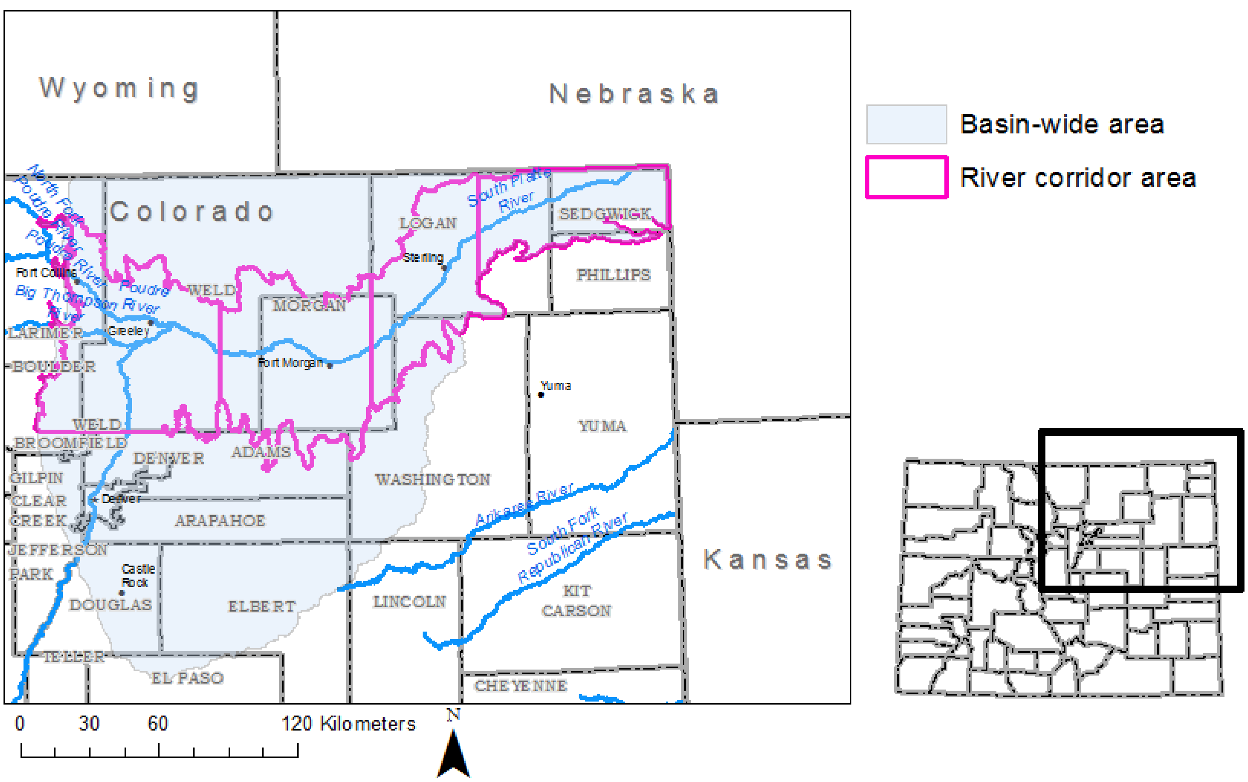

Figure 1. Study site along the South Platte River corridor in northeastern Colorado.

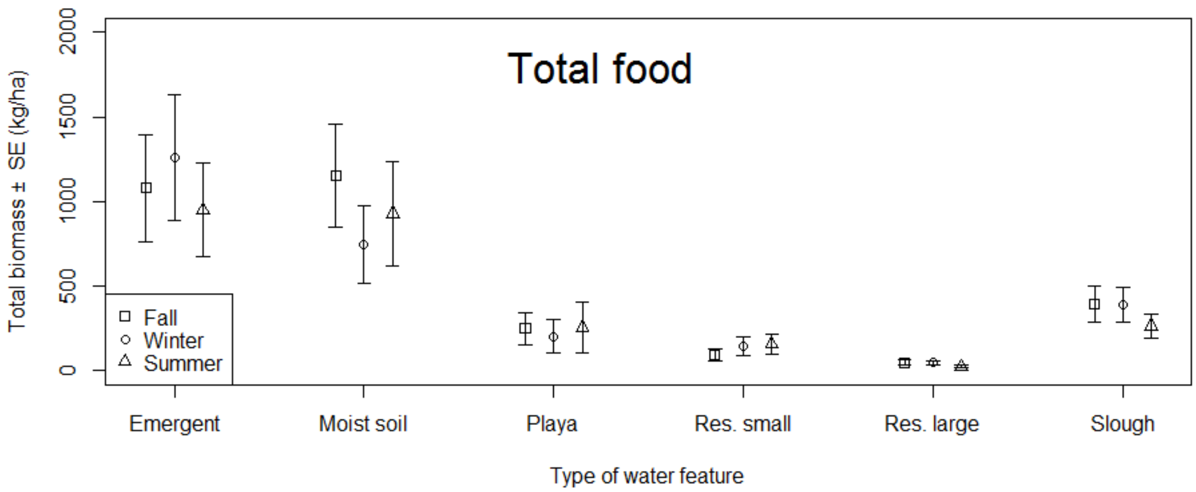

Figure 2. Total food biomass of food for ducks in six types of water features in northeastern Colorado.

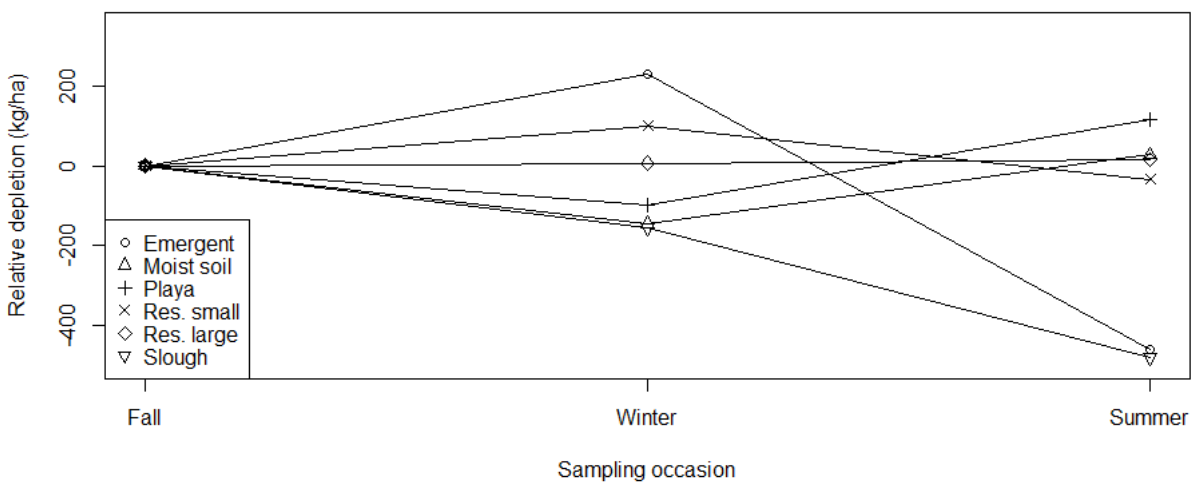

Figure 3. Relative food biomass depletion of sites during fall, winter, and summer sampling occasions.

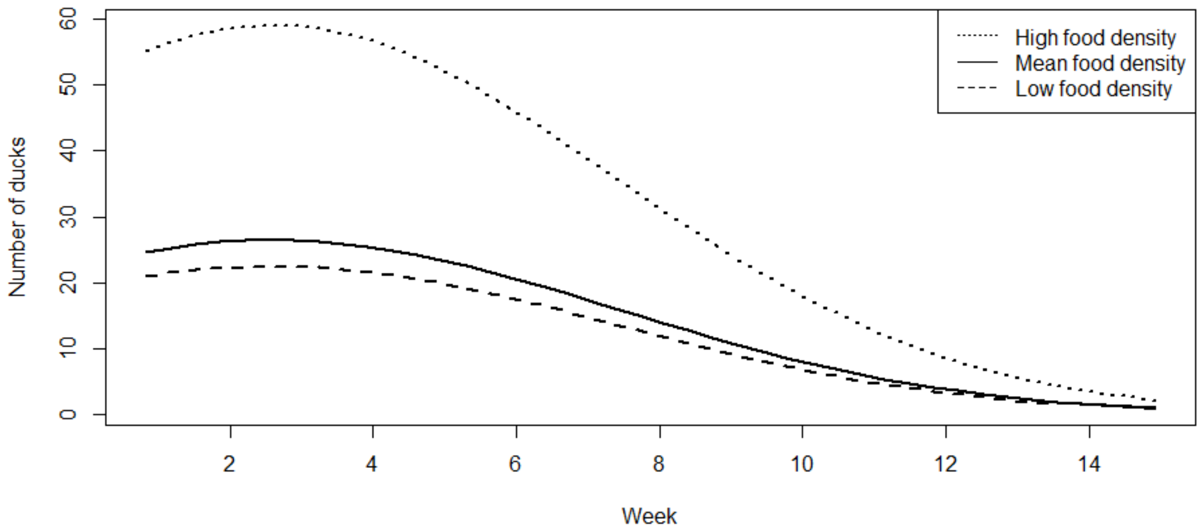

Figure 4. Ducks counted on study sites during spring with various amounts of food present. Week one was the last week of February each year.

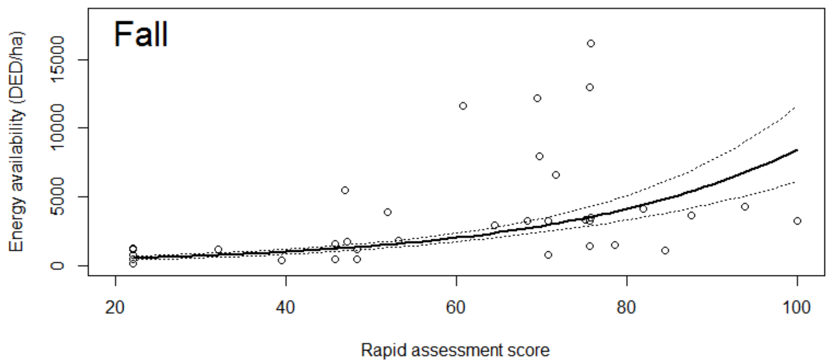

Figure 5. The relationship between rapid assessment score and energy availability (DED/ha) during fall (Sep-Oct) 2015 sampling. The solid line represents predicted values from a linear model using rapid assessment score to predict energy availability. Energy availability was natural log transformed in analysis to reduce heteroskedasticity but values were backtransformed in the figure. Dotted lines represent ± one standard error.

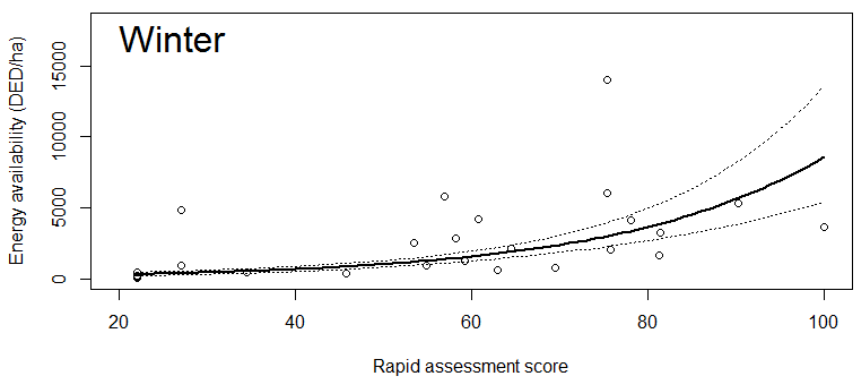

Figure 6. The relationship between rapid assessment score and energy availability (DED/ha) during winter (Feb-Mar) 2016 sampling. The solid line represents predicted values from a linear model using rapid assessment score to predict energy availability. Energy availability was natural log transformed in analysis to reduce heteroskedasticity but values were backtransformed in the figure. Dotted lines represent ± one standard error.

Publications, presentations, workshops and committee involvement by Avian Research staff October 2016 – December 2017

PUBLICATIONS

Apa, A. D., T. R. Thompson, and K. P. Reese. 2017. Juvenile greater sage-grouse survival, movements, and recruitment in Colorado. Journal of Wildlife Management 81:652-668.

Behney, A. C., R. O'Shaughnessy, M. W. Eichholz, and J. D. Stafford. *In press.* Indirect risk effects reduce feeding efficiency of ducks during spring. Ecology and Evolution.

Behney, A. C., R. O'Shaughnessy, M. W. Eichholz, and J. D. Stafford. *In revision.* Worth the reward? An experimental assessment of risk-taking behavior along a life history gradient.

Conrey, R. Y., D. W. Tripp, E. N. Youngberg, and A. O. Panjabi. Bird and mammalian carnivore response to plague in prairie dog colonies. *Accepted for online publication*. Knuffman, L., ed. 2018. America's Grasslands Conference: United for Conservation. Proceedings of the 4th Biennial Conference on the Conservation of America's Grasslands. November 14-16, 2017, Fort Worth, TX. Washington, DC: National Wildlife Federation.

Decker, K. L., A. Pocewicz, S. Harju, M. Holloran, M. M. Fink, T. P. Toombs, and **D. B. Johnston**. 2017. Landscape disturbance models consistently explain variation in ecological integrity across large landscapes. Ecosphere 8:4 DOI 10.1002/ecs2.1775

Gerber, B. D., M. B. Hooten, C. P. Peck, M. B. Rice, **J. H. Gammonely**, **A. D. Apa**, and A. J. Davis. *In review.* No reason to leave: extreme site fidelity of a lekking species in a homogeneous and unpredictable environment. Journal of Animal Ecology.

Gerber, B. D., M. B. Hooten, C. P. Peck, M. B. Rice, **J. H. Gammonely, A. D. Apa**, and A. J. Davis. *In review*. Accounting for location uncertainty in azimuthal telemetry data improves ecological inference. Movement Ecology.

Gunn, C., K. M. Potter, J. P. Beason, and **K. Aagaard**. *In review*. Sexually dimorphic plumage characteristics in the Northern Black Swift. Journal of Field Ornithology.

Rice, M. B., **A. D. Apa**, and L. A. Wiechman. 2017. The importance of seasonal resource selection when namaging a threatened species: targeting conservation actions within critical habitat designations for the Gunnison sage-grouse. Wildlife Research. hppt://dx doi.org/10.1071/WR17027.

Shyvers, J. E., **B. L. Walker**, and B. R. Noon. *In review*. Assessment of dual-frame surveys for estimating greater sage-grouse populations. Journal of Wildlife Management.

Zimmerman, S., Aldridge, C., **A. Apa**, and S. Oyler-McCance. *In review*. Improved methods of translocation evaluation using genetic data: a case study with Gunnison Sage-grouse. Condor.

PRESENTATIONS, WORKSHOPS, AND COMMITTEES

Aagaard, K. CPW introductory presentation. Fort Collins, CO, November 1, 2017.

Apa, A. D. CPW Science support, Associated Counties of Northwestern Colorado greater sage-grouse mapping project.

Apa, A. D. CPW Science support, Colorado Habitat Exchange.

Apa, A. D. Technical support, CPW Northwest region ruffed grouse translocation project.

Apa, A.D. CPW science support, United States Fish and Wildlife Service Species Status Assessment Science Expert Team for Gunnison sage-grouse.

Apa, A. D. Faculty Committee member for M.S. degree candidate Rachel Barker (Harris), University of Wisconsin-Madison.

Apa, A. D. Faculty Committee member for M.S. degree candidate Alyssa Kircher, University of Wisconsin-Madison.

Apa, A. D. CPW science support, CPW Terrestrial greater sage-grouse transplant project.

Apa, A. D. CPW science support, North American Grouse Partnership on sage-grouse captive-rearing.

Apa, A. D. CPW science support, Calgary Zoo, Captive-rearing of sage-grouse.

Apa, A. D. Technical support, Comments to the NW Regional Manger on support letter for Mineland Reclamation Award for Trapper Mine.

Apa, A. D. Science support, U.S. Fish and Wildlife Service Arapaho National Wildlife Refuge, technical support on sage-grouse management. 16 August 2017.

Apa, A. D. Columbian sharp-tailed grouse ecology. Black Canyon Audubon Society, Montrose, CO, September 28, 2017.

Apa, A.D. Science support, Collaborative Action Plan for Gunnison sage-grouse.

Behney, A. C. Avian response to habitat management in northeast Colorado. Colorado Parks and Wildlife Northeast Biology Days. Sterling, CO, June 6, 2017.

Behney, A. C. Waterfowl Ecology 101. Colorado Parks and Wildlife Northeast Region Biology Days. Sterling, CO, June 7, 2017.

Behney, A. C. Executive board member, Central Mountains and Plains Section of The Wildlife Society.

Behney, A. C., and **R. Y. Conrey (chair)**. CPW Animal Care and Use Committee.

Conrey, R. Y. Proposal defense and Graduate Committee meeting for M.S. candidate Tyler Michels, University of Colorado Denver, Denver, CO: May 3, 2017 (additional meetings in Fort Collins, CO: February 6 and March 9, 2017).

Conrey, R. Y., M. M. Middleton, D. W. Tripp, and J. H. Gammonley. Occupancy of mammalian carnivores on prairie dog colonies affected by plague. Presented at Colorado Chapter of the Wildlife Society 2017 Annual Meeting, Fort Collins, CO, February 16, 2017.

Conrey, R. Y. How can you explore nature, help birds, and be a scientist? Presented workshop during career week, Creative Kids Corner, Wellington, CO, April 6, 2017.

Conrey, R. Y. Burrowing Owl and shortgrass community. Poster and activity table at HOOTenanny Owl and Music Festival, Audubon Society of Greater Denver, Littleton, CO, September 23, 2017.

Conrey, R. Y. Great Plains Landscape Conservation Cooperative, Science Committee. Conference call: August 4, 2017. Meeting with Science Coordinator, Fort Collins CO: October 25, 2017.

Conrey, R. Y., D. W. Tripp, E. N. Youngberg, and A. O. Panjabi. Bird and mammalian carnivore response to plague in prairie dog colonies. Presented at America's Grasslands Conference, Fort Worth, TX, November 15, 2017.

J. DeCoste, **R. Y. Conrey**, J. H. Gammonley, and W. L. Kendall. Nest survival of bald eagles in Colorado. Presented at Colorado Chapter of the Wildlife Society 2017 Annual Meeting, Fort Collins, CO, February 16, 2017.

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

Gammonley, J. H. Central Flyway wing bee, Hartford, KS, February 13-17, 2017.

Gammonley, J. H. Central Flyway Waterfowl, Webless Migratory Game Bird, and Central Management Unit Dove Technical Committee meetings, Wichita, KS, February 18-20, 2017.

Gammonley, J. H. CPW Avian Research update. Intermountain West Joint Venture State Conservation Partners meeting, Salida, CO, March 29-30, 2017.

Gammonley, J. H. Mid-Continent Mallard Adaptive Harvest Management Committee workshop, Kansas City, MO, June 6-8, 2017.

Gammonley, J. H. Central Flyway Waterfowl Technical Committee and Council meetings, Manhattan, KS, August 26-31, 2017.

Gammonley, J. H. Future of Waterfowl Management Workshop, Shephardstown, WV, September 26-28, 2017.

Johnston, D. B. Co-advisor for Ph.D. Candidate Magda Garbowski, Colorado State University, Fort Collins.

Johnston, D. B., P. L. Chapman, C. S. Brown, and A. Monty. Manipulating cheatgrass seed dispersal to benefit native plants. National Native Seed Conference. Washington, D.C. February 17, 2017.

Garbowski, M. G., C. S. Brown, and **D. B. Johnston.** Restoring semi-arid lands with superabsorbent polymers under reduced precipitation and threat of *Bromus tectorum* invasion. High Altitude Revegetation Conference. Fort Collins, CO. March 9, 2017.

Johnston, D. B. P. L. Chapman, C. S. Brown, and A. Monty. Manipulating cheatgrass seed dispersal to benefit restoration. High Altitude Revegetation Conference. Fort Collins, CO. March 9, 2017.

Johnston, D. B. Habitat research ideas. Northwest Region Meeting. Grand Junction, CO. March 29, 2017.

Johnston, D. B. Field lecture and tour: Restoration of oil and gas impacts for wildlife. Colorado State University Restoration Case Studies course (Mark Paschke, professor). Piceance Basin, CO. August 16, 2017.

Johnston, D. B. Meeting of the Colorado Habitat Exchange. Denver, CO. August 30, 2017.

Johnston, D. B. Habitat research ideas, manipulating cheatgrass seed dispersal, and update on Dry Creek Basin study. Southwest Region Meeting. Navajo State Park, CO. September 27, 2017.

Walker, B. L. CPW Science support, Associated Counties of Northwestern Colorado greater sage-grouse mapping project.