CONSERVATION INNOVATION GRANTS

FINAL Progress Report

Grantee Name: Bird Conservancy of the Rockies (doing business as Rocky Mtn. Bird Observatory)	
Project Title: Informing habitat enhancement and fence-marking projects to increase Greater Sage-grouse and other sagebrush obligate bird populations.	
Agreement Number: 69-3A75-12-188	
Project Director: Laura Quattrini	
Contact Information: 230 Cherry Street, Fort Collins, CO 80521	Phone Number: 970-482-1707 ext. 21 E-Mail: laura.quattrini@birdconservancy.org
Period Covered by Report: 7/1/2012 – 8/30/2016	
Project End Date: 8/31/2016	

United States Department of Agriculture

Natural Resources Conservation Service

Contents

Executive Summary

The sagebrush sea is a critical landscape in North America in that it provides vial ecological, hydrological, biological, agricultural, and recreational ecosystem services and is managed for equally diverse uses (Homer et al. 2015). Several birds found in this landscape are termed 'sagebrush obligate' (i.e., sage-grouse, sagebrush sparrow, and sage thrasher) and rely upon the sagebrush ecosystem for their survival. However loss and degradation of sagebrush is correlated with declines in distribution and abundance of these sagebrush obligate species leading to increased attention by state and federal agencies, bird conservation initiatives, private landowners and non-profit organizations.

This Conservation Innovation Grant facilitated Bird Conservancy of the Rockies (hereafter Bird Conservancy) and partners accomplish objectives that will help reverse declining bird population trends. We had the following significant accomplishments:

- Utilized existing bird monitoring data to build bird occupancy- and density- habitat models for Brewer's sparrow, sagebrush sparrow, and sage thrasher. This information will help determine how land management actions can influence the vegetation structure of different sagebrush communities and in turn affect available habitat. These models are incorporated into the Decision Support Tool.
- Developed and distributed a survey for resource professionals and landowner input on considerations for land management – 145 people responded.
- Developed a Decision Support Tool that can optimize Conservation Practices (of a subset of those listed in the Conference Report for the NRCS SGI (USFWS 2010) that are most applicable to achieve positive increases in targeted bird species (including sage-grouse) while maximizing forage production for sustainable grazing.
- Completed four "Sagebrush dependent birds and management actions" workshops in CO, WY, and MT to increase knowledge for bird species found within the sagebrush ecosystem and disseminate information for how the DST works – nearly 130 people in attendance.
- Distributed approximately 5,700 *Pocket Guide to Sagebrush Birds*.
- Developed and distributed 500 copies of *Voices of Sagebrush Birds* CD
- Built a user-friendly web-interface for the Decision Support Tool.
- Finished Version 1 of the *Incorporating Birds into Sagebrush Management* manual.
- Did nearly 400 landowner visits to discuss habitat enhancement projects within sagebrush country.
- Received permission from 20 landowners in Sublette Co., WY to mark fences along their property line and access their property to complete fence line strike surveys.
- Completed two seasons of fence marking study field work resulting in 64 confirmed fence collisions by greater sage-grouse.
- Published a technical report that reports on the results of the fence marking study.

Project Introduction

Sagebrush birds are a key indicator for the health and sustainability of sagebrush habitats. Their continuing population declines has led to increased attention on their status by state and federal agencies, bird conservation initiatives, private landowners and non-profit organizations. The State of the Birds Report for 2011 identifies that 39% of aridland (including sagebrush) bird species are of conservation concern and more than 75% are declining (NABCI 2011). Several sagebrush obligate bird species (i.e., species that are reliant on sagebrush habitat for their survival) have been listed by state agencies as threatened or sensitive and others have been petitioned for listing with the federal Endangered Species Act (ESA) (Knick et al. 2003, Rich et al. 2005). These species face threats such as exotic plant invasion, altered fire cycles, altered livestock grazing practices, and habitat fragmentation resulting from residential/energy development.

The greater sage-grouse (*Centrocercus urophasianus*) was petitioned to be listed under the ESA and, in 2015, was determined to have a "Not Warranted" status by the US Fish & Wildlife Service (USFWS). This followed an unprecedented conservation partnership across the western US that worked to reduce threats to the greater sage-grouse. Specifically, the Natural Resources Conservation Service (NRCS) Sage Grouse Initiative (SGI) was created to establish healthy, sustainable populations of Sage-grouse on both private and federally/state leased land. The SGI funding was used to improve, create, and protect habitat for Sage-grouse while supporting sustainable ranching on lands in 11 western states using Conservation Practices (ex. Brush Management 314, Range Planting 550, Upland Habitat Management 645) listed in the *USFWS Conference Report for the Natural Resources Conservation Service Sage-grouse Initiative*.

Other avian species that breed in the sagebrush landscape, including species of greatest conservation need, will respond to Conservation Practices implemented to benefit sage-grouse (Rich et al. 2005, Rowland et al. 2006). Sagebrush obligate birds are heavily dependent upon vegetation structure and species composition and respond quickly to changes in the distribution and availability of specific habitat features (Knick and Rotenberry 2000). As such, bird species found in this landscape can be used to monitor and evaluate the health of sagebrush habitats and the effectiveness of practices implemented to benefit Greater Sage-grouse (Hutto 1998).

We proposed to provide knowledge and tools necessary to raise land managers' and landowners' awareness about sagebrush birds and their habitat needs and demonstrate how sagebrush bird conservation can be incorporated into land management actions. Specifically, we proposed to develop a web-based Decision Support Tool (DST) that helps land managers optimize forage production while achieving viable populations of sagebrush obligate birds, do outreach to raise awareness for sagebrush obligate birds and field test the efficacy of different types of fence markers at preventing sage-grouse collisions. With an expanded knowledge and toolset land managers will be able to get a bigger return for the conservation dollar. The result will be more informed land management decisions and seamless conservation implementation across private and public lands.

Project Activities & Results

Objective 1: Development of a Decision Support Tool / Structured Decision-Making Process:

A Decision Support Tool (DST) provides a snapshot of complex ecological dynamics by incorporating spatial data, habitat features, biological information, economics, stakeholder interests, etc. In order to better understand the habitat requirements of sagebrush obligate birds at multiple scales to inform small- and large-scale management of the landscape on both public and private lands we decided to use a structured decision-making framework that integrates the conservation problem, stakeholder objectives, management alternatives (Conservation Practices), outcomes and tradeoffs (Hammond et al. 2002, Marcot et al. 2012).

STAKEHOLDER OBJECTIVES

Most of the sage-steppe landscapes are working rangelands, thus there is a need to balance management strategies for numerous stakeholders. We surveyed and met with stakeholders to ensure their conservation and socio-economic concerns were addressed in the development of the Decision Support Tool (DST). Here we will identify which land management options are most pertinent to include for the majority of stakeholders.

We created and posted a survey on surveymonkey.com (see https://files.birdconservancy.org/index.php/s/WtboxrinPGyotIa). It was sent to various resource professionals and landowners who have some connection with sagebrush land management and encouraged them to send it to their colleagues to fill out (snowball sampling technique). The survey was open from 11/27/12 through 1/11/13. A total of 145 people completed the survey. Of this, 15 were private landowners and managers, 78 were public land managers, 53 were resource professionals who assist private landowners, and 21 'others'. Because landowners were a smaller group than the others their responses in the following rankings did not have as much weight in the total (combined) responses. Therefore, looked carefully at that group's responses.

Results:

- We reached the correct group of stakeholders – only 1.5% of the people that started the survey did not make land management decisions on land with sagebrush.
- We asked respondents to rank the top 9 considerations when making land management decisions (Table 1). Interestingly, "effect on wildlife" was # 1 for all respondents and #2 for landowners (behind "water conservation").
- To tease apart what attributes of vegetation and wildlife (from previous question) are important we asked respondents to rank the following considerations (Table 2).
- 86.9% of respondents said they would like to learn more about sagebrush dependent birds and their habitat needs. For the 9% that answered "depends" they listed "available time," "training location/proximity," and "if there's information about other species besides Greater Sage-grouse" as deciding factors.
- 92.4% of respondents said they would consider including sage dependent bird habitat needs into land management decisions if they knew the action(s) would increase population levels of at-risk species.
- All respondents were gave greater importance to managing for multiple species over a single species (Question 7).
- Respondents were "interested" or "very interested" in attending a 1-day (74.3%) or 2-day (62.7%) training session that covered the topics listed in the questions above.
- When asked what they would specifically like the training sessions to cover the three responses that rose to the top were:
  - How different bird species respond to land management actions
  - Which management actions benefit Sage-grouse AND other bird species
  - Prioritizing areas on the landscape to implement management actions
- Respondents said the best months to hold the trainings were February and March

Table 1. Results from stakeholder survey. Question # 5: "Rank how important each of the following categories are to you when making land management decisions using a 7-point scale (1=Not Important, 7=Very Important)"

Category*	Private Landowners	Public land resource professionals	Resource professionals assisting private landowners	Total (combined)
Effects on wildlife	2	1	2	1
Effects on vegetation	3	2	1	2
Where on the landscape management actions should be placed	7	4	3	3
Federal and state regulations	8	3	4	4
Research supporting the management actions and goals	10	5	5	5
Soil conservation	4	6	7	6
Water conservation	1	8	6	7
Cost of management actions	5	9	8	8
Technical assistance received from resource professionals	6	7	9	9

Note: "Water conservation" ranked number one for landowners but ranked at 6th and 7th places for resource professionals. In addition, "cost of management actions" ranks higher for landowners than resource professionals.

* Not all categories that were in the survey are included in this table.

Table 2. Results from stakeholder survey. Question #6: "Rate the importance of the following vegetation attributes in how you make land management decisions using a 7-point scale (1=Not Important, 7=Very Important)"

Vegetation attributes	Private Landowners	Public land resource professionals	Resource professionals assisting private landowners	Total (combined)
Presence of non-native/ invasive species	2	1	1	1
Sagebrush or other shrub cover/ density	5	2	4	2
Grass ground cover/ density	5	5	2	3
Forb (flowering plant) ground cover/ density	9	4	3	4
Grass varieties	3	6	5	5
Forb varieties	8	3	6	6
Total vegetation cover	1	7	7	7
Overall vegetation density	4	9	8	8
Bare soil cover	6	10	10	9

SPECIES OCCUPANCY/ HABITAT RELATIONSHIPS/ DISTRIBUTION MAPS

Results from the survey helped us develop the structure for the DST. Most importantly, resource professionals placed a greater importance on the "habitat needs of a suite of species" when considering wildlife and land management decisions. Because of this we did a site occupancy analysis of the sagebrush obligate birds (Pavlacky et al. 2012, Mutter et al. 2015) which describes the presence-absence of species (MacKenzie 2005). This population measure is useful for determining the response of multiple species to conservation practices and allows us to make generalizations throughout the range of the survey area.

We developed habitat relationships and distribution maps using the Integrated Monitoring in Bird Conservation Regions (IMBCR 2008) Program and data collected in 2010 and 2011 across they sagebrush ecosystem in Colorado, Wyoming, Montana, Idaho, and North and South Dakota (White et al. 2010). This region includes three Major Land Resource Areas (MLRA, USDA 2006) (including 17 Ecological Sites) that are important for managing greater sage-grouse in the eastern part of the range, including the Cool Central Desertic Basins and Plateaus (34A) in Colorado and Wyoming, Northern Rolling High Plains, Northern Part (58A) in Wyoming, and Northern Rolling High Plains, Southern Part (58B) in Montana (Table 3). The dataset included 802 grid cells and 6,786 point counts in 2010, and 855 grid cells and 8,484 point counts in 2011.

Table 3. MLRA/Ecological Sites incorporated into the DST.

MLRA	Ecological Site
34A - Cool Central Desertic Basins and Plateaus	Clayey 7-9 Green River and Great Divide Basins Clayey 10-14 Foothills and Basins West Clayey 10-14 High Plains Southeast Loamy 7-9 Green River and Great Divide Basins Loamy 10-14 Foothills and Basins West Loamy 10-14 High Plains Southeast Sandy 7-9 Green River and Great Divide Basins Sandy 10-14 Foothills and Basins West Sandy 10-14 High Plains Southeast
58A - Northern Rolling High Plains, Northern Part	Clayey RRU 58A-C 11 14 pz Clayey RRU 58A-E 10 14 pz Silty RRU 58A-C 11 14 pz Silty RRU 58A-E 11 14 pz
58B - Northern Rolling High Plains, Southern Part	Clayey 10-14 Northern Plains Clayey 15-17 Northern Plains Loamy 10-14 Northern Plains Loamy 15-17 Northern Plains

Both the general habitat type and specific features of the habitat help to determine the wildlife species found in an area. By determining the habitat relationships for the sagebrush obligate bird species we can determine where species are most prevalent (distribution) and predict how they'll respond to Conservation Practices that will change habitat conditions. Thus, we developed habitat relationship models to predict the response of the species to potential changes in local habitat condition from some Conservation Practices.

The habitat relationships were developed from bird data collected at 12 acre point count plots and vegetation data collected at 2 acre plots. We studied ground cover and grass height to predict species responses to grazing management. In addition, we investigated sagebrush cover and shrub height for different vegetation types contained in the LANDFIRE database (USGS 2010), such as big sagebrush, mountain big sagebrush and salt desert shrub, to predict how the species may respond to shrub management. Finally, we studied woodland canopy cover to predict the responses of the species to conifer management.

We discovered that Brewer's sparrow occupancy at point count locations varied by vegetation type and declined with increasing bare ground cover (Fig. 1). The occupancy rates were greatest in mountain big sagebrush and big sagebrush, and were lower in the other vegetation types (Fig. 1). Brewer's sparrow occupancy also increased with big sagebrush cover and was greatest where shrub height was approximately 3 ft (Fig. 2). Finally, Brewer's sparrow occupancy was negatively related to woodland canopy cover (Fig. 3).

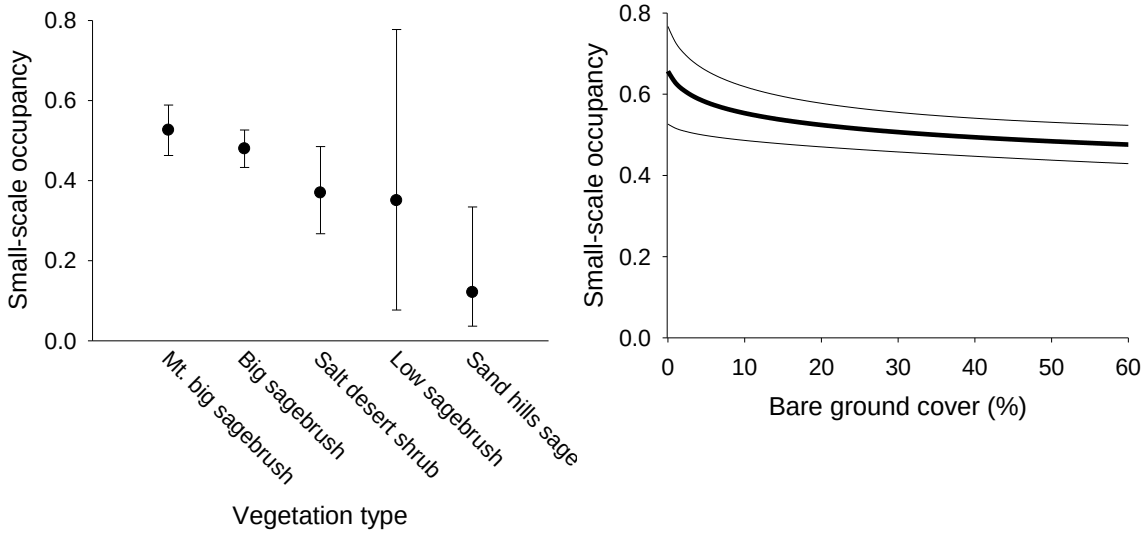

Figure 1. The small-scale occupancy of the Brewer's sparrow by vegetation type and bare ground cover in the big sagebrush vegetation type. The bold symbols and line represent the occupancy rate for point count plots at average values of the other habitat variables, and the error bars and bounding lines are 95% confidence intervals.

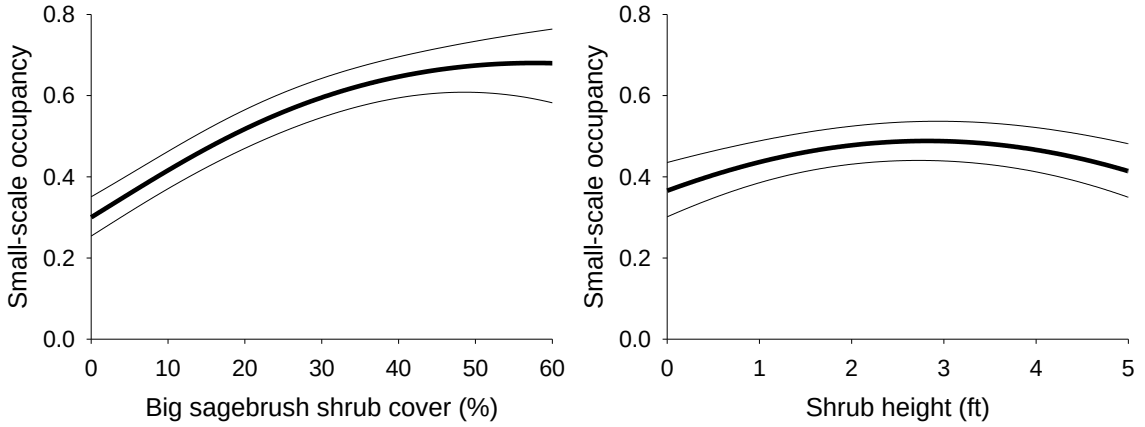

Figure 2. The small-scale occupancy of the Brewer's sparrow by big sagebrush cover and shrub height in the big sagebrush vegetation type. The bold lines represent the occupancy rate at point count locations for point count plots at average values of the other habitat variables and the bounding lines are 95% confidence intervals.

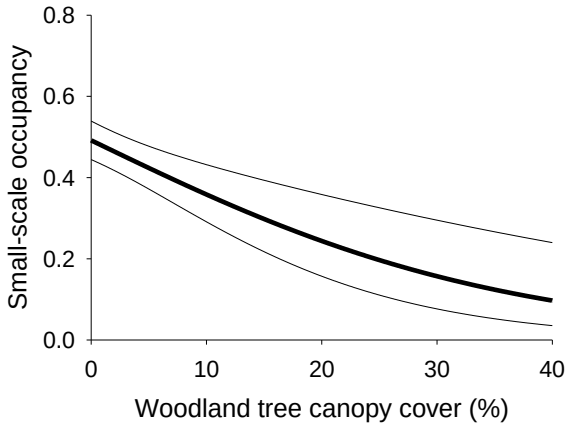

Figure 3. The small-scale occupancy of the Brewer's sparrow by woodland tree canopy cover in the big sagebrush vegetation type. The bold line represents the occupancy rate at point count locations for point count plots at average values of the other habitat variables and the bounding lines are 95% confidence intervals.

The occupancy rates of the sagebrush sparrow varied by vegetation type and increased with increasing grass height (Fig. 4). Sagebrush sparrows occurred more frequently in the salt desert shrub vegetation type and less frequently in mountain big sagebrush and big sagebrush (Fig. 4). The occupancy rates of the sagebrush sparrow occupancy were positively related to big sagebrush cover and negatively related to shrub height (Fig. 5). In addition, the occupancy rates of the sagebrush sparrow declined with increasing woodland canopy cover (Fig. 6).

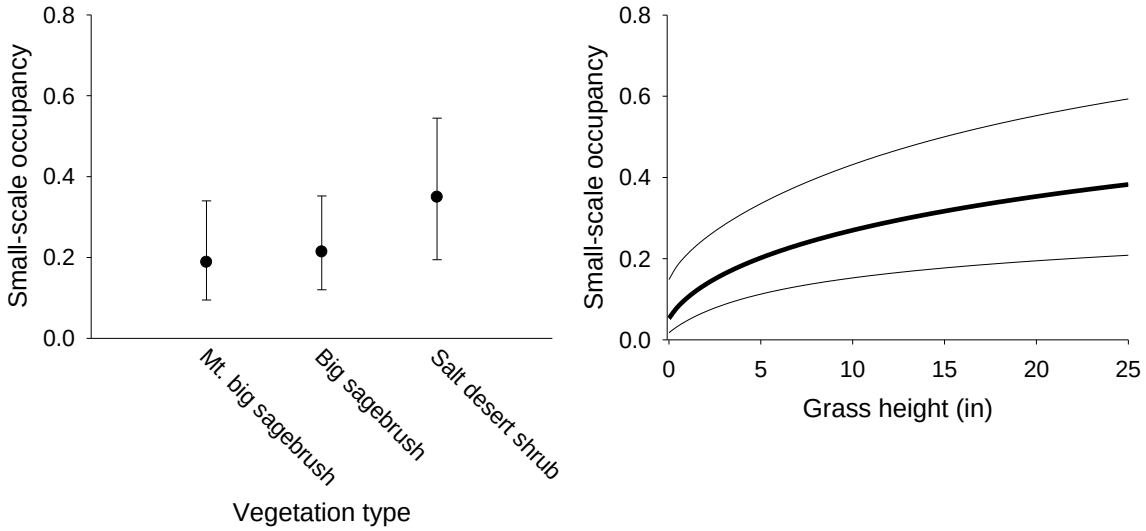

Figure 4. The small-scale occupancy of the sagebrush sparrow by vegetation type and grass height in the big sagebrush vegetation type. The bold symbols and line represent the occupancy rate for point count plots at average values of the other habitat variables, and the error bars and bounding lines are 95% confidence intervals.

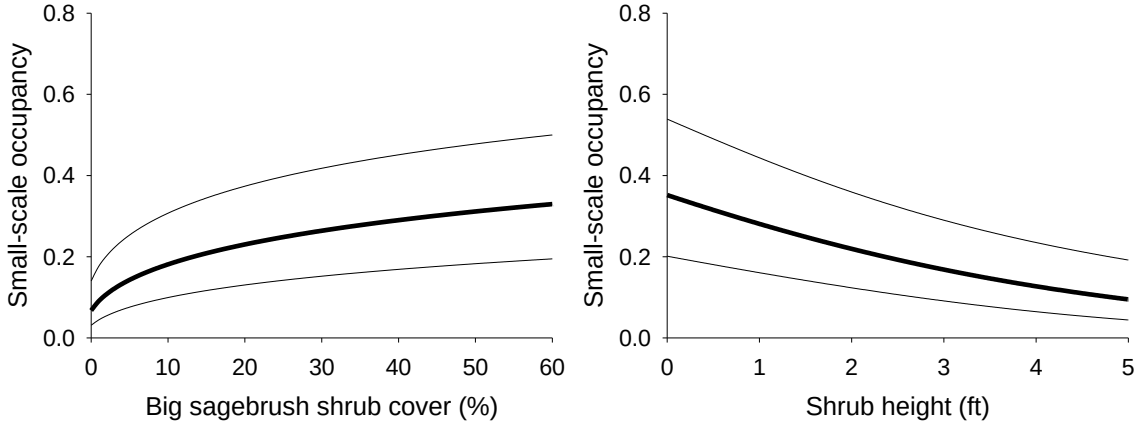

Figure 5. The small-scale occupancy of sagebrush sparrow by big sagebrush cover and shrub height in the big sagebrush vegetation type. The bold line represents the occupancy rate at point count locations for point count plots at average values of the other habitat variables and the bounding lines are 95% confidence intervals.

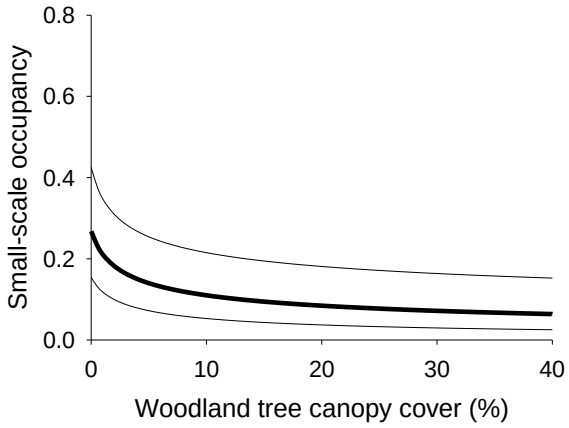

Figure 6. The small-scale occupancy of the sagebrush sparrow by woodland tree canopy cover in the big sagebrush vegetation type. The bold line represents the occupancy rate at point count locations for point count plots at average values of the other habitat variables and the bounding lines are 95% confidence intervals.

Sage thrasher occupancy at point count locations did not vary by vegetation type, but occupancy increased with increasing forb ground cover (Fig. 7). Sage thrasher occupancy was positively related to shrub cover and was greatest when shrub height was approximately 2 ft (Fig. 8). Finally, the occupancy rates of the sage thrasher declined with increasing tree canopy cover (Fig. 9).

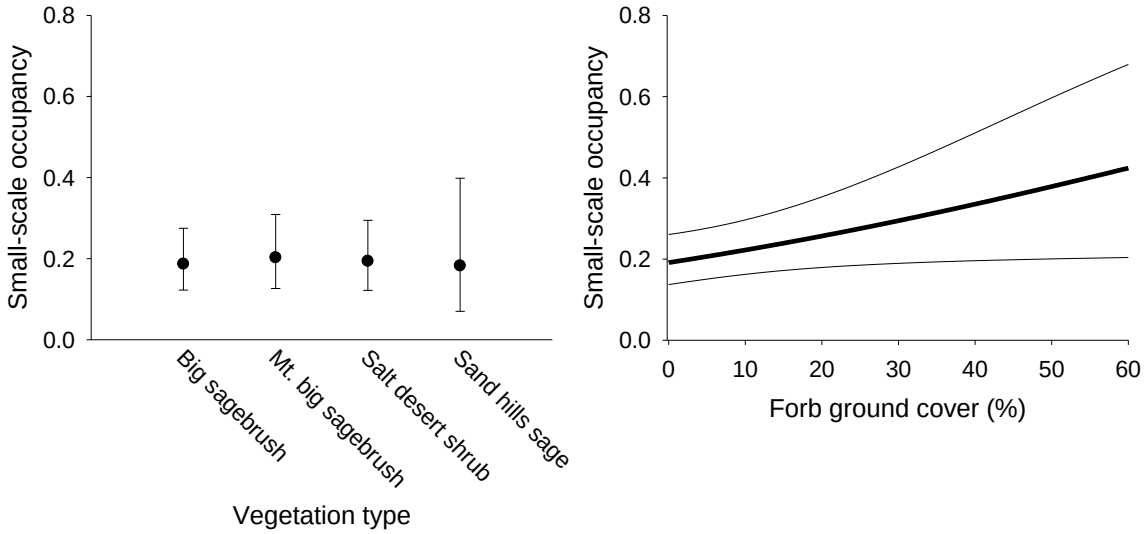

Figure 7. The small-scale occupancy of the sage thrasher by vegetation type and forb ground cover in the big sagebrush vegetation type. The bold symbols and line represent the occupancy rate for point count plots at average values of the other habitat variables, and the error bars and bounding lines are 95% confidence intervals.

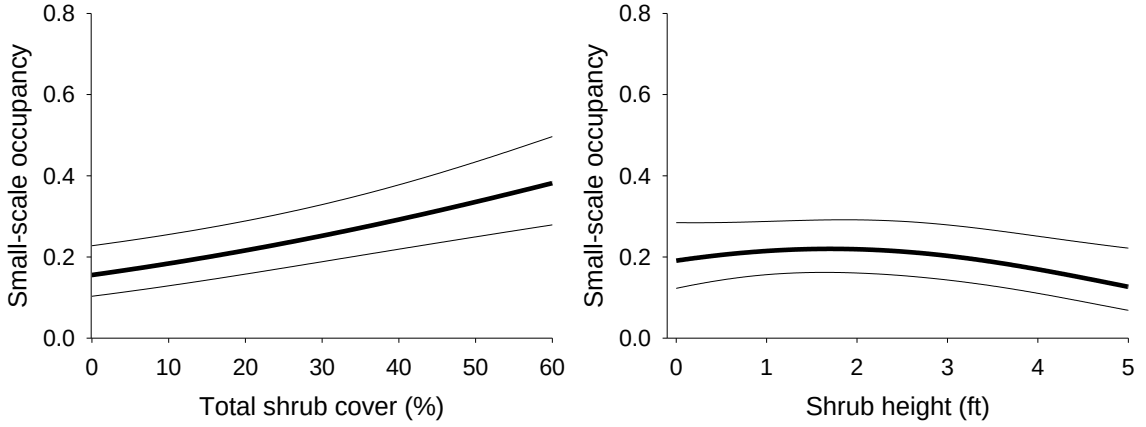

Figure 8. The small-scale occupancy of the sage thrasher by total shrub cover and shrub height in the big sagebrush vegetation type. The bold line represents the occupancy rate at point count locations for average vegetation conditions in the study area and the bounding lines are 95% confidence intervals.

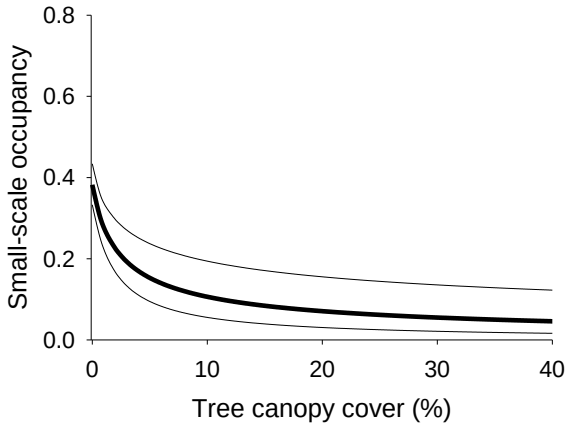

Figure 9. The small-scale occupancy of the sage thrasher by tree canopy cover in the big sagebrush vegetation type. The bold line represents the occupancy rate for point count plots at average values of the other habitat variables and the bounding lines are 95% confidence intervals.

Large-scale analyses of landscape composition were used to develop distribution maps for the three sagebrush obligate bird species across the region. The distribution maps were developed at the scale of 247 ac grid cells using bird data collected in the IMBCR (2008) program and land cover data in the LANDFIRE database (USGS 2010). We studied the land cover of different vegetation types in the grid cells (e.g., big sagebrush, mountain big sagebrush, salt desert shrub) to develop "thunderstorm-type" distribution maps for the species (Fig. 10-12). We also investigated elevation, and latitude and longitude to identify geographic range boundaries for the species. We summed the occupancy rates for the three songbird species in each grid cell to estimate species richness and overlaid the map with greater sage-grouse 100% breeding polygons (Doherty et al. 2010) to identify landscapes that are important for the conservation of multiple species (Fig. 13).

The distribution of the Brewer's sparrow was primarily driven by the land cover of big sagebrush, mountain big sagebrush and grassland, and this species had the largest geographic range size of the three sagebrush obligates (Fig. 10).

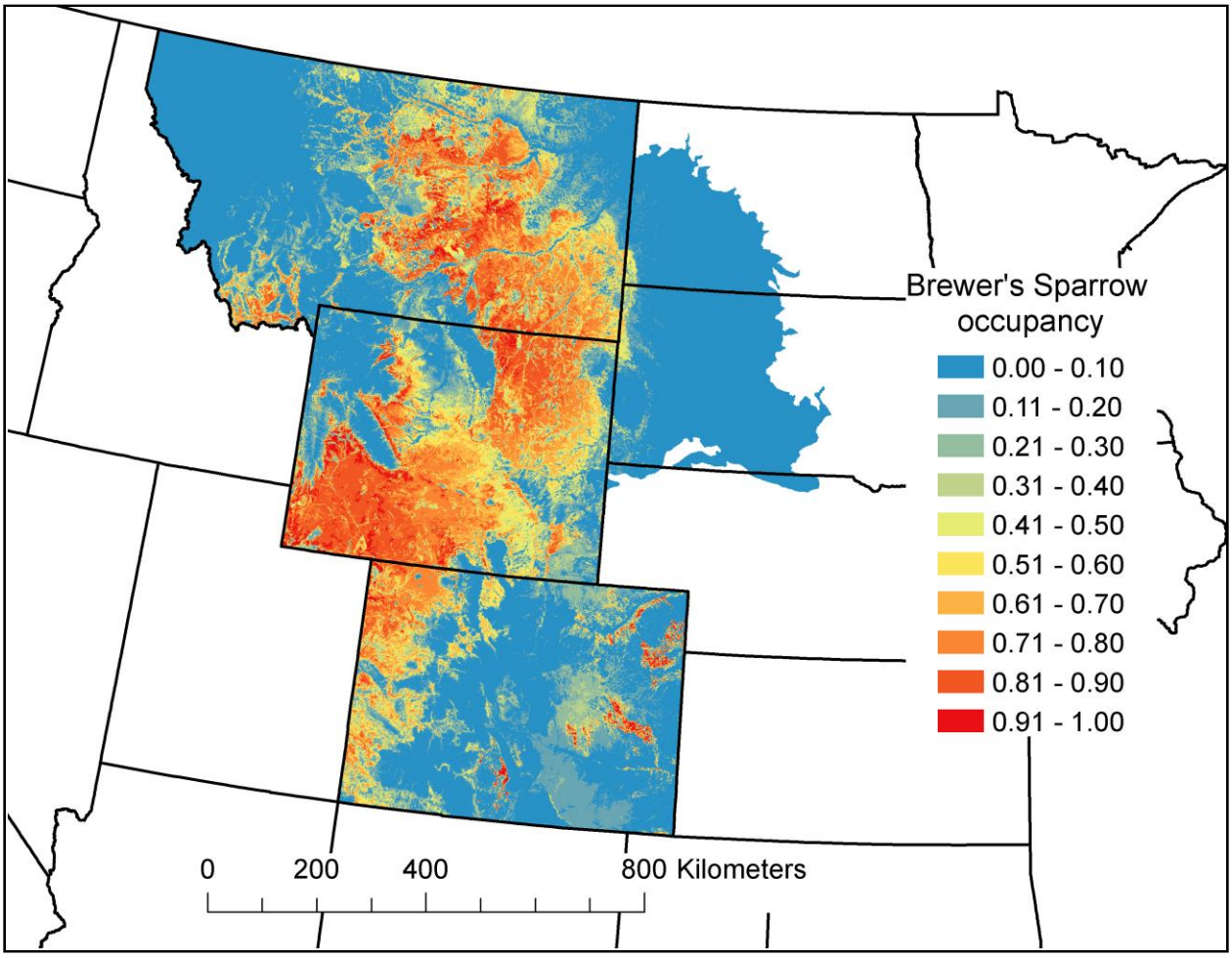

Figure 10. The predicted distribution of the Brewer's Sparrows from the Integrated Monitoring in Bird Conservation Regions program.

The sagebrush sparrow had the smallest geographic range size of the three sagebrush obligates (Fig. 11), and the distribution of this species was primarily driven by the land cover of big sagebrush, mountain big sagebrush and salt desert shrub.

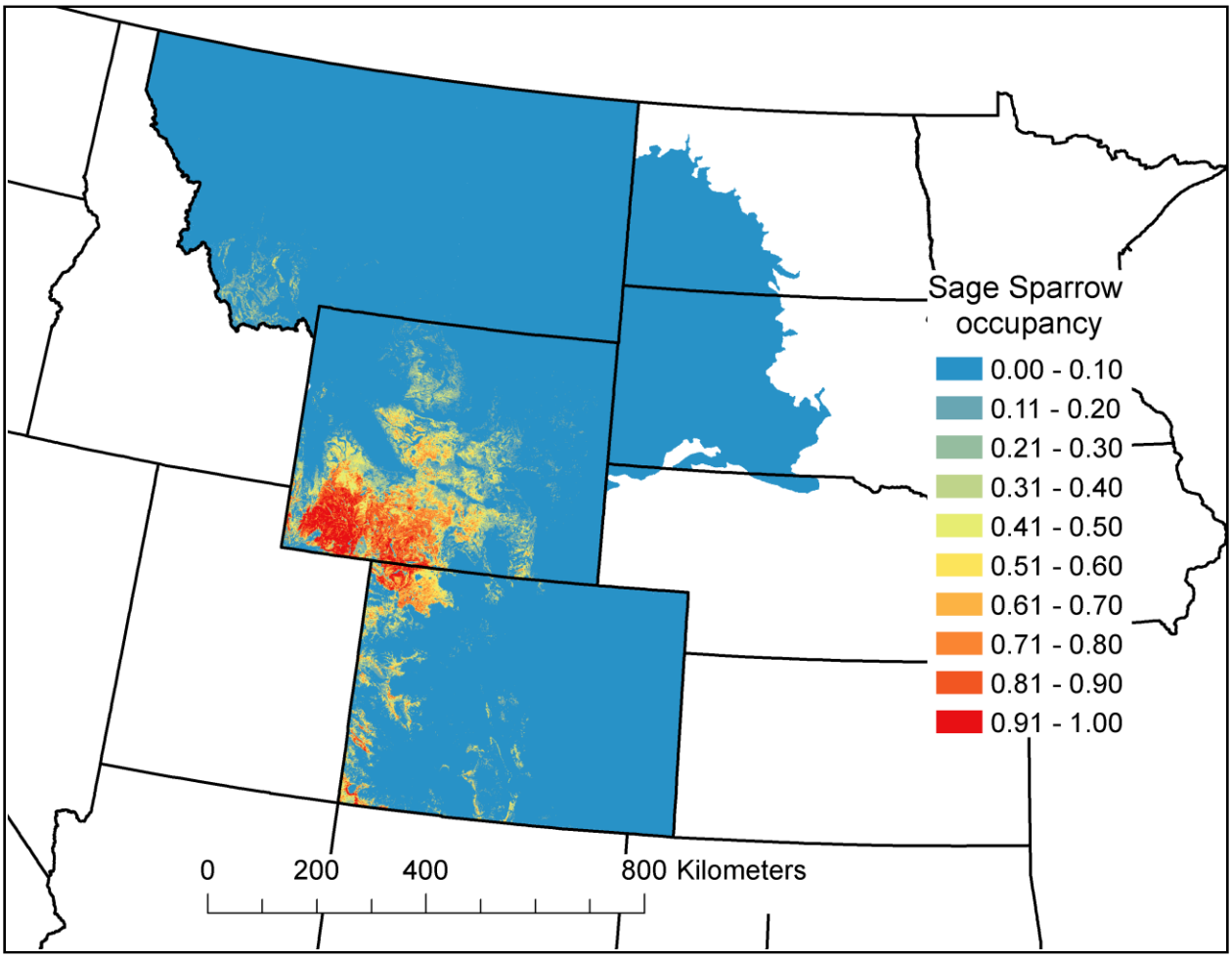

Figure 11. The predicted distribution of the sagebrush sparrow from the Integrated Monitoring in Bird Conservation Regions program.

The distribution of the sage thrasher was primarily driven by the land cover of big sagebrush, mountain big sagebrush and salt desert shrub and this species had a geographic range size intermediate between the Brewer's sparrow and sagebrush sparrow (Fig. 12).

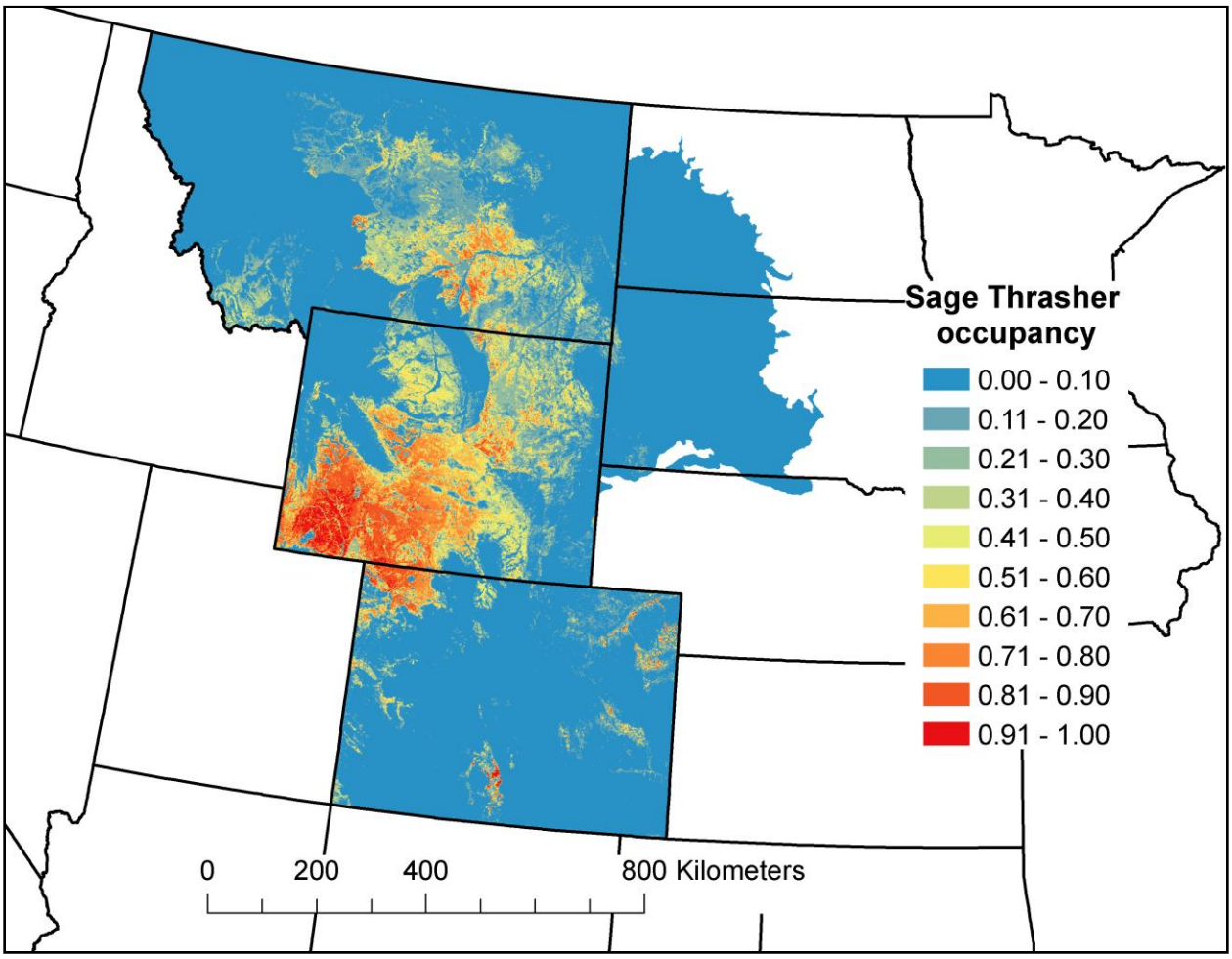

Figure 12. The predicted distribution of the sage thrasher from the Integrated Monitoring in Bird Conservation Regions program.

The average number of bird species within the 100% breeding polygons of the greater sage-grouse was 1.1 species (SD = 0.7) and the average number of bird species outside these areas was 0.3 bird species (SD = 0.4) richness outside these areas (Fig. 13), which indicated species richness was approximately 4 times greater within the greater sage-grouse breeding polygons than outside these areas. The species richness distribution showed a biodiversity hotspot for sagebrush obligate songbirds in southwestern Wyoming and northwestern Colorado (Fig. 13).

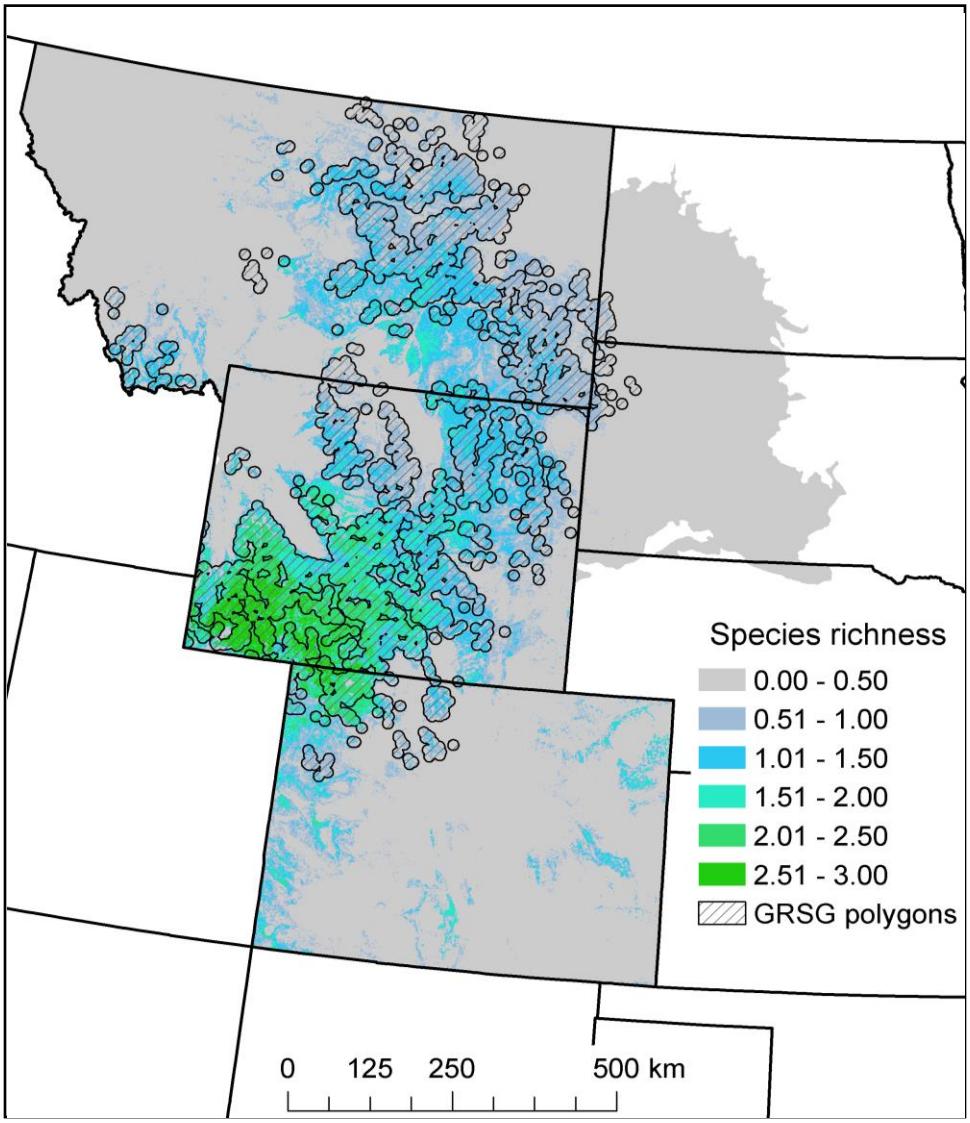

Figure 13. Predicted bird species richness of the Brewer's sparrow, sagebrush sparrow and sage thrasher from the Integrated Monitoring in Bird Conservation Regions program. The hatched areas are greater sage-grouse (GRSG) 100% breeding polygons.

The habitat relationships indicated the occupancy of all three sagebrush obligates increased with increasing big sagebrush cover and declined with increasing woodland cover. From these relationships, we predict that brush management of sagebrush will reduce the occupancy rates of the sagebrush obligates, whereas brush management of conifers to below 10% will increase the occupancy rates of all the species. However, similar to the findings of Norvell et al. (2014), the sagebrush obligates showed variable relationships to features

that make-up important nesting habitat for greater sage-grouse. Nesting habitat for the greater sage-grouse is characterized by sagebrush cover between 10 % and 30 %, sagebrush height between 11 in and 32 in, grass-herbaceous cover > 15 % and grass height > 6 in (Connelly et al. 2000). Brewer's sparrow occupancy plateaued above the 30% upper range of sagebrush cover, but the optimal shrub height was well within the range of the greater sage-grouse. Sagebrush sparrow occupancy plateaued above 20% sagebrush cover, with a close correspondence to greater sage-grouse habitat, but often used salt desert shrublands with lower shrub heights. Sage thrasher occupancy continued to increase with total shrub cover above the upper range, but the optimal shrub height was well within the range of greater sage-grouse habitat. Although the sagebrush obligate species differed in their responses to sagebrush cover and height, all three sagebrush obligate bird species exhibited high occupancy rates within the range of nesting habitat for the greater sage-grouse (Rowland et al. 2006).

We used songbird responses to ground cover features to better understand how grazing management for improving greater sage-grouse nesting habitat may improve habitat conditions for sagebrush obligate songbirds. Interestingly, all three sagebrush obligate songbirds responded to different features of ground cover. The Brewer's sparrow was negatively related to bare-ground cover, the sagebrush sparrow was positively related to grass height and the sage thrasher was positively related forb ground cover. Although each songbird species on its own does not respond to the full range of important ground cover features for greater sage-grouse nesting habitat, taken together, the ground cover requirements for the assemblage of sagebrush obligate songbirds closely corresponds to those of greater sage-grouse nesting habitat. In addition, the positive relationship between sage thrasher occupancy and forb ground cover overlaps with greater sage-grouse brood-rearing habitat (Connelly et al. 2000). These results suggest that grazing management to improve greater sage-grouse nesting habitat will likely increase habitat conditions for sagebrush obligate songbirds (Rowland et al. 2006, Williams et al. 2011).

Finally, the large-scale distribution maps indicate the species richness of sagebrush obligate birds is greater within the 100% breeding polygons for the greater sage-grouse (Doherty et al. 2010) than in other areas. The close association between the distribution of greater sage-grouse and sagebrush obligate songbirds suggests that targeted landscape and habitat conservation for the greater sage-grouse has the potential to influence populations of other sagebrush-dependent birds. Considering regional variation of the species distributions, the species richness of sagebrush obligate birds was greatest in southwestern Wyoming and northwestern Colorado, suggesting that landscape and habitat management for the greater sage-grouse in this region may be an efficient way to achieve multi-species conservation of sagebrush obligate birds.

DST DEVELOPMENT

After estimating occupancy for the sagebrush obligate bird species and developing habitat relationship models and distribution maps, the last step is to build the framework and web-interface for the Decision Support Tool (DST).

With input from stakeholders who participated in the survey and provided feedback at the workshops we developed the objectives of the DST. The DST is meant to help land managers 1) increase the suitability sage-grouse nesting habitat, 2) increase the occurrence of sagebrush-obligate songbird species, and 3) increase forage production for sustainable livestock grazing. For the first objective we measured the habitat suitability objective for the greater-sage grouse using modified scores of the Colorado Wildlife Habitat Evaluation Guide (CO GRSG Steering Committee 2008). The second (songbird) objective is achieved with the large-scale distribution maps that describe the occurrence of the species at regional scales, and the small-scale habitat relationships describe responses of species to local conservation practices. The values for the third (forage production) objective were derived for each vegetation state using data presented in published

Ecological Site Descriptions (ESDs) (Table 3; NRCS 2011). By including an objective to increase forage production, the highest ranking Conservation Practice (Table 4) will promote the viability of sustainable ranching operations.

Conservation Practices included in the tool were highly used management options listed in the Conference Report (Table 4). The modification of grazing systems to support conservation objectives was identified as an important tool for land managers (Manier et al. 2013). However, we did not evaluate specific details of grazing systems such as timing, intensity, schedule of rotation or rest duration. Instead the tool assumed successful implementation of a carefully designed grazing management plan over the course of a SGI or EQIP contract (Manier et al. 2013). We assumed that grazing rotations will increase the cover of native perennials and provide high quality vegetation condition, and deferred grazing with utilization levels of 30 to 40 percent will provide improved vegetation conditions (Manier et al. 2013).

Table 4. Conservation Practices included in DST. Continuous grazing represents season-long grazing, rotation grazing corresponds to rotational grazing with alternating periods of use and rest within a season, and deferred grazing represents discontinuance or deferment of grazing for a specified time period, including rest rotation where a pasture is deferred for an entire calendar year (USDA 2003). By default, brush management will reduce sagebrush cover to 2.5% and conifer cover to 4%, but a custom reduction in brush cover can be set in the optional desired conditions of the DST.

Continuous Grazing
Continuous Grazing and Shrub Management – Sagebrush
Continuous Grazing and Shrub Management – Conifer
Rotation Grazing
Rotation Grazing and Shrub Management – Sagebrush
Rotation Grazing and Shrub Management - Conifer
Deferred Grazing
Deferred Grazing and Shrub Management – Sagebrush
Deferred Grazing and Shrub Management - Conifer
None (Current vegetation state and conditions)

The ESDs are important for predicting vegetation responses to management because each ESD has a specific State and Transition Model that describes how management affects vegetation condition and forage production. We are using the “Vegetation States” and “State and Transition Model” in each ESD to describe how the different management actions affect vegetation structure. Then we link the large-scale distributions and local habitat relationships for the bird species to the changes in vegetation structure in the pasture or ranch. In a similar fashion, the proximity to sage-grouse core areas and suitability sage-grouse nesting habitat are tied to the changes in vegetation structure. The sage-grouse, songbird and forage production objectives are linked to the management alternatives, vegetation changes, and State and Transition Models using a Bayesian Belief Network (Bashari et al. 2008, Marcot et al. 2012). We created the Bayesian Belief Networks using GeNIe 2.0 software and developed the web interface using SMILE Engine (BayesFusion, LLC, www.bayesfusion.com, accessed 8 March 2016) (Fig. 14).

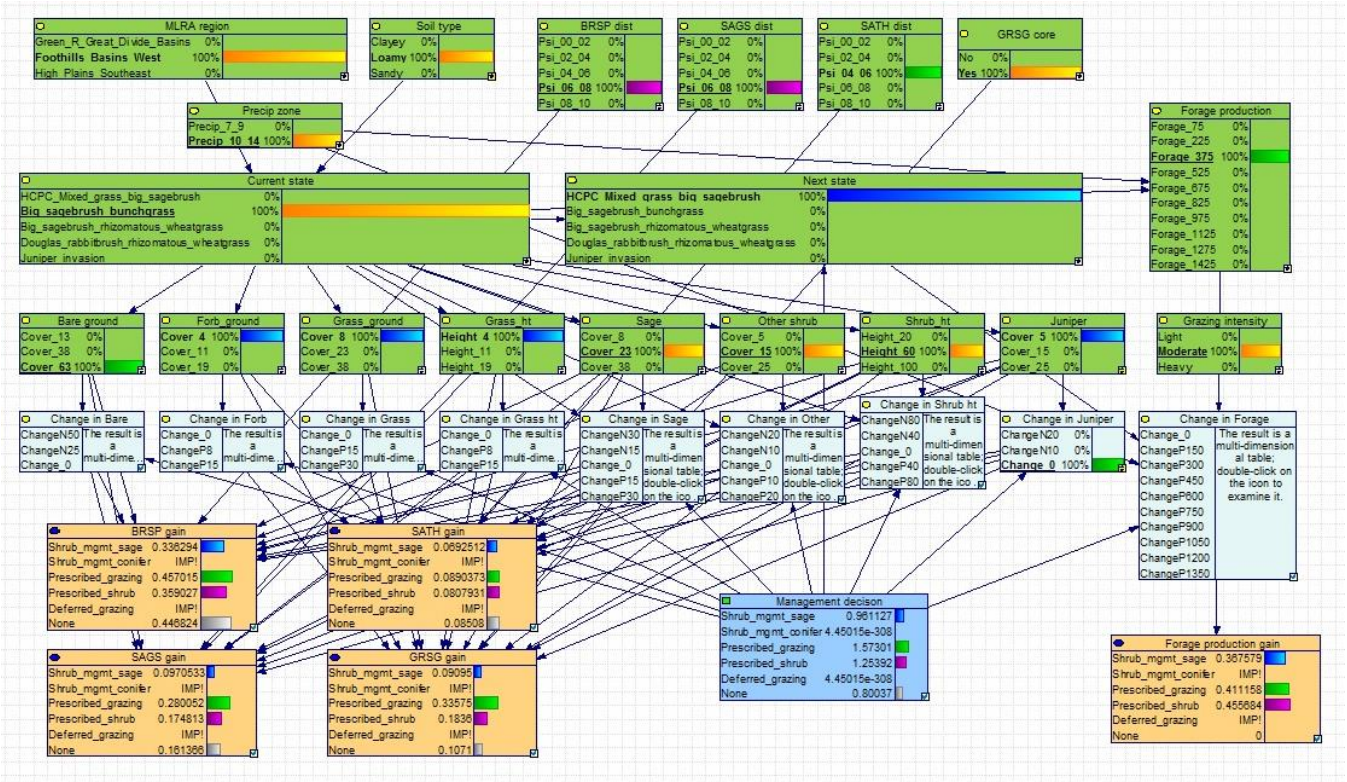

Figure 14. Visual representation of how the sage-grouse, songbird and forage production objectives are linked to the management alternatives, vegetation changes, and State and Transition Models within the Decision Support Tool.

The result is a tool that can identify 1) where, within the sagebrush ecosystem resource dollars should be allocated to provide the best outcomes for the objectives and 2) which conservation practices are most effective for achieving the objectives. In addition, the tool can be applied outside greater sage-grouse core areas to determine which landscapes and Conservation Practices are important for songbirds and sustainable grazing. The tool can be found at http://rmbo.org/dst/. Instructions for use can be found here https://files.birdconservancy.org/index.php/s/1pbQ533B5ARl3C5

Objective 2: Raising Awareness

With partner funding, RMBO will coordinate training sessions for resource professionals and landowners to increase their awareness for sagebrush birds and learn how to make use of the DST. Increased awareness will enable land managers to incorporate the needs of sagebrush obligate bird species into management plans for Sage-grouse while achieving objectives of agricultural producers.

WORKSHOPS

The stakeholder survey results (see above) also helped us design the curriculum for the training sessions. An overwhelming number of the survey participants (126 out of 145) were interested in learning more about sagebrush dependent birds and their habitat needs and would consider their needs when making land management decisions (134 out of 145) warranting the need for the training sessions. In spring 2014, we held four "Sagebrush Dependent Birds and Management Actions" trainings were held in Colorado, Wyoming, and Montana (Fig. 15).

Figure 15. Flyer for one of the Sagebrush and Management Decisions in the Sagebrush Ecosystem workshop.

The workshops accomplished the following for participants:

- Increased awareness for Sagebrush Obligate Songbirds (SOBs), identification and habitat needs,
- Introduced and solicited feedback on a prototype Decision Support Tool (DST) which helped predict outcomes of habitat enhancement and restoration on SOBs populations, and
- Introduced information to influence future management decisions for multiple bird species.

Bird Conservancy presented to almost 130 people from BLM (27.5%), NRCS (15.8%), state natural resource agencies (15.7%), non-profits (7.2%), Energy corporations (6.4%), USFWS (5.9%), US Forest Service (FS) (5.3%), private consultants (5.3%), University (student and employee; 4.9%), Conservation Districts (3%), and a handful of landowners (Figs. 16 & 17). We gave an overview of Bird Conservancy's monitoring program (Integrated Monitoring in Bird Conservation Regions) and how that data is used to build bird-habitat relationship models. We discussed the ecology of birds and how our bird-habitat relationship models are correlated with different species. We covered how to identify each in the field and gave an informational presentation on Bird Conservancy's Avian Data. We concluded the workshops with an overview of the development of the DST and used the opportunity to assist with our structured decision making process of the adaptive management framework we are using to develop the DST. This method requires stakeholder involvement and objective setting with the understanding, in our case, that sage-steppe landscapes are working rangelands and there is a need for balanced management for numerous stakeholders. Ultimately, we want to ensure that stakeholder conservation and socio-economic concerns are addressed.

Figure 16. SWAT biologists in attendance at Craig, CO workshop

Figure 17. Participants at Rawlins, WY workshop.

Participants also evaluated the workshops and the usefulness of the information. Overall the workshops scored a 3.91 out of 5.0 for the information being useful to the participants. Individual topic scores were greatest for avian ecology and ID (4.41 / 5.0) which indicates resource professionals are interested in learning more about sagebrush obligate bird species. Topic scores were lowest for the DST overview and discussion (3.2 / 5.0). This actually was as expected due to these workshop sections being focused more on their feedback on the DST to us. In some verbal conversations after the workshops as well as written comments on the evaluation, many of the participants were very appreciative of us getting their feedback for the development of the DST – all expressed how important that would be for building a tool that will work well and be well-used.

WEBINAR

In January of 2016, Bird Conservancy conducted an on-line webinar "Sagebrush Bird ID & Habitat Needs." A total of 57 people attended the live webinar. Participants included 45% NRCS, 15% BLM, 15% USFS, 10% state, 10% other federal, and 5% non-profit. Bird Conservancy also posted a link to the webinar on YouTube which has had 99 unique views and has been shared by 3 viewers. The webinar has also been shared by Idaho Fish and Game Department and IWJV. The webinar can be found with this link: https://youtu.be/_NDr42HFsRc?list=PLsuvgr-yGQydc9QtR6AEyTpv7OPmtq6cY.

AUDIO CDS OF SAGEBRUSH BIRD CALLS AND SONGS

Cornell University's Lab of Ornithology developed and made 500 *Voices of Sagebrush Birds* CD for Bird Conservancy (Fig. 18). We've distributed all of these at the workshops and other outreach opportunities and on-line requests.

Figure 18. Cover of the Voices of Sagebrush Birds CD.

POCKET GUIDE TO SAGEBRUSH BIRDS

We continuously get requests for this guide. During the grant cycle we've dispersed approximately 5,700 guides.

MANUAL DEVELOPMENT

The manual has gone through several drafts with several authors contributing. While we did have great interest in creating a manual that would be useful to both landowner and resource professional, in the end, the manual is a bit more technical than we've been told landowners would have an interest in.

Version 1 of this guide is intended for conservation practitioners working in the sagebrush ecosystem in the eastern part of sagebrush range, including Colorado, Wyoming, western South Dakota, Montana and southeast Idaho, as some of the management tools described are only valid in those areas. The purpose of the guide is to provide information and share tools and other resources available that help guide

conservation actions aimed to manage sagebrush habitats for diverse bird communities. Information in this guide is applicable on both public and private lands. This guide is not meant to take place of the local knowledge gained from long-term interactions with the land being managed; land management goals and objectives are usually very site specific and will be different under different environmental, political, social, and economic circumstances.

The guide has five sections. The *Introduction* provides the justification of why it is important to consider all sagebrush obligate birds when planning for land management. The *Sagebrush Ecosystem* section gives general information about the ecosystem. This ecosystem is not just one expansive field of sagebrush; there are many microhabitats and different plant associations that make up the overall ecosystem that are each important to different species of birds. Understanding the ecological classification system used to describe those plant associations will be important for making informed management decisions. We provide general information about Major Land Resource Areas and ecological site descriptions, used by resource agencies to describe ecosystem dynamics and give reference for additional information sources. The section on *Birds as Indicators* will give the reader a general understanding of the different components of habitat that are potentially important for the presence or absence of a bird species. *The Conservation Actions* section provides general management suggestions when a particular activity is occurring at a site. *The Tools for Management Decisions* section provides a more detailed description of several tools land managers can use to enhance decisions that foster a multi-species approach to conservation. *Appendix A* provides details for 19 bird species found within the sagebrush ecosystem. These details will give readers a better understanding of specific habitat requirements necessary for a species to be present and will give managers the knowledge they need to incorporate these requirements into land management decisions. *Appendix B* gives an explanation of the two larger scale monitoring efforts in North America that can provide more rigorous population statuses for bird species. The manual is available using this link https://files.birdconservancy.org/index.php/s/K7VQG1QAkcH9QkM; because it is still version one of the final we have not shared it publically.

ONE-ON-ONE LANDOWNER VISITS

During the course of this grant cycle, four Bird Conservancy Sage-grouse Private Lands Wildlife Biologists (PLWB) reached out to landowners to do one-on-one landowner visits. They did nearly 400 visits with different ranches to discuss potential habitat enhancement projects and assist them with applying for various conservation funding sources. Oftentimes, these visits are done in partnership with other agencies. The landowner visits are a great opportunity for resource professionals to share their expertise with each other and the landowners.

PARTNERSHIPS/ RAISING AWARENESS

Another venue for raising awareness is by attending meetings with partners and giving presentations at natural resource conferences. Bird Conservancy's Executive Director, Stewardship Director, Science Director, and Biometrician have all attended meetings and had conversations to build and maintain partnerships with various agencies and organizations for this project. Some examples of these meetings and presentations include:

Meetings:

- Sage Grouse Initiative partner meetings
- Association of Fish and Wildlife Agencies meetings
- Wyoming Chapter of The Wildlife Society annual conference
- Intermountain West Joint Venture meetings
- Northern Great Plains Joint Venture meetings

- Executive Director visited with Assistant Chief of NRCS and Under Secretary Bonnie about the DST, the initiative and need for measures of success for the sagebrush obligate suite of birds in September in Washington, D.C.
- Executive Director visited with Audubon of the Rockies and World Wildlife Fund about the DST and modeling a similar effort in the grasslands.
- Bird Conservancy has been conference calling with IWJV and other partners to develop a Sage Obligate Outreach Strategy that will raise awareness of managers about at-risk birds and their habitat requirements and communicate recent investments in planning tools and how to use them (see below).

Presentations

- Pavlacky, D.C., Jr., J.A. Blakesley, and D.J. Hanni. August 2013. Hierarchical occupancy estimation to predict bird species distributions. American Ornithologists' Union/ Cooper Ornithological Society: 2013, Chicago, Illinois, USA.
- North American Wildlife and Natural Resources Conference – Sage Grouse Executive Committee meeting in Washington, DC.
- Gallagher, S.W., D. Pavlacky, L. Quattrini, T. VerCauteren. Bird Conservancy Conservation Efforts in the Sagebrush Steppe, Western Association of Fish and Wildlife Agencies, Summer meeting 2013, Omaha, NE (July 2013)
- 5th International Partners in Flight Conference and Conservation Workshop – Snowbird, UT (August 2013)
- Pavlacky, D. C., Jr., D. J. Hanni, and S. Gallagher. September 2014. Integrating monitoring data and ecological site descriptions to achieve multi-species bird conservation in working landscapes. Annual meeting of American Ornithologists' Union, Cooper Ornithological Society, and Society of Canadian Ornithologists. Estes Park, Colorado, USA
- 79th North American Wildlife and Natural Resources Conference – Denver, CO (March 2014)
- Pavlacky, D. C. February 23-26, 2016. An example of multi-species integration in habitat management. Sagebrush Ecosystem Conservation: All Lands, All Hands. Salt Lake City, UT.

Objective 3: Fence-marking study

The density of fences in sagebrush has increased dramatically over the last 50 years (Braun 1998, Connelly et al. 2000, Johnson et al. 2011, Knick et al. 2011). A number of studies have found evidence that greater sage-grouse do collide with anthropogenic structures, and fences are routinely marked to reduce these collisions (Beck et al. 2006, Christiansen 2009, Stevens et al. 2012). However, there is little empirical evidence on fence characteristics and the surrounding landscape to influence the probability or abundance of collisions. Additionally, there is no research on the efficacy of different styles of fence markers in minimizing collision risk. With data from two field seasons of surveying 26 miles of marked and unmarked fence lines, we developed a multi-scale occupancy model to evaluate a previously created collision risk model for GRSG, estimate how factors at landscape and local scales impact the probability of collisions, and to determine the most cost-effective marking options to reduce GRSG collisions (VanLanen et al. 2016). We found evidence for 64 confirmed fence collisions by GRSG during the two-year study, with 15 detected in 2014 and 49 detected in 2015 (Fig. 19). Over 60% of sites (16 of 26) and 26% of fence segments (27 of 104) contained evidence of one or more collisions. We found little evidence for differences in collision risk within our study area between areas defined as "high" or "moderate" risk in a pre-existing collision risk map. We also found substantial evidence for the ability of markers to reduce collision probabilities (~58% reduction), though there was little difference between the three marker types investigated. We found strong evidence for lower occupancy probabilities at fences with wood posts and those farther from leks. Our results also indicate a negative relationship between occupancy probabilities and the

difference between fence and vegetation heights. Collision probabilities were lower at unmarked fences with wood posts than at marked fences with wood and t-posts. We recommend that, when possible, markers be placed on fences close to leks, on fencing with t-posts, and/or in areas with shorter vegetation. Furthermore, we recommend the use of the least expensive, vinyl without reflective tape, marker in future fence marking efforts.

Figure 19. Evidence of what we consider a "confirmed strike," with feathers remaining in the fence.

For the full technical report please use this link https://files.birdconservancy.org/index.php/s/U5cG6YgFVSgMD0f. A review of the report was published on the Sage Grouse Initiative website - http://www.sagegrouseinitiative.com/new-report-fence-markers-work-prevent-sage-grouse-collisions/. In addition, researchers are currently working on getting a peer-reviewed paper for this project published.

Conclusion

Lessons Learned

We had several lessons learned about this project as, oftentimes, projects do not get implemented as originally anticipated. We had the following set-backs during the grant cycle:

- Data modeling took much longer than anticipated for a few reasons. A new program was used for this (Program GENIE) which was met with a learning curve. In addition, we cannot simply use a broad brush approach to managing across the sagebrush ecosystem as hundreds of ecological sites exist within the sagebrush range. Thus we used the Ecological Site Descriptions to guide the tool. This was a tedious task 1) because there are so many ESDs within our focal area, and 2) because each ESD and the corresponding state and transition models/values needed to be entered into the Program GENIE separately.
- Colorado Parks and Wildlife was the only state not willing to share their Sage-grouse lek information in the development of a fence collision risk model (Stevens et al. 2013). As such we were not able to design a fence marking study in Colorado (the proposed location for the project). We moved the study to Sublette Co., WY and had to install the fence markers ourselves, rather than having the help of private landowners we worked with in Colorado. Therefore, the fence marking project ended up being more time and money consuming than originally thought.
- We subcontracted a business to create the web-based user interface for the DST. Much staff time went into working with the subcontractor which unfortunately ended up not providing deliverables as outlined in the sub-agreement and did not build a quality interface, again wasting time and money. We were able to recover from this set back by subcontracting someone we have worked with in the past and knew they would be able to deliver a final product. The result is our current DST interface. It is adequate and provides necessary information, however does not operate as we originally wanted. It is our goal to secure additional funds to build the original concept of the web-interface.

In summary, Bird Conservancy achieved the deliverables we set out to accomplish. A few setbacks however prevented the level of detail and quality we originally anticipated. We built the habitat relationship models that were incorporated into the development of the Decision Support Tool. We involved stakeholders in the development of the tool to ensure its usefulness. A web-interface was built for ease of use of the Decision Support Tool. We put on workshops and a webinar to help raise awareness for sagebrush birds and discuss tools for resource professionals and landowners to utilize while making land management decisions. We developed a first version of the *Incorporating Bird Conservation into Sagebrush Management* manual and distributed thousands of *Pocket Guide to Sagebrush Birds* and 500 copies of a *Voices of Sagebrush Birds* audio CD. We completed two fence collision study field seasons and developed a final technical report.

Summary of links:

- Sagebrush landscape stakeholder survey https://files.birdconservancy.org/index.php/s/WtboxrinPGyotIa
- *Integrating Bird Conservation into Sagebrush* Management – Version 1 https://files.birdconservancy.org/index.php/s/K7VQG1QAkcH9QkM
- *Pocket Guide to Sagebrush Birds* *http://www.pointblue.org/uploads/assets/education/SagebrushPocketGuide_050611_reduced.pdf*
- Decision Support Tool http://rmbo.org/dst/
- DST Instructions https://files.birdconservancy.org/index.php/s/1pbQ533B5ARl3C5
- Fence Marking Study technical report https://files.birdconservancy.org/index.php/s/U5cG6YgFVSgMD0f

References

Bashari, H., C. Smith, and O. J. H. Bosch. 2008. Developing decision support tools for rangeland management by combining state and transition models and Bayesian belief networks. Agricultural Systems 99:23-34.

Beck, J.L., Reese, K.P., Connelly, J.W. and Lucia, M.B., 2006. Movements and survival of juvenile greater sage-grouse in southeastern Idaho. Wildlife Society Bulletin, 34(4): 1070-1078.

Braun, C. E. 1998. Sage Grouse declines in western North America: what are the problems? Proc. West. Assoc. State Fish and Wildl. Agencies, 78:139-156.

Christiansen, T. 2009. Fence marking to reduce greater sage-grouse (*Centrocercus urophasianus*) collisions and mortality near Farson, Wyoming – summary of interim results. Wyoming Game and Fish Department.

Colorado Greater Sage-grouse Steering Committee (CO GRSG Steering Committee). 2008. Colorado greater sage-grouse conservation plan. Colorado Parks and Wildlife, Denver, Colorado, USA.

Connelly, J. W., M. A. Schroeder, A. R. Sands, and C. E. Braun. 2000. Guidelines to manage sage grouse populations and their habitats. Wildlife Society Bulletin 28::967–985.

Doherty, K. E., J. D. Tack, J. S. Evans, and D. E. Naugle. 2010. Mapping breeding densities of greater sage-grouse: a tool for range-wide conservation planning. U.S. Department of Interior, Bureau of Land Management, Washington, D.C., USA.

Favreau, J. M., C. A. Drew, G. R. Hess, M. J. Rubino, F. H. Koch, and K. A. Eschelbach. 2006. Recommendations for assessing the effectiveness of surrogate species approaches. Biodiversity and Conservation 15:3949-3969.

Hammond, J. S., R. L. Keeney, and H. Raiffa. 2002. Smart choices: a pracical guide to making better life decisions. Broadway Books, New York, USA.

Hutto, R. L. 1998. Using landbirds as an indicator species group. Pp. 75-92. In: J.M. Marzluff and R. Sallabanks (eds.), Avian Conservation: Research and Management. Island Press, Washington, DC.

Integrated Monitoring in Bird Conservation Regions (IMBCR). 2008. Bird Conservancy of the Rockies, Brighton, Colorado, USA. <http://www.birdconservancy.org/what-we-do/science/monitoring/imbcr-program/>. Accessed 21 September 2015.

Johnson, D. H., M. J. Holloran, J. W. Connelly, S. E. Hanser, C. L. Amundson, and S. T. Knick. 2011. Influences of environmental and anthropogenic features on greater sage-grouse populations, 1997-2007. Pages 407—450 in S. T. Knick and J. W. Connelly, editors. Greater sage grouse: ecology and conservation of a landscape species and its habitats. Studies in Avian Biology Series, Volume 38, University of California Press, Berkeley, USA.

Knick, S.T. and J.T. Rotenberry. 2000. Ghosts of habitats past: the relative contribution of landscape change to current habitat associations of shrubsteppe birds. Ecology. 81: 220 – 227.

Knick, S.T., D.S. Dobkin, J.T. Rotenberry, M.A. Schroeder, W.M. Vander Haegen, and C.Van Riper III. 2003. Teetering on the Edge or Too Late? Conservation and Research Issues for Avifauna of Sagebrush Habitats. The Condor 105:611–634.

Knick, S.T., and J.W. Connelly. 2011. Greater sage-grouse and sagebrush: An introduction to the landscape. Introduction in S.T. Knick, and J.W. Connelly, eds. Greater sage-grouse: ecology and conservation of a landscape species and its habitats. Studies in Avian Biology. 38th. University of California Press, Berkeley, USA. Pp. 24

MacKenzie, D. I. 2005. What are the issues with presence-absence data for wildlife managers? Journal of Wildlife Management 69:849-860.

Manier, D. J., D. J. A. Wood, Z. H. Bowen, R. M. Donovan, M. J. Holloran, L. M. Juliusson, K. S. Mayne, S. J. Oyler-McCance, F. R. Quamen, D. J. Saher, and A. J. Titolo. 2013. Summary of science, activities, programs, and policies that influence the rangewide conservation of greater sage-grouse (*Centrocercus urophasianus*). U.S. Geological Survey Open-File Report 2013–1098. U.S. Geological Survey, Fort Collins, Colorado, USA.

Marcot, B. G., M. P. Thompson, M. C. Runge, F. R. Thompson, S. McNulty, D. Cleaves, M. Tomosy, L. A. Fisher, and A. Bliss. 2012. Recent advances in applying decision science to managing national forests. Forest Ecology and Management 285:123-132.

Mutter, M., Pavlacky D. C. Jr, Van Lanen N. J., and R. Grenyer. 2015. Evaluating the impact of gas extraction infrastructure on the occupancy of sagebrush-obligate songbirds. Ecological Applications 25:1175–1186.

Natural Resources Conservation Service (NRCS). 2011. Ecological Site Description. U. S. Department of Agriculture, Natural Resources Conservation Service, Washington, D. C., USA. <https://esis.sc.egov.usda.gov/Welcome/pgReportLocation.aspx?type=ESD#top>. Accessed 26 June 2013.

Norvell, R. E., T. C. Edwards, and F. P. Howe. 2014. Habitat management for surrogate species has mixed effects on non-target species in the sagebrush steppe. The Journal of Wildlife Management 78:456-462.

Pavlacky, D. C., Jr., J. A. Blakesley, G. C. White, D. J. Hanni, and P. M. Lukacs. 2012. Hierarchical multi-scale occupancy estimation for monitoring wildlife populations. Journal of Wildlife Management 76:154-162.

Rich, T.D., M.J. Wisdom, and V.A. Saab. 2005. Conservation of sagebrush steppe birds in the interior Columbia Basin. Gen. Tech. Rep. PSW-GTR-191. Pp. 589-606. In: Ralph, C.J., T. Rich, L. Long (eds.), Proceedings of the Third International Partners in Flight Conference, USDA, Forest Service, Pacific Southwest Research Station, Albany, CA.

Rowland, M. M., M. J. Wisdom, L. H. Suring, and C. W. Meinke. 2006. Greater sage-grouse as an umbrella species for sagebrush-associated vertebrates. Biological Conservation 129:323-335.

Stevens, B.S., J.W. Connelly, and K.P. Reese. 2012. Multi-scale assessment of greater sage-grouse fence collision as a function of site and broad scale factors. The Journal of Wildlife Management, 76(7): 1370-1380.

Stevens, B.S., D.E. Naugle, J.W. Connelly, T. Griffiths, and K.P. Reese. 2013. Mapping sage-grouse fence-collision risk: spatially explicit models for targeting conservation implementation. Wildlife Society Bulletin, 37(2): 409-415.

United States Department of Agriculture (USDA). 2003. National range and pasture handbook. U. S. Department of Agriculture, Natural Resources Conservation Service, Grazing Lands Technology Institute, Washington, D. C., USA. <http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084>. Accessed 25 July 2016.

United States Department of Agriculture (USDA). 2006. Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin. U. S. Department of Agriculture Handbook 296. United States Department of Agriculture, Natural Resources Conservation Service, Washington, D.C., USA.

USDI Fish and Wildlife Service (USFWS). 2010. Conference Report for the Natural Resources Conservation Service Sage-grouse Initiative (SGI). 106 pp.

US Geological Survey (USGS). 2010. Landfire 1.2.0: existing vegetation type layer. U.S. Department of the Interior, Geological Survey Sioux Falls, South Dakota, USA. <http://landfire.cr.usgs.gov/viewer/>. Accessed 18 June 2013.

Van Lanen, N.J., A.W. Green, T.R. Gorman, L.A. Quattrini, and D.C. Pavlacky Jr. 2016. Evaluating Efficacy of Fence Markers in Reducing Greater Sage-Grouse Collisions With Fencing Final Report. Bird Conservancy of the Rockies. Brighton, Colorado, USA.

White, C. M., N. J. V. Lanen, D. C. Pavlacky, Jr., J. A. Blakesley, R. A. Sparks, J. M. Stenger, J. A. Rehm-Lorber, M. F. McLaren, F. Cardone, J. J. Birek, and D. J. Hanni. 2010. Integrated Monitoring in Bird Conservation Regions (IMBCR): 2010 annual report. Rocky Mountain Bird Observatory, Brighton, Colorado, USA.

Williams, M. I., G. B. Paige, T. L. Thurow, A. L. Hild, and K. G. Gerow. 2011. Songbird relationships to shrub-steppe ecological site characteristics. Range Ecology and Management 64:109-118.