

**Utah's Adaptive Resources Management
Greater Sage-grouse Local Working Groups
2016 Annual Report**



Photo by Todd Black

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Utah's Adaptive Resources Management Greater Sage-grouse Local Working Groups



Submitted by

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Table of Contents

Executive Summary	4
Utah’s Conservation Strategy	5
Utah’s Sage-grouse Local Working Groups	6
National Recognition for Utah’s Incentive-Based Approach to Conservation.....	7
The Science Foundation for Utah’s Sage-grouse Management Areas	7
Utah Sage-grouse Management Areas Encompass Seasonal Habitats	8
Increasing Useable Space for Sage-grouse	9
Enhancing Sage-grouse Brood-rearing Habitats.....	10
Increasing Chick Survival.....	10
Juvenile Sage-grouse Survival.....	12
Sage-grouse Female Reproduction Costs and Effects of Climate	14
Sage-grouse Responses to Active Management	14
Sage-grouse Hunting in Utah.....	15
Using Lek Counts to Track Population Response to Management	15
Translocations to Augment Declining Sage-grouse Populations.....	17
Predation Management	18
Habitat Management, Arthropods, and Sage-grouse Production.....	19
Grazing and Sagebrush Treatment: Consequences for Winter Habitat	19
Tall Structures and Sage-grouse	21
Genetic Connectivity	23
Funding Partners	23
Box Elder County Adaptive Resources Management (BARM) Sage-Grouse Local Working Group	25
Castle Country Adaptive Resources Management (CaCoARM) Sage-Grouse Local Working Group	28
Color Country Adaptive Resources Management (CCARM) Sage-Grouse Local Working Group	29
East Box Elder County Adaptive Resources Management (EBARM) Sage-Grouse Local Working Group	31
Morgan/Summit Adaptive Resources Management (MSARM) Sage-Grouse Local Working Group	32

Parker Mountain Adaptive Resources Management (PARM) Sage-Grouse Local Working Group	34
Rich County Coordinated Resources Management (RICHCO) Sage-Grouse Local Working Group	36
Southwest Desert Adaptive Resources Management (SWARM) Sage-Grouse Local Working Group	38
Strawberry Valley Adaptive Resources Management (SVARM) Sage-Grouse Local Working Group	39
Uintah Basin Adaptive Resources Management (UBARM) Sage-Grouse Local Working Group	41
West Desert Adaptive Resources Management (WDARM) Sage-Grouse Local Working Group	43
References	45
Appendix 1. Research Published Since the Utah Plan Was Signed (2013-2016)	49

Figure

Figure 1. Greater Sage-grouse Management Areas (SGMAs) within Utah. The SGMAs (outlined in red) represent the best opportunity for high-value, focused conservation efforts for the species in Utah (Dahlgren et al. 2016a). The conservation approach outlined in the Utah Plan recognized current land uses and being compatible with species conservation, and identified potential future uses which may cause conflict with the needs of the species. The sage-grouse populations within the SGMAs all lend themselves to increases through appropriate protection and habitat enhancements, so each SGMA identifies and maps areas on the landscape that provide these additional habitat enhancement opportunities (Opportunity Areas) for greater sage-grouse	24
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Status of Greater Sage-grouse Research, Management, and Policy in Utah

2013-2016

Executive Summary

The State of Utah has a long history and tradition of successful wildlife management and conservation. In the case of the greater sage-grouse (*Centrocercus urophasianus*), significant contributions to the science, management, and conservation of the species have been achieved under state management authority. The first strategic plan for greater sage-grouse was developed in 2002, revised in 2009 and again in 2013. Each plan iteration has incorporated the latest research on local sage-grouse ecology and responses to management actions as well as consolidated state-wide strategies to guide future management and conservation in Utah. These cumulative actions validate the role and impact of state management authority and role of voluntary conservation measures in achieving certainty in sage-grouse conservation.

In 1996, Utah State University Extension initiated a long-term collaboration with the state of Utah to develop a community-based conservation (CBCP) adaptive resources management local working group (LWG) process throughout Utah to begin addressing localized threats to sage-grouse and sagebrush obligate species that inhabit Utah. The CBCP has enhanced communications and collaboration among private stakeholders, local, regional and state governments, and state and federal management agencies and mitigated regional and statewide conservation threats to sage-grouse and other sagebrush obligate species. Eight years subsequent to the first CBCP meetings, environmental organizations petitioned the U.S. Fish and Wildlife Service (USFWS) to list the sage-grouse as endangered under the federal Endangered Species Act (ESA).

In March 2010, the USFWS designated the greater sage-grouse (*C. urophasianus*) as a candidate species for ESA protection (USFWS 2010). Their decision was based on continued habitat fragmentation and inadequate regulatory mechanisms at the local, state, and federal levels to curtail the impacts. Because sage-grouse are landscape species that inhabit lands owned and managed by multiple jurisdictions, the preservation of large tracts of suitable habitat and the management of these areas to maintain connectivity between populations will be paramount to their conservation. Listing of the sage-grouse for protection under the ESA would limit state management authority and impact local, state and regional economies.

Within Utah, Governor Gary H. Herbert chartered a Task Force to develop recommendations for a statewide plan for the conservation of sage-grouse and provide for the continued economic health of the state. In 2013, the Conservation of Greater Sage-grouse in Utah (Plan) was published. The Plan was possible because of the two decades of research and community involvement accomplished through the CBCP partnership. In February 2015, Governor Herbert signed an Executive Order (EO) to implement the Plan. The EO recognized and credited the CBCP for conducting the baseline research and community involvement essential to building the

Plan. Because of the CBCP extension and research efforts, the state of Utah possessed unparalleled knowledge about the factors essential to the species conservation. When CBCP local working group (LWG) plans and state and federal agency efforts were aggregated into a statewide plan for sage-grouse, the collective result provided an organized approach for addressing the factors used by the USFWS to measure the success of conservation actions. Dr. Messmer has demonstrated an ability to translate community-based conservation planning into management, and management into population change. Since 1996, the CBCP's partners have restored over 500,000 acres of sage-grouse habitat and protected over 94% of the state's sage-grouse populations on 7.5 million acres in 11 sage-grouse management areas. Since inception, the state of Utah has committed over \$150 million to implement LWG identified incentive-based conservation strategies. Utah sage-grouse populations in the CBCP planning areas have stabilized. Because of the CBCP vision, community involvement in sustainable conservation has dramatically increased. Because of Utah's efforts and others range wide, the USFWS announced in September 2015 that sage-grouse did not warrant ESA protection.

Utah's Conservation Strategy

The Utah Plan (Utah 2013) protects high-quality habitat, enhances impaired habitat, and restores converted habitat for the portion of the range-wide sage-grouse population inhabiting Utah by eliminating USFWS and State identified species conservation threats. The Utah Plan embodies the best available science accumulated over the past 70 years and reflects the ecology of sage-grouse in Utah (Dahlgren et al. 2016a). Utah's Plan is **not lek-centric** as are other state plans and protects 94% of the birds in Utah including small, peripheral populations as well as the southernmost population of sage-grouse across the range.

Greater sage-grouse are managed as an upland game species as well as state sensitive species by the Utah Division of Wildlife Resources (UDWR). Research conducted in the Gunnison Basin of southwestern Colorado and San Juan County in southeastern Utah found that two species of sage-grouse inhabit both states. Sage-grouse populations that occur south and east of the Colorado River in Utah (Grand and San Juan counties) constitute a recently described species of sage-grouse, known as the Gunnison sage-grouse (*C. minimus*).

Greater sage-grouse are located throughout the rest of the state. The Gunnison Sage-grouse Conservation Plan was completed in 2000 by the San Juan County Gunnison Sage-Grouse Working Group (SWOG 2000). This document has been used to guide management of Gunnison sage-grouse in Utah. Therefore, Gunnison sage-grouse management and conservation strategies are not included in this narrative.

Utah supports an estimated 6% of the total range-wide sage-grouse population (Western Association of Fish and Wildlife Agencies 2015). These populations are distributed throughout the northern, western, and central parts of Utah where they occupy a discontinuous habitat base that reflects the natural topography and geography of the Utah landscape. Greater sage-grouse were thought to have been historically distributed in all 29 Utah counties. This belief is based largely on the historical distribution of sagebrush, pioneer records, and museum specimens (Beck et al. 2003). Current estimates suggest that sage-grouse may occupy up to 8 million acres or

about 41% of the historic habitats in Utah (Beck et al. 2003). The largest Utah sage-grouse populations are found in western Box Elder County, on Blue and Diamond Mountains in Uintah County in northeastern Utah, in Rich County, and on Parker Mountain in south central Utah. Smaller populations are found dispersed throughout the state. The Utah Plan (2013) encompasses over 7.5 million acres of the currently occupied habitat providing the best opportunity to conserve the species in the state.

Utah established an extensive statewide database which documents more than 30,000 sage-grouse locations. This database, under the direction of Dr. Terry Messmer at Utah State University (USU), also includes seasonal habitat-use data recorded by graduate students and technicians supervised by research faculty at USU, Brigham Young University (BYU), and UDWR biologists using established range-wide protocols. To date, the Utah database for sage-grouse is the most comprehensive source for local population occurrences of its kind as these records directly reflect sage-grouse habitat use.

Utah's Sage-grouse Local Working Groups

As half of Utah's greater sage-grouse populations occur on private lands, successful conservation depends upon gaining broad support from local communities and private landowners. In 1996, USU Extension, through the CBCP, began organizing and facilitating sage-grouse local working groups throughout Utah. The CBCP initiated a process that enhanced coordination and communication between community-based adaptive resource management working groups, private, and public partners. Additionally, the program developed and implemented "seamless" plans for designated Utah geographic areas that contribute to the conservation of sage-grouse and other wildlife species that inhabit Utah's sagebrush ecosystems and enhance the economic sustainability of local communities. Membership and participation in LWG meetings and has grown steadily in Utah. The LWG sage-grouse conservation plans, previous annual reports, and meeting minutes can be accessed at www.utahcbcp.org.

Currently, there are 11 regional Local Working Groups (LWGs) operating in Utah. Each LWG has developed a local conservation plan was incorporated into the Utah Plan (2013). The LWGs and their plans provided the basis of implementation of sage-grouse actions in Utah. The CBCP facilitators worked closely with LWG members, state and federal, and private partners to implement the Utah Plan's (2013) goal of protecting high-quality sagebrush habitat to address and ameliorate the threats facing the sage-grouse while balancing the economic and social needs of the residents of Utah through a coordinated program. The Utah Plan (2013) incorporates and enhances the earlier efforts of LWGs to protect sage-grouse and their habitats.

The CBCP LWGs conservation plans encompass the historical range of greater sage-grouse in Utah as identified in the Strategic Management Plan for Sage-grouse (UDWR 2002, 2009) and the Utah Plan (2013). The CBCP has provided long-term support to ensure the LWG administrative needs are met. Since inception, the CBCP has been financially supported by UDWR, Utah State University Extension, the Jack H. Berryman Institute, private landowners, public and private natural resources management and wildlife conservation agencies and organizations. Implementation of the Utah Plan (2013) will require enhanced communication and cooperative efforts among local, state, and federal agencies, working in concert with private

interests. In addition to participating as active contributors to the Utah planning process, the LWGs continue to implement their local sage-grouse conservation plans.

The CBCP also have developed and released an app based on the publication entitled “*Sage-grouse Habitat in Utah: A Guide for Landowners and Managers*” (Utah CBCP 2011). Over 5,000 copies of the printed publication were distributed. The app is the first of its kind, and although developed in Utah, is applicable throughout the sage-grouse range, which includes 11 western states and two Canadian provinces. The app provides managers and landowners with immediate and pertinent information about sagebrush management and sage-grouse habitat needs and can be accessed from anywhere in the field. It can assist in planning management actions to help conserve the sage-grouse population. The app will help landowners, federal, and state partners better recognize characteristics of favorable sage-grouse habitat and assist them in developing projects to benefit species conservation across its range.

The Utah Plan (2013) endorsed and incorporated the CBCP LWG process, network, education and outreach efforts, and local conservation plans. The Utah Plan (2013) provided additional guidance and support to continue area-specific management programs focused on maintaining, improving, and restoring local sage-grouse populations and their habitats. The LWGs now operate under the umbrella of the Utah Plan (2013). The LWG plans are based on research conducted by USU, Brigham Young University, UDWR, and the U.S. Forest Service (USFS). This research continues to provide the scientific basis for the Utah Plan.

National Recognition for Utah’s Incentive-Based Approach to Conservation

The Utah CBCP was nationally recognized for its role in developing the Utah Plan. In 2015 the Utah CBCP was recognized by the Western Extension Directors with the Award of Excellence. In 2016, The Wildlife Society further recognized the CBCP conservation impacts with its Group Achievement Award (<http://wildlife.org/conservation-of-the-future/>). On more than one occasion, the CBCP has been touted as the embodiment of Aldo Leopold’s vision for wildlife conservation in North America. Ranchers Jay and Diane Tanner, long-time participants in the CBCP, have noted that the program has deepened and enriched stakeholders’ interest in and appreciation for the role of science in public and private land management.

In addition to the Group Achievement Award, Dr. Terry Messmer, CBCP Director, was awarded the 2016 Caesar Kleberg Award for Excellence in Applied Research (<http://wildlife.org/kleberg-award-develops-dynamic-working-group-process/>). The award recognized his leadership in conducting the two decades of research that provided the scientific basis for the publication of Utah’s Conservation Plan for Greater Sage-grouse in 2013 and his leadership in developing and directing the Utah CBCP.

The Science Foundation for Utah’s Sage-grouse Management Areas

The Sage-grouse Management Areas (SGMAs) represent the best opportunity for high-value, focused conservation efforts for the species in Utah. They were formulated to reflect the biological and geographical areas currently occupied by a population or populations of sage-

grouse. They were specifically designed, using Utah's greater sage-grouse data and research, to encompass the habitats used by sage-grouse during seasonal movements.

The USFWS has emphasized the need to focus conservation efforts on protecting and enhancing the priority habitats as the essential mechanism for species conservation (USFWS 2013). In addition, better knowledge of sage-grouse seasonal movements for a species is essential to conservation planning and implementation efforts (USFWS 2013). Generally, sage-grouse seasonal habitats have been defined using three broad categories: breeding, summer, and winter. Breeding habitats consist of areas where pre-laying, lekking, nesting, and early brooding activities occur; summer habitat consist primarily of late brooding areas; and winter habitat occurs in areas where sagebrush is available above the snow throughout the winter for food and cover. Some populations are considered non-migratory, using a specific landscape to meet all their seasonal habitat requirements while other populations may migrate > 30 miles between seasonal habitats. Within populations, individuals may also exhibit unique movement strategies between seasonal habitats. The Utah Plan (2013) synthesized UDWR sage-grouse lek location data and seasonal movement information, obtained by two decades of research to delineate eleven SGMAs. This approach, based on the best available research and data, recognized and accepted current land uses and identified potential future uses that may conflict with species conservation (Utah Plan 2013, Dahlgren et al. 2016a, Dahlgren et al. 2016b).

Utah's SGMAs encompass > 90 percent of Utah breeding populations, seasonal movements, and the landscapes that provide the greatest potential to increase sage-grouse usable space through habitat protection and enhancements (Dahlgren et al. 2016a). The SGMAs incorporated sage-grouse radio-telemetry location data collected from 13 study areas from 1998 to 2013 to determine seasonal movements across populations.

The seasonal movements of Utah's sage-grouse populations reflect availability of habitat space. Populations occupying smaller isolated habitats moved shorter distances than populations occupying larger contiguous habitats, which are more typical of habitats in other states. The seasonal movement distances for Utah sage-grouse populations were generally less than those reported range-wide but were reflective of localized and the naturally non-contiguous nature of many sagebrush habitats in the southern Great Basin and Colorado Plateau.

Utah Sage-grouse Management Areas Encompass Seasonal Habitats

Based on telemetry-data, Utah's SGMAs encompassed 88%, 80%, and 89% of all nest, summer, and winter locations, respectively. When weighted by the sum of maximum males counted for each lek within each study area during the years with radio-marked sage-grouse, the percentages increased to 97%, 95%, and 96% of nest, summer, and winter locations, respectively. Based on this analysis, Utah's SGMAs achieved the USFWS recommendations of targeting conservation efforts in priority areas (USFWS 2013).

The Utah Plan (2013) was developed to protect habitat and associated populations of sage-grouse by implementing the strategic landscape planning principles. The Utah Plan designates priority areas for sage-grouse conservation (USFWS 2013). Using a strategic landscape management approach optimizes species conservation planning benefits by considering investment tradeoffs

which favor areas that are likely to yield the greatest conservation returns over areas that have limited or compromised potential to respond positively to management actions. These distinctions in tradeoffs across landscapes are becoming increasingly paramount to the success of future conservation efforts in the face of limited resources.

Research completed by USU confirms that sage-grouse populations in the Rich County area of Utah are connected to populations in eastern Idaho and western Wyoming (Cardinal and Messmer 2016), populations in Box Elder, Tooele, Juab, and Beaver Counties are connected to populations in southern Idaho and Nevada (Reinhart et al. 2013, Robinson and Messmer 2013), and populations in the Uintah and Daggett County areas are connected to populations in Wyoming and Colorado (Bredinger et al. 2013). The Utah Plan recognizes the importance of managing sage-grouse populations that cross jurisdictional boundaries during seasonal movement. The Utah Plan supports the premise that sage-grouse conservation is achievable because the species are still wide spread throughout western North America and large intact sagebrush communities still exist. As such the conservation actions completed in Utah provide a framework for more certainty for populations that inhabit sage-grouse landscapes in adjoining states. However, the Utah Plan also recognizes that because sage-grouse population growth rates are relatively slow compared to other gallinaceous birds and sagebrush systems respond over long time frames to restoration efforts, it may take several breeding cycles before management effects are noticeable (Messmer 2013, Dahlgren et al. 2016b).

Increasing Useable Space for Sage-grouse

Sage-grouse occupied habitat in Utah largely reflects the topography and geography of Utah. The geography is characterized by mountainous terrain, separated by broad valleys in the Great Basin, and by deeply incised canyons in the Colorado Plateau. Sage-grouse habitat may be found in intact blocks or natural fragments in the Great Basin, or in disconnected “islands” of habitat in the Colorado Plateau (Dahlgren et al. 2016a).

The Utah Plan (2013) has placed emphasis on increasing usable space for sage-grouse in naturally fragmented habitat as a means of increasing both production and connectivity. The reduction and removal of juniper (*Juniperus* spp.) and pinyon pine (*Pinus edulis*; PJ) encroachment in SGMAs where the sagebrush and herbaceous understory is relatively intact may provide the greatest potential to create and enhance sage-grouse habitat in Utah.

Conifer encroachment into sage-grouse habitat has been identified as a threat to sage-grouse populations. Utah research suggests sage-grouse will use areas within SGMAs where PJ has been removed within a short period of time (< 1 to 3 years) post-treatment, especially if the treatment site has sagebrush remaining in the understory, mesic areas nearby, and the site is near existing sage-grouse use areas (Frey et al. 2013, Cook et al. 2017). Field observations in 2015 have documented a sage-grouse female successful nesting in areas where conifer removal projects were being conducted. The female nested under sagebrush in an area where the conifer canopy have been removed by a bullhog (Sandford et al. 2015). In the four years previous to the bullhog treatment, sage-grouse use had never been documented in the area during on-going habitat use studies where we were monitoring radio-marked birds. Sandford et al. (2017) reported that female sage-grouse on the Box Elder SGMA that nest in or near PJ treatments area had increased

nest and brood success. This research was the first to document an effect of conifer removal on sage-grouse production. These data and observations validate that the Utah Plan's effort to increase usable space through PJ removal projects has the potential to benefit sage-grouse populations in Utah.

Enhancing Sage-grouse Brood-rearing Habitats

Sage-grouse have the lowest reproductive rate of any North American game bird. Thus it is believed populations may be less able to recover from population declines as quickly as those of most other game birds. However, recovery rate may also be affected by favorable environment conditions (Guttry et al. 2013a, Caudill et al. 2014a). Research conducted on Parker Mountain SGMA has provided new knowledge regarding this relationship.

Parker Mountain is located in south-central Utah in Garfield, Piute, and Wayne counties. Parker Mountain is approximately 265,584 acres and is managed by private, state, and federal entities. The Parker Mountain Adaptive Resources Management Local Working Group (PARM) was organized in 1997 with one central goal – they wanted to “grow more grouse” to mitigate the risks of the species being listed. Although concerns about declining sage-grouse populations led to the formation of PARM, the group's commitment to sustaining their community and its natural resources through research and management has been the driving force keeping the group working together.

In the past decade, PARM's efforts have increased sage-grouse populations from an estimated 125 males counted on leks in 1996 to over 1,400 in 2007. The habitat work conducted to “grow more grouse” has been accomplished largely with funding provided through conservation provisions of USDA's Farm Bill. The PARM has implemented a long-term adaptive resource management habitat monitoring and research program to evaluate the effects of management actions on greater sage-grouse and other wildlife populations. This research is part of a long-term database that has provided new insights regarding the effects of management actions on sage-grouse vital rates and ultimately recruitment in Utah and range-wide. These contributions are discussed below.

Increasing Chick Survival

Obtaining timely and accurate assessment of sage-grouse chick survival and recruitment is an important component of species management and conservation. Dahlgren et al. (2006) studied the effects of reducing sagebrush canopy cover to enhance forb availability for sage-grouse chicks in the Parker Mountain SGMA. Low chick survival was identified as major factor limiting recruitment. Dahlgren et al. (2006) evaluated the effects of two mechanical (Dixie harrow and Lawson aerator) treatments and one chemical (Tebuthiuron) treatment on sage-grouse use of brood-rearing habitats. To conduct this experiment, Dahlgren et al. (2006) identified 19 100-acre plots that exhibited 40% mountain big sagebrush (*A. tridentata vaseyana*) canopy cover and randomly assigned 16 as treatment or controls (4 replicates each). The Tebuthiuron and Dixie-harrow-treated plots exhibited increased forb cover than the control plots post-treatment. Sage-grouse brood use was higher in Tebuthiuron than control plots and the increased use was attributed to increased herbaceous cover, particularly forbs. In all plots, sage-

grouse use was greatest within 10 m of the edge of the treatments where adjacent sagebrush cover was still available. Although the treatments studied resulted in the plots achieving sage-grouse brooding-rearing habitat guidelines, they recommended caution in applying these observations at lower elevations, in areas with less annual precipitation or a different subspecies of big sagebrush.

Based on these results, PARM implemented a long-term management program where up to 500 acres (200 ha) of sage-grouse breeding habitat where sagebrush cover exceeded 40 % canopy cover were treated annually with low rate applications of Tebuthiuron. Utah State University in partnership with PARM, UDWR, BLM, and USFS continued to monitor sage-grouse populations in response to the treatments and also evaluated the survey methodology used to determine sage-grouse response.

However, land-use treatments that remove or reduce sagebrush canopy in areas occupied by sage-grouse are controversial given the species' conservation status. In 2015, Utah Governor Gary R. Herbert signed an Executive Order (EO) that included a statement that sagebrush removal in sage-grouse habitats was highly discouraged and that future sagebrush treatment using state funding could only be justified if a net benefit to sage-grouse would be probable. Although many studies have shown negative impacts of sagebrush treatments on sage-grouse, research completed by Utah State University on the Parker Mountain Sage-grouse Management Area (SGMA) suggest a positive effects for the species if the treatments occur in higher elevation late brood-rearing habitats. Sagebrush removal treatments completed at large scales and/or in breeding and wintering habitats is certainly not appropriate. However, in high elevation late summer brooding habitats when grouse use more open canopy areas with higher forb cover, small mosaic treatments may improve brooding habitat.

Researchers from BYU and USU studied mechanical treatments of sagebrush that were implemented in Strawberry Valley SGMA in 2009. They analyzed before and after location data from radio-marked sage-grouse using the area to assess habitat selection before and after treatments. They found that sage-grouse, especially during the brooding period selected for treated areas following sagebrush canopy removal compared to pre-treatment years. This study occurred in a high elevation highly resilient mountain big sagebrush community with high average annual precipitation. Similar studies in lower elevations of Wyoming big sagebrush have not shown such positive results. This new study, along with other studies from Utah, provided the parameters and justification required by the EO for when sagebrush treatments would likely be beneficial to sage-grouse for future management decisions (Baxter et al. 2017).

Dahlgren et al. (2010) examined factors that influenced chick survival. They radio-marked 1- to 2-day-old sage-grouse chicks in 2005–2006 on Parker Mountain and monitored their survival to 42 days. They then modeled effects of year, hatch date, chick age, brood-female age, brood-mixing, and arthropod abundance on chick survival. Their best model revealed an average survival estimate of 0.50 days to 42 days, which was the highest level ever documented range wide for the species.

Brood-mixing (chicks leaving natal brood to join with other non-natal broods) occurred in 21% (31/146) of chicks and 43% (18/42) of broods they studied. Moreover, yearling females had more chicks leave their broods than did adults. They found that survival may be higher among chicks that switch broods compared to those that stayed with their natal mother until fledging. Thus, brood-mixing may be an adaptive strategy leading to increased sage-grouse chick survival and higher productivity, especially among chicks born to yearling females. Their findings also indicated that arthropod abundance may be an important driver of chick survival, particularly during the early brood-rearing period and, therefore, sage-grouse populations may benefit from a management strategy that attempts to increase arthropod abundance via brood habitat management (Dahlgren et al. 2006).

Guttry et al. (2013a) refined this research by studying the effects of landscape scale environmental variation on sage-grouse chick survival. Effective long-term wildlife conservation planning for a species must be guided by information about population vital rates at multiple scales. Sage-grouse population growth rates appear to be particularly sensitive to hen and chick survival rates. While considerable information on hen survival exists, there is limited information about chick survival at the population level.

Guttry et al. (2013a) analyzed sage-grouse chick survival rates from the Parker Mountain SGMA and south central Idaho across 9 years to further determine what landscape variables may affect survival and ultimately recruitment. They analyzed the effects of 3 groups of related landscape scale covariates (climate, drought, and phenology of vegetation greenness). Models with phenological change in greenness (NDVI) performed poorly, possibly because seasonal variation in forb and grass production was being masked by sagebrush canopy. The top drought model resulted in substantial improvement in model fit relative to the base model and indicated that chick survival was negatively associated with winter drought. These results suggest possible effects of climate variability on sage-grouse chick survival if winter droughts become a common occurrence.

Juvenile Sage-grouse Survival

Little information has been published on mortality of juvenile sage-grouse or the level of production necessary to maintain a stable population. Among western states, long-term juvenile to hen ratios have varied from 1.40 to 2.96 juveniles per hen in the fall. In recent years, this ratio has declined to 1.21 to 2.19 juveniles per hen. It has been reported that at least 2.25 juveniles per hen should be present in the fall population for stable to increasing sage-grouse populations. Caudill et al. (2013), Caudill et al. (2014), and Caudill et al. (2016a) provided new range wide insights regarding the role of juvenile sage-grouse ecology.

Sage-grouse are entirely dependent on sagebrush for food and cover during winter. Thus the loss or fragmentation of important wintering areas could have a disproportionate affect on population size. To study the juvenile sage-grouse winter habitat use, Caudill et al. (2013) radio-marked and monitored 91 juvenile sage-grouse in south central Utah from 2008 to 2010 (Parker Mountain SGMA). Thirty-four individuals survived to winter (January to March) and were used to evaluate winter habitat use.

They found that juvenile sage-grouse used winter habitats characterized by 0 to 5% slopes regardless of aspect and slopes 5 to 15% with south-to-west facing aspects. The importance of high slope (5 to 15%) wintering habitats has not been previously documented in the sage-grouse literature. Most winter use was on a small proportion (3%; 2,910 ha) of available habitat. These important wintering habitats may not be readily identifiable in typical years, and consequently, due to their elevation, may be more susceptible to land management treatments focused on increasing early season livestock or big game winter forage, rendering them unsuitable for winter use by sage-grouse. Prior to implementing land management treatments in lower elevation sagebrush sites with slopes $\leq 5\%$ regardless of aspect and slopes 5 to 15% south to west in aspect, managers should consider the potential effects of such treatments on the availability of suitable winter habitat to mitigate against winters with above-normal snowfall. This information has been incorporated in the Utah Plan (2013) and is the basis of an ongoing research effort coordinated by USU to model general and essential winter habitats.

Adult sage-grouse females and juvenile survival has been reported to influence population growth rates (Dahlgren et al. 2010). However, assessing the sensitivity of population growth rates to variability in juvenile survival has proven difficult because of limited information concerning this potentially important demographic rate. Sage-grouse survival rates are commonly assessed using necklace-type radio transmitters. Recent technological advances have led to increased interest in the deployment of dorsally mounted global positioning system (GPS) transmitters for studying sage-grouse ecology. However, the use of dorsally mounted transmitters has not been thoroughly evaluated for sage-grouse, leading to concern that birds fitted with these transmitters may experience differential mortality rates.

Caudill et al. (2014a) also evaluated the effect of transmitter positioning (dorsal vs. necklace) on juvenile sage-grouse survival using a controlled experimental design with necklace-style and suture-backpack very high frequency (VHF) transmitters. They monitored 91 juveniles captured in the Parker SGMA from 2008 to 2010. Nineteen females were equipped with backpacks, 14 males with backpacks, 39 females with necklaces, and 19 males with necklaces. They used Program MARK to analyze juvenile survival data. Although effects were only marginally significant from a statistical perspective, sex and transmitter type had biologically meaningful impacts on survival. Dorsally mounted transmitters negatively affected daily survival. Temporal variation in juvenile sage-grouse daily survival was best described by a quadratic trend in time, where daily survival was lowest in late September and was high overwinter. An interaction between the quadratic trend in time and year resulted in the low point of daily survival shifting within the season between years (27 vs. 17 Sep for 2008 and 2009, respectively). Overall (15 Aug–31 Mar) derived survival ranged 0.42–0.62 for females and 0.23–0.44 for males.

For all years pooled, the probability of death due to predation was 0.73, reported harvest was 0.16, unreported harvest was 0.09, and other undetermined factors were 0.02. They reported 0% and 6.8% crippling loss (from hunting) in 2008 and 2009, respectively. Caudill et al. (2014a) recommended the adoption of harvest management strategies that attempt to shift harvest away from juveniles and incorporate crippling rates. In addition, they recommended that future survival studies on juvenile sage-grouse should use caution if implementing dorsally mounted transmitters because of the potential for experimental bias. This has implications of studies that use rump mounted global positioning system (GPS) radio-collars to assess sage-grouse survival

rates. The use of GPS radio-collars without comparable vital rate data collected by using VHF radio-collars could bias sage-grouse survival rate estimates.

Sage-grouse Female Reproduction Costs and the Effects of Climate

Research on long-lived *iteroparous* species has shown that reproductive success may increase with age until the onset of senescence and that prior reproductive success may influence current reproductive success. These complex reproductive dynamics can complicate conservation strategies, especially for harvested species. Further complicating the matter is the fact that most studies of reproductive costs are only able to evaluate a single measure of reproductive effort.

Caudill et al. (2014b), Caudill et al. (2016a), and Caudill et al. (2016b) evaluated the effects of climatic variation and reproductive trade-offs on multiple sage-grouse reproductive vital rates. Based on over a decade of field observations obtained from sage-grouse inhabiting the Parker Mountain SGMA, they hypothesized that reproduction was influenced by previous reproductive success. They studied female reproductive activity from sage-grouse radio-marked and monitored from 1998–2010 on the SGMA to assess effects of climate and previous reproductive success on subsequent reproductive success. Neither nest initiation nor clutch size were affected by climatic variables or previous reproductive success. However, they found that both nest and brood success were affected by climatic variation and previous reproductive success. Nest success was highest in years with high spring snowpack, and was negatively related to previous brood success. Brood success was positively influenced by moisture in April, negatively associated with previous nest success, and positively influenced by previous brood success. Both positive and negative effects of previous reproduction on current year reproduction were reported suggesting high levels of individual heterogeneity in female reproductive output (Dahlgren et al. 2010). Their results supported previous research in indicating that climatic variability may have significant negative impacts on reproductive rates (Gutteny et al. 2013a). These results support the Utah Plan objectives of increasing the sage-grouse habitat base. The creation of a larger habitat base will increase the potential for increased production and recruitment in years when climatic conditions are favorable (Dahlgren et al. 2010, Gutteny et al. 2013a, Caudill et al. 2014b, Caudill et al. 2016b).

Sage-grouse Responses to Active Management

The Utah Plan (2013) protects high-quality habitat, enhances impaired habitat, and restores converted habitat for the portion of the range-wide sage-grouse population inhabiting Utah by eliminating USFWS and State identified species conservation threats. In addition to Utah efforts, BLM, USFS, and the other western states with sage-grouse populations and habitats, have initiated planning and other actions designed to mitigate the identified threats, protect important sagebrush habitats, and develop adequate regulatory mechanisms to eliminate the need for a listing under the ESA. The science used to develop the Utah Plan (2013) is the basis of the BLM and USFS planning processes in the state. The following are elements of Utah's active management to address threats to greater sage-grouse.

Sage-grouse Hunting in Utah

Although hunting was not cited as a high priority threat by the USFWS (2010), stakeholders question why state wildlife agencies continue to allow sage-grouse hunting given the status of the species. Limited hunting of sage-grouse is currently allowed by permit only in the Box Elder, Rich-Morgan-Summit, Uintah, and Parker Mountain Emery SGMAs. These SGMAs have the largest stable populations. Hunt quotas are determined annually based on very conservative estimates, and are based on criteria found in the Utah Plan. Decreases in population in any particular year due to natural or human caused events, will lead to a reduced number of hunting permits or cancellation of the hunt for the year.

Fees collected from hunters are typically expended only for the benefit of species that is hunted. If sage-grouse were not hunted, expenditures from that funding source for the species' benefit would cease. Sage-grouse hunting also maintains the interest of the sportsman's community by continuing a viable hunting program and allows for collecting scientific data regarding recruitment from the birds harvested (Utah Plan 2013).

In 2008, the demand for sage-grouse hunting permits in Utah exceeded their availability, raising questions about why hunters choose to pursue this species. Guttery et al. (2015) hypothesized that the pending ESA listing decision increased hunter demand for permits. They surveyed randomly selected hunters who obtained permits to hunt sage-grouse in Utah in 2008-2010 (n = 838) to determine their motivations for hunting sage-grouse and determinants of hunter satisfaction. The most commonly reported reasons for hunting sage-grouse were to spend time with family, for tradition, and meat. Although the potential ESA listing was not a major motivational factor in 2009 or 2010, the percentage of respondents selecting this option did increase by 7%. Hunter awareness of the ESA listing status increased by 18% during this period. Sage-grouse hunter participation rates declined by 1.63% between 2008 and 2009 continuing a trend documented by UDWR since 2004 (UDWR, unpublished data). However, participation rates experienced an approximate 5% increase between 2009 and 2010.

Guttery et al. (2015) recommended that conservation strategies for sage-grouse must carefully weigh the social and biological implications of hunting. Because of the role of long-lived adult females in brood-mixing, and ultimately production (Dahlgren et al. 2010), the UDWR delayed the opening of the sage-grouse hunt to reduce the harvest on adult females. This change allowed for increased amalgamation of the individual broods into larger flocks to reduce adult brood female risks to harvest. Guttery et al. (2015) concluded the adaptive harvest regulations adopted by UDWR that link sage-grouse hunting opportunities to annually estimated population sizes and female reproductive contributions constitute an effective and conservative harvest management strategy based on the best available science.

Using Lek Counts to Track Population Responses to Management

Obtaining valid population estimates is essential to understanding the effects of management and conservation strategies on population trajectories. The Utah Plan (2013) proposes specific strategies to protect, maintain, improve, and enhance sage-grouse populations and habitats within the established SGMAs. Unlike other state plans, the Utah Plan (2013) establishes specific

annual population and habitat objectives. Specifically for sage-grouse populations, the Utah Plan proposes to sustain an average male lek count of 4100 males (based on a ten-year rolling average on a minimum of 200 monitored leks) and increase the population of males to an average of 5000 (based on the same ten-year rolling average on a minimum of 200 monitored leks) within the established SGMAs.

Leks are the center of breeding activity for sage-grouse. Male sage-grouse begin to congregate on leks in late February/early March and perform a ritualized courtship display. Courtship displays are strongly correlated to pre and early dawn hours and quickly wane within a couple of hours following sunrise. Females are attracted to leks by the male courtship displays and mating is thought to primarily occur on the lek. Lek attendance may continue as late as early June, but typically peaks during April in Utah (Guttery et al. 2011).

As sage-grouse populations decline, the number of males attending leks may decline or the use of some leks may be discontinued. Likewise, as populations increase, male attendance may increase and/or new leks may be established or old leks reoccupied. There is little or no evidence that suggests lek habitat is limiting. Additional lek habitat can be created if needed, but does not guarantee that sage-grouse males will utilize the created lek habitat.

Lek counts have been widely used as an index for sage-grouse population change and to guide management decisions (Guttery et al. 2011). Counts of male sage-grouse attending leks during the breeding season have also been used to estimate the breeding population size by assuming a detection probability and sex ratio. In the latter case, managers often assume a 2:1 female biased ratio. However, this sex ratio has not been validated and may result in biased population estimates. The UDWR had assumed a 75% detection rate for male sage-grouse on leks and a 2:1 female biased sex ratio (UDWR 2002, 2009).

Guttery et al. (2011) evaluated the validity of using lek-counts to estimate populations in Utah. They concluded that the standard UDWR counts which are used to monitor most sage-grouse leks may omit, on average, 2 males. Additionally, they found that only 56% of all available males were actually attending leks at any given time. Their results demonstrated that male lek attendance rates fluctuate throughout the breeding season, but typically peaked at or before sunrise. As such, they recommended that lek counts should be conducted as early as possible to obtain the most accurate counts. This may result in fewer leks being counted per morning but will provide more representative data.

Guttery et al. (2013b) also evaluated sex ratios at hatch, 42 days of age, and at harvest to determine if sex ratios were biased for sage-grouse in Utah. Sex ratios at hatch and at 42 days of age did not differ from parity. Harvest data suggested that sage-grouse may exhibit a slight female-biased sex ratio (1.458:1) in the fall. The Utah Plan (2013) has incorporated this new information into sage-grouse population estimates based on lek count data.

The validity of lek counts for monitoring changes in population numbers remains suspect (Guttery et al. 2011). However, their utility as a measure of population production has never been evaluated. Dahlgren et al. (2016c) evaluated using standard lek count protocols which followed range wide guidelines to determine if they reflected change in population growth or

lambda. They concluded that male-based leks counts of sage-grouse can be an effective index to overall population change. These results have range wide implications as they provide a basis for states to track sage-grouse population responses to management and conservation actions.

Translocations to Augment Declining Populations

Translocations have been recommended to reestablish, augment, and sustain genetic diversity in declining wildlife populations, including sage-grouse. Utah has experimented with sage-grouse translocations intended as conservation efforts to establish and/or enhance existing populations. The sage-grouse populations on Wildcat and Horn Mountains (Carbon SGMA) provides an example of a successful translocation. From 1987-1990 15 males and 35 hens with juveniles were released in the area. The populations still exist with 27 strutting males observed in 2008.

The Strawberry Valley SGMA in central Utah provided a dramatic example of the decline of sage-grouse in Utah. In 1939, the UDWR estimated that 3,000-4,000 sage-grouse inhabited this high mountain valley in the 1930s. In 1999, the Strawberry Valley SGMA population was estimated at 250-350, representing a population decrease of 88-94%. Most of this decline was attributed to anthropogenic causes (roads, Strawberry Reservoir, non-native predators, and reductions in habitat quantity and quality). The population in Strawberry Valley SGMA is now estimated at > 500 breeding adults. This increase is attributed to the success of translocation efforts, habitat improvements, and predator control (Baxter *et al.* 2013). Characteristics common to successful sage-grouse translocations include suitable contiguous sagebrush habitats enveloped by geomorphic barriers, a residual resident population, pre-nesting releases, and active mammalian predator management (Baxter *et al.* 2013, Baxter *et al.* 2017).

Because of increasing habitat fragmentation, UDWR wildlife managers were interested in learning if translocations can be used to sustain smaller meta-populations that inhabit remote landscapes that exhibited suitable habitat but lacked geomorphic barriers. From 2009-2010, Gruber-Hadden *et al.* (2016) compared vital rates and behaviors of 60 translocated and 15 resident radiomarked female sage-grouse and their broods on Anthro Mountain, in the Ashley National Forest of northwest Utah. Translocated birds were released within 200 m of an active lek on Anthro Mountain. Anthro Mountain consists of 2,500 ha of suitable but non-contiguous breeding habitat ranging in elevation of 2,400-2,800 m. The sage-grouse that were translocated were captured on the Parker Mountain SGMA. The Parker birds were selected as the source population for the translocation because the population was robust and stable, ≥ 100 km from the release site, and was genetically compatible to Anthro Mountain sage-grouse (Briedinger *et al.* 2013). The source area also exhibited topography and elevations similar to Anthro Mountain.

Adult survival, nest success, and brood success estimates for both resident and translocated birds varied annually, but were lower than range wide averages (Gruber *et al.* 2016). Adult survival was higher in 2010 than 2009 and survival differed among resident status (i.e., resident, newly translocated, and previously translocated). Nest success was higher for resident than translocated birds and was positively related to grass height. In 2009 and 2010, chick survival to day 50 was higher for chicks of resident than translocated females. Chick survival for both groups was positively related to grass cover and grass height. Area of occupancy for translocated (45 km²) and resident females (40 km²) overlapped by 68%.

Although the translocated birds were genetically similar to the resident birds (Breidinger et al. 2013), and exhibited similar behavior patterns, the low overall vital rates for both groups suggested that managers may need to fully consider the potential interaction of vegetation structure, seasonal habitat juxtaposition, and their potential relationship to predation when planning future translocations to augment isolated, remote sage-grouse populations that occupy space limited and fragmented habitats.

Predation Management

Increased predation has been identified as a population threat in several SGMAs. This threat has primarily been associated with increased populations of corvids (primarily ravens) and emergence of non-native canids (Baxter et al. 2013, Robinson and Messmer 2013). While predator control has not been recognized as a long-term solution to a general rangewide decline in populations of greater sage-grouse, it may be an effective tool to increase survival of specific populations (Baxter et al. 2013).

Baxter et al. (2013) studied the survival rates of sage-grouse that had been translocated to the Strawberry Valley SGMA over a 13 year period. Their objectives were to estimate seasonal and annual survival rates for resident and translocated sage-grouse and identify environmental and behavioral factors associated with survival to include mammalian predator control. They captured and radio-collared 535 individual sage-grouse (male and female, resident and translocated). Their top model of survival, which accounted for 22% of the AIC_c weight, included 3 seasons that varied by year where rates were influenced by residency, sex, and whether a female initiated a nest. A group-level covariate for the number of canids killed each year was supported as this variable improved model fit. Annual estimates of survival for females ranged between 28% and 84% depending on year and translocation source. Survival was consistently highest during the fall–winter months with a mean monthly survival rate of 0.97 (95% CI = 0.96–0.98). They suggested managers consider enhancing nesting habitat, translocating sage-grouse, and controlling predators to improve survival rates of sage-grouse (Baxter et al. 2013).

Predation is often tied to habitat quality, particularly in areas where an interface exists between human disturbance and the remaining habitat (Utah Plan 2013). Many of Utah's sage-grouse populations inhabit naturally-fragmented habitats. Robinson and Messmer (2013) studied sage-grouse populations that inhabit the Sheeprock and Ibaph SGMAs in Utah's West Desert. These areas are geographically separated by the Great Salt Lake. Livestock grazing by domestic cattle was the dominate land use, and mammalian predator control for livestock protection was conducted in both SGMAs. However, corvid control was conducted only in the Sheeprock SGMA. During the study, they also documented 6 new leks that had not been previously surveyed.

Habitat structure was similar at brood-rearing and random sites for both SGMAs. They also reported higher nest and brood success and the ratio of chicks per successful brood for both populations in 2005 than 2006. Spring precipitation in 2005 was twice the 30-year average following a 5-year drought. However, chick recruitment estimates for both populations regardless of year were lower than reported in the published literature. Adult sage-grouse

survival rate estimates in Sheeprock and Ibaph SGMAs were lower and higher, respectively, than published reports indicated. They believed these observations reflected difference in meso-predators communities.

Habitat Management, Arthropods, and Sage-grouse Production

Arthropods are an important component of early brood-rearing habitat (Patterson 1952). Ants (*Hymenoptera*) and beetles (*Coleoptera*) are often the most important groups of arthropods eaten by young sage-grouse. However, the direct relationship between insect availability and sage-grouse chick survival in a natural setting is poorly understood.

Robinson and Messmer (2013) reported that increased precipitation in 2005 in the Sheeprock and Ibapah SGMAs in Utah's West Desert contributed to the subsequent increase in forb production. They hypothesized that increased forb production translated into an increase in number and volume of arthropods collected in 2005 vs 2006. During both years of their study, the numbers and volumes of arthropods collected were also greater at brood than in random sites. This increase in forbs and arthropods may have contributed to the higher number of chicks per successful brood in 2005, compared to 2006 (Robinson and Messmer 2013).

Although Dahlgren et al. (2010) reported no direct relationship between arthropods and vegetation measurements, they suggested that arthropod abundance in the immediate vicinity of broods may have influenced chick survival during the early brood-rearing period for sage-grouse inhabiting the Parker Mountain SGMA.

Grazing and Sagebrush Treatments: Consequences for Winter Habitat

Conservation of sagebrush communities remains is one of the most difficult and pressing concerns in western North America. Many of these communities are grazed by domestic livestock. The implementation of management experiments of sufficient scale to evaluate sage-grouse responses to range management practices remains problematic. However, long-term case studies across large landscapes can provide important insights regarding sage-grouse responses to livestock grazing and related range management practices.

Dahlgren et al. (2015a) analyzed 24 years of sage-grouse population data collected across 3 large landscapes in northern Utah and southwestern Wyoming to assess sage-grouse responses to corresponding land management in the Rich SGMA. During this period sage-grouse populations on Deseret Land and Livestock (DLL), a privately-owned ranch, increased compared to surrounding populations that inhabited BLM allotments as small scale sagebrush removal treatments (< 300 acres) were being conducted within a prescriptive grazing management framework. The increased sage-grouse populations were maintained for nearly 15 years where after they declined to approximate levels reported in surrounding populations. The declines were attributed to prolonged, adverse winter weather conditions accompanied by increased snow accumulations.

The authors attributed the DLL sage-grouse population increases to the small scale sagebrush treatments which translated into larger broods than recorded on adjacent BLM grazing allotments. However, the small annual reductions in sagebrush may have culminated in reduced

availability of sagebrush winter cover. During the winter sage-grouse use sagebrush for both food and cover, with specific use areas selected based on sagebrush type, nutrition, availability of sagebrush above the snow. This reduced availability of winter habitat coupled with an extreme winter (e.g., 2010-2011), where cold wet conditions continue into the nesting period, may have resulted in decreased survival of adult sage-grouse and possibly nest success contributing to the corresponding decreases in lek counts over subsequent years. This case study highlights the importance of maintaining sagebrush habitats with adequate amounts of tall sagebrush for sage-grouse to use during extreme winters and nesting periods and the role of monitoring sage-grouse populations using lek and broods counts and hunter surveys to determine their response to management (Dahlgren et al. 2006; Dahlgren et al. 2010; Guttery et al. 2015, Dahlgren et al. 2016c). Research is continuing to evaluate sage-grouse responses to prescribed and season-long grazing in the Rich SGMA.

Thacker et al. (2010) provided new insights in determining sage-grouse sagebrush winter forage preferences. The identification and protection of important winter habitats is a conservation priority. Thus better information is needed regarding sage-grouse sagebrush winter dietary preferences for application to management. The objective of their research was to determine if chemical analysis of fecal pellets could be used to characterize winter sage-grouse diets as a substitute for more invasive methods. To conduct this research, they collected and analyzed fecal pellets and sagebrush samples from 29 different sage-grouse flock locations in the Box Elder and Parker Mountain SGMAs. Using gas chromatography, they were able to identify crude terpene profiles that were unique to Wyoming sagebrush and black sagebrush (*A. nova*). They subsequently used the profiles to determine sagebrush composition of sage-grouse fecal pellets, to better reflect sage-grouse winter diets. This technique provided managers with a tool to determine which species or subspecies of sagebrush may be important in the winter diets of sage-grouse populations.

The winter diet for sage-grouse consists almost entirely of sagebrush leaves, and individual birds may gain weight while foraging on sagebrush (Dahlgren et al. 2015b). Previous studies have reported higher crude protein and lower monoterpene concentrations in the sagebrush species selected as winter forage by sage-grouse. However, no studies have attempted to link female sage-grouse vital rates (i.e., nest initiation and success, egg fertility, clutch size, and adult survival) to crude protein or monoterpene concentrations of sagebrush plants browsed during pre-nesting periods. From March to May 2013, Wing and Messmer (2016) monitored pre-nesting diets for 29 radio-marked female sage-grouse in the Box Elder SGMA in northwestern Utah to determine if a relationship existed between foraging patterns and vital rates. They randomly located radio-marked female sage-grouse ≥ 3 times during the study period and subsequently sampled 70 sagebrush communities where they were observed to determine which sagebrush species or subspecies were browsed and if samples collected of the browsed plants differed in nutritional quality (i.e., crude protein) and chemical composition (i.e., monoterpenes) from non-browsed plants in the areas sampled and non-browsed randomly selected plants in adjacent sagebrush communities. Seventy-three percent of these sites where radio-marked females were located consisted entirely of black sagebrush (*A. nova*) communities. Percent crude protein and total monoterpene concentration in black sagebrush and Wyoming big sagebrush did not differ between browsed, non-browsed, and non-browsed random plants. Browsed black sagebrush plants were lower in average percent crude protein and higher in total monoterpene concentration than browsed Wyoming big sagebrush. Apparent nest success, age of nesting females, egg

fertility, clutch size and female monthly survival rates for the radio-marked sage-grouse they monitored did not differ based on sagebrush crude protein and total monoterpene content. However, all of the radio-marked female sage-grouse observed in black sagebrush communities where the collected plant samples exhibited higher concentrations of an unidentified monoterpene successfully hatched nests. All of the nests of radiomarked female sage-grouse outside these areas failed. Their results lend additional support to previous published work regarding sage-grouse preferences for black sagebrush as pre-nesting forage and suggest a potential link to nest success

Tall Structures and Sage-grouse

Most existing utility corridors (pipelines, roads, major overhead electrical transmission lines) within Utah SGMAs are well-defined (Utah Plan 2013). Tall structures associated with energy transmission and development (e.g. power lines, communication towers, wind turbines, and other installations) and associated operation and maintenance activities in sage-grouse habitat may impact the species through habitat avoidance and increased predation rates. The USFWS has recommended the use of various buffer distances between tall structures and occupied sage-grouse habitats to mitigate the potential impacts.

In 2005 the Western Association of Fish and Wildlife Agencies (WAFWA) convened the Greater Sage-grouse Range-wide Issues Forum (Forum) to engage stakeholders in the identification of strategies to address species conservation issues. One of the issues identified by the Forum was the effect of tall structures on sage-grouse. Tall structures were defined as power lines, communication towers, wind turbines, and other installations excluding livestock fencing.

In 2010 the Utah Wildlife-in-Need Foundation (UWIN) in cooperation with Rocky Mountain Power/PacifiCorp (RMP) and the UDWR facilitated a public input process (i.e., focus group workshops) which included a synthesis of existing literature and contemporary federal, provincial and state tall structure siting policies to address Forum concerns. The specific products were: 1) literature synthesis of existing information (published and unpublished) regarding the predicted and potential effects of tall structures on sage-grouse, 2) summary of contemporary policies regarding siting and other requirements to mitigate potential effects, 3) identification of knowledge gaps, and 4) prioritization of research needs regarding tall structures effects on sage-grouse conservation.

Stakeholders reviewed published information to evaluate the scientific basis for the potential impacts of tall structures on sage-grouse. At the time of the UWIN review there were no peer reviewed, experimental studies reported in the scientific literature that specifically documented increased avoidance or predation on sage-grouse because of the construction, operation, and maintenance of tall structures (UWIN 2010). A review of the scientific literature regarding sage-grouse since completion of the 2010 review produced no new published information, but recent unpublished reports have begun to address the issue (Messmer et al. 2013).

Stakeholders were concerned that the science upon which tall structure siting decisions are based was lacking. Because the science was lacking, “effective” temporal and spatial setbacks and buffers stipulations may differ by governmental agency. Stakeholders concluded viable estimates of sage-grouse mortality resulting from power line collisions and predation are also lacking.

They believed a better understanding of the extent and causal factor of mortality attributed to tall structures would help state and federal agencies refine siting criteria and develop BMPs and other conservation measures to mitigate potential impacts (Messmer et al. 2013).

Contemporary sage-grouse BMPs are largely lek-centric. The stakeholder review of the literature could not identify a consistent source or scientific basis for recommended buffer zones. The USFWS acknowledged similar concerns in the sage-grouse status review. Stakeholders concluded no research has been conducted to evaluate the effectiveness of current BMPs or buffers. For effective BMPs to be developed, stakeholders concurred that better science-based information will be needed regarding the effects of tall structures on sage-grouse reproductive success, recruitment, and survival at the population level (Messmer et al. 2013).

To adequately assess the impacts of tall structures on sage-grouse, conditions before and after the activity in question must be compared. Stakeholders identified specific questions regarding the relationship between sage-grouse and tall structures that need additional study (Messmer et al. 2013). To address stakeholder concerns, UWIN facilitated a consortium process in 2011 that engaged sage-grouse biologists, statisticians, and managers from agencies, academia, industry, and others in a process to develop a standardized research protocol for assessing the potential impacts of tall structures on sage-grouse. The protocol was subsequently endorsed by WAFWA Directors in 2011 as the standard for assessing the potential impacts of tall structures on sage-grouse.

Hansen et al. (2016) evaluated sage-grouse habitat use before and after construction of the Sigurd-Red Butte (SRB) 345-kilovolt (kV) transmission line in winter habitat. The SRB line was constructed in the fall of 2014, and was sited parallel to a pre-existing 500-kV transmission line through salt-desert habitat on the western edge of the Bald Hills Sage-Grouse Management Area in southern Utah. They deployed Global Positioning System transmitters on 2 female and 16 male sage-grouse from 2014–2016 and compared collected locations to data independently acquired in the winter of 2011–2012 to determine if the construction of the SRB transmission line altered sage-grouse winter habitat use. Using the 2014–2016 data, they developed a resource selection function (RSF) model to quantify the influence of transmission line presence on sage-grouse movements while accounting for low quality habitat (salt-desert) near the transmission line. Post-construction data were compared to the 2011–2012 data to evaluate whether RSF-predicted changes in relative probability of use were reflected in actual shifts in habitat use before and after construction. They did not detect increased avoidance by sage-grouse when comparing spatial distributions between winters. Their results suggests that immediate negative effects of new transmission line construction can be eliminated by implementing best management practices such as co-locating the transmission line in a preexisting energy corridor where impacts on habitat selection have already occurred, and siting the line in poor-quality habitat that does not fragment existing habitat.

Until better information is available, the Utah Plan (2013) recommends siting new electrical transmission lines, and where feasible and consistent with federally, required electrical separation standards, in existing corridors, or at a minimum, in concert with existing linear features in sage-grouse habitat. Siting linear features accordingly is deemed to be mitigation for the siting of that linear feature. Mitigation for the direct effects of construction is still required.

Genetic Connectivity

Because of concerns regarding the potential for increased energy development to further fragment sagebrush habitat, thus isolating sage-grouse populations and resulting, in genetic drift, inbreeding, local extinction, or rapid divergence. Breidinger et al. (2013) conducted a genetic survey of 3 remote sage-grouse populations in northeastern Utah to assess mitochondrial diversity relative to other portions of the species' range. They did not detect any unusual haplotype compositions in these populations. However, haplotype composition of the Anthro Mountain population and Strawberry Valley SGMA reference populations differed from haplotype compositions of other northeastern Utah populations. These populations are spatially separated by Desolation Canyon of the Green River. This canyon constitutes a geographic barrier to gene flow in this area, given low population densities and reduced dispersal potentials. This potential barrier will be an important consideration in future conservation efforts such as translocations. The haplotype composition of the Anthro Mountain and Strawberry Valley reference populations have subsequently been altered by translocations subsequent to our sampling effort (Baxter et al. 2013, Gruber-Hadden et al. 2016).

The mitochondrial (Breidinger et al. 2013) data confirm that there is restricted gene flow between Utah populations west of the Green River and other adjacent populations to the north and east. State biologists have corroborated the results of these research projects using seasonal movement data of radio-collared sage-grouse.

Funding Partners

The longevity, continuity, consistency, and hence accuracy of the sage-grouse database used to develop the Utah Plan (2013) attests to the commitment and resolve of the partners that have funded and supported the research. These partners included Utah Reclamation, Mitigation, and Conservation, UDWR, BLM, USFWS, USFS, Sportsmen for Fish and Wildlife, BYU, Western Alliance to Expand Student Opportunities, Berry Petroleum, S. J. and Jessie Quinney Foundation, USU Extension, USU Quinney College of Natural Resources, Quinney Professorship for Wildlife Conflict Management, Jack H. Berryman Institute, Enduring Resources LLC, the Parker Mountain Grazing Association, Deseret Land and Livestock, Pheasants Forever, Natural Resource Conservation Service, Idaho Fish and Game Department, Rich County Coordinated Resource Management Group, Rich County Commission, West Box Elder Coordinated Resource Management Group, Utah Department of Agriculture and Food, USDA Wildlife Services, Anadarko Petroleum, Bill Barrett Corporation, Utah Chapter of the Wildlife Society, Cooperative Sagebrush Initiative, Rocky Mountain Power, PacifiCorp, Utah Wildlife in Need Foundation, Utah Department of Natural Resources, SUFCO Mine (Canyon Fuel Company), Kerr River Pipeline, Ruby Pipeline, Utah Public Lands Policy Coordination Office, Utah Legislature, Utah Community-Based Conservation Program, Della Ranches, Utah Conservation Districts, Grouse Creek Livestock Associations, USDA Poisonous Plants Lab, USDA Animal Research Service, and the Utah Cooperative Wildlife Management Association.

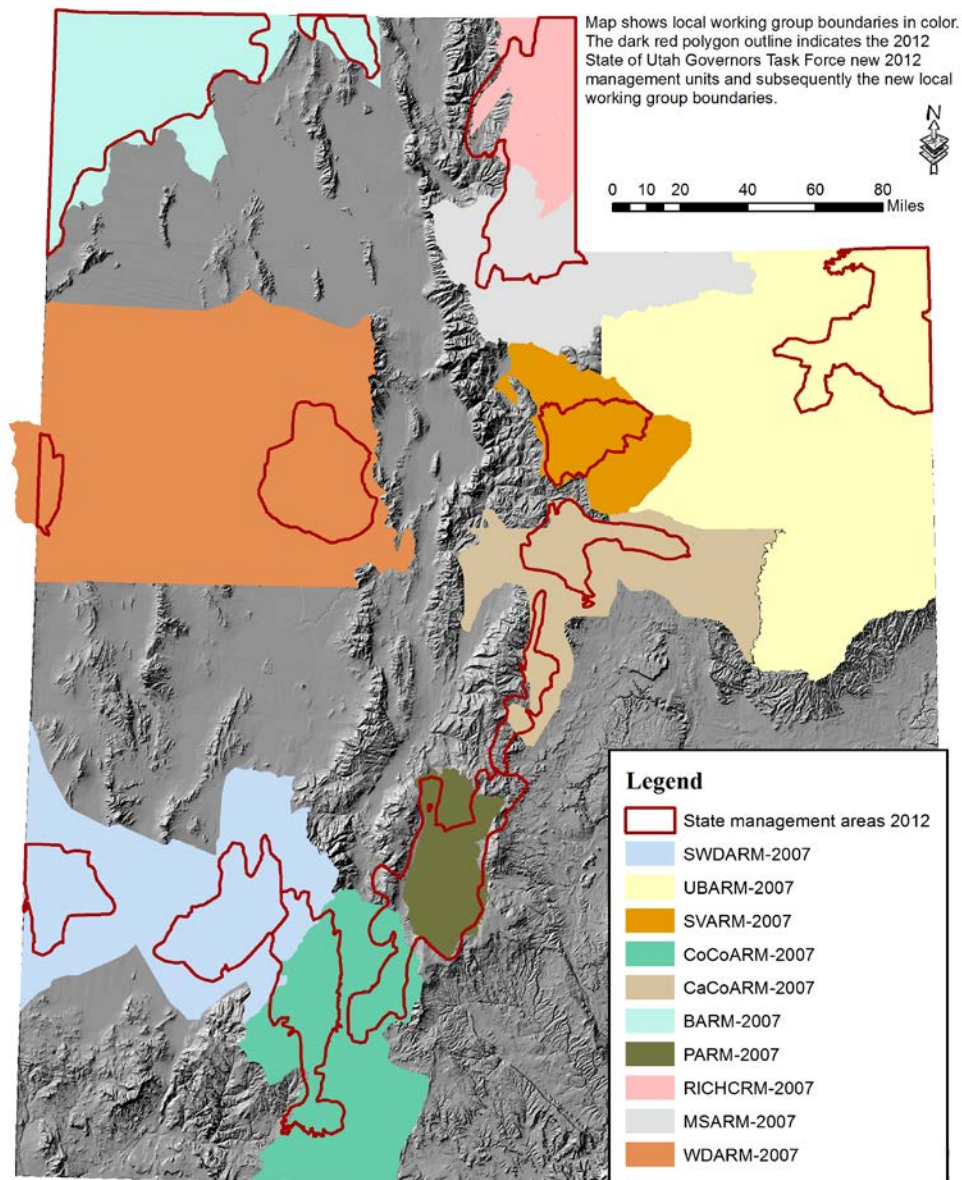


Figure 1. Sage-grouse Management Areas (SGMAs) in Utah (Utah Plan 2013). The SGMAs (outlined in red) represent the best opportunity for high-value, focused conservation efforts for the species in Utah (Dahlgren et al. 2016a). The conservation approach outlined in the Utah Plan recognized current land uses as being compatible with species conservation, and identified potential future uses which may cause conflict with the needs of the species. The sage-grouse populations within the SGMAs all lend themselves to increases through appropriate protection and habitat enhancements, so each SGMA identifies and maps areas on the landscape that provide these additional habitat enhancement opportunities (Opportunity Areas) for greater sage-grouse.

Box Elder County Adaptive Resources Management (BARM) Sage-Grouse Local Working Group

The Box Elder Adaptive Resource Management Plan (BARM) Sage-grouse LWG was organized in 2001 by Terry Messmer. In 2011 the West Box Elder Coordinated Resource Management (WBECRM) was organized and the effect of the LWG combined into the WBECRM plan. The CRM provides overall direction and guidance for habitat projects within the conservation area and SGMA. The CRM established a sage-grouse subcommittee as part of the plan. The committee meets throughout the year to address and discuss sage-grouse specific issues of concern, management actions, and strategies. The subcommittee reports these to the WBECRM. Diane Tanner is the facilitator for the group. David Dahlgren is the CRM sage-grouse committee chairperson.

Description of Area and General Population Information

The WBECRM encompasses western Box Elder County, from the Snowville area west to the UT/NV border and south to the shoreline of the Great Salt Lake. Sage-grouse habitat in this area is broken down into 3 sub regions, the Grouse Creek, Pilot, and Raft River range. See http://utahcbcp.org/files/uploads/BARMSAGRPlan_Final.pdf for maps and figures.

Although our knowledge of sage-grouse populations in the area is incomplete, research efforts in the area continue to map sage-grouse movements and habitat-use patterns in the Grouse Creek and Raft River Mountains. These research efforts have identified important brooding and winter areas.

CRM Meetings

Type	Date	Location	# attending	Comments
Meeting	16 Feb 2016	Park Valley, UT	33	Annual Schedule and Committee updates
Meeting	19 Apr 2016	Park Valley, UT	24	Hot Topics Meeting
Field Tour	7 Jun 2016	West BE County	85	Combined with WRI tour
Meeting	15 Nov 2016	Park Valley, UT	33	WRI Project Presentations

Current Projects by the West Box Elder CRM:

Name	Treatment Type	Proposed Date	Partners	Comments
Sagebrush Ecosystem Alliance	NA	Summer 2017	NRCS, USU Ext, GIP, IJV, BLM	Start a coordinator to work with permittees and BLM
Dry Basin Project	Pinyon-Juniper removal and fire break	Spring 2016	Cons. District, GIP, UDWR, USFWS, BLM	Near a large sage-grouse lek, fire breaks evaluated by GIP and USU Ext.
Warm Springs Project	Pinyon-Juniper Removal	Fall 2017	BLM, UDWR, USU Ext.	Proposed WRI Project for 2017
Multiple SGI PJ Removal on Private Lands	Pinyon-Juniper Removal	Fall 2017	NRCS-SGI, GIP, Cons. District	This includes various PJ projects across West Box Elder

Project and Research Highlights

The conifer removal and effects on sage-grouse study is continuing. C. Sandford (MS graduate student advised by Dr. Messmer) was able to finish his Thesis and has a significant paper accepted in *Rangeland Ecology & Management*, which was published in 2017 (Sandford et al. 2017). This paper demonstrates not only a selection for conifer treatment, but an increase in nest and brood survival rates for sage-grouse. Justin Small continues to monitor radio-marked sage-grouse in the area and has employed GPS radios attached to grouse to evaluate management actions, including conifer removal.

The West Box Elder CRM group is an active and self-sufficient group, with a local facilitator (i.e., Diane Tanner, local landowner). Quarterly meetings are held during the year, including a summer field tour. Additionally, the sub-committees are meeting regularly and many projects are moving forward, specifically PJ treatment projects. The landscape is clearly changing across West Box Elder where PJ has encroached into sagebrush communities. West Box Elder continues to be the place where significant projects are implemented that will benefit sage-grouse and the entire sagebrush ecosystem. Of particular note, USU Extension will be hiring a coordinator for the Sagebrush Ecosystem Alliance (SEA) project. This coordinator will work with private and agency partners, specifically permittees and the BLM, to help build more

capacity for the management and conservation of sagebrush systems. The SEA is currently set for a three-year effort.

Castle Country Adaptive Resources Management (CaCoARM) Sage-grouse Local Working Group

The Castle Country Adaptive Resource Management Plan (CaCoARM) Sage-grouse LWG was organized in 2004 by Terry Messmer. Lorien Belton is the group facilitator.

Description of Area and General Population Information

The CaCoARM conservation area encompasses occupied sage-grouse habitats primarily in Carbon County, with portions of Utah and Sanpete County. Sage-grouse habitat in this area is naturally fragmented by both geology and topography. Although the sage-grouse habitat locally is in the Carbon SGMA boundary, the Tavaputs Plateau is outside the SGMA, the LWG continues to work with landowners in the Tavaputs area and watch the population dynamics there in addition to the primary focus on the birds within the SGMA.

CaCoARM Meetings and Field Tours

Type	Date	Location	# attending	Comments
Landowner appreciation dinner	April 6, 2016	Price	30	Presentations and entertainment
Field Tour	July 20, 2016	Emma Park	14	Tour focused on erosion of soil and restoration efforts in wet areas of sage-grouse habitats
Meeting	November 16, 2016	Price	7	Updates on BLM instructional memoranda

Project and Research Highlights

The Carbon group has had a large amount of staff turnover within partner organizations and agencies in recent years, including 2016. In addition, because the group has not been dealing with any urgent, pressing issues related to sage-grouse, attendance among landowners has decreased. There is growing interest, however, in expanding juniper treatment projects to private lands, having more discussion about how to protect wet areas that both sage-grouse and livestock depend on, and bringing weed issues more into the conversations.

Color Country Adaptive Resources Management (CCARM) Sage-grouse Local Working Group

The Color Country Adaptive Resource Management (CCARM) Sage-grouse LWG is facilitated by Nicki Frey. The main purpose of the LWG is to provide a framework of strategies and associated actions that can be implemented to abate threats, address information gaps, and guide monitoring efforts. Strategies developed by CCARM were designed to be specific to the local area while taking into consideration the guidelines at a range wide level.

Description of Area and General Population Information

The Panguitch Management Area is located in southern Utah, in Kane, Garfield, Paiute and Wayne Counties, incorporating more than a dozen, often connected leks. Due to the population exchange throughout this Management Area, and its incorporation of the southern-most sage-grouse lek, it is considered an important population for Utah.

This population uses a series of leks throughout the habitat area, with some males visiting more than one lek per season. The population is distributed north-south in a series of linked valleys and benches, and constrained by mountains and canyons. There is a large range in the number of males in attendance among these leks. Movement of sage-grouse from one valley or bench to another among seasons is necessary to meet their seasonal habitat requirements in the highly variable annual weather conditions of this region. Movements among valleys are not present in each group of sage-grouse, and not all used areas are known to managers.

Project and Research Highlights

CCARM had a productive 2016. We commented on over a dozen WRI projects, providing ideas to improve projects, guiding project methods to increase the benefits to sage-grouse, and providing written support for these projects. We continued to assist the Alton Coal Development mitigation strategy plans and committed to assist with monitoring 5 sage-grouse that use the area around the current mine. CCARM also commented on the ACD supplement draft EIS for the federal lease application. Dr. Frey continued her WREN program with Kanab High School in 2016. She had students from Kanab high school collect data at the Alton grouse study site, and discussed the reclamation efforts that have been conducted in that area. Additionally, Rowland Hall, from Utah County, participated in WREN in April; while the weather was treacherous, they collected data on sage-grouse habitat characteristics and discussed grouse ecology.

In the late summer, CCARM joined the WRI Southern Region's tour to look at watershed restoration programs. We learned about streambank restoration, explored a newly establish beaver dam and the beaver dam analog that controls the water level of the beaver dam, and were even able to release Boreal toads into the new beaver pond. Over 70 people attended this field trip.

In the fall, we deployed 3 new transmitters in Sink Valley to continue the ACD monitoring project. We employed high-school volunteers to assist with the trapping. In December, Dr. Frey provided an update to the sage-grouse monitoring program. She is coordinating with Mr. Rhett

Boswell, UDWR, to conduct a habitat analysis of the grouse. He will create a resource selection function analysis to determine how often grouse use treated areas. We will also be conducting a survey in Garfield county to gather the public's opinion to the WRI program as it benefits greater sage-grouse. Dr. Frey also presented her research update to Kanab, at an annual BLM open house. This has led to Dr. Frey assisting Kane County with their county management plan. Finally, Dr. Petersen and Dr. Frey published the results of Dr. Petersen's study of grouse response to the mine in the Human Wildlife Interactions journal. Also in December, CCARM hosted the BLM's presentation of the IMs. This presentation was posted online (<http://utahcbcp.org/htm/groups/colorcountry>).

East Box Elder County Adaptive Resources Management (EBARM) Sage-Grouse Local Working Group

The East Box Elder LWG was formed in November 2015. The LWG group consists of private landowners, state and federal agency personnel, and conservation district members. The group elected C. J. Roberts and Brett Selman as their co-chairs for the group. The first objectives of the group are to learn more about the sage-grouse population in their area, which consists of nearly all private land. This included lek searches, recording wintering grouse, and communicating with landowners for their knowledge. This group is facilitated by Dave Dahlgren.

Description of Area and General Population Information

The East Box Elder area is the Sage-Grouse Management Area that lies west of I-15 and north of I-84. There are only 2 or 3 active known leks in the area with relatively few birds at each lek. Most of the lower elevations have been converted to dry farming at European settlement. Most of the sagebrush habitat is in the higher elevation rangelands. Much of the sagebrush habitat has been fragmented over the years and fire continues to be one of the most significant threats to the sagebrush communities. Cheatgrass invasion following fire is also an extensive issue in the area. The landownership is predominantly private and there is only a small section of BLM in the northwest portion. The area is unique in that private landowners are numerous and landownership is not generally in large blocks. This creates its own challenges and opportunities.

East Box Elder LWG meetings.

Type	Date	Location	# attending	Comments
Meeting	7 Jan 2016	Tremonton	23	Discussed objective and future goals
Community Gathering	18 Feb 2016	Tremonton	46	Presentations on sage-grouse biology and management were made to a community audience
Field tour	28 Oct 2016	Pocatello Valley	22	Visited the recent burn, some lek sites, and talked about sage-grouse habitat needs

Project and Research Highlights:

The LWG donated funds to purchase a GPS unit to be put out on a sage-grouse within the area. Efforts were made during the spring of 2016 to locate and trap a sage-grouse for this purpose, but the attempts were unsuccessful. We will try again during the spring of 2017 to deploy the GPS radio on a sage-grouse within the boundaries of the LWG.

Morgan-Summit Adaptive Resources Management (MSARM) Local Sage-grouse Working Group

The Morgan-Summit Adaptive Resource Management (MSARM) focuses on southern half of the Rich-Morgan-Summit Sage-Grouse Management Area (SMGA). This group is facilitated by Lorien Belton.

Description of Area and General Population Information

The LWG area falls in Morgan and Summit Counties. The two counties consist largely of privately-owned land, particularly where sage-grouse are found. Sage-grouse habitat in these areas occurs at higher elevations and is usually more mesic than some of Utah's other sage-grouse areas. Although our knowledge of sage-grouse populations in the area is incomplete, the UDWR believes the birds in this area are connected to populations in Rich County and southwestern Wyoming. During the development of the Utah Plan, maps of the MSARM area were combined with the Rich County area to reflect this population connectivity.

MSARM Meetings and Field Tours, October 2014 – January 2016

Type	Date	Location	# attending	Comments
Meeting	April 11, 2016	Coalville	9	Research updates, field tour planning, other updates
Field tour	July 14, 2016	Henefer Divide	15	Visits to several private ranches to track grouse and discuss seasonal use
Meeting	October 25, 2016	Coalville	10	Review of first year's research findings, other research questions, and the draft state mitigation rule
Dinner meeting	February 8, 2016	Wanship	22	Landowner appreciation and research presentation and Q&A

Project and Research Highlights

During 2016, the group focused substantial time and effort on the ongoing research in the area. As the group has not previously done research studies to understand local sage-grouse seasonal movements and population connectivity, each new piece of information was of great interest. Preliminary information was provided to landowners in January 2016 (as noted in the previous annual report) and additional conversations were had at meetings throughout the year. The research has raised considerable other questions that would require additional funding and effort to answer. The group is very interested in making sure that the momentum from this initial work is kept alive.

Other key topics addressed during the year included the draft mitigation rule in development by the state of Utah, and the need for easements. The easements subteam works to ensure that the multiple private and public entities working with landowners on easements in sage-grouse habitat are working with similar information and are coordinating with regard to priorities and strategies that will benefit the local sage-grouse populations.

Parker Mountain Adaptive Resource Management (PARM) Local Sage-grouse Working Group

The Parker Mountain Adaptive Resource Management Plan (PARM) Sage-grouse LWG was organized in 1997 by Terry Messmer. PARM consists of state and federal agency personnel, representatives from local government, non-profit organizations, academic institutions, private industry, and private individuals. This LWG is currently facilitated by Dave Dahlgren.

Description of Area and General Population Information

The PARM LWG area covers portions of Garfield, Piute, and Wayne Counties that contain occupied sage-grouse habitats. Sage-grouse habitat in this area is well connected and the majority of the sage-grouse can be found on the Awapa and Aquarius plateaus. It is broken down into three sub regions; the Parker, Fish Lake, and Grass Valley. See <http://utahcbcp.org/files/uploads/parm/PARMfml-10-06-web.pdf> for maps and figures. The sage-grouse populations at Wildcat Knoll and Horn Mountain have been included with the Parker Mountain SGMA. The stakeholders (e.g., USFS, Emery County, etc.) working on these two populations have joined PARM.

The PARM area has been the most studied population of sage-grouse in Utah going back to 1998 and there have been several publications made available through these research efforts in addition to annual reports. See <http://utahcbcp.org/htm/groups/parkermountain> for more information. The Wildcat Knoll and Horn Mountain had two years of research with radio-marked grouse from 2008-2009.

PARM meetings and field tours.

Type	Date	Location	# attending	Comments
Meeting	27 Jan 2016	Loa	14	Updates and plans for the year
Lek Counts	7 Apr 2016	Parker Mtn.	12	Counted all leks on Parker Mountain Area
Meeting	27 Jul 2016	Loa	14	Toured the Mytoge Mtn. Project Area and the cheatgrass treatments on Parker Mtn.
Meeting	25 Oct 2016	Loa	23	Research review meeting

Project and Research Highlights

The USFS has proposed a large conifer removal project in the Mytoge Mountain area. Currently a WRI project proposal has been submitted for this effort. The project area contains two sage-grouse leks. The Dog Flat Lek is at the heart of the treatment area and will likely benefit the most from this project. USU is planning on deploying 5 or more GPS radios on Dog Flat during the spring of 2017. Other partners are also looking for funds to support monitoring efforts. This is a unique opportunity to get pre-treatment information on sage-grouse habitat use for a conifer

removal project. The conifer removal at the Cedar Groves has been completed and we look forward to monitoring the habitat improvements for this project in the future.

In 2016 Nate Dulfon finished his Thesis on vegetation characteristics of sagebrush on Parker Mountain. He found that spike treatments improved sage-grouse habitat and forage for livestock on the mountain. He also characterized the black sagebrush communities. We look forward to publishing his research in peer-reviewed journals in the future.

We currently have a WRI project for cheatgrass control on Parker Mountain. We monitored the treatment areas in September 2016 prior to chemical treatment in November. We will follow up monitoring in September 2017 to see what resulted from our treatment efforts.

Rich County Coordinated Resource Management Sage-grouse Local Working Group

The Rich County Coordinated Resource Management (CRM) Sage-grouse LWG (RICHCO) is facilitated by David Dahlgren. The RICHCO consists of state and federal agency personnel, representatives from local government, non-profit organizations, academic institutions, private industry, and private individuals.

Description of Area and General Population Information

The Rich CRM is located in northeastern Utah, and is a significant population center for grouse in three states – Utah, Idaho, and Wyoming. The SGMA management area includes Cache, Rich, Weber, Morgan, Summit and Wasatch Counties. The area boundary was determined by consulting with adjacent states, UDWR, and the Morgan-Summit Adaptive Resources Management Local Sage-grouse Working Group, and the CRM. It incorporates vegetation types used by sage-grouse, mostly in the Wyoming Basins eco-region.

Rich County CRM meetings and field tours.

Type	Date	Location	# attending	Comments
Meeting	5 Jan 2016	Randolph	23	Updates and plans for the year
Lek Count	5 Apr 2016	North Rich County	8	Counted leks in the northern portion of the SGMA
BLM Meeting	21 Jun 2016	Randolph	25	BLM held a public meeting concerning the Crawford Mtn. conifer removal project
Field Tour	21 Jul 2016	Crawford Mtns.	16	Toured the Crawford Mtn. BLM Conifer removal project area.
Meeting	26 Oct 2016	Randolph	18	Discussed future projects and discussed general information for planning
Meeting	15 Dec 2016	Randolph	21	Project presentations and update meeting. Also had a board meeting.

Projects Proposed to Rich County CRM

The BLM is planning a large conifer removal project on the Crawford Mountains. This project was cancelled several years ago due to local public petitioning. However, the Rich CRM and BLM worked together to get the local citizens and interest groups better educated and spent time in meetings and in the field discussing the project.

Additionally, the NRCS, SGI, and GIP have multiple projects to improve grazing systems and management across the county. Included in this is the Three Creeks Project, which will change

the grazing system to a more high intensity low duration system on the public (BLM and USFS) and private allotments. The BLM is currently in its decision making process and we eagerly await their NEPA decision.

Project and Research Highlights

USU continues to monitor the sage-grouse population in Rich County. GPS radios on sage-grouse were added to the monitoring effort this year. Two cattle herds, one on Three Creeks and one on Deseret Land and Livestock, were also marked with GPS radios to help understand grazing distribution and how grouse may respond to grazing. This research will be some of the first to evaluate the impacts of grazing to grouse habitat selection and vital rates.

Southwest Desert Adaptive Resource Management (SWARM) Sage-grouse Local Working Group

The Southwest Desert Adaptive Resource Management sage-grouse LWG (SWARM) consists of community members from Beaver and Iron Counties and is facilitated by Nicki Frey. The LWG meets every other month to discuss issues and concerns with grouse management and conservation in our region. The Governor's Task Force has recommended the development of two SGMAs in the LWG conservation area; Hamlin Valley and Bald Hills.

Project and Research Highlights

SWARM had a productive 2017. We commented on over a dozen WRI projects, providing ideas to improve projects, guiding project methods to increase the benefits to sage-grouse, and providing written support for these projects. We also participated in a BLM review to determine departure from soil condition classifications in Hamlin Valley. We provided ground truthing to the model that will direct habitat treatments in the next decade. We also initiated a new GPS telemetry study in Hamlin Valley to determine the extent of the connectivity between Utah and Nevada. We will use a resource selection function model created by Mr. Rhett Boswell, UDWR, to determine how sage-grouse use treated areas. We also deployed 10 transmitters in Dog Valley, to the north of Panguitch, to continue our analysis of how grouse are distributed in the Panguitch SGMA and if they are connected to the Bald Hills SGMA. We employed college students to assist in trapping in Dog Valley. For both of these studies, we are focusing on hens and recruitment success.

In the late summer, SWARM joined the WRI Southern Region's tour to look at watershed restoration programs. We learned about streambank restoration, explored a newly establish beaver dam and the beaver dam analog that controls the water level of the beaver dam, and were even able to release Boreal toad into the new beaver pond. Over 70 people attended this field trip.

In December, Dr. Frey provided the group with a research update, including the completed thesis of Erica Hansen. Ms. Hansen has published her thesis about sage-grouse response to disturbance, including transmission lines and fire, to the USU Digital Commons. Additionally, her work on the transmission lines has been published in the *Human-Wildlife Interactions* journal. Also in December, CCARM hosted the BLM's presentation of the IMs. This presentation is also posted online.

Strawberry Valley Adaptive Resource Management (SVARM) Sage-grouse Local Working Group

The Strawberry Valley Adaptive Resource Management (SVARM) sage-grouse LWG is facilitated by Lorien Belton.

Description of Area and General Population Information

The LWG conservation area covers Wasatch and Duchesne Counties. There are leks and associated nesting/brood-rearing areas both at high elevations around the Strawberry Reservoir, as well as in the lower-elevation Fruitland area in Duchesne County. The birds winter primarily in Fruitland. In recent years, the population has grown increasingly stable. Predator control efforts, particularly with regard to red fox control, have played a large role in helping the sage-grouse population rebound from previous lows.

SVARM Meetings and Field Tours, October 2014 – January 2016

Type	Date	Location	# attending	Comments
Meeting	February 3, 2016	Heber	10	Habitat project planning
Meeting	April 21, 2016	Cancelled	-	Both presenters cancelled
Field tour	August 2, 2016	Strawberry Reservoir	8	Habitat projects: past projects and future planning
Meeting	November 1, 2016	Heber	8	Proposed developments near the reservoir, habitat project planning

Project and Research Highlights

The Strawberry sage-grouse group has been very focused on the next round of habitat projects in the area to benefit grouse. The projects are designed to be implemented gradually over a number of years, but planned as a cohesive set of similar efforts. During the extended planning phase, the group has been careful to consider how the exact location, bird usage information, weed situation, grazing leases, and other circumstances factor in to planning appropriate treatments and working with all the appropriate partners. During the summer field tour, the group visited many of the proposed project locations to observe conditions and plan strategic treatments. The group also is paying careful attention to how past treatments have grown back over the years (such as in Trout Creek) and whether the long-term vegetation response has been as beneficial to grouse as the short-term response. These results will influence the type of treatments done in the future.

Another topic of conversation are two developments proposed near the reservoir. The LWG stays apprised of changes to county approvals, and provides information to the county as appropriate on how sage-grouse might be impacted by any new proposed actions. As the original approvals for the developments were done years ago, a component of the discussion

includes keeping everyone apprised of the history and how that factors in to decisions that are yet to be made.

BYU continues to participate actively in the group, helping by sharing the extensive knowledge gathered over the years about seasonal habitat usage, bird movements in response to treatments, and other topics.

Uintah Basin Adaptive Resource Management Local Working Group

The Uintah Basin Adaptive Resource Management (UBARM) sage-grouse LWG is facilitated by Lorien Belton. It is closely tied to the Uintah Basin Partners for Conservation and Development, often coordinating meeting scheduling between the two groups.

Description of Area and General Population Information

The Uintah Basin sage-grouse group covers parts of Duchesne, Uintah, and Daggett counties. A large population with multiple leks inhabits the Diamond Mountain area north of Vernal. This area has mixed landownership, including private, state, and federal lands, and is used primarily for agricultural purposes. The Diamond Mountain population is one of the few populations in Utah that is robust enough to support a limited sport hunt in the fall. Additional sage-grouse populations occur south and west of Vernal in areas including Forest Service land on Anthro Mountain, and BLM land further south. The southern populations in particular are in areas that have been highly impacted by oil and gas development. Some populations also occur farther south into the Book Cliffs. Populations on Seep Ridge, Deadman Bench, Little Mountain, Anthro Mountain, and Diamond Mountain have been the subject of research studies in recent years.

UBARM Meetings and Field Tours

Type	Date	Location	# attending	Comments
Meeting	February 16, 2016	Vernal	24	Policy implementation updates, bird tracking, hydrology
Meeting	April 6, 2016	Vernal	17	New fire management systems, policy updates, population tracking
Meeting	December 6, 2016	Vernal	25	Population movements, BLM update, mitigation policy plans

Project and Research Highlights

The group in the Uintah Basin this year has focused on understanding upcoming and newly implemented policy on a range of topics. Extensive conversations have happened within the groups on BLM RMP amendments implementation, fire policy changes to improve habitat protection, and the upcoming state habitat mitigation rule.

The group also works very closely with the regional UPCD team on projects. Many of the proposed projects in the WRI project proposal database for this region are related to sage-grouse habitat objectives and are derived from the joint efforts of many partners on both of the groups.

Research has expanded into several new areas, where birds are being fitted with GPS collars to learn more about the sage-grouse movements in the northeastern-most area of the state. USFS and BLM have both purchased GPS collars, and UDWR is doing the tracking and data

management. Because there is a much more data analysis that could be done beyond simply tracking movements, BYU will be helping to analyze the data. In the Three Corners area, Goslin Mountain, Antelope Flat, and Bear Top are the areas of focus. Little Mountain, Diamond Mountain, Blue Mountain, and Anthro Mountain birds are getting collars and being tracked.

West Desert Adaptive Resource Management Local Working Group

The West Desert Basin Adaptive Resource Management (WDARM) sage-grouse LWG is facilitated by Lorien Belton. The group covers two areas: Ibapah, on the western border of Utah with Nevada, and the Sheeprock Mountains (in Tooele and Juab counties). Due to concern over population declines in the Sheeprocks, the WDARM group has also become the Technical Committee tasked for overseeing a series of enhanced efforts in the Sheeprocks to reduce threats to sage-grouse and help the population rebound. Since July 2015, WDARM has increased its meeting frequency from three-four times a year to approximately every other month. The group will continue its increased activity until the urgent need for coordination and implementation goes down. Although the majority of the groups' focus is on the Sheeprocks population area, the group tries to meet once each year in Ibapah.

Description of Area and General Population Information

The West Desert Adaptive Resource Management LWG conservation area encompasses sage-grouse habitats in Tooele and Juab counties. The two primary population locations are far apart: one in western Tooele County in the Ibapah region (including the Goshute Tribe's land), and the other at the eastern side of the two counties, known as the Sheeprocks. These more eastern populations include birds in the Vernon area as well as in the Tintic Mountains. Population trends in the area have declined over the last few years. In 2015, lek counts which rebounded in other part of the state, including Ibapah, did not rebound in the Sheeprocks.

Meetings and Field Tours

Type	Date	Location	# attending	Comments
Meeting	January 28, 2016	Tooele	25	WRI projects, hydrology research, sage-grouse research, recreation
Meeting	March 7, 2016	Tooele	24	Research and management updates, recreation communications,
Meeting	April 25, 2016	Tooele	18	Recreation management, research updates, predation, project and funding planning
Field tour	July 27, 2016	Vernon area	22	Conifer removal, sage-grouse habitat usage
Meeting	October 11, 2016	Tooele	21	Fire management, large-scale EAs, recreation signage
Meeting	December 12, 2016	Tooele	28	BLM policies, hydrology research
Meeting	January 26, 2017	Tooele	23	Research updates, BLM travel management planning, WRI project review

Project and Research Highlights

The WDARM group has been very active this year. There has been considerable interest, both within the working group and more broadly within the state, in the translocation efforts to bring sage-grouse from Parker Mountain and Box Elder County to help augment the declining sage-grouse populations in the Sheeprocks Sage-Grouse management area. Multiple partners and many volunteers assisted in the trapping activities and research follow-up. The group discusses additional knowledge gained through this research at each meeting. Now into the second year, the group is gearing up again for additional translocations in the spring of 2017.

A key conversation over the past year in the WDARM group revolves around water. One project designed to understand the long-term impact on groundwater from conifer removal treatments is underway in the sage-grouse area. Because the WDARM group has been very active in long-term planning efforts for multi-year conifer-removal strategies, it was an ideal area to test the impact of conifers on hydrology. The Utah Geological Survey is spearheading the research, with frequent input from sage-grouse group members on factor to consider, location, and other project design details. In addition to this research, the group is working to increase their understanding of how water sources such as springs, wet meadows, and snowfall may factor into sage-grouse survival. This is an ongoing process of learning and will continue into future years.

Fire management and post-fire habitat improvement work has also been an important topic. Several fires burned in the general Sheeprocks area this year, providing opportunity for habitat projects and additional information sharing about rehabilitation efforts, new coordination between agencies, and project responses.

Finally, the group continues to work on recreation-related issues, including signage for recreational users of the area, better understanding the process of travel planning generally, discussion of how to incorporate traffic counter data (or other recreation data) into the ongoing tracking and research on sage-grouse movements in the Sheeprocks, and discussing ways to improve education for recreationists in the area. This involves input from federal and state agencies regarding their travel and trails planning or policies, as well as county efforts on signage and State Parks on coordination and management work.

Last, but not least, WDARM continues its strong efforts on direct habitat improvement, proposing multiple projects with interagency and cross-boundary coordination. With several the newly approved RCPP funding source in addition to regular WRI funding opportunities for projects, the group anticipates being able to increase the pace of habitat project work in future years, on both public and private lands in the area, for the benefit of sage-grouse.

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Appendix 1. Research Published Since the Utah Plan Was Signed (2013-2016)

These research papers provide the scientific foundation for Utah's Greater Sage-grouse Conservation Plan. We provide a brief summary of the findings. Copies of these and other papers can be found at www.utahcbcp.org or by following the link provided.

Cook, A., T.A. Messmer, and M.R. Guttery. 2017. Greater sage-grouse use of mechanical conifer reduction treatments in northwest Utah. *Wildlife Society Bulletin*. (This paper has been accepted for publication, but has not yet been released).

Summary: Annually, an estimated 200,000 acres of sage-grouse habitat is degraded by pinyon and juniper (conifer) encroachment. Sage-grouse responses to conifer encroachment may include avoidance of otherwise available habitats, lek abandonment, and subsequent population declines. Thus, restoration sage-grouse habitats encroached by conifer that still exhibit intact sagebrush understories is a priority conservation action identified by the Utah Greater Sage-grouse Conservation Strategy. The authors used sage-grouse fecal pellet surveys and radio-telemetry location data to identify vegetation and landscape attributes that may influence sage-grouse use of conifer removal treatments in the Box Elder Sage-grouse Management Area that were completed using mechanical methods. Sage-grouse use of conifer removal treatments was positively associated with irrigated pasture and alfalfa hay within 0.6 mile and negatively associated with conifer canopy cover within 0.3 mile of treatments. Sage-grouse selected treatments within 0.6 miles of mesic or wet habitats and sagebrush cover. They documented sage-grouse use of 9 of 16 mechanical conifer removal treatments and suggest that mechanical conifer removal treatments should be located adjacent to occupied sage-grouse habitat and should be large enough scale to reduce nearby conifer cover. In Utah, plan partners have removed over 300,000 acres of conifer encroachment targeting large areas that exhibit these criteria.

Baxter, J.J., R.J. Baxter, D. K. Dahlgren, and R. T. Larsen. 2017. Resource Selection by Greater Sage-Grouse Reveals Preference for Mechanically Altered Habitats, *Rangeland Ecology and Management*. <http://dx.doi.org/10.1016/j.rama.2017.01.007>

Summary: Land-use treatments that remove or reduce sagebrush canopy in areas occupied by sage-grouse are controversial given the species conservation status. In 2015, Utah Governor Gary R. Herbert signed an Executive Order (EO) that included a statement that sagebrush removal in sage-grouse habitats was highly discouraged and that future sagebrush treatment using state funding could only be justified if a net benefit to sage-grouse would be probable. Although many studies have shown negative impacts of sagebrush treatments on sage-grouse, research completed by Utah State University on the Parker Mountain Sage-grouse Management Area (SGMA) suggest positive effects for the species if the treatments occur in higher elevation late brood-rearing habitats. Sagebrush removal treatments completed at large scales and/or in breeding and wintering habitats are certainly not appropriate. However, in high elevation late summer brooding habitats when grouse use more open canopy areas with higher forb cover,

small mosaic treatments may improve brooding habitat. The authors of this paper studied mechanical treatments of sagebrush previously implemented in Strawberry Valley SGMA in 2009. They analyzed before and after location data from radio-marked sage-grouse using the area to assess habitat selection before and after treatments. They found that sage-grouse, especially during the brooding period selected for treated areas following sagebrush canopy removal compared to pre-treatment years. This study occurred in a high elevation highly resilient mountain big sagebrush community with high average annual precipitation. Similar studies in lower elevations of Wyoming big sagebrush have not shown such positive results. This new study, along with other studies from Utah, provided the parameters and justification required by the EO for when sagebrush treatments would likely be beneficial to sage-grouse for future management decisions.

Sandford, C.P., M.T. Kohl, T.A. Messmer, D.K. Dahlgren, A. Cook, and B.R. Wing. 2017. Greater Sage-Grouse Resource Selection Drives Reproductive Fitness in a Conifer Removal Strategy. *Rangeland Management and Ecology*.

http://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=3458&context=wild_facpub

Summary: The encroachment of juniper (*Juniperus* spp.) and pinyon-pine (*Pinus* spp.; conifers) woodlands into sagebrush ecosystems has been identified as a species conservation threat. Since 2007, federal, state, and private land managers have implemented management action to removed conifer from thousands of acres where they have encroached on sagebrush habitats. Despite the scale of contemporary conifer treatments, little was known if sage-grouse would use these areas, and if so, would the females who nested and raised broods in or near the treated area be successful. To answer this question, the authors monitored nest and brood success rates for 96 radio-marked sage-grouse from 2012-2015 that inhabited conifer-dominated landscapes in the Box Elder Sage-grouse Management Area in Utah where mechanical conifer removal projects were completed. They not only demonstrated that sage-grouse selected for nest and brooding sites closer to conifer removal areas and that the probability of individual nest and brood success declined as sage-grouse females selected sites farther from conifer removal areas. Their research provided the first evidence that mechanical conifer removal treatments can increase suitable available breeding habitats for female sage-grouse. The sage-grouse that occupied these areas experienced enhanced nest and brood success. Over time these projects will contribute to increasing overall populations in Utah and provide an example for other states to follow.

Cardinal C.J. and T.A. Messmer. 2016. Ecology of sage-grouse populations inhabiting the northwestern Wyoming Basin of North America. *Human Wildlife Interactions*.

<http://www.berrymaninstitute.org/files/uploads/pdf/journal/fall2016/CardinalAndMessmer.pdf>

Summary: Range-wide population declines of greater sage-grouse have been largely attributed to habitat loss and fragmentation. However, the specific conservation threats affecting sage-grouse populations may differ by region. Although the status of the Bear Lake Plateau and Valley (BLPV) sage-grouse populations in the Wyoming Basin has been monitored using male lek counts since the 1960s, little was known about their ecology, seasonal movements, and

habitat use patterns. From 2010–2012, the authors radio-marked 153 sage-grouse (59 females and 94 males) with very high frequency necklace-style radio-collars throughout the BLPV study area, which encompassed parts of Bear Lake County, Idaho, and Rich County, Utah. They monitored the radio-marked sage-grouse to estimate the factors affecting vital rates, seasonal movements, and habitat use. Radio-marked sage-grouse primarily used seasonal habitats in Idaho and Utah, but some individuals used seasonal habitats in Wyoming. The average annual survival rate for the radio-marked sage-grouse was 53% ($\pm 3\%$). Average female nest success (23%; 95% CI = 18–29%) was lower than range-wide estimates. Brood success varied between 2011 and 2012, with higher brood survival observed in 2012. Twenty-four percent of radio-marked sage-grouse were migratory, engaging in seasonal movements ≥ 6 miles. Poor recruitment attributed to low nest and brood survival may be impacting overall population stability. Because the radio-marked sage-grouse used seasonal habitats in 3 states, they recommended that Utah, Idaho, and Wyoming coordinate in the development of a tri-state management plan to better conserve this population.

Wing, B. and T.A. Messmer. 2016. Effect of pre-breeding foraging patterns on greater sage-grouse vital rates in Utah's Box Elder Sage-grouse Management Area. *Human Wildlife Interactions*. <http://digitalcommons.usu.edu/hwi/vol10/iss2/4/>

Summary: Greater sage-grouse depend on sagebrush to complete its annual life cycle. The winter diet for sage-grouse consists almost entirely of sagebrush leaves, and individual birds may gain weight while foraging on sagebrush. Previous studies have reported higher crude protein and lower monoterpene concentrations in the sagebrush species selected as winter forage by sage-grouse. However, no studies have attempted to link female sage-grouse vital rates (i.e., nest initiation and success, egg fertility, clutch size, and adult survival) to crude protein or monoterpene concentrations of sagebrush plants browsed during pre-nesting periods. From March to May 2013, the authors monitored pre-nesting diets for 29 radio-marked female sage-grouse in the Box Elder Sage-grouse Management Area in northwestern Utah to determine if a relationship existed between foraging patterns and vital rates. They randomly located radio-marked female sage-grouse ≥ 3 times during the study period and subsequently sampled 70 sagebrush communities where grouse were observed. The objective was to determine which sagebrush species or subspecies were browsed and if samples collected of the browsed plants differed in nutritional quality (i.e., crude protein) and chemical composition (i.e., monoterpenes) from non-browsed plants in the areas sampled and non-browsed randomly selected plants in adjacent sagebrush communities. Seventy-three percent of these sites where radio-marked females were located consisted entirely of black sagebrush (*A. nova*) communities. Percent crude protein and total monoterpene concentration in black sagebrush and Wyoming big sagebrush did not differ between browsed, non-browsed, and non-browsed random plants. Browsed black sagebrush plants were lower in average percent crude protein and higher in total monoterpene concentration than browsed Wyoming big sagebrush. Apparent nest success, age of nesting females, egg fertility, clutch size and female monthly survival rates for the radio-marked sage-grouse they monitored did not differ based on sagebrush crude protein and total monoterpene content. However, all of the radio-marked female sage-grouse observed in black sagebrush

communities where the collected plant samples exhibited higher concentrations of an unidentified monoterpene successfully hatched nests. All of the nests of radio-marked female sage-grouse outside these areas failed. Their results lend additional support to previous published work regarding sage-grouse preferences for black sagebrush as pre-nesting forage and suggest a potential link to nest success.

Hansen, E.P., A.C. Stewart, and S.N. Frey. 2016. Influence of transmission line construction on winter sage-grouse habitat use in Southern Utah. *Human-Wildlife Interaction*.
<http://digitalcommons.usu.edu/hwi/vol10/iss2/5/>

Summary: The construction and operation of electric power transmission lines (“power lines”) and their associated infrastructure has been identified as a conservation threat to the greater sage-grouse. The conservation buffer zones recommended by state and federal agencies to avoid potential impacts on breeding populations differ because information regarding the effects of power lines on sage-grouse is lacking. Little information is available regarding sage-grouse responses to power lines placed in winter habitat. The authors evaluated sage-grouse habitat use before and after construction of the Sigurd-Red Butte (SRB) 345-kilovolt (kV) transmission line in winter habitat. The SRB line was constructed in the fall of 2014, and was sited parallel to a pre-existing 500-kV transmission line through salt-desert habitat on the western edge of the Bald Hills Sage-Grouse Management Area in southern Utah. They deployed Global Positioning System transmitters on 2 female and 16 male sage-grouse from 2014–2016 and compared collected locations to data independently acquired in the winter of 2011–2012 to determine if the construction of the SRB transmission line altered sage-grouse winter habitat use. Using the 2014–2016 data, they developed a resource selection function (RSF) model to quantify the influence of transmission line presence on sage-grouse movements while accounting for low quality habitat (salt-desert) near the transmission line. Post-construction data were compared to the 2011–2012 data to evaluate whether RSF-predicted changes in relative probability of use were reflected in actual shifts in habitat use before and after construction. They did not detect increased avoidance by sage-grouse when comparing spatial distributions between winters. Their results suggests that immediate negative effects of new transmission line construction can be eliminated by implementing best management practices such as co-locating the transmission line in a preexisting energy corridor where impacts on habitat selection have already occurred, and siting the line in poor-quality habitat that does not fragment existing habitat.

Dahlgren, D.K., T.A. Messmer, B.A. Crabb, R.T. Larsen, T.A. Black, S.N. Frey, E.T. Thacker, R.J. Baxter, and J.D. Robinson. 2016. Seasonal Movements of Greater Sage-Grouse Populations in Utah: Implications for Species Conservation. *Wildlife Society Bulletin*.
<http://utahcbcp.org/files/uploads/publications/DahlgrenEtal2016SeasonalMovements.pdf>

Summary: Greater sage-grouse are considered an umbrella species for sagebrush landscapes in western North America. In 2015, the U.S. Fish and Wildlife Service determined sage-grouse unwarranted for protection under the Endangered Species Act (1973) because of conservation actions in priority areas. Understanding seasonal movements is key to delineation and

assessment of priority conservation areas. The authors monitored radio-marked sage-grouse from 1998 to 2013 throughout Utah to determine seasonal movements. Maximum distance from lek of capture to summer locations was greater for males than females, whereas females moved farther than males from lek to winter and summer to winter locations. Adult females moved farther than yearlings from lek to nest and summer to winter areas. They concluded the state of Utah's Sage-Grouse Management encompassed >95% of Utah sage-grouse populations. They further suggested that seasonal movements could be facilitated by increasing usable habitat space through management actions. This is the management basis of the Utah's sage-grouse conservation strategy.

Gruber-Hadden, N., T.A. Messmer, M. Guttery, D. Koons, and B. Maxfield. 2016. Population vital rates of resident and translocated females greater sage-grouse in a space-limited landscape. *Journal of Wildlife Management*. <http://utahcbcp.org/files/uploads/publications/Gruber-HaddenEtal2016.pdf>

Summary: Translocations have been recommended to reestablish, augment, and sustain genetic diversity in declining wildlife populations, including greater sage-grouse. Characteristics of successful sage-grouse translocations include suitable contiguous sagebrush, seasonal habitats surrounded by geomorphic barriers, a residual resident population, and pre-nesting releases. From 2009 to 2010, the authors studied vital rates of 60 translocated and 15 resident radio-marked female sage-grouse and their broods on Anthro Mountain, in the Ashley National Forest, northeastern Utah, to determine whether translocations could augment a declining meta-population that inhabited suitable breeding habitats in a small spatially isolated landscape. Survival rates, and nest and brood success estimates for the resident and translocated sage-grouse we studied were lower than reported range-wide averages. Nest success was similar for resident and translocated birds. Daily survival rates for chicks 0–19 days of age for resident females in 2009 and in 2010 were higher than for chicks raised by translocated females. In 2009 and 2010, daily survival rates for chick 20–50 days of age were slightly higher for chicks reared by resident females than chicks reared by translocated females. Although most translocated birds remained on the study area (82%), the low overall survival rates they reported suggest that managers need to consider factors such as habitat space and predation affecting survival of adult females, nests, and chicks when planning future translocations.

Caudill, D., M.R. Guttery, E. Leone, G. Caudill, and T.A. Messmer. 2016. Age dependence and individual heterogeneity in reproductive success of greater sage-grouse. *Journal of Avian Biology*. http://www.utahcbcp.org/files/uploads/publications/Caudill_etal_2016_agedependence.pdf

Summary: Research on grouse species has shown that reproductive success may increase with age until the onset of senescence. However, from the population perspective, increased reproductive success with age could be a consequence of within-individual variation (e.g. ageing, breeding experience, foraging ability hypotheses), between-individual variation (e.g. individual heterogeneity, frailty, selection, delayed breeding hypotheses), or a combination thereof. The

authors evaluated within- and between-individual variation in reproductive success of greater sage-grouse. They monitored female reproductive activity from 1998–2010 for sage-grouse that were radio-marked on the Parker Mountain Sage-grouse Management Area in southcentral Utah. They detected a positive effect of female sage-grouse age on nest initiation and success. Their results support Utah’s strategy of managing all sage-grouse seasonal habitats to enhance long-term female sage-grouse survival rates.

Caudill, D., M. Theron, B. Bibles, and T.A. Messmer. 2016. Factors affecting seasonal movements of juvenile Great Sage-grouse: A reconceptualized nest survival model. *Condor*. 118:139-147.

http://www.utahcbcp.org/files/uploads/publications/Caudill_etal_2016_Condorjuvenile.pdf

Summary: Estimating the climatic and habitat factors that affect animal movement patterns (e.g., migration, dispersal, site fidelity) is informative for management and conservation. Juvenile greater sage-grouse have been identified as having a significant influence on population growth, but relatively little is known about factors that influence survival, movement, and the potential interrelation between the two. Movement out of fall habitat has been suggested to influence the survival of juvenile Greater Sage-Grouse. The authors used nest survival model (equating movement out of a focal area with failure of a nest) analyze the factors affecting juvenile sage-grouse movements in the Parker Mountain Sage-grouse Management Area in south-central Utah. They found that juveniles' seasonal movements were affected by precipitation. In the absence of precipitation, the probability of movement increased weekly through time (within a year). Weekly precipitation increased the probability of movement in earlier weeks, but the effect of precipitation attenuated in later weeks (i.e. interaction parameter). The precipitation was likely non-accumulating snowfall, given the observed below-freezing temperatures. They suggested that changes in precipitation (mainly snowfall) that result from climate change could influence the timing and duration of seasonal movements (i.e. population-level time to complete movement) in migratory sage-grouse populations. Their results support the importance of focusing management efforts on protecting seasonal habitats rather than just around leks. This is the basis for Utah’s Plan.

Dahlgren, D.K., M.R. Guttery, T.A. Messmer, D. Caudill, R.D. Elmore, R. Chi, and D.N. Koons. 2016. Warranted but Precluded: Evaluating Vital-Rate Contributions to Greater Sage-Grouse Population Dynamics to Inform Conservation. *Ecosphere*.

<http://utahcbcp.org/files/uploads/publications/DahlgrenEtAl2016Ecosphere.pdf>

Summary: Species conservation efforts often use short-term studies that fail to identify the vital rates that contribute most to population growth. Although the greater sage-grouse is sometimes referred to as an umbrella species in the sagebrush biome of western North America, the failure of proposed management strategies to focus on key vital rates that may contribute most to achieving population stability remains problematic for sustainable conservation. To address this dilemma, the authors performed both prospective and retrospective perturbation analyses of a life cycle model based on a 12-yr study conducted on sage-grouse populations that inhabit the Parker

Mountain Sage-grouse Management Area in southcentral Utah. They compared estimates of annual finite population growth rates (λ) from our female-based life cycle models to those attained from male-based lek counts. Post-fledging (i.e., after second year, second year, and juvenile) female survival parameters contributed most to past variation in λ during their study and had the greatest potential to change λ in the future, indicating these vital rates as important determinants of sage-grouse population dynamics. In addition, annual estimates of λ from female-based life cycle models and male-based lek data were similar, providing the most rigorous evidence to date that lek counts of males can serve as a valid index of sage-grouse population change. Their research demonstrates the need for more long-term studies of species vital rates across the life cycle. Both of these results reinforce Utah's sage-grouse conservation strategy which call for use of lek trends to evaluate the effectiveness of conservation and management actions.

Dahlgren, D.K, T.A. Messmer, and E. T. Thacker. 2016. Considerations for Sage-grouse Management Objectives. Utah State University Extension Fact Sheet.

<http://utahcbcp.org/files/uploads/publications/ConsiderationsSage-GrouseManagementObjectives.pdf>

Summary: There are more decisions being made now concerning sage-grouse conservation than ever before. Understanding sage-grouse populations and their ecology is critical to avoiding well intended, but mistaken, management objectives for the species. USU Extension published the above fact sheet to help decision makers create and address management objectives with the best available information and to avoid common pitfalls when it comes to this species. To read more go to http://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=2654&context=extension_curall

Dahlgren, D.K., E.T. Thacker, and T.A. Messmer. 2015. What Does a Sage-Grouse Eat? USU Extension - Publications. http://digitalcommons.usu.edu/extension_curall/779

Summary: USU Extension also published a fact sheet on sage-grouse diets. The fact sheet reports the seasonal changes in diets for sage-grouse and provides a list of forbs that have been consumed by sage-grouse. To read more go to

http://utahcbcp.org/files/uploads/publications/Sage-Grouse_DietFactSheet2015.pdf

Dahlgren, D.K., R.T. Larsen, R. Danvir, G. Wilson, E.T. Thacker, T.A. Black, D.E. Naugle, J. W. Connelly, and T.A. Messmer. 2015. Greater Sage-Grouse and Range Management: Insights From a 24-year Case Study in Utah. Rangeland Management and Ecology.

<http://www.bioone.org/doi/abs/10.1016/j.rama.2015.07.003?af=R>

Summary: Conservation of sagebrush systems is one of the most difficult and pressing concerns in western North America. Sagebrush obligates, such as greater sage-grouse have experienced population declines as sagebrush systems have degraded. Science-based management is crucial to improve certainty in range management practices. Although large-scale implementation of management regimens within an experimental design is difficult, long-term case studies provide

opportunities to improve learning and refine hypotheses. The authors used 25 years of data across three large landscapes in northern Utah and southwestern Wyoming to assess sage-grouse population change and corresponding land management differences in a case study design. Sage-grouse lek counts at our Desert Land and Livestock (DLL) study site increased relative to surrounding populations in correspondence with the implementation of small-acreage sagebrush treatments designed to reduce shrub cover and increase herbaceous understory within a prescriptive grazing management framework. The higher lek counts were sustained for nearly 15 years. However, with continued sagebrush treatments and the onset of adverse winter conditions, DLL lek counts in treated sagebrush mosaics decreased more than in untreated reference sites. The authors hypothesize that sagebrush treatments on DLL increased availability of grasses and forbs to sage-grouse, similar to other studies, but that cumulative annual reductions in sagebrush may have reduced availability of sagebrush cover for sage-grouse seasonal needs at DLL, especially when extreme winter weather occurred. Governor Herbert's 2015 Executive Order embraced these results by calling for a detailed review process before management projects are implemented to reduce sagebrush cover.

Guttery, M.R., T.A. Messmer, M.W. Brunson, D.K. Dahlgren, and J.D. Robinson. 2015. Hunter Motivations for Pursuing a Declining Species: Insights from Greater Sage-Grouse Hunters in Utah. *Animal Conservation*. <http://onlinelibrary.wiley.com/doi/10.1111/acv.12213/abstract>

Summary: As a hunted species becomes increasingly rare, the effort required to locate and harvest an individual tends to increase. As rarity increases, governmental oversight, including changes in hunting regulations and protection of habitats and individuals using mechanisms such as the U.S. Endangered Species Act (ESA), can be used to mitigate extinction risks. However, recent research has demonstrated the existence of a feedback mechanism through which increased rarity may increase hunter demand for opportunities to pursue rare species before the opportunity is lost. This phenomenon, referred to as the anthropogenic Allee effect, may exacerbate exploitation, thereby resulting in disproportionately large effects of harvest on vulnerable species. In 2010, the US Fish and Wildlife Service designated greater sage-grouse as a candidate for listing under the ESA. Although sage-grouse are a candidate for ESA listing, they are still hunted throughout much of their current range. In 2008, the demand for sage-grouse hunting permits in Utah exceeded their availability, raising questions about why hunters choose to pursue this species. The authors hypothesized that the pending ESA listing decision increased hunter demand for permits. They surveyed randomly selected hunters who obtained permits to hunt sage-grouse in Utah in 2008–2010 to determine their motivations for hunting sage-grouse and determinants of hunter satisfaction. The most commonly reported reasons for hunting sage-grouse were to spend time with family, for tradition, and meat. Although the potential ESA listing was not a major motivational factor in 2009 or 2010, the percentage of respondents selecting this option did increase by 7%. Hunter awareness of the ESA listing petition also increased by 18% during this period. Their results provided new insights on the sociological importance and potential threats of hunting rare species.

Sandford, C., D. Dahlgren, and T. A. Messmer. 2015. Greater Sage-Grouse Female Selects Nest Site in an Active Conifer Mastication Treatment. *The Prairie Naturalist*.

https://www.researchgate.net/publication/290445165_Sage-Grouse_Nests_in_an_Active_Conifer_Mastication_Site

Summary: Past research has documented sage-grouse avoidance of conifer cover and negative effects of conifer cover on lek counts, and sage-grouse habitat-use following conifer removal. However, the authors presented the documentation of a sage-grouse using a conifer masticated area during an active treatment for breeding habitat, specifically nesting. Their observation provides support for previous recommendations that if conifer treated areas are located adjacent to occupied sage-grouse habitat, these restored sagebrush communities will be readily occupied. The results support Utah's strategy of removing conifers to create more available habitat for sage-grouse.

Caudill, D., M.R. Guttery, B. Bibles, T.A. Messmer, G. Caudill, E. Leone, D.K. Dahlgren, and R. Chi. 2014. Effects of climatic variation and reproductive trade-offs vary by measure of reproductive effort in greater sage-grouse. *Ecosphere*.

http://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=3433&context=wild_facpub

Summary: Research on long-lived grouse species has shown that reproductive success may increase with age, until the onset of senescence, and that prior reproductive success may influence current reproductive success. Such complex reproductive dynamics can complicate conservation strategies, especially for harvested species. Further complicating the matter is the fact that most studies of reproductive costs are only able to evaluate a single measure of reproductive effort. The authors systematically evaluated the effects of climatic variation and reproductive trade-offs on multiple reproductive vital rates for greater sage-grouse. Based on over a decade of field observations conducted on sage-grouse populations that inhabited Utah's Parker Mountain Sage-grouse Management Area, they hypothesized that reproduction is influenced by previous reproductive success. They monitored female sage-grouse reproductive activity from 1998 to 2010, and used generalized linear mixed models to assess effects of climate and previous reproductive success on subsequent reproductive success. Neither nest initiation nor clutch size were found to be affected by climatic variables or previous reproductive success. However, both nest and brood success were affected by climatic variation and previous reproductive success. Nest success was highest in years with high spring snowpack, and was negatively related to previous brood success. Brood success was positively influenced by moisture in April, negatively associated with previous nest success, and positively influenced by previous brood success. Both positive and negative effects of previous reproduction on current year reproduction were observed, possibly indicating high levels of individual heterogeneity in female reproductive output. Their results support previous research in indicating that climatic variability may have significant negative impacts on reproductive rates and emphasize the importance of increasing and maintaining the habitat space available to sage-grouse.

Caudill, D., T.A. Messmer, B. Bibles, and M.R. Guttery. 2014. Greater sage-grouse juvenile

survival in Utah. *Journal of Wildlife Management*.

<http://utahcbcp.org/files/uploads/parm/CaudillEtAl2014.pdf>

Summary: Greater sage-grouse adult hen and juvenile survival have been shown to have significant influence on population growth rates. However, assessing the sensitivity of population growth rates to variability in juvenile survival has proven difficult because of limited information concerning the potentially important demographic rate. Sage-grouse survival rates are commonly assessed using necklace-type radio transmitters. Recent technological advances have led to increased interest in the deployment of dorsally mounted global positioning system (GPS) transmitters for studying sage-grouse ecology. However, the use of dorsally mounted transmitters has not been thoroughly evaluated for sage-grouse, leading to concern that birds fitted with these transmitters may experience differential mortality rates. The authors evaluated the effect of transmitter positioning (dorsal vs. necklace) on juvenile sage-grouse survival using a controlled experimental design with necklace-style and suture-backpack very high frequency (VHF) transmitters. To evaluate the effects of temporal variation, sex, and transmitter type on juvenile sage-grouse survival, they monitored 91 juveniles captured on the Parker Mountain Sage-grouse Management Area in south-central Utah from 2008 to 2010. They instrumented 19 females with backpacks, 14 males with backpacks, 39 females with necklaces, and 19 males with necklaces. Sex and transmitter type were deemed to have biologically meaningful impacts on survival. Dorsally mounted transmitters appeared to negatively affect daily survival. For all years pooled, the probability death was due to predation was 0.73, reported harvest was 0.16, unreported harvest was 0.09, and other undetermined factors was 0.02. They observed 0% and 6.8% crippling loss (from hunting) in 2008 and 2009, respectively. They recommend the adoption of harvest management strategies that attempt to shift harvest away from juveniles and incorporate crippling rates. In addition, future survival studies on juvenile sage-grouse should use caution if implementing dorsally mounted transmitters because of the potential for experimental bias. The interest in using GPS transmitters to map sage-grouse movements and habitat-use is increasing. To ensure we are accounting for the potential bias on sage-grouse vital rates, sage-grouse studies in Utah continue to deploy VHF transmitters along with GPS transmitters.

Breidinger, L.S., K.E. Mock, and T.A. Messmer. 2013. Greater sage-grouse and natural gas development in Utah: using population genetic data for conservation efforts. *Western North American Naturalist*. 73:177-183.

<http://utahcbcp.org/files/uploads/publications/BreidingerEtAl2013LeahSmith.pdf>

Summary: Population declines of greater sage-grouse throughout the western United States have been attributed to the loss, degradation, and fragmentation of sagebrush habitats. Increased energy development may further fragment sagebrush habitat, isolating sage-grouse populations and resulting in genetic drift, inbreeding, local extinction, or rapid divergence. The authors conducted a genetic survey of 3 remote sage-grouse populations in northeastern Utah to assess mitochondrial diversity relative to other portions of the species' range. They did not detect any unusual haplotype compositions in these populations. However, haplotype composition of the

Anthro Mountain and Strawberry Valley reference populations differed from haplotype compositions of other northeastern Utah populations. These populations are spatially separated by Desolation Canyon of the Green River. This canyon may constitute a geographic barrier to gene flow in this area, given low population densities and reduced dispersal potentials. This potential barrier will be an important consideration in future conservation efforts such as translocations. The halotype composition of the Anthro Mountain and Strawberry Valley reference populations may be altered by translocations subsequent to our sampling effort. These results validated the boundaries of Utah's Sage-grouse Management Areas in protecting priority sage-grouse populations in Utah.

Guttry, M.R., T.A. Messmer, E.T. Thacker, N. Gruber, and C.M. Culumber. 2013. Greater sage-grouse sex ratios in Utah: implications for reporting population trends. *Journal of Wildlife Management*. 77:1593-1597. <http://onlinelibrary.wiley.com/doi/10.1002/jwmg.620/abstract>

Summary: Greater sage-grouse are a species of conservation concern throughout western North America. Obtaining valid population estimates is essential to understanding population trajectories and the effects of management. Counts of male sage-grouse attending leks during the breeding season are used directly as a population index or to estimate the breeding population size by assuming a detection probability and sex ratio. In the latter case, managers often assume a 2:1 female-biased ratio. However, this sex ratio has not been validated and may result in biased population estimates. The authors re-evaluated sex ratios at hatch, 42 days of age, and at harvest to determine if sex ratios were biased for sage-grouse in Utah. Sex ratios at hatch and at 42 days of age did not differ from parity. Harvest data suggested that sage-grouse may exhibit a slight female-biased sex ratio (1.458:1) in the fall. They recommended caution when using lek count data to estimate population size if sex ratios have not been validated. This information is now being used to estimate sage-grouse populations range-wide.

Guttry, M.R., D.K. Dahlgren, T.A. Messmer, J.W. Connelly, K.P. Reese, P.A. Terletzky, N. Burkepile, and D.N. Koons. 2013. Effects of landscape-scale environmental variation on greater sage-grouse chicks survival. *PLoS ONE* 8:e65582. <http://utahcbcp.org/files/uploads/parm/GuttryEtal2013.pdf>

Summary: Effective long-term wildlife conservation planning for a species must be guided by information about population vital rates at multiple scales. Greater sage-grouse populations declined substantially during the twentieth century, largely as a result of habitat loss and fragmentation. In addition to the importance of conserving large tracts of suitable habitat, successful conservation of this species will require detailed information about factors affecting vital rates at both the population and range-wide scales. Research has shown that sage-grouse population growth rates are particularly sensitive to female and chick survival rates. While considerable information on hen survival exists, there is limited information about chick survival at the population level, and currently there are no published reports of factors affecting chick survival across large spatial and temporal scales. The authors analyzed greater sage-grouse chick survival rates from 2 geographically distinct populations across 9 years. The effects of 3 groups

of related landscape-scale covariates (climate, drought, and phenology of vegetation greenness) were evaluated. Models with phenological change in greenness (NDVI) performed poorly, possibly due to highly variable production of forbs and grasses being masked by sagebrush canopy. The top drought model resulted in substantial improvement in model fit relative to the base model and indicated that chick survival was negatively associated with winter drought. Our overall top model included effects of chick age, hen age, minimum temperature in May, and precipitation in July. These results provided important insights into the possible effects of climate variability on sage-grouse chick survival and support the Utah conservation strategy of increasing the habitat available to sage-grouse to abate the effects of climate changes on sage-grouse survival.

Messmer, T.A., R. Hasenyager, J. Burruss, and S. Liquori. 2013. Stakeholder contemporary knowledge needs regarding the potential effects of tall structures on sage-grouse. *Human Wildlife Interactions*. 7:273-298. <http://www.berrymaninstitute.org/files/uploads/Messmer.pdf>

Summary: The U.S. Energy Policy Act of 2005 required all state and federal agencies to grant utilities access permits to promote reliable, renewable energy production and transmission. Contemporary transmission relies largely on above-ground electric transmission structures and lines. The construction, operation, and maintenance of tall structures, such as power lines, communication towers, wind turbines, and other installations and their associated activities in sage-grouse habitats were identified as a conservation threat by the U.S. Fish and Wildlife Service in its decision to designate greater sage-grouse (*C. urophasianus*; sage-grouse) as a candidate species for protection under the Endangered Species Act of 1973. The Greater Sage-grouse Range-wide Comprehensive Strategy identified a need to synthesize the research on the effects of tall structures on sage-grouse as the first step in a process to develop best management practices (BMPs) to minimize potential negative impacts on the species. The Utah Wildlife-in-Need Foundation (UWIN) facilitated a public input process in 2010 to assess stakeholder contemporary knowledge regarding the effects of tall structures on sage-grouse. Stakeholders reviewed published information to evaluate the scientific basis for the potential impacts of tall structures on sage-grouse. At the time of the UWIN review, stakeholders concluded that there were no peer-reviewed, experimental studies reported in the scientific literature that specifically documented increased avoidance or predation on sage-grouse because of the construction, operation, and maintenance of tall structures. Consequently, stakeholders were concerned that the science upon which tall structure siting decisions are based was lacking, and as a result, temporal and spatial setbacks and buffers stipulations may differ by governmental agency. Stakeholders recommended that research implemented to address their concerns include experimental designs that simultaneously address multiple knowledge gaps, include metrics assessing potential individual and cumulative impacts of each tall structure type, and a collaborative process that allows preliminary results to be implemented in an adaptive management approach to actively refine BMPs. Lastly, stakeholders recommended that industry be provided mitigation incentives as part of a comprehensive strategy to fund desired research. A review of the scientific literature regarding sage-grouse since completion of the 2010 review

produced no new published information, but recent unpublished reports have begun to address the issue.

Messmer, T.A. 2013. Lessons learned from the greater sage-grouse: challenges and emerging opportunities for agriculture and rural communities. Policy Brief 6. National Agricultural and Rural Development Policy Center, Michigan State University, East Lansing, Michigan. USA. http://utahcbcp.org/files/uploads/publications/PolicyBrief_SageGrouse.pdf

Summary: The author reviewed the last decade of sage-grouse conservation policy and identified sets of recommendations that if implemented could create new opportunities for community involvement in sage-grouse conservation policy.

Reinhart, J.S., T.A. Messmer, and T.A. Black. 2013. Inter-seasonal movements in tri-state greater sage-grouse: implications for state-centric conservation plans. *Human-Wildlife Interactions*. 7:172-181. https://www.researchgate.net/publication/287751983_Inter-seasonal_movements_in_tri-state_greater_sage-grouse_Implications_for_state-centric_conservation_plans

Summary: The U.S. Fish and Wildlife Service (USFWS) designated greater sage-grouse as a candidate species to receive protection under the Endangered Species Act in 2010. Several states in the western United States have developed management plans to mitigate the listing factors identified by the USFWS. However, sage-grouse populations inhabit sagebrush (*Artemisia* spp.) ecosystems that may transcend multiple state boundaries. If sage-grouse inter-seasonal movements encompass habitats in multiple states and if state-centric wildlife management strategies differ, species conservation may be further complicated. Additionally, if these populations are located in peripheral state boundary areas, they may also receive less management focus both because of their remoteness and state agency emphasis on interior populations. The Grouse Creek sage-grouse population that inhabits extreme northwestern Utah where the state borders eastern Nevada and southern Idaho exemplifies this situation. This population inhabits the Box Elder Sage-grouse Management Area. The authors monitored 50 radio-collared sage-grouse from 2005 to 2006 to document inter-seasonal movements relative to sex and age and state boundaries. Radio-collared sage-grouse migrated an average of 13.1 km from breeding (range = 0.2 to 69.3, SE = 14.4) to summer range, 22.6 km from summer (range = 0.2 to 46.1, SE = 12.6) to winter range, and 25.4 km from winter (range = 1.1 to 37.2, SE = 13.4) to return to spring range. Ten radio-marked birds (20%) used seasonal habitats in Idaho, Nevada, and Utah. Males were more likely to engage in long-distance movements than females during the breeding season. They confirmed that within a geographically defined state population, individuals may exhibit diverse inter-seasonal migration strategies. Their results support the need for increased coordination among states that share occupied sagebrush habitats to develop interstate sage-grouse conservation plans and the importance of defining sage-grouse seasonal habitat-use areas to guide state-wide conservation efforts. This is the basis of Utah's sage-grouse conservation strategy.

Robinson, J.D. and T.A. Messmer. 2013. Vital rates and seasonal movements of two isolated greater sage-grouse populations in Utah's West Desert. *Human Wildlife Interactions*. 7:182-194. <http://utahcbcp.org/files/uploads/westdesert/RobinsonMessmer2013.pdf>

Summary: Declines in greater sage-grouse populations in Utah over the last century parallel range-wide trends. However, little is known about the ecology of sage-grouse populations that inhabit Utah's naturally fragmented habitats. Utah's West Desert sage-grouse populations occupy sagebrush habitats that are geographically separated by the Great Salt Lake, and largely confined to the Sheeprock (Sheeprock Sage-grouse Management Area) and Deep Creek (Ibapah Sage-grouse Management Area) watersheds. From 2005 to 2006, the authors monitored sage-grouse that were radio-collared in each watershed to determine the factors affecting the vital rates in these isolated populations. Livestock grazing by domestic cattle was the dominant land use, and mammalian predator control for livestock protection was conducted in both watersheds. Corvid control was conducted only in the Sheeprock watershed. During the study, the authors identified 6 leks that had not been previously documented. Seasonal migration patterns for individual radio-collared sage-grouse in both watersheds varied across the sites. Habitat structure metrics were similar at brood-rearing and random sites for both areas. Nesting and brood success and the ratio of chicks per successful brood were higher for both populations in 2005 than 2006. We attributed these annual differences in vital rates to seasonal variation in precipitation. Spring precipitation in 2005 was twice the 30-year average following a 5-year drought. However, chick recruitment estimates for both populations regardless of year were lower than reported in the published literature. Adult sage-grouse survival rate estimates in Sheeprock and Deep Creek watersheds were lower and higher, respectively, than published reports indicated. These differences may reflect a difference in meso-predators communities particularly red fox. Sage-grouse conservation strategies in both areas should continue to emphasize protection of brood-rearing and seasonal habitat, but the risk of population extirpation as a consequence of extended droughts predicted by climate change models and the invasion of small meso-predators may remain problematic for these populations. This information was used by the West Desert Adaptive Resources Management Local Working Group to develop their sage-grouse management plan. Their plan was subsequently embraced by the Utah Plan.

Frey, S.N., R. Curtis, and K. Heaton. 2013. Response of a small population of greater sage-grouse to tree removal: Implications of limiting factors. *Human-Wildlife Interactions*. 7:260-272. <http://utahcbcp.org/files/uploads/color/HWWaltonSageGrouse.pdf>

Summary: In Utah, greater sage-grouse range has been reduced to 50% of what is considered historical availability due to habitat degradation and loss. In an effort to improve sage-grouse habitat in southern Utah, the U.S. Bureau of Land Management (BLM) conducted a tree-removal treatment in 2005. The authors conducted a study to determine if (a) the tree-removal treatment was effective at creating new sage-grouse habitat, and (b) if characteristics of used habitat were similar to those reported in previous literature. The treatment resulted in increased abundance of grasses and forbs. Additionally, shrub percentage cover and height was not negatively affected by the treatment. Sage-grouse used the treated areas more than expected based on availability

within the first year of the treatment. The vegetation resulting from the treatment used by sage-grouse in all seasons was lower in percentage shrub, grass, forb composition, and average height than the range of previously reported habitats for late-brood rearing, fall and winter seasons of use. Sage-grouse's quick positive response to the treated area suggests that suitable habitat is limited in this region. This study provided some of the first evidence of sage-grouse positive responses to conifer removal.

Baxter, R.J., R.T. Larsen, and J.T. Flinders. 2013. Survival of resident and translocated greater sage-grouse in Strawberry Valley, Utah: a 13-year study. *Journal of Wildlife Management* 77:802-811. <http://utahcbcp.org/files/uploads/publications/BaxterEtAl2013sagrtranslocation.pdf>

Summary: Survival of greater sage-grouse has been well described in large populations across the species' range. Very little published information exists, however, on survival rates of translocated sage-grouse or grouse from a long-term (>10 yr) study. The authors wanted to estimate seasonal and annual survival rates; assess differences in survival between resident and translocated, adult and yearling, and male and female sage-grouse; identify environmental and behavioral factors associated with survival; and assess the influence of mammalian predator control on survival rates of radio-marked sage-grouse in the Strawberry Valley Sage-grouse Management Area (SGMS) in northcentral Utah from 1998 to 2010. They captured and fitted 535 individual sage-grouse (male and female, resident and translocated) with radio transmitters over a 13-year period and monitored them weekly. The top model of survival, which accounted for 22% of the AICc weight, included 3 seasons that varied by year where rates were influenced by residency, sex, and whether a female initiated a nest. A group-level covariate for the number of canids killed each year received some support as this variable improved model fit compared to identical models without it, although confidence intervals around β estimates overlapped zero slightly. All other demographic or environmental variables showed little or no support. Annual estimates of survival for females ranged between 28% and 84% depending on year and translocation source. Survival was consistently highest during the fall–winter months with a mean monthly survival rate of 0.97 (95% CI = 0.96–0.98). They suggested managers consider enhancing nesting habitat, translocating sage-grouse, and possibly controlling predators to improve survival rates of sage-grouse before conducting translocation. These recommendations are being used to guide sage-grouse translocations in the Sheeprock SGMA.