

**U.S. FISH AND WILDLIFE SERVICE  
SPECIES STATUS ASSESSMENT  
BI-STATE DISTINCT POPULATION SEGMENT OF  
GREATER SAGE-GROUSE**



**July 26, 2013**

# TABLE OF CONTENTS

<b>EXECUTIVE SUMMARY .....</b>	<b>5</b>
<b>BIOLOGICAL INFORMATION.....</b>	<b>7</b>
<i>Species Description .....</i>	<i>7</i>
<i>Taxonomy.....</i>	<i>7</i>
<i>Habitat.....</i>	<i>8</i>
Sagebrush Ecosystem .....	9
Seasonal Habitat Selection and Life History Characteristics.....	10
<i>Home Range .....</i>	<i>15</i>
<i>Life Expectancy and Survival Rates.....</i>	<i>15</i>
<i>Historical Range/Distribution .....</i>	<i>16</i>
<i>Current Range/Distribution and Population Estimates/Annual Lek Counts .....</i>	<i>17</i>
1. Pine Nut PMU .....	21
2. Desert Creek-Fales PMU .....	22
3. Mount Grant PMU.....	23
4. Bodie PMU .....	24
5. South Mono PMU.....	26
6. White Mountains PMU.....	27
<i>Bi-State DPS Population Trends.....</i>	<i>29</i>
<i>Land Ownership .....</i>	<i>31</i>
<b>IMPACT ANALYSIS.....</b>	<b>33</b>
<i>Urbanization and Habitat Conversion .....</i>	<i>33</i>
Summary of Urbanization and Habitat Conversion Impacts .....	38
<i>Infrastructure.....</i>	<i>38</i>
1. Roads .....	40
2. Power Lines .....	43
3. Fences .....	47
4. Communication Towers.....	49
5. Landfills.....	50
Summary of the Potential Impacts From Infrastructure.....	51
<i>Mining .....</i>	<i>52</i>
<i>Renewable Energy Development .....</i>	<i>54</i>

<b><i>Grazing and Rangeland Management</i></b> .....	<b>58</b>
Summary of Potential Grazing and Rangeland Management Impacts .....	64
<b><i>Nonnative and Native Invasive Plants</i></b> .....	<b>65</b>
Nonnative Invasive Plants .....	65
Native Invasive Plants .....	67
Summary of Nonnative and Native Invasive Plants .....	69
<b><i>Wildfires and Altered Fire Regime</i></b> .....	<b>69</b>
Wildfire and its History in Sagebrush Ecosystems .....	69
Wildfire Frequency Within Sage-grouse Range .....	70
Potential Impacts of Fire on Sage-grouse and its Habitat .....	71
Potential Recovery of Sagebrush Habitat Following Wildfire .....	73
Impact of Wildfires and an Altered Fire Regime Within the Bi-State Area .....	74
<b><i>Climate</i></b> .....	<b>76</b>
Drought.....	76
Climate Change .....	78
<b><i>Overutilization Impacts</i></b> .....	<b>83</b>
Commercial Hunting .....	83
Recreational Hunting .....	84
<b><i>Recreation</i></b> .....	<b>87</b>
<b><i>Scientific and Educational Uses</i></b> .....	<b>90</b>
<b><i>Disease or Predation</i></b> .....	<b>93</b>
Disease.....	93
Predation.....	99
<b><i>Small Population Size and Population Structure</i></b> .....	<b>105</b>
<b><i>Pesticides and Herbicides</i></b> .....	<b>110</b>
<b><i>Contaminants</i></b> .....	<b>113</b>
<b><i>Existing Regulatory Mechanisms</i></b> .....	<b>113</b>
Local Regulatory Mechanisms .....	113
State Regulatory Mechanisms .....	114
Federal Laws and Regulations .....	118
Summary of Existing Regulatory Mechanisms .....	126
<b>CONSERVATION EFFORTS</b> .....	<b>127</b>
<b><i>Past and Ongoing Management Efforts</i></b> .....	<b>128</b>
<b><i>Conservation Efforts On Private Lands</i></b> .....	<b>131</b>
<b><i>2012 Bi-State Action Plan</i></b> .....	<b>132</b>
<b><i>2013 Conservation Objectives Team (COT) Report</i></b> .....	<b>132</b>

<i>Habitat Conservation Plans or Other Management Plans Under Development .....</i>	<b>134</b>
<b>OVERALL SUMMARY OF SPECIES STATUS AND IMPACTS .....</b>	<b>135</b>
<i>Summary of Species Status.....</i>	<b>135</b>
<i>Summary of Threats Analysis .....</i>	<b>138</b>
Urbanization and Habitat Conversion.....	139
Infrastructure .....	139
Mining .....	140
Renewable Energy Development.....	140
Grazing and Rangeland Management.....	141
Nonnative and Native Invasive Plants .....	141
Wildfires and Altered Fire Regime.....	142
Climate .....	143
Overutilization and Scientific and Education Uses.....	144
Disease or Predation .....	144
Small Population Size and Population Structure .....	145
Pesticides and Herbicides .....	145
Contaminants .....	145
Existing Regulatory Mechanisms .....	145
Synergistic Impacts.....	146
<i>Overall Summary .....</i>	<b>146</b>
<b>REFERENCES CITED .....</b>	<b>148</b>
<b>APPENDIX A—DEFINITIONS.....</b>	<b>187</b>
<b>APPENDIX B—POPULATION MANAGEMENT UNIT (PMU) MAPS .....</b>	<b>190</b>
<b>APPENDIX C—NON-REGULATORY MECHANISMS EVALUATED .....</b>	<b>197</b>

**SCIENTIFIC NAME:** *Centrocercus urophasianus*

**COMMON NAME:** Greater sage-grouse (Bi-State Distinct Population Segment)

**ANIMAL GROUP AND FAMILY:** Birds, Phasianidae (pheasants, grouse, turkeys, and partridges)

## **EXECUTIVE SUMMARY**

The Bi-State population of greater sage-grouse is a distinct population segment (DPS) of sage-grouse for which the U.S. Fish and Wildlife Service (Service) determined in March 2010 that listing is warranted under the Endangered Species Act. This report documents and analyzes the current status of and threats to the Bi-State DPS. Here we summarize status and impacts and identify the current (approximately last 10 years) trend for each.

### **Status:**

- There has been a reduction from historical range and habitat of greater than 50 percent; the current trend is a slow, continued reduction in range and habitat.
- There has been a reduction from historical abundance of greater than 50 percent. The current trend in abundance is unknown, but it is expected to gradually decrease for at least five of the six Population Management Units (PMUs). This is of critical concern to the species because fluctuations in the four small, less secure PMUs are likely to result in extirpations and loss of population redundancy within the Bi-State DPS.
- All six PMUs of the Bi-State DPS include poor connectivity within and among PMUs; the current trend in connectivity is slowly deteriorating, and this is of critical concern to the species because it increases the risk of loss of individual PMUs via stochastic events.
- Remaining habitat is increasingly fragmented within all six PMUs; the current trend in habitat fragmentation is a slow increase.
- Well known leks in the center of the species' range that have remained protected over time have long-term monitoring data suggesting stable population trends.
- Trends for most leks are unknown, especially on periphery of the species' range. This is of critical concern to the species because there is a pattern of historical extirpations of peripheral leks and populations for the Bi-State DPS.
- Recent extensive and intensive surveys for the Bi-State DPS rangewide did not significantly increase the known number of leks or individuals.
- The size of the Bi-State population is generally below theoretical minimums for long-term persistence reported in scientific literature; populations are especially small and increasingly isolated outside the two largest (core) PMUs of South Mono and Bodie.

#### Impacts:

- There are multiple impacts to habitat interacting in the Bi-State DPS, and no one impact stands out.
- Sage-grouse are long-lived, habitat specialists with low reproductive rates and particularly sensitive to habitat fragmentation caused by multiple, interacting impacts.
- *Pinus edulis* (pinyon pine) and various *Juniperus* (juniper) species encroachment has caused significant habitat reduction; the current trend in woodland encroachment is increasing, but mitigated partially by ongoing woodland removal projects.
- Urbanization has caused significant habitat reduction; the current trend in urbanization is increasing, but slowly.
- Infrastructure development (e.g., roads) has caused significant habitat fragmentation; the current trend in this impact is increasing, but slowly.
- The fire-invasive species cycle destroys native plant communities and sage-grouse habitat; the current trend in habitat loss from fire and invasive species is increasing.
- Small population size and meta-population isolation increases risk to sage-grouse; the current trend in small, isolated populations is gradually increasing. This is of critical concern to the species because fluctuations in the four small, less secure PMUs are likely to result in extirpations and loss of population redundancy within the Bi-State DPS.
- Predation is locally impacting sage-grouse, such as that occurring in the South Mono PMU near a landfill; the current trend in predation for the Bi-State DPS rangewide is unknown.
- There is uncertainty over long-term impacts from climate change and its effects on other factors like invasive species; however, change is anticipated.

Habitat restoration and protection efforts are actively occurring, including removal of encroaching pinyon-juniper trees and securing conservation easements on some private land to ensure it continues to be managed to provide habitat for sage-grouse. Partnerships are strong and conservation interest currently high. This area has maintained an active Bi-State Local Planning Group since the early 2000s, and the Group is active in Nevada and California. Also, the Bureau of Land Management (BLM) Bishop Field Office has a demonstrated track record of avoiding substantial development impacts in the Bodie and South Mono PMUs, which is in part why those two PMUs have the largest remaining populations.

In 2012, an existing sage-grouse conservation plan (i.e., 2004 Bi-State Plan) completed by the Bi-State Local Planning Group was updated. This new document (i.e., 2012 Bi-State Action Plan) is a general roadmap toward species conservation. However, it lacks specificity in key areas. For example, it identifies the importance of pinyon-juniper removal, but does not specify how much and where removal is necessary. It also lacks assurances of funding or implementation. The 2012 Bi-State Action Plan includes many measures similar to those in the 2004 Bi-State Plan that were never funded or implemented. Recently, the Service and multiple States convened a Conservation Objectives Team (COT) to produce a recommendation regarding the degree to which threats need to be reduced or ameliorated to conserve the greater sage-

grouse. The 2013 COT Final Report (Service 2013, entire) addresses greater sage-grouse across its entire range, including the Bi-State DPS in Nevada and California. Obtaining funding and successfully implementing conservation measures in the 2012 Bi-State Action Plan and the COT Final Report has been and will continue to be challenging given competing resource needs. However, funding available through the Sage Grouse Initiative (SGI) of the Natural Resources Conservation Service (NRCS) is helping maintain momentum for implementation of conservation measures on private lands in the Bi-State DPS.

## BIOLOGICAL INFORMATION

### *Species Description*

The greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse) is the largest North American grouse species. Adult male sage-grouse range in length from 66 to 76 centimeters (cm) (26 to 30 inches (in)) and weigh between 2 and 3 kilograms (kg) (4 and 7 pounds (lbs)). Adult females are smaller, ranging in length from 48 to 58 cm (19 to 23 in) and weighing between 1 and 2 kg (2 and 4 lbs). Males (cocks) and females (hens) have dark grayish-brown body plumage with many small gray and white speckles, fleshy yellow combs over the eyes, long pointed tails, and dark green toes. Males also have blackish chin and throat feathers, conspicuous phylloplumes (specialized erectile feathers) at the back of the head and neck, and white feathers forming a ruff around the neck and upper belly. During breeding displays, males exhibit olive-green apteria (fleshy bare patches of skin) on their breasts (Schroeder *et al.* 1999, p. 2).

### *Taxonomy*

Sage-grouse are members of the family Phasianidae, which is a diverse group consisting of over 50 genera commonly known as grouse, turkeys, pheasants, partridges, francolins, and Old World quail. They are one of two congeneric (closely related) sage-grouse species, the other species being the Gunnison sage-grouse (*Centrocercus minimus*). In 1957, the American Ornithologists' Union (AOU) (AOU 1957, p. 139) recognized two subspecies of the sage-grouse, the eastern (*Centrocercus urophasianus urophasianus*) and western (*C. u. phaios*), based on information from Aldrich (1946, p. 129). The original designation of the western subspecies was based on differences in coloration (reduced white markings and darker feathering on western birds) among 11 specimens collected from 8 locations in Washington, Oregon, and California. The AOU has not published a revised edition of their *Check-list of North American Birds* at the subspecies level, so the eastern and western sage-grouse subspecies are still recognized by the AOU (Banks 2000). However, the AOU (1998, p. xii) noted that a "number of currently recognized subspecies, especially those formally named early in this century, probably cannot be validated by rigorous modern techniques."

Since 1957, the validity of the subspecies of sage-grouse have been questioned by taxonomic authorities (Johnsgard 1983, p. 109, 2002, p. 108; Drut 1994, p. 2; Schroeder *et al.* 1999, p. 3; Banks 2000, 2002; Benedict *et al.* 2003, p. 301), as described in the Taxonomy section of the 2010 12-month finding (Service 2010, pp. 13,912–13,913). Banks (2000) stated that it was "weakly characterized", but that it would be wise to continue to regard western sage-grouse as

taxonomically valid “for management purposes.” The Western Association of Fish and Wildlife Agencies (WAFWA), an organization of 23 State and Provincial agencies charged with the protection and management of fish and wildlife resources in the western United States and Canada, questioned the validity of the western sage-grouse subspecies in its Conservation Assessment of Greater Sage-grouse and Sagebrush Habitats (Connelly *et al.* 2004, pp. 8-4 to 8-5). In its conservation assessment and strategy for sage-grouse, the Oregon Department of Fish and Wildlife (ODFW) stated that “recent genetic analysis (Benedict *et al.* 2003) found little evidence to support this subspecies distinction, and this Plan refers to sage-grouse without reference to subspecies delineation...” (Hagen 2005, p. 5). The Integrated Taxonomic Information System (ITIS), a database representing a partnership of United States, Canadian, and Mexican agencies, other organizations, and taxonomic specialists designed to provide scientifically credible taxonomic information, lists the taxonomic status of western sage-grouse as “invalid – junior synonym” (ITIS 2010).

In our 12-month finding on petitions to list three entities of sage-grouse (Service 2010, pp. 13,988–13,990), we found that the Bi-State population of sage-grouse meets our criteria as a DPS of the greater sage-grouse under Service policy (Service 1996, entire). This determination was based principally on genetic information, where the DPS was found to be both markedly separated and significant to the remainder of the sage-grouse taxon. The Bi-State DPS defines the far southwest limit of the species’ range along the border of eastern California and western Nevada (Stiver *et al.* 2006, pp. 1–11; Service 2006, 76,060). Sage-grouse in the Bi-State area contain a large number of unique genetic haplotypes not found elsewhere within the range of the species (Benedict *et al.* 2003, p. 306; Oyler–McCance *et al.* 2005, p. 1,300; Oyler–McCance and Quinn 2011, p. 92). The genetic diversity present in the Bi-State area population is comparable to other populations, suggesting that the differences are not due to a genetic bottleneck or founder event (Oyler–McCance and Quinn 2011, p. 91). These studies provide evidence that the present genetic uniqueness exhibited by Bi-State area sage-grouse developed over thousands and perhaps tens of thousands of years, hence, prior to the Euro-American settlement (Benedict *et al.* 2003, p. 308; Oyler–McCance *et al.* 2005, p. 1,307).

While the Bi-State population may have been isolated for an amount of time similar to the Gunnison sage-grouse population and are genetically unique, they do not currently demonstrate an appreciable behavioral difference in male mating display from the greater sage-grouse as has been documented in the Gunnison sage-grouse (Taylor and Young 2006, p. 40). Comparative studies of other aspects of their morphology and behavior have not been conducted. Using new genetic sequencing methods, Oyler-McCance (2011, unpublished data) explored both presumably neutral genes and those under selection to re-examine these divisions. Results suggest that the genetic uniqueness present in the Bi-State DPS is significant; however, Oyler-McCance (2011, unpublished data) does not suggest that the population should be classified as a unique species.

### *Habitat*

Sage-grouse depend on a variety of shrub-steppe vegetation communities throughout their life cycle and are considered obligate users of several species of sagebrush including *Artemisia tridentata* Nutt. ssp. *wyomingensis* Beetle and Young (Wyoming big sagebrush), *A. t.* Nutt. ssp.



*vaseyana* (Rydb.) Beetle (mountain big sagebrush), and *A. t.* Nutt. ssp. *tridentata* (basin big sagebrush) (Patterson 1952, p. 48; Braun *et al.* 1976, p. 168; Connelly *et al.* 2000a, pp. 970–972; Connelly *et al.* 2004, p. 4-1; Miller *et al.* 2011, pp. 148–149). Sage-grouse also use other sagebrush species such as *A. arbuscula* Nutt. (little sagebrush), *A. nova* A. Nelson (black sagebrush), and *A. cana* Pursh (silver sagebrush) (Schroeder *et al.* 1999, pp. 4–5; Connelly *et al.* 2004, p. 3-4). Thus, sage-grouse distribution is strongly correlated with the distribution of sagebrush vegetation (Schroeder *et al.* 2004, p. 364).

### Sagebrush Ecosystem

Sagebrush is the most widespread vegetation in the intermountain lowlands of the western United States (West and Young 2000, p. 259) and is considered one of the most imperiled ecosystems in North America (Knick *et al.* 2003, p. 612; Miller *et al.* 2011, p. 147 and references therein). Scientists recognize between 13 and 14 species and 12 and 13 subspecies of sagebrush (Connelly *et al.* 2004, p. 5-2; Miller *et al.* 2011, p. 148), each with unique habitat requirements and responses to perturbations (West and Young 2000, p. 259). Sagebrush species and subspecies occurrence in an area is dictated by local soil type, soil moisture, and climatic conditions (West 1983, p. 333; West and Young 2000, p. 260; Miller *et al.* 2011, pp. 149–150). The degree of dominance by sagebrush varies with local site conditions and disturbance history. Plant associations, typically defined by perennial grasses, further define distinctive sagebrush communities (Miller and Eddleman 2000, pp. 10–14; Connelly *et al.* 2004, p. 5-3) and are influenced by topography, elevation, precipitation, and soil type. These ecological conditions influence the response and resiliency of sagebrush and their associated understories to natural and human-caused changes.

Sagebrush is typically divided into two groups: Big sagebrush and low sagebrush, based on their affinities for different soil types (West and Young 2000, p. 259). Big sagebrush species and subspecies, such as Wyoming big sagebrush, usually occur on moderately deep, coarse-textured, and well-drained soils (Miller *et al.* 2011, p. 149). Low sagebrush, such as black sagebrush, typically occur where erosion has exposed clay or calcified soil horizons (West 1983, p. 334; West and Young 2000, p. 261). Reflecting these soil differences, big sagebrush will die if surfaces are saturated long enough to create anaerobic conditions for 2-3 days (West and Young 2000, p. 259). Some low sagebrush are more tolerant of occasionally supersaturated soils, and many low sagebrush sites are partially flooded during spring snowmelt. None of the sagebrush taxa tolerate soils with high salinity (West 1983, p. 333; West and Young 2000, p. 257). Sagebrush have fibrous tap root systems, which allow the plants to draw surface soil moisture and to access water deep within the soil profile when surface water is limited (West and Young 2000, p. 259).

All species of sagebrush produce large ephemeral leaves in the spring, which persist until reduced soil moisture occurs in the summer. Most species also produce smaller, overwintering leaves in the late spring that last through summer and winter. Most sagebrush flower in the fall. However, during years of drought or other moisture stress, flowering may not occur. Although initial seed viability and germination are high, seed dispersal is limited. Sagebrush seeds, depending on the species, remain viable for 1-3 years. However, Wyoming big sagebrush seeds do not persist beyond the year of their production (West and Young 2000, p. 260).

Sagebrush is long-lived, with plants of some species surviving up to several hundred years (West 1983, p. 340). They produce allelopathic chemicals, which are biochemicals that influence and typically reduce seed germination, seedling growth, and root respiration of competing plant species, and inhibit the activity of soil microbes and nitrogen fixation. Sagebrush has resistance to environmental extremes, with the exception of fire and occasionally defoliating insects (e.g., webworm (*Aroga* spp.); West 1983, p. 341). Most species of sagebrush are killed by fire (West 1983, p. 341; Miller and Eddleman 2000, p. 17; West and Young 2000, p. 259), and historical fire-return intervals are estimated to be as long as 350 years, depending on sagebrush type and environmental conditions (Baker 2011, pp. 191–192). Natural sagebrush recolonization in burned areas depends on the presence of adjacent live plants for a seed source or on the seed bank, if present (Miller and Eddleman 2000, p. 17), and requires from decades to over a century for full recovery (Baker 2011, pp. 194–195).

Plants associated with the sagebrush understory vary, as does their productivity. Both plant composition and productivity are influenced by moisture availability, soil characteristics, climate, and topographic position (Miller *et al.* 2011, pp. 151–154). Forb abundance can be highly variable from year to year and is largely affected by the amount and timing of precipitation (Miller *et al.* 2011, p. 153).

The sagebrush vegetation community in the Bi-State area has changed over time. The extent of this community has been reduced due to both anthropogenic and natural processes acting independently, as well as due to interactions between them. Further, the quality and functionality of the remaining sagebrush community, as it pertains to sage-grouse, has also been influenced by these drivers of change. For example, woodland succession has reduced the extent of sagebrush habitat and influenced the degree to which sagebrush habitat sites are connected to one another. Looking forward, this process as well as others such as alterations of the native herbaceous understory, which is influenced by disturbance and climate change, will challenge our ability to maintain the viability of the sagebrush community. -There are currently areas of sagebrush contained within the Bi-State region that remain relatively intact and retain integrity (e.g., Bodie Hills, Long Valley).

#### Seasonal Habitat Selection and Life History Characteristics

Sage-grouse require large, interconnected expanses of sagebrush with healthy, native understories (Patterson 1952, pp. 9, 48; Knick *et al.* 2003, p. 623; Connelly *et al.* 2004, pp. 4-1 to 4-15; Connelly *et al.* 2011b, p. 82; Pyke 2011, pp. 534–535; Wisdom *et al.* 2011, p. 453), in part to accommodate a seasonal shift in habitat selection within the sagebrush ecosystem. Large-scale characteristics within surrounding landscapes influence sage-grouse habitat selection (Knick and Hanser 2011, p. 402). Sage-grouse exhibit strong site fidelity (loyalty to a particular area) to migration corridors and seasonal habitats, including breeding, nesting, brood-rearing, and wintering areas, even when a particular area may no longer be of value (Connelly *et al.* 2004, p. 3-1; Connelly *et al.* 2011b, p. 82). Adult sage-grouse rarely switch inter-annual use among these seasonal habitats once they have been selected, limiting the species' adaptability to habitat changes (Berry and Eng 1985, pp. 238–240; Fischer *et al.* 1993, p. 1,039; Holloran and Anderson 2005, p. 749; Connelly *et al.* 2011b, p. 82).

Sage-grouse move (migrate) seasonally among various habitat types driven by breeding activities, nest and brood-rearing site requirements, seasonal changes in the availability of food resources, and response to weather conditions (Connelly *et al.* 2004, p. 3-5). Research results have parsed the annual life cycle of sage-grouse into unique seasonal habitat requirement categories, but in general annual habitat use can be categorized into three seasons (which are not always mutually exclusive): (1) Breeding; (2) brood rearing/summer; and (3) winter, as well as the pathways that link these habitats together (Connelly *et al.* 2011b, pp. 71–80). Migration can occur between distinct winter, breeding, and summer areas or the seasonal-use areas may be variously integrated (e.g., winter and breeding areas may be the same and brood-rearing sites are disjunct). Migration distances of up to 161 kilometers (km) (100 miles (mi)) have been recorded (Patterson 1952, p. 189), and distances birds travel vary depending on the locations of seasonal habitats (Schroeder *et al.* 1999, p. 3). Migration distances for female sage-grouse generally are less than for males (Connelly *et al.* 2004, p. 3-4), but not always (Beck 1977, p. 23). The relatively large seasonal and annual movements emphasize the landscape nature of the sage-grouse (Knick *et al.* 2003, p. 624; Connelly *et al.* 2011a, p. 67). Finally, sage-grouse dispersal (permanent movements to other areas) is poorly understood (Connelly *et al.* 2004, p. 3-5) and appears sporadic (Dunn and Braun 1986, p. 89). Information available regarding seasonal migrations and migratory corridors for sage-grouse in the Bi-State area is variable. Some local breeding complexes (a general aggregation of birds associated with a particular lek or collection of leks in relatively close proximity to one another) remain fairly resident throughout the year while others demonstrate a more itinerant nature (Casazza *et al.* 2009, p. 8). This variation in movement patterns is also evident among individuals within a single breeding complex. Radio telemetry data has increased our understanding of annual movements and seasonal use areas, but it has generally failed to accurately depict corridors linking seasonal habitats. Current research, headed by the U.S. Geological Survey, using Global Positioning System (GPS) technology is intended to aid in identifying these corridors.

During the spring breeding season, male sage-grouse gather to perform courtship displays at leks or traditional strutting grounds. Areas of bare soil, short-grass steppe, windswept ridges, exposed knolls, or other relatively open sites typically serve as leks (Patterson 1952, p. 83; Connelly *et al.* 2004, p. 3-7 and references therein). Leks are often surrounded by denser shrub-steppe cover, which is used for escape, thermal, and feeding cover. The proximity, configuration, and abundance of nesting habitat are key factors influencing lek location (Connelly *et al.* 1981, pp. 153–154; Connelly *et al.* 2000a, p. 970). Leks can be formed opportunistically at any appropriate site within or adjacent to nesting habitat (Connelly *et al.* 2000a, p. 970); therefore, lek habitat availability is not considered a limiting factor for sage-grouse (Schroeder 1999, p. 4). Nest sites are selected independent of lek locations, but the reverse is not true (Bradbury *et al.* 1989, p. 22; Wakkinen *et al.* 1992, p. 382). Thus, leks are indicative of nesting habitat.

Leks range in size from less than 0.04 ha (0.1 ac) to over 36 ha (90 ac) (Connelly *et al.* 2004, p. 4-3) and can host from a few to hundreds of males (Johnsgard 2002, p. 112). Males defend individual territories within leks and perform elaborate displays with their specialized plumage and vocalizations to attract females for mating. Although males are capable of breeding the first

spring after hatch, these yearling males are rarely successful in breeding on leks (Schroeder *et al.* 1999, p. 14). Traditionally, it was thought that a relatively small number of dominant males accounted for the majority of copulations on each lek (Schroeder *et al.* 1999, p. 8). However, Bush (2009, p. 106) found that on average 45.9 percent (range 14.3–54.5 percent) of genetically identified males in a population fathered offspring in a given year, indicating that males and females engage in off-lek copulations.

Females are known to travel more than 20 km (12.5 mi) to their nest site after mating (Connelly *et al.* 2000a, p. 970), but distances between nests and leks where breeding occurs are generally shorter (Connelly *et al.* 2004, p. 4-5; Connelly *et al.* 2011a, p. 62). Data compiled from a series of studies across the species' range suggest the average distance between a female's nest and the lek on which she was first observed ranged from 1.3 to 7.8 km (0.8 to 4.8 mi) (Schroeder *et al.* 1999, p. 12; Connelly *et al.* 2011a, p. 62). In the California portion of the Bi-State area a similar pattern is apparent as the majority of radio-marked hens, with few exceptions, nested within 2–3 km (1.2–1.8 mi) of their lek site of capture (Casazza *et al.* 2009, pp. 15, 23, 30). The spatial arrangement of habitats and the degree of habitat disturbance or fragmentation may influence nest locations with respect to lek sites, with females moving farther to nest in areas exposed to greater degrees of habitat impacts (Schroeder *et al.* 1999, p. 12; Lyon and Anderson 2003, p. 489; Connelly *et al.* 2011a, p. 62).

Female sage-grouse exhibit strong fidelity to nesting locations (Lyon 2000, p. 20; Connelly *et al.* 2004, p. 4-5; Holloran and Anderson 2005, p. 747). Interannual distances between nests are frequently less than 1 km (0.6 mi) and often much less than this (Connelly *et al.* 2011b, p. 74 and references therein). In addition, renesting attempts are frequently in close proximity to the original nest. In the rare instances when movement to new nesting areas does occur, nesting success does not necessarily improve (Connelly *et al.* 2004, p. 3-6; Holloran and Anderson 2005, p. 748; Moynahan *et al.* 2007, p. 1,777).

Productive nesting areas are typically characterized by sagebrush with an understory of native grasses and forbs, horizontal and vertical structural diversity that provides an insect prey base, herbaceous forage for pre-laying and nesting hens, and cover for incubating hens (Gregg 1991, p. 19; Schroeder *et al.* 1999, p. 4; Connelly *et al.* 2000a, p. 971; Connelly *et al.* 2004, pp. 4-17 to 4-18; Connelly *et al.* 2011b, p. 73). Sage-grouse also use other shrub or bunchgrass species for nest sites (Klebenow 1969, p. 649; Connelly *et al.* 2000a, p. 970; Connelly *et al.* 2004, p. 4-4; Kolada *et al.* 2009a, p. 1,336). Shrub canopy and grass cover provide concealment for sage-grouse nests and young and are critical for reproductive success (Barnett and Crawford 1994, p. 116; Gregg *et al.* 1994, p. 164; DeLong *et al.* 1995, p. 90; Connelly *et al.* 2004, p. 4-4). General vegetation characteristics of successful nest sites include sagebrush canopy cover greater than 15 percent, sagebrush heights of 30–80 cm (11.8–31.5 in), and grass/forb heights of 18 cm (7.1 in) (Connelly *et al.* 2000a, p. 977; Hagen *et al.* 2007, p. 48). However, the degree to which each of these site characteristics influence nest success appears to vary across the species' range (Holloran *et al.* 2005, p. 645; Kolada *et al.* 2009a, pp. 1,336–1,337).

Nest success data for the Bi-State DPS suggest that nesting habitat in the Bi-State area should contain greater than 20 percent sagebrush canopy cover and greater than 40 percent total shrub cover, with shrub height not appearing influential (Kolada *et al.* 2009a, p. 1,336; Kolada *et al.*

2009b, p. 1,343). This canopy cover standard is generally greater than those reported elsewhere, although, Holloran *et al.* (2005, p. 647) reported similar results from Wyoming. In addition, there is currently no support for an influence of understory cover and height on either nest site selection or nest success (Kolada *et al.* 2009a, p. 1,336; Kolada *et al.* 2009b, p. 1,343). Similar results are apparent in other locations in Nevada, but these investigations also suggest a trade-off between overstory and understory cover (Coates and Delehanty 2010, pp. 245–246); implying, as overstory cover increases, the need for understory cover diminishes and vice versa. Thus, cover provides concealment for sage-grouse nests and young and is critical for reproductive success, however the composition of these cover components appears to vary regionally (Barnett and Crawford 1994, pp. 116–117; Gregg *et al.* 1994, pp. 164–165; DeLong *et al.* 1995, pp. 90–91; Connelly *et al.* 2004, p. 4-4, Kolada *et al.* 2009a, p. 1,336; Kolada *et al.* 2009b, p. 1,343).

The likelihood of a female sage-grouse nesting in a given year averages 78 percent in western areas of the range (California, Nevada, Idaho, Oregon, Washington, Utah), and this estimate is consistent with reported results in the Bi-State area (Casazza *et al.* 2009, p. 46; Connelly *et al.* 2011a, p. 63). Adult females have higher nest initiation rates than yearling females (Schroeder *et al.* 1999, p. 13; Connelly *et al.* 2011a, p. 63).

The reported range in nest success (percentage of nests hatching one or more eggs) varies widely (15–86 percent) across the species' range (Schroeder *et al.* 1999, p. 11), but there is no statistically significant support for age-specific rates of nest success across the range of the species or within the Bi-State area (Kolada *et al.* 2009b, p. 1,343; Connelly *et al.* 2011a, p. 64). Within the California portion of the Bi-State DPS, estimated nest survival using maximum likelihood methods was 43 percent (Kolada *et al.* 2009b, p. 1,344). However, nest success varies among subpopulations in the Bi-State area, ranging from 21 to 68 percent (Kolada *et al.* 2009b, p. 1,344). Across the species' range in the western United States, average nest success for sage-grouse in undisturbed sagebrush habitats is 51 percent and 37 percent in disturbed habitats (Connelly *et al.*, 2011a, p. 58, and references therein). Presumably the variation in nest success across the Bi-State DPS and between disturbed and undisturbed habitats across the range of the species is due to variation in predator abundance or predator success facilitated by habitat condition. However, researchers often do not differentiate the cause of nest failure, thus there may be other mechanisms (hen abandonment) influencing nest success within these locations. Re-nesting attempts by sage-grouse only occur if the original nest is lost (Schroeder *et al.* 1999, p. 11), and re-nesting rates for the species averages 28.9 percent with a range from 5 to 41 percent (Connelly *et al.* 2004, p. 3-11). The impact of re-nesting on annual productivity for most sage-grouse populations is unclear, however its influence on population dynamics is thought to be limited (Crawford *et al.* 2004, p. 4).

Little information is available on the level of productivity (number of chicks per hen that survive to fall) necessary to maintain a stable population (Connelly *et al.* 2000b, p. 970). Clutch size in sage-grouse ranges from 6 to 9 eggs with an average of 7 eggs per nest (Connelly *et al.* 2011a, p. 62). Research reporting an average of 6.5 eggs/nest in the Bi-State area (Casazza *et al.* 2009, p. 2) is consistent with this rangewide estimate. Long-term productivity estimates of 1.40–2.96 chicks per hen across the species' range have been reported (Connelly and Braun 1997, p. 20), with productivity apparently declining slightly after 1985 to 1.21–2.19 chicks per hen (Connelly

and Braun 1997, p. 20). Connelly *et al.* (2000a, p. 970 and references therein) suggest that 2.25 chicks per hen are necessary to maintain stable to increasing populations. Due to low chick survival and limited re-nesting, there is little evidence that populations of sage-grouse produce large annual surpluses (Connelly *et al.* 2011a, p. 67).

Hens rear their broods in the vicinity of the nest site (within 0.2–5 km (0.1–3.1 mi)) for 2–3 weeks following hatching (Connelly *et al.* 2004, p. 4-8). However, the degree to which this early brood rearing habitat represents a unique habitat patch selected by sage-grouse hens or represents a selected movement corridor to access late brood-rearing mesic sites is not clear. Regardless, forbs and insects are essential nutritional components for chicks during this life phase, thus early brood-rearing habitat must provide adequate cover adjacent to areas rich in forbs and insects to ensure chick survival (Klebenow and Gray 1968, p. 81; Johnson and Boyce 1991, p. 90; Connelly *et al.* 2000a, p. 977; Connelly *et al.* 2004, p. 4-9). Research suggests selected habitat condition during this period differs compared to nesting habitat. Generally, early brood-rearing habitat has greater species diversity, forb cover, grass cover, and grass height, and less shrub cover compared to nesting habitat (Hagen *et al.* 2007, p. 46; Casazza *et al.* 2011, p. 158; Connelly *et al.* 2011b, pp. 75–76 and references therein).

All sage-grouse gradually move from sagebrush uplands to more mesic areas (moist areas such as upland meadows) during the late brood-rearing/summer period (3 weeks post-hatch) in response to summer desiccation of herbaceous vegetation (Connelly *et al.* 2000a, p. 971; Connelly *et al.* 2011b, pp. 76–77 and references therein). Research in the Bi-State area suggests across the entire brood-rearing (early and late) period, habitats used by sage-grouse include non-wooded riparian communities, springs, seeps, mesic upland meadows, or the margins of irrigated hay meadows and alfalfa fields (Casazza *et al.* 2011, pp. 162–163). Furthermore, brood-rearing foraging habitats are selected for and provide for an increased probability of successful recruitment when these areas have an increased perennial forb cover, increased plant species richness, greater meadow to sagebrush edge (ratio of perimeter to area), and are a greater distance from woodlands (Casazza *et al.* 2011, pp. 162–163). Sage-grouse will use free water, although they do not require it since they obtain water from their food. However, natural water bodies and reservoirs provide mesic areas often rich in succulent forb and insect food sources, thereby attracting sage-grouse hens with broods (Connelly *et al.* 2004, p. 4-12). Broodless hens and cocks also use mesic areas in close proximity to sagebrush cover during the late summer, often arriving before hens with broods (Connelly *et al.* 2004, p. 4-10).

As vegetation continues to desiccate through the late summer and fall, sage-grouse shift their diet entirely to sagebrush (Schroeder *et al.* 1999, p. 5). Winter sagebrush stand selection is influenced by snow depth (Patterson 1952, p. 184; Hupp and Braun 1989, p. 827), availability of sagebrush above the snow to provide cover (Connelly *et al.* 2004, p. 4-13 and references therein), and topography (e.g., elevation, slope, and aspect) (Beck 1977, p. 22; Crawford *et al.* 2004, p. 5).

### *Home Range*

In the Bi-State area, sage-grouse home range sizes range from 608 to greater than 24,800 hectares (ha) (1,502 to greater than 61,000 acres (ac)) (Casazza *et al.* 2009, p. 8). Variation occurs among individuals and local breeding complexes, presumably due in part to behavior and juxtaposition of seasonal habitats. Migratory movements reported in Connelly *et al.* (2000a, p. 969), those movements that are greater than 10 km (6.2 mi) between seasonal habitats, are generally uncommon in the Bi-State area, although some individuals have been known to make long seasonal movements that exceed this migratory definition. Recent research in the northern portion of the Bi-State DPS has documented typical movements between breeding and brood-rearing/summer habitats of greater than 40 km (24 mi), with at least one individual moving nearly 160 km (100 mi) from their lek of capture to summer and winter habitats (USGS 2013, p. 8). While it is apparent that some areas encompassed within these movement boundaries are used only briefly as movement corridors, the extent of these movements demonstrate the large-scale annual habitat requirements of the Bi-State DPS.

Estimating an average home range for sage-grouse is difficult due to the large variation in sage-grouse movements both within and among populations related to the spatial availability of habitats required for seasonal use. Pyke (2011, p. 540) estimated that greater than 4,000 ha (9,884 ac) of sagebrush is necessary for sage-grouse population sustainability. However, he did not indicate whether this value was for migratory or non-migratory populations. Connelly *et al.* (2011a, p. 60) summarized seasonal home ranges reported in several studies and noted significant variation depending on season and migratory nature of a population (from less than 100 ha (247 ac) to over 140,000 ha (345,947 ac)). The pattern and scale of annual movements among local breeding complexes of sage-grouse within the Bi-State area, and the degree to which a given habitat patch can fulfill the species' annual habitat needs, are dependent on the arrangement and quality of habitats across the landscape.

### *Life Expectancy and Survival Rates*

Sage-grouse typically live between 3 and 6 years after reaching adulthood, but individuals 9 years of age have been recorded in the wild (Connelly *et al.* 2004, p. 3-12). Hens are generally considered to survive longer than males due to disproportionate predation on males at leks or the higher physiological demands of male chick growth (Schroeder *et al.* 1999, p. 14; Zablan *et al.* 2003, p. 148). However, Sedinger *et al.* (2011, p. 324) reports nearly identical annual survival rates between genders in Nevada. The average annual survival rate for male sage-grouse across their range (all ages combined) varies from 38 to 62 percent while the female average annual survival rate varies from 55 to 75 percent (Schroeder *et al.* 1999, p. 14; Zablan *et al.* 2003, p. 148; Sedinger *et al.* 2011, p. 324). Higher female survival rates has generally been the rationale for assuming a female-biased sex ratio in adult birds (Schroeder 1999, p. 14; Johnsgard 2002, p. 621) and resulting in breeding populations with between 1 and 3 females per male (Atamian and Sedinger 2010, p. 19; Connelly *et al.* 2011a, p. 66). Over-winter mortality of both sexes has generally been reported as low (Connelly *et al.* 2000b, p. 229; Connelly *et al.* 2004, p. 9-4). However, survival during this period can vary annually and among populations and can influence population dynamics (Moynahan *et al.* 2006, p. 1,535; Anthony and Willis 2009, p. 542; Sedinger *et al.* 2011, p. 325). Juvenile survival (from hatch to first breeding season) ranges from

7 to 60 percent and is affected by food availability, weather, age of brood female (broods with adult females have higher survival), habitat quality, harvest and weather (Schroeder *et al.* 1999, p. 14; Connelly *et al.* 2004, p. 3-12; Connelly *et al.* 2011a, pp. 65–66).

In the Bi-State area, adult survival ranges from 8 to 76 percent annually, with significant variation occurring among local breeding populations (Farinha 2011, p. 37; Sedinger *et al.* 2011, p. 321). For adult males, estimated annual survival rates range between 8 and 68 percent and for adult females from 15 to 76 percent (Farinha 2011, p. 37). The general pattern of seasonal survival exhibited by sage-grouse across their range, whereby over-winter survival is generally higher than the remainder of the year, is also apparent in the Bi-State DPS. We are unaware of any data available to assess juvenile survival.

### *Historical Range/Distribution*

The Bi-State DPS of sage-grouse historically occurred throughout most of Mono, eastern Alpine, and northern Inyo Counties, California (Hall *et al.* 2008, p. 97), and portions of Carson City, Douglas, Esmeralda, Lyon, and Mineral Counties, Nevada (Gullion and Christensen 1957, pp. 131–132; Espinosa 2006). The current range of the DPS in California is presumed reduced from the historical range (Leach and Hensley 1954, p. 386; Hall 1995, p. 54; Schroeder *et al.* 2004, pp. 368–369), but the extent of range loss is not well understood. Hall (1995, p. 54) estimated an approximately 71 percent decline in sage-grouse distribution within the California portion of the Bi-State area, including a 58 percent reduction within Mono County and 88 percent and 95 percent reductions in Alpine and Inyo Counties, respectively. However, Hall *et al.* (2008, p. 96) suggest no significant contraction from historical range has been documented in Mono County. Furthermore, Hall *et al.* (2008, p. 96) note an extirpation from northern Inyo County. There is evidence demonstrating seasonal habitat use in southern Alpine County (Leviathan Peak) and the northwest corner of Mono County (Slinkard Valley) has been greatly reduced or abandoned (California Department of Fish and Wildlife (CDFW) 2012). The discrepancies in the California results likely stem from two sources: (1) Vegetation information used in the mapping process, and (2) how information pertaining to sage-grouse occurrence is interpreted. For example, there are areas within California where sage-grouse were documented historically, but whether an historical occurrence represented a location that regularly supported sage-grouse or was a sighting of birds outside their normal distribution is not discernible. Therefore, recent surveys failing to document sage-grouse in these same locations may reflect: (1) Vegetation mapping that inaccurately identified habitat as suitable for sage-grouse, (2) the original sightings representing irregular occurrences or sighting locations were generalized and attributed to nearest significant landmark, (3) a lack of recent survey effort, or (4) a true extirpation. Such uncertainties exist throughout the range of the Bi-State DPS, as well as for greater sage-grouse across the West. In Nevada, Gullion and Christensen (1957, pp. 131–132) reported that sage-grouse occurred in Esmeralda, Mineral, Lyon, and Douglas Counties, and each of these Counties remains occupied. In addition, sections of Carson City County were likely part of the original range of the species in Nevada; and sage-grouse may still occur in this county but use is sporadic (Espinosa 2006). The extent of the range loss in Nevada has not been estimated but there have presumably been contractions in distribution (Stiver 2002, pers. comm.).



Our understanding of the extent to which areas of historical use by sage-grouse in the Bi-State area has been lost is complicated by the quality and availability of information. Our evaluation suggests range contractions based on bird occurrence data (see our qualitative assessment of this change in distribution in the “Current Range/Distribution and Population Estimates/Annual Lek Counts” section below). Changes in vegetation communities (as described in the “Impact Analysis” section below) also suggest alterations in Bi-State DPS distribution. The principle mechanisms influencing bird distribution are likely: (1) Woodland succession into sagebrush vegetation communities due to alterations in primary disturbance regime (fire), and (2) conversion of sagebrush vegetation communities to agricultural use or via urbanization. We estimate these two mechanisms have resulted in loss of sagebrush vegetation extent on the order of 50 percent within the Bi-State area over the past 150 years. However, other unknown mechanisms may have also affected this vegetation change. In general, range contractions are more apparent in the northern extent of the Bi-State DPS, although the entire DPS has realized some loss in sagebrush vegetation distribution. Habitat loss and the resulting fragmentation have also contributed to isolation of breeding complexes.

#### *Current Range/Distribution and Population Estimates/Annual Lek Counts*

In 2001, the State of Nevada sponsored development of the *Nevada Sage-Grouse Conservation Strategy* (Sage Grouse Conservation Planning Team 2001, entire). This Strategy established Population Management Units (PMUs) for Nevada and California as management tools for defining and monitoring sage-grouse distribution (Sage Grouse Conservation Planning Team 2001, p. 31). The PMU boundaries represent generalized subpopulations or local breeding complexes and were delineated based on aggregations of leks, known seasonal habitats, and telemetry data. Six PMUs were designated for the Bi-State DPS (from north to south): Pine Nut, Desert Creek-Fales, Bodie, Mount Grant, South Mono, and White Mountains (Figure 1; Appendix A). Due to biology and management, the Bodie and Mount Grant PMUs are often combined. Individual PMUs range from approximately 220,000 ha (543,000 ac) to over 700,000 ha (1.75 million ac) in area. The total amount of currently suitable sage-grouse habitat (as defined by the Resource Selection Function (RSF) model in combination with data provided by the BLM and U.S. Forest Service (USFS) in 2008 (Appendix B; Bi-State Technical Advisory Committee (TAC) 2012, unpublished data; BLM and USFS 2008a, entire)) across all PMUs is slightly less than 591,000 ha (1,460,000 ac) (Table 1). This total does not include areas currently unsuitable for the Bi-State DPS that could be restored as suitable habitat.

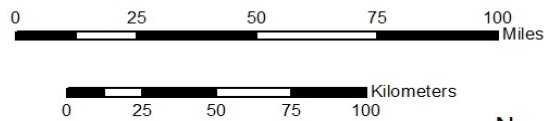
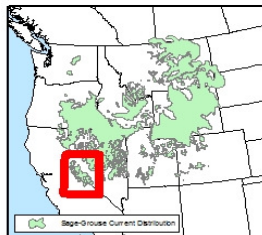
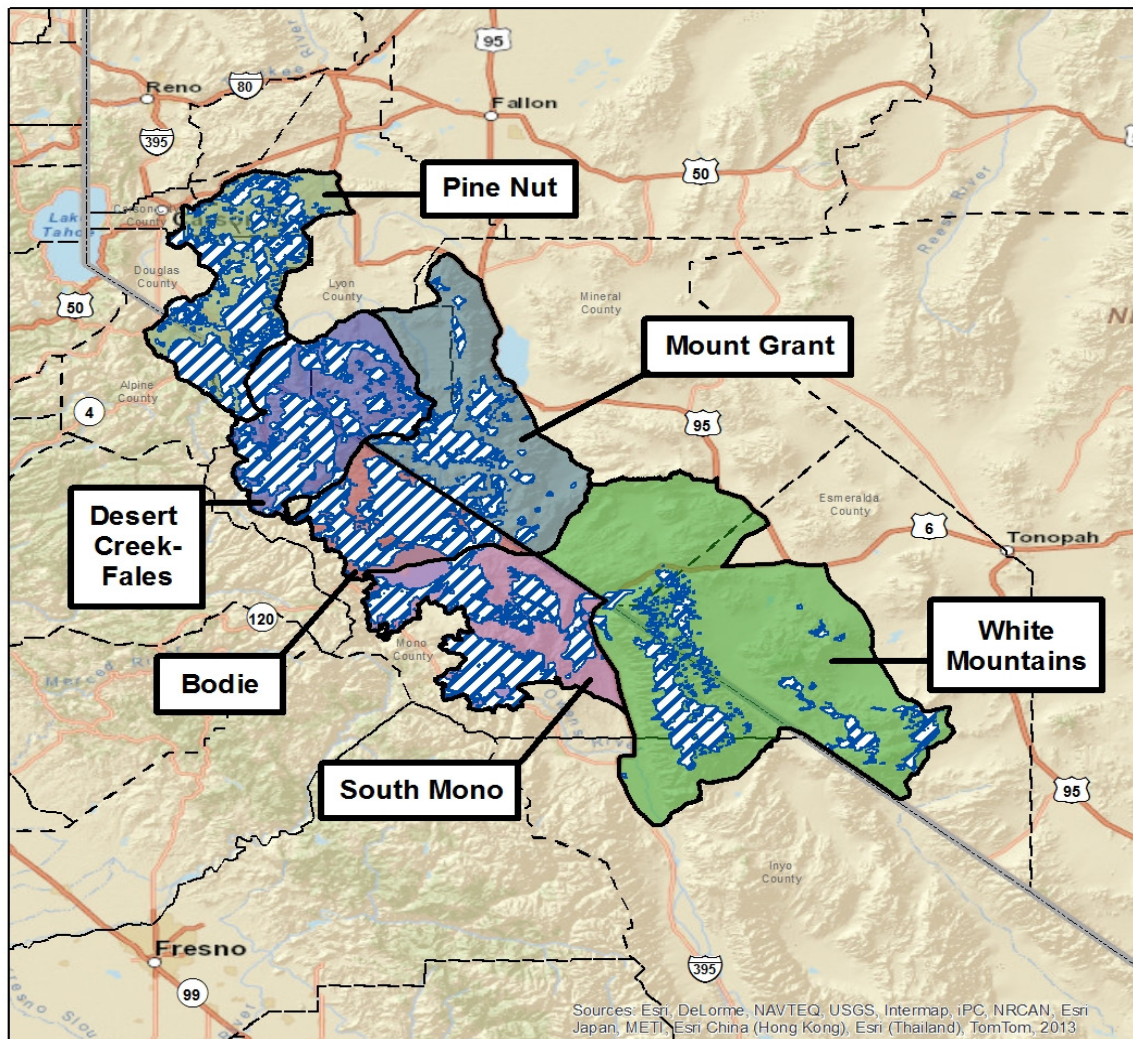
In 2004, the States of Nevada and California completed the *Greater Sage-Grouse Conservation Plan for the Bi-State Area of Nevada and Eastern California* (Bi-State Local Planning Group 2004, entire). Contained within this plan are descriptions of the PMUs, a generalized threats assessment, and historical occurrence information. This 2004 plan was revised in 2012. The 2012 *Bi-State Action Plan* (Bi-State TAC 2012, entire) provides updates on population status, threats assessment, conservation efforts implemented, and a strategic approach toward future conservation efforts. In addition, the 2012 plan incorporated mapping to better understand the areas of importance to sage-grouse in the Bi-State area and to assist land managers in decision making pertaining to land use actions. Both of these plans, as well as information from local area biologists and a number of research studies conducted over the past decade, were used to

construct brief descriptions of historical and current range and population status of sage-grouse in the Bi-State DPS by PMU (presented below).

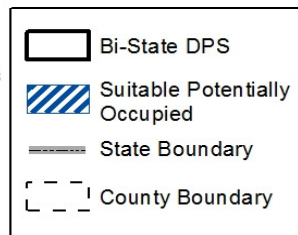
Sage-grouse populations are classically described as exhibiting multi-annual fluctuations, indicating that some mechanism or combination of mechanisms are causing populations to fluctuate through time. Fedy and Doherty (2010, entire) demonstrate that these fluctuations represent true cycles and document durations of 7–8 years for each cycle in Wyoming. Furthermore, Blomberg *et al.* (2012, p. 9) show annual rates of population growth in sage-grouse are strongly influenced by weather, especially annual rainfall that generally supports vegetation and insect production and presumably improves sage-grouse recruitment. Thus, we recognize that populations fluctuate naturally through time and that spring lek counts represent an index of population trends. Also of note is that a standardized lek survey protocol was not established until 1987 in the California portion of the Bi-State DPS (CDFW 2012, *in litt.*); and in Nevada, lek survey effort has been variable but increasing over the past decade (Nevada Department of Wildlife (NDOW) 2012, *in litt.*). This lack of consistent survey methodology within and between States in the Bi-State DPS creates problems in comparing annual survey data and detecting valid trends in abundance.



## Bi-State DPS of Greater Sage-Grouse



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Map Date: January 31, 2013



**Figure 1.** Population Management Units (PMUs) and Resource Selection Function (RSF) model output depicting suitable habitat for sage-grouse within the Bi-State DPS, Nevada and California.

**Table 1.** Bi-State DPS Population Management Units (PMUs), PMU size, estimated suitable sage-grouse habitat, estimated range in population size, number of active leks, and reported range in total males counted on all leks within each PMU.

<b>PMU</b>	<b>Total Size hectares (acres)*</b>	<b>Estimated Suitable Habitat hectares (acres)**</b>	<b>Estimated Population Size range (2002–2012)***</b>	<b>Current Number of Active Leks****†</b>	<b>Lek count (number of males) range (2002–2012)***</b>
<b>Pine Nut</b>	232,440 (574,373)	116,844 (288,727)	50–331	1	6–22
<b>Desert Creek-Fales</b>	229,858 (567,992)	118,419 (292,620)	317–1,268	8	30–190
<b>Mount Grant</b>	282,907 (699,079)	60,948 (150,608)	85–1,412	8	12–>140
<b>Bodie</b>	141,490 (349,630)	96,241 (237,817)	522–2,400	13	124–510
<b>South Mono</b>	234,508 (579,483)	118,398 (292,570)	859–2,005	11	204–426
<b>White Mountains</b>	709,768 (1,753,875)	79,334 (196,039)	Data not available	2+	Data not available
<b>Total (all PMUs combined)</b>	1,830,972 (4,524,432)	590,184 (1,458,381)	1,833–7,416	43	376–1,288

\* Bi-State Local Planning Group (2004, pp. 11, 32, 63, 102, 127, 153 )

\*\* BI-State TAC (2012, unpublished data); BLM (2008, unpublished data)

\*\*\* CDFW (2012, *in litt.*), NDOW (2012, *in litt.*)

† Active—two or more strutting males during at least 2 years in a 5-year period.

NOTE—Area values for “Total Size” and “Estimated Suitable Habitat” may not sum due to rounding.

Historically, there were as many as 122 leks reported in the Bi-State area, although this number is almost certainly an overestimate as locations were poorly documented. Currently, there are 43 active leks within the Bi-State DPS (Table 1). Leks occur in all six PMUs, with the greatest concentrations occurring in the Bodie and South Mono PMUs. The following PMU descriptions and population estimates include data from the following sources: NDOW (2012, *in litt.*); CDFW (2012, pers comm.); Bi-State Local Planning Group (2004, entire); and Bi-State TAC (2012, unpublished data; 2012, entire).

## 1. Pine Nut PMU

The Pine Nut PMU encompasses the Pine Nut Mountains in Nevada and is the northern-most PMU in the Bi-State DPS. The majority of the PMU is located east of Highway 395 in Lyon and Douglas Counties, Nevada. It extends from the Carson River south to the West Fork Walker River. The southwestern boundary extends into California encompassing Slinkard Valley to the ridge of the Sierra Nevada mountains near Woodford, California. The Pine Nut PMU is the most limited PMU with respect to current sage-grouse population size and proportionally, it appears to have experienced the greatest reduction of sagebrush vegetation over the past 150 years (i.e., loss of suitable sagebrush habitat and reduced sage-grouse abundance) as compared to other PMUs. The extant population in the Pine Nut PMU annually moves from breeding locations in the northern extent of the PMU to summer habitats in the southern portion of the PMU, utilizing small corridors and isolated patches of habitat during this migration of approximately 40 km (25 mi). Much of the east side of this PMU in Smith Valley, Nevada, was cleared of sagebrush several decades ago for ranching operations, thus likely influencing distribution of birds in the area and connection of this PMU with the Desert Creek-Fales PMU to the south. Sage-grouse are still occasionally documented in Smith Valley, but these are rare occurrences. Distribution on the western and southern borders of the PMU, in proximity to Gardnerville and Holbrook Junction, Nevada, has also contracted, and sage-grouse use of these areas has been largely eliminated (Bi-State TAC 2012, p. 18; 2012, unpublished data).

In the southwest portion of the PMU, historical occurrences were near the Leviathan Peak and Slinkard Valley areas in California. While use of these and surrounding sites appears to have been all but eliminated in the past 25 years, historical use was not well documented. Recent telemetry research in the Pine Nut Mountains has documented sage-grouse briefly using the Leviathan Peak area before moving further south into the Sweetwater Mountains (Desert Creek-Fales PMU) (USGS 2012a, p. 3.). Thus, this section of the PMU may still provide some connectivity to the Desert Creek-Fales PMU, but probably to a lesser degree than it had historically. Finally, historically occupied sage-grouse habitat occurred in the southern Virginia Range immediately north of the Pine Nut Mountains. Sage-grouse have not been documented in the Virginia Range since the 1980s. While it is unknown if the former Virginia Range population was genetically related to sage-grouse in the Bi-State DPS, the Virginia Range and the Pine Nut Mountains are in close proximity to one another; thus, a connection between the two populations was historically possible.

Over the past decade, the estimated sage-grouse population for the Pine Nut PMU has ranged between 50 and 331 birds associated with one active lek (Table 1). Overall, this PMU has the lowest estimated population size and lowest number of active leks of the six PMUs within the range of the Bi-State DPS. The single lek in the northern portion of the Pine Nut Mountains (known as Mill Canyon Dry Lake) is the only known consistently active lek in this PMU. An additional lek in the southern extent of the mountain range has not had strutting activity documented since 2007 (NDOW 2012, unpublished data). It is unclear if this southern lek has been abandoned or if the original documentation captured a rare event or simply misclassified random bird sightings for actual strutting activity. Recent telemetry research in the Pine Nut

Mountains suggests the potential for additional undocumented small leks in the south-central portion of the PMU (USGS 2013, p. 2).

Since 2000, the average male attendance at the Mill Canyon Dry Lake lek has been approximately 14 males (Bi-State TAC 2012, p. 17). Twenty-two males were counted in 2003, and 6 males were counted in 2008 (Bi-State TAC 2012, p. 17). In 2013, no birds were documented at this lek, although a small number (<5) of males were seen strutting at two other locations in the central portion of the PMU (USGS 2013, p. 2). Existing abundance data are insufficient to assess population trends. The Pine Nut Mountains are difficult to access, thus making lek surveys challenging.

## 2. Desert Creek-Fales PMU

The Desert Creek-Fales PMU is located immediately to the south of the Pine Nut PMU and similarly overlaps the Nevada and California border. It extends from southern Smith Valley in Nevada south to the East Fork Walker River. The PMU's western boundary is generally marked by the Sierra Nevada mountains, extending east to encompass the Pine Grove Hills in Nevada. The Sweetwater Mountains extend north to south through the central portion of the PMU and generally delineate the border between the two States. This PMU includes two breeding complexes: Desert Creek (Nevada) and Fales (California).

Within the Nevada portion of this PMU, woodland succession and urban/exurban development have negatively influenced sagebrush and sage-grouse distribution (Bi-State TAC 2012, pp. 24–25). This includes much of the Pine Grove Hills on the eastern side of the PMU as well as locations in the Wellington Hills and Sweetwater Mountains along the Nevada and California border. A reduction of all seasonal habitats is apparent, but likely of greatest importance is the loss of brood-rearing/summer habitat, resulting in a near complete reliance of sage-grouse on private irrigated pasture during this season (Bi-State TAC 2012, p. 25). Additional habitat loss has occurred in proximity to the Desert Creek Road and Sweetwater Summit areas in the central portion of the PMU, which has likely restricted breeding and wintering habitat and is possibly affecting connection with PMUs to the south. Recent habitat restoration efforts appear to have mitigated some historical habitat loss (Bi-State TAC 2012, p. 26).

Similarly, within the California portion of this PMU, urbanization (particularly near the Fales breeding complex) and woodland succession have contracted distribution and connectivity of sage-grouse populations (Bi-State TAC 2012, p. 25). Along the Highway 395 corridor, areas of known historical use have contracted. South and east of the Fales breeding complex contractions have presumably occurred in the Huntoon Valley, Mount Jackson, and Sweetwater Mountains areas where historical connections with Bridgeport Valley, the Bodie PMU, and the Nevada portion of the Desert Creek-Fales PMU were likely more robust.

Over the past decade, the estimated sage-grouse population for the Desert Creek-Fales PMU has ranged from 317 to 1,268 birds on approximately 8 active leks (Table 1). Data from four leks are used to evaluate the trend in the Desert Creek breeding complex. One or two additional sites within this PMU are considered when tallying maximum male attendance, although activity at these sites is not consistent on an annual basis. The long-term average male attendance across

the 4 trend leks is approximately 24 males (Bi-State TAC 2012, p. 23). This average is influenced by one of these trend leks becoming inactive, with no males counted within the last 3 years. It is possible that this lek has moved locations but this remains unconfirmed. The long-term average attendance for each trend lek independently is approximately 14, 16, 25, and 28 males, with the latter average associated with the recently inactive lek discussed above. In addition, a previously unknown lek was discovered in 2012 to the east of Nevada State Route 338 near Dalzell Canyon; 24 males were documented strutting on this lek.

The Fales breeding complex is located in northern Mono County, California. It is composed of two active and two inactive leks located near Sonora Junction, in proximity to the intersection of Highway 395 and California Highway 108. One additional lek is located in the extreme northeast corner of Mono County in the Sweetwater Mountains. Surveys of the four Fales breeding complex leks in proximity to Sonora Junction began in the early 1950s and 1960s. The average number of males counted on these 4 leks combined was 78 from 1953 to 1980 (Bi-State TAC 2012, p. 23). The high count occurred in 1963 when 205 males were counted; approximately 50 percent of these males were documented on a single lek (Lek #1), which is located approximately 50 m (164 ft) from Highway 395. Between 1957 and 1970, annual attendance on Lek #1 averaged 36 males; use declined to an average of 9 males (Bi-State TAC 2012, p. 24), and in 1981, lek activity ceased. From 1987 to 2012 (after the disappearance of Lek #1), the average number of males counted on the 3 remaining Sonora Junction leks was 26 and ranged between 13 and 39 males (CDFW 2012, unpublished data). In 2004, another lek (Lek #4) in the Fales breeding complex became inactive, potentially caused by a single family home development that occurred within 50 m (165 ft) of the lek. In 2012, possible strutting activity was noted on Lek #4; the males observed may have shifted from consistently active Lek #2 nearby. Since 1981, the Fales breeding complex has remained small but seemingly stable in abundance. The Sweetwater Mountains lek was known but not surveyed prior to 2003; it is not surveyed regularly due to limited access. In 2003 and 2004, 10 and 22 males were documented, respectively (CDFW 2012, unpublished data) in 2012, 18 males were counted (Bi-State Lek Surveillance Program 2012, p. 8).

### 3. Mount Grant PMU

The Mount Grant PMU is located to the east and southeast of the Desert Creek-Fales PMU. The PMU boundary encompasses the Wassuk Range, a portion of Excelsior Mountains, and low elevation sites near the East Fork Walker River. Woodland succession, and potentially to a lesser extent historical and current mining activity, has most negatively influenced bird distribution within the Mount Grant PMU (Bi-State TAC 2012, pp. 36–37). Historical sage-grouse populations occurred in the southeast portion of the PMU on and around Mount Hicks and Powell and Table Mountains. While the amount of survey effort expended has not been quantified, no sage-grouse have been reported in these locations for over a decade. Additional habitat loss has occurred between upper elevation sites in the Bodie Hills and Wassuk Range and lower elevation sites near the East Fork Walker River, particularly near China Camp, lower Bodie Creek, and lower Rough Creek. Several traditional brood-rearing meadow sites adjacent to these locations have apparently become inactive.



Over the past decade, the estimated sage-grouse population for the Mount Grant PMU has ranged from 85 to over 1,400 birds, including 8 active leks (Table 1). This PMU is composed of three connected areas: two high elevations areas associated with Aurora Peak and the Wassuk Range (centered on Mount Grant), and one low elevation area called Ninemile Flat (located in the East Fork Walker River valley) between the two high elevation areas. This PMU is also connected with the Bodie PMU (a portion of the sage-grouse population in each PMU moves seasonally to the other). Surveys in the Mount Grant PMU have been sporadic due to difficulty accessing several locations, and that variability affects the accuracy of population size estimates.

In general, 3 consistently active leks have been counted since 2004, with an average of approximately 21 males per lek (Bi-State TAC 2012, p. 35). The largest known lek is located near Aurora Peak along the Nevada-California border, and it is generally considered the eastern extension of the Bodie PMU breeding complex. The high count of 94 males for this lek was recorded in 2006, with a low of 14 in 2009; in 2011, 52 males were counted (Bi-State TAC 2012, p. 35), and in 2012, 47 total birds (males and females) were reported (Bi-State Lek Surveillance Program 2012, p. 34). Further east of this lek, historical strutting activity was known to occur near Mount Hicks and Mud Springs Canyon, although these locations have not been active in over 20 years (NDOW 2009a, unpublished data).

North of Ninemile Flat, 2 active leks have been consistently surveyed over the past decade, and numbers have ranged from only a few to over 50 males on each lek (Bi-State TAC 2012, 35). The locations of these leks have moved during this timeframe and count data quality associated with these leks has been compromised by observer confusion over lek location. A third lek to the south of Ninemile Flat (which historically had been reliably attended) has exhibited significantly diminished activity in the past 3–4 years; however, a previously undocumented lek discovered approximately 1.2–1.9 km (2–3 mi) to the northwest in 2012 may represent a shift in its location (Bi-State Lek Surveillance Program 2012, pp. 5–6). This newly discovered lek had a high male count of 27 (Bi-State Lek Surveillance Program 2012, p. 6). Finally, a second previously undocumented lek was discovered in 2012 near Masonic Road between the East Fork Walker River and the Bodie Hills, and a total of 5 males were documented (Bi-State Lek Surveillance Program 2012, p. 5). In 2013, this lek was not active.

Leks in the Wassuk Range have not been surveyed consistently due to topographic obstacles that require aerial survey methods. In 2005 and 2006, a total of 19 and 33 males, respectively, were counted in the Wassuk Range (NDOW 2009a, unpublished data; Bi-State TAC 2012, p. 35). During 2012, at least 4 active leks were documented surrounding Mount Grant and a total of 139 birds (males and females) were counted (Bi-State Lek Surveillance Program 2012, p. 13).

#### 4. Bodie PMU

The Bodie PMU encompasses the Bodie Hills located southwest of Bridgeport, California, and north of Mono Lake. Most of the PMU is located to the east of Highway 395, but a small portion extends west of Highway 395 to the Sierra Nevada mountains. Loss of historical sage-grouse range in the Bodie PMU has been most influenced by woodland succession (The Nature Conservancy (TNC) 2009, entire; Bi-State TAC 2012, p. 30; USGS 2012b, unpublished data). Significant stands of *Pinus monophylla* (pinyon pine) and to a lesser extent *Juniperus* sp.



(juniper) occur at mid- to low-elevations on all flanks of the Bodie Hills as well as across the Sierra Nevada mountains side of the PMU. Perennial water and meadow habitats in the Bodie PMU are generally privately owned and provide important sage-grouse habitat during the brood-rearing/summer season. While natural vegetation succession processes—in the absence of disturbance—have resulted in loss of sagebrush habitat that continues to fragment and isolate the population within this PMU, the extent of habitat loss and fragmentation attributable to land use change (i.e., urban development and agricultural conversion) appears minimal.

Over the past decade, the estimated sage-grouse population for the Bodie PMU has ranged from 522 to 2,400 birds on approximately 13 active leks (Table 1). This PMU represents a significant core population in the Bi-State DPS because of the number of birds it contains. Best available information also indicates that this PMU harbors the highest number of active leks as compared to other PMUs within the range of the Bi-State DPS.

Approximately 8 leks have been surveyed in the Bodie PMU since the late 1980s with some locations being counted as far back as the 1950s. Numerous satellite leks (i.e., sites used sporadically in years of high sage-grouse abundance) have also been identified in the Bodie PMU. The majority of leks are located in the Bodie Hills east of Highway 395, but at least one long-term lek and several associated satellite leks occur west of the Highway. In 2012, two previously undocumented leks were discovered near Little Bodie Mine; it is not known if these are regularly attended leks or satellite sites due to the high numbers of sage-grouse documented in 2012 (Bi-State Lek Surveillance Program 2012, p. 9).

Since 1987 (when the standardized lek survey protocol was established), the long-term average male attendance across an average of 10 leks in the Bodie PMU is 194 (Bi-State TAC 2012, p. 29). The minimum count recorded was 64 males on 6 leks in 1998, and the maximum was 510 males on 14 leks in 2012. While the low 1998 count may be partially attributable to reduced survey effort, it appears this low count is largely reflective of reduced sage-grouse numbers. Since 2008 (when 136 males were counted on 12 leks), the number of males counted each year has increased to this 2012 high point (Bi-State TAC 2012, p. 29). Long-term trends have cycled, with numbers since 2010 indicating an overall population increase. Although we are unclear why the numbers of birds have been increasing since 2008, we surmise that favorable weather and improved habitat conditions in the area may be contributing to this short-term upward trend. However, because sage-grouse populations exhibit multi-annual cycles, the population size will naturally fluctuate over time and may eventually experience a downward trend.

Sage-grouse population growth in the Bodie PMU has been positive and negative over the past 40 years with no discernible long-term trend (Garton *et al.* 2011, p. 324). This fluctuation should be anticipated in a normally functioning sage-grouse population and is generally a concern only when the number of individuals present during the low point in the fluctuations is small. The average number of males per active lek declined by 41 percent between 1965 and 2007, but since 1991 the minimum number of males counted has been trending upward (Garton *et al.* 2011, p. 324). The last two survey years are encouraging because they demonstrate a significant increase in the potential peaks associated with the population fluctuations. While these increasing peaks in fluctuations do not infer increasing lows, coupled with the general increase in the number of

males counted since the early 1990s, the Bodie PMU may be moving toward a cycle that oscillates at generally higher numbers as compared to the other PMUs.

## 5. South Mono PMU

The South Mono PMU is comprised of three generally discrete locations or breeding complexes: (1) Long Valley, (2) Parker Meadow, and (3) Granite Mountain. The PMU extends from Mono Lake in the north to California Highway 6 in the south, and from the California and Nevada border in the east to approximately the Sierra Nevada mountains in the west. In the South Mono PMU, sage-grouse were likely historically distributed in many of the same areas utilized today (Bi-State Local Planning Group 2004, p. 162), although there has been an estimated reduction in sagebrush extent of approximately 13 percent (USGS 2012b, unpublished data) due to woodland succession; this has likely altered sage-grouse distribution and fragmented connectivity among breeding complexes and neighboring PMUs. In addition, loss and fragmentation of habitat due to other causes (infrastructure, wildfire, water development) has likely altered sage-grouse occurrence. In Long Valley there may be specific locations where distribution has been reduced, but these areas appear limited in extent and confined to peripheral locations within the breeding complex. Changes in the occurrence of sage-grouse in the Parker Meadow and Granite Mountain portions of the PMU are unclear, but likely greater. These locations have been altered since European settlement, especially as it pertains to water management, but the impact this activity has had on habitats in the area is not well understood. The Granite Mountain and Adobe Valley area (north of Highway 120) contains an extensive expanse of sagebrush habitat and has been known to support birds during severe winters (Bi-State Local Planning Group 2004, p.161). However, no consistent use of Adobe Valley is currently occurring and use of the Granite Mountain area is relatively limited. This inconsistent use is presumed to be caused by the general lack of water and meadow habitat in the area, which has likely decreased in the past century. Furthermore, to the east of Adobe Valley in the vicinity of Pizona Creek, a potential connectivity corridor exists between populations in the South Mono and White Mountains PMUs. The vegetation within this corridor has apparently changed due to woodland succession, and a recent aerial survey suggests that current vegetation is not suitable sage-grouse habitat (Bi-State Lek Surveillance Program 2012, p. 36).

Over the past decade, the estimated sage-grouse population for the South Mono PMU has ranged from 850 to 2,000 birds, including 11 active leks (Table 1). Although surpassed by the Bodie PMU in 2012, traditionally the South Mono PMU has had the highest estimated population size as compared to the other PMUs within the range of the Bi-State DPS. The Long Valley breeding complex includes at least eight consistently active leks and associated satellite sites located along the upper Owens River drainage and the Crowley Lake Basin. The Granite Mountain breeding complex includes two inactive leks located in the Adobe Valley and Sage Hen Summit areas. The Parker Meadow breeding complex includes one consistently active lek site located south of Parker Creek at the northwest end of the June Lake Loop Road.

Long Valley represents the largest population in the South Mono PMU and, in conjunction with the Bodie PMU, these two PMUs represent the core populations of the Bi-State DPS. Sage-grouse have been counted in the Long Valley breeding complex since the early 1950s. Historical maximum male attendance counts occurred in 1962, 1963, and 1986, when 408, 405, and 406

male were counted, respectively, on 6–7 leks (Bi-State TAC 2012, p. 44). The long-term average peak male attendance between 1987 and 2012 is approximately 250, counted on an average of 9 leks. The high count during this period was 418 males in 2012, and the low count was 165 males in 1991 (CDFW 2012, unpublished data). Between 1989 and 2003, male attendance remained at or below the long-term average of 250 birds in Long Valley (Bi-State TAC 2012, p. 44). From 2004 to 2007, male attendance increased and ranged between 120 and 144 percent of long-term average. Male counts declined below the long-term average in 2008 and 2009, but have consistently surpassed this mark since 2010 (possibly due to variables associated with weather or the sage-grouse's life cycle). The population in Long Valley has demonstrated positive and negative growth rates over the past 40 years (Garton *et al.* 2011, p. 329), although fluctuations have been relatively tempered and the population trend appears generally stable based on these data.

Two leks are known to exist in the Granite Mountain breeding complex (Adobe and Gaspipe). From 1984 to 1994, the Adobe lek had an average attendance of 11 males (Bi-State TAC 2012, p. 45). Beginning in 1995, numbers declined until the Adobe lek became inactive in 2001. The Gaspipe lek in this breeding complex was discovered in 1990. Between 1990 and 2008, maximum lek attendance occurred in 2005 and 2006 with consecutive counts of 16 males. No strutting activity has occurred at either of these leks since 2008, however, sage-grouse are still encountered in the vicinity suggesting either that the location of the strutting grounds has changed or that at least some seasonal use of the area occurs.

Sage-grouse have been known to occur in the Parker Meadow breeding complex area since the 1950s, although lek monitoring did not occur until 2002. One small lek is active although there has been occasion when satellite sites have experienced strutting activity (CDFW 2012, unpublished data). Since 2002, a high count of 17 males occurred in 2003 and a low count of 3 males occurred in 2010 (Bi-State TAC 2012, p. 45).

## 6. White Mountains PMU

The White Mountains PMU is the southernmost PMU in the Bi-State DPS, encompassing the White Mountains along the border of Nevada and California. It extends from the Candelaria Hills and Truman Meadows areas in the north to California Highway 168 in the south and from California Highway 6 in the west to the Silver Peak Range, Nevada, in the east. Historical and current distributions of sage-grouse in the White Mountains are not well understood. The area is difficult to access and, due to elevation, heavy snow conditions are typical during the spring breeding season. In addition, the number, size, and activity of leks in the White Mountains are poorly known due to infrequent and opportunistic surveys. Historical accounts in Esmeralda County, Nevada, suggest bird densities there have likely always been low. Anecdotal evidence suggests birds historically occurred in the Silver Peak Range and in the hills surrounding Magruder Mountain, Nevada (Bi-State Local Planning Group 2004, p. 108). Both of these ranges have limited sagebrush habitat and are separated from the White Mountains to the west by several miles of unsuitable habitat. The last, unverified, reported sighting in these mountain ranges occurred in 1998 (Bi-State Local Planning Group 2004, p. 108). The Volcanic Hills area in northern Esmeralda County also has limited sagebrush habitat and is disjunct from the White Mountains proper. A past survey of the Volcanic Hills documented a single individual but

additional anecdotal information suggest occasional use (Bi-State Lek Surveillance Program 2012, p. 38). While bird sign (e.g., droppings) has been reported in this area, data are too limited to discern if there have been changes in use of this area by sage-grouse.

The major extent of sage-grouse distribution in the Nevada portion of the White Mountains PMU occurs along the eastern benches of the White Mountains in the western portion of Esmeralda County. This encompasses an area from approximately Chiatovich Creek, north to the Esmeralda and Mineral County line, with the majority of sage-grouse use centered on Trail Canyon. Historical use was apparently limited (Bi-State Local Planning Group 2004, p. 108). Current use of this area may have been negatively influenced by recent housing developments in the Chiatovich Creek area (Bi-State Lek Surveillance Program 2012, p. 38). No birds were detected in the area during a 2012 survey. Historical occurrence has also been documented northwest of Trail Canyon centered on Sagehen Flat and to the north of Nevada Highway 6 surrounding Truman Meadows and McBride Flat. A 2012 aerial survey did not detect birds in these areas and surveyors observed that the current habitat did not appear suitable to sage-grouse (Bi-State Lek Surveillance Program 2012, p. 36). These areas likely afforded the greatest connectivity with the Adobe Valley area within the South Mono PMU, but this connectivity appears to be currently compromised.

Historical sage-grouse distribution within the California portion of the White Mountains PMU is poorly understood. Habitat loss along lower elevation sites due primarily to woodland succession is apparent but has not been quantified (Bi-State TAC 2012, p. 40). The majority of historical and current use occurs in the central to southern portion of the White Mountains from approximately Tres Plumas Flat south to Black Mountain. While not contained within the delineated White Mountain PMU polygon, there is historical documentation of sage-grouse in the Coyote Flat area to the southwest of Bishop, California, and other locations along the eastern foothills of the Sierra Nevada mountains as far south as Independence, California (USFS 1966, p. 4). However, these locations are no longer occupied and were not included in the PMU designations (Hall 2008, p. 97).

The current estimated sage-grouse population size for the White Mountains PMU is unknown, and the best available information indicates there may be a minimum of two active leks in Nevada and probably several additional leks in California (Table 1).

There have been 3 years of recent helicopter lek inventory surveys conducted within the White Mountains PMU. Helicopter surveys in March 2006 documented 206 sage-grouse (males and females; Bi-State TAC 2012, p. 40). Birds were observed at high elevation (approximately 2,900 m (9,514 ft)) in the general vicinity of Bucks Peak, Red Peak, and Iron Mountain, and north toward Tres Plumas Flat and Chiatovich Flat. During helicopter surveys in March 2006 and April 2008, CDFW (Bi-State TAC 2012, p. 40) documented a total of 206 and 33 sage-grouse (male and female), respectively in the vicinity of the Mono and Inyo County line, centered near Sagehen Flat and Blanco Mountain. These flights were conducted relatively early in the breeding season, thus no active strutting activity was observed and no lek sites were recorded.

During April 4–7, 2012, three helicopter surveys were conducted in the White Mountains:

(1) A survey of Queen Valley and north toward Truman Meadows and McBride Flat did not produce any sightings, and this area was generally described as currently lacking suitable habitat (Bi-State Lek Surveillance Program 2012, p. 36). Historical bird occurrence in these areas has been reported, but confirmation of regular use is not available (Bi-State Local Planning Group 2004, p. 109). Eight individuals were observed north of Pinchot Creek near the Esmeralda and Mineral County line.

(2) A survey of the east side of the White Mountains was conducted between Perry Aiken Creek and extended north toward the Mineral and Esmeralda County line, Nevada, and the southern extent of Queen Valley. No sage-grouse were detected and little suitable habitat was noted. In the lower Trail Canyon area a total of 18 birds were documented. Twelve individuals were associated with a single location (one presumed lek), including five strutting males, three hens, and four unknowns; the remaining six individuals were a mix of hens and cocks, and these single bird sightings occurred within less than 1.6 km (1 mi) of the strutting activity. A survey of the north end of the White Mountains (in the vicinity of Mustang Point and Kennedy Flats before moving east to the Volcanic Hills) indicated that suitable habitat in both of these locations appeared limited and no birds were detected. Eight individuals were detected north of Pinchot Creek near the Esmeralda and Mineral County line. No strutting activity was documented but the occurrence of both males and females in the same area suggest the presence of a breeding ground.

(3) A survey of the middle to southern half of the White Mountains and Coyote Flats located to the southwest of Bishop, California, detected no birds in the Coyote Flats area and no birds between the Tres Plumas Flat area in the White Mountains, north to Chiatovich Flat area. In the south-central portion of the White Mountains a total of 64 individuals were recorded. The survey area encompassed much of the landscape where previous sightings occurred, generally centered on Tres Plumas Flat and south to Iron Mountain and the upper Wyman Creek areas. Group size ranged from 1 to 12 individuals, and while no strutting activity was documented, several locations were possible lek sites.

### *Bi-State DPS Population Trends*

Three range-wide trend assessments of the Bi-State DPS have been conducted: 2004 (Connelly *et al.* 2004), 2008 (WAFWA 2008), and 2011 (Garton *et al.* 2011).

In 2004, WAFWA conducted a partial population trend analysis for the Bi-State area (Connelly *et al.* 2004, Chapter 6). The WAFWA recognizes four populations of sage-grouse in the Bi-State area, which represent the same overall extent delineated by the six PMUs described in the 2012 Bi-State Action Plan and this document. Two of the WAFWA populations (North Mono Lake and South Mono Lake) had sufficient data for trend analysis (Connelly *et al.* 2004, pp. 6-60 to 6-62). The North Mono Lake population encompasses the Bodie, Mount Grant, and Desert Creek-Fales PMUs, while the South Mono Lake population encompasses the South Mono PMU. These

two populations do not encompass the entire Bi-State area but do represent a large percentage of known leks. The North Mono Lake population displayed a significant negative trend from 1965 to 2003, and the South Mono Lake population displayed a nonsignificant positive trend over this same period (Connelly *et al.* 2004, pp. 6-69 to 6-70).

In 2008, WAFWA (2008, Appendix D) conducted a similar trend analysis on the same two populations identified above using a different statistical method for the periods from 1965 to 2007, 1965 to 1985, and 1986 to 2007. The trend for the North Mono Lake population, as measured by maximum male attendance at leks, was negative from 1965 to 2007 and 1965 to 1985, but variable from 1986 to 2007; results suggest an increasing trend beginning in about 2000. Results for the South Mono Lake population suggest a negative trend from 1965 to 2007, a stable trend from 1965 to 1985, and a variable trend from 1986 to 2007; these results also suggest a positive trend beginning around 2000.

In 2011, Garton *et al.* (2011, pp. 324–330) conducted a third trend analysis on the same populations used in the two previous WAFWA analyses. Garton *et al.* (2011, p. 324) reported that the average number of males per lek in the North Mono Lake population declined by 35 percent and the average number of males per active lek declined by 41 percent from the 1965–1969 to 2000–2007 assessment periods. Based on a reconstructed minimum population estimate for males from 1965 to 2007, the overall population showed irregular fluctuations between peaks in 1970 and 1987 of 520 to 670 males, with lows above 100 and no consistent long-term trend over the 40-year period. In the South Mono Lake population, the average number of males per lek increased by 218 percent from the 1965–1969 to 1985–1989 assessment periods but declined by 49 percent from the 1985–1989 to 2000–2007 assessment periods (Garton *et al.* 2011, p. 325). Based on reconstructed minimum male counts, the population showed no obvious trend through time with between 200 and 600 males attending leks. The average annual rate of change for both populations suggests that population growth has been, at times, both positive and negative over the past 40 years (Garton *et al.* 2011, pp. 324–330).

None of these assessments attempted to analyze population trends for the Pine Nut or White Mountains PMUs due to limited data. Further, while the Mount Grant PMU is considered part of the North Mono Lake population described in the above analyses, data were censored due to quality, thus the North Mono Lake PMU trend analyses described above are relevant to the Bodie and Desert Creek-Fales PMUs only.

In general, these three studies suggest that population growth within these two delineated WAFWA populations has fluctuated over the past 40 years. Further, it appears that the North Mono Lake population (Bodie and Desert Creek-Fales PMUs) displays greater variation in population growth rate (both positive and negative) with more indications of decline as compared to the South Mono Lake population (South Mono PMU). Garton *et al.* (2011, p. 310) used their reconstructed male counts to forecast future probabilities of population persistence. They conclude that the probabilities of declining below a quasi-extinction threshold (as defined by less than 50 breeding adults per population) were 15 and 38 percent over the next 30 and 100 years, respectively, for the North Mono Lake population and less than 1 percent over the next 100 years for the South Mono Lake population. Furthermore, Garton *et al.* (2011, p. 310) indicate that long-term persistence (as defined by less than 500 breeding adults per population) is

questionable for both core populations with a high probability of dropping below this threshold in the next 30 years (100 percent for North Mono Lake population and 81.5 percent for South Mono Lake population).

The CDFW and NDOW annually conduct lek counts in the Nevada and California portions of the Bi-State area, respectively, that are used as an index to population trends and to estimate sage-grouse numbers for each PMU in the Bi-State DPS. Low and high population estimates are derived by combining a corrected number of males detected on a lek with an estimated number of females (i.e., an assumed sex ratio of two females to one male) and two lek detection rates (to capture the uncertainty associated with finding leks).

Recent ranges of spring population estimates and maximum numbers of males on leks are presented in Table 1 for the South Mono, Bodie, Mount Grant, and Desert Creek-Fales PMUs (CDFW 2012, *in litt.*; NDOW 2012, *in litt.*). Table 1 also includes population estimates for the Nevada portion of the Pine Nut PMU (NDOW 2012, *in litt.*), but does not include population estimates for the White Mountains PMU due to limited data. Population estimates derived from spring lek counts are problematic due to unknown true sex ratios and the percentage of uncounted leks. However, the trends derived from these data provide a reasonable indication of sage-grouse status and the extent of the populations in the Bi-State DPS.

### *Land Ownership*

Land ownership varies throughout the Bi-State DPS (Table 2). Although the largest portion (approximately 89 percent) is Federal, private lands also provide important habitats for sage-grouse.

- Federal lands in the Bi-State area are managed by the BLM Bishop Field Office, BLM Carson City District Office, BLM Tonopah Field Office, Inyo National Forest (INF), and Humboldt-Toiyabe National Forest (HTNF). The Department of Defense also has management authority for portions of the Mount Grant PMU (Table 2).
- Approximately 13 Wilderness Study Areas (WSA) overlap the Bi-State DPS and encompass approximately 5,400 ha (13,400 ac) in the Pine Nut PMU, 62,240 ha (153,800 ac) in the Bodie PMU, 23,560 ha (58,230 ac) in the South Mono PMU, and 15,175 ha (37,500 ac) in the White Mountains PMU.
- California Wildlife Management Areas, which are California State-owned and managed lands, occur in four PMUs. A total of approximately 6,224 ha (15,380 ac) are located at Sonora Junction and along the East Fork Walker River downstream of Bridgeport Reservoir (Desert Creek-Fales PMU); in Slinkard and Little Antelope Valleys (Pine Nut PMU); along Green Creek, Conway Summit, and the Bodie Bowl (Bodie PMU); and at River Spring Lakes (South Mono PMU). These lands are managed for the benefit of wildlife and each of these locations encompasses seasonally important sage-grouse habitat.
- Lands owned or managed for the benefit of Native American Tribes occur in four PMUs. The Washoe Tribe of Nevada & California owns approximately 24,281 ha (60,000 ac) of Bureau of Indian Affairs (BIA)-managed allotments in the Pine Nut PMU. The Death Valley Timbi-sha Shoshone Tribe owns approximately 553 ha (1,367 ac) of allotment lands in the White Mountains PMU, which is similarly managed by the BIA. The

Bridgeport Paiute Indian Colony owns approximately 16 ha (40 ac) in the Bodie PMU on the edge of Bridgeport, California, on which a housing development occurs. The Utu Utu Gwaitu Paiute Tribe of the Benton Paiute Reservation owns at least 161 ha (398 ac) in the South Mono PMU, and we believe an additional 16 ha (40 ac) in the PMU is under tribal ownership, although we are unaware of the ownership specifics.

**Table 2.** Population Management Units (PMUs), size, and land ownership status in the Bi-State DPS, California and Nevada.

PMU	Total Size hectares (acres)	Land Management/Ownership Distribution hectares (acres) <sup>1</sup>					
		BLM	USFS	Native American	Private	State/ County/ City	DOD
<b>Pine Nut</b>	232,224 (573,839)	139,531 (344,791)	28,527 (70,492)	24,281 (60,000; approx.)	34,316 (84,798)	5,567 (13,758)	—
<b>Desert Creek-Fales</b>	229,858 (567,992)	2,472 (6,110)	199,757 (493,612)	—	26,594 (65,716)	1,032 (2,552)	—
<b>Mount Grant</b>	28,146 (699,670)	113,277 (279,916)	121,773 (300,910)	11,316 (27,963)	16,974 (41,945)	—	19,803 (48,936)
<b>Bodie</b>	132,108 (326,447)	72,852 (180,022)	32,934 (81,382)	16 (40)	23,857 (58,952)	2,460 (6,081)	—
<b>South Mono</b>	234,508 (579,483)	81,250 (200,775)	126,295 (312,084)	178 (441)	7,147 (17,662)	19,636 (48,522)	—
<b>White Mountains</b>	709,768 (1,753,875)	589,107 (1,455,716)	99,367 (245,542)	—	21,292 (52,616) —		
<b>TOTAL</b>	<b>1,821,613 (4,501,306)</b>	<b>998,493 (2,467,330)</b>	<b>608,656 (1,504,022)</b>	<b>35,792 (88,444)</b>	<b>133,170 (329,073) plus White Mountains</b>	<b>10,656 (26,335) plus White Mountains</b>	<b>19,803 (48,936)</b>

1 – BLM = Bureau of Land Management; USFS = U.S. Forest Service; DOD = Department of Defense.

NOTE—Area values may not sum due to rounding.



- A relatively small amount of City and County owned lands occur in five PMUs. The most significant acreage occurs in the South Mono PMU where approximately 14,500 ha (36,000 ac) are owned by the City of Los Angeles and managed by the Los Angeles Department of Water and Power (LADWP).
- Privately-owned lands occur in each PMU. These lands are generally scattered parcels and predominantly are associated with water features and managed as ranching operations. Some subdivision of historical ranching lands to higher density exurban development has occurred and is expected to continue into the future.

## IMPACT ANALYSIS

### *Urbanization and Habitat Conversion*

Urbanization has directly eliminated sage-grouse habitat (Braun 1998, p. 145). Overall within the Great Basin ecoregion, the area uninhabited by humans has decreased from 90,000 km<sup>2</sup> (34,749 mi<sup>2</sup>) in 1990 to less than 12,000 km<sup>2</sup> (4,633 mi<sup>2</sup>) in 2004 (Knick *et al.* 2011, p. 212). Since 1950, the western U.S. human population growth rate has exceeded the national average (Leu and Hanser 2011, p. 255), and this has led to increases in urban, suburban, and rural development. In addition to direct habitat loss, interrelated indirect effects from urbanization include construction of associated infrastructure (e.g., fences, power lines, communication towers, and roads; see “Infrastructure” section below), increases in invasive plant species (see “Nonnative and Native Invasive Plants” section below), and increases in domestic (e.g., pets) and wildlife predator species (see “Disease and Predation” section below). This section of the Impact Analysis specifically discusses direct impacts to sage grouse populations (e.g., behavioral changes) and habitat associated with urbanization and habitat conversion.

Traditional land use in the Bi-State area was primarily farming and ranching operations. While conversion of sagebrush vegetation communities to alternative vegetation types (e.g., pasture grass) continues to occur in the Bi-State area, the rate of this conversion has lessened. However, today some of these lands are being sold and converted to low-density residential housing developments (Bi-State TAC 2012, pp. 18, 24, 41). Historical and recent alterations, as well as ongoing conversion of sagebrush vegetation to support ranching operations and through urban or exurban expansion, poses the greatest risk to persistence of sage-grouse in the Pine Nut, Desert Creek-Fales, and South Mono PMUs and to a lesser degree in the Bodie, and White Mountains PMUs (Bi-State Local Planning Group 2004, pp. 24, 47, 88, 169; Bi-State Technical Advisory Committee 2012, pp. 18, 24, 31, 41, 46). Currently, approximately 8 percent of land encompassed by PMU delineations in the Bi-State area is privately owned (Bi-State Local Planning Group 2004, pp. 11, 32, 63, 102, 127, 153), and not all of these lands are likely to be developed.

In each PMU, sage-grouse home ranges include private lands that are critical to fulfilling annual habitat needs (Casazza 2009, p. 9), including the majority of mesic areas (i.e., upland meadows) within the range of the Bi-State DPS needed by sage-grouse during the late brood-rearing period. Sage-grouse are known to display strong site fidelity to traditional seasonal habitats and loss of

specific sites can have pronounced population impacts. Examples of important sage-grouse habitat on private lands include:

- (1) In the Desert Creek-Fales PMU, sage-grouse use of private lands near Burcham and Wheeler Flats has been documented to encompass 10–15 percent of their home range, depending on the season (Casazza *et al.* 2009, p. 19).
- (2) In the Nevada side of the Desert Creek-Fales PMU, essentially all brood-rearing habitat occurs on privately owned irrigated pasture land (NDOW 2011, entire).
- (3) In the Bodie PMU, sage-grouse use private lands 10–20 percent of the time, with use most pronounced during the summer and winter months (Casazza 2009, p. 27). In addition, some sage-grouse breeding in this PMU move to wintering habitat on private land in Nevada on the adjacent Mount Grant PMU (Casazza 2009, p. 27).
- (4) In the Mount Grant PMU, private lands are used by sage-grouse throughout the year, especially irrigated pasture during the late summer brood-rearing period (Espinosa 2008, pers. comm.; NDOW 2011, p. 4).
- (5) In the South Mono PMU, sage-grouse use private lands 25–50 percent of the time, with use most pronounced during the summer months on lands owned by the City of Los Angeles.

Urbanization and exurbanization (i.e., low density housing development with less than one housing unit per ha (2.5 ac)) has affected and continues to affect sage-grouse habitat in the Nevada portion of the Pine Nut and Desert Creek-Fales PMUs through the direct conversion of sagebrush vegetation communities and other indirect mechanisms that influence sage-grouse occurrence (Bi-State Local Planning Group 2004, pp. 24, 47; Bi-State Technical Advisory Committee 2012, pp. 18, 24). Historical and ongoing expansions of Minden, Gardnerville, and Carson City, Nevada have displaced sagebrush vegetation communities in the greater Carson Valley and continue to encroach upon the west side of the Pine Nut Mountains (Pine Nut PMU), largely extirpating sage-grouse from these areas recently (Bi-State TAC 2012, p. 18). Additional loss of sagebrush habitat in the southern portion of the Pine Nut PMU has likely occurred in the past decade as housing development in proximity to Holbrook Junction, Nevada continues to expand (Abele 2012, pers. obs.). In the northern portion of the Desert Creek-Fales PMU, subdivision of larger ranching properties into exurban housing developments has occurred over the past decade (NDOW 2006, p. 4). These recent developments result in diminished habitat suitability as well as loss and fragmentation of sagebrush vegetation and sage-grouse distribution, thus impacting our ability to recover the Bi-State DPS in these areas, particularly as ongoing indirect effects from past development are realized.

Within the California portion of the Desert Creek-Fales PMU, historical and ongoing development pressures exist in proximity to the Fales breeding complex located near Sonora Junction, California. Development along the Highway 395 corridor likely altered historical sage-grouse distribution (e.g., Huntoon Valley) and lek persistence, affecting population size and connectivity with Bridgeport Valley and the Bodie PMU. More recently, private land

development has occurred on Burcham Flat and, in 2012, a single family residence was constructed within several hundred meters of the Burcham Flat lek (one of three remaining leks in the California portion of the PMU). A similar event (i.e., single family residence development) occurred in 2004 approximately 50 m from a lek site on Burcham Flat, this lek site subsequently became inactive in 2006 (Bi-State TAC 2012, p. 24).

Private lands are scattered throughout the Bodie PMU, with the largest contiguous blocks of private parcels occurring in the Bridgeport Valley. To date, the extent of habitat loss and fragmentation attributable to land use change and development in the Bodie PMU is generally limited. However, the extent of historical use by sage-grouse in the Bridgeport Valley is not known. The majority of private lands in the Bodie PMU are currently characterized as rangeland; however, the potential for conversion of these private lands for commercial, residential, or recreational development is apparent, with particular concern for areas that are currently providing connectivity between the Bodie, Mount Grant, and Desert Creek-Fales PMUs. For example, Sinnamon Meadow (501 ha, 1,240 ac) in the Bodie PMU provides important brood-rearing and late summer habitat (Bi-State TAC 2012, p. 88), and the property was sold in 2012. While land developers demonstrated interest in the property, the new landowner intends to continue ranching operations and is pursuing, in cooperation with several nongovernmental and governmental entities, an agricultural conservation easement that may provide future protection from development (Johnson 2012, pers. comm.).

In the South Mono PMU, habitat loss and fragmentation attributed to land use change and development have been limited to date also. However, extensive development in the Mammoth Lakes and Crowley Drive areas exert additional land use pressure on the PMU. The majority of private land in the PMU is owned by the City of Los Angeles and managed by the LADWP, and most of these parcels are associated with perennial water and provide important brood-rearing habitat. However, the LADWP is developing a Habitat Conservation Plan (HCP) with the Service and the California Department of Fish and Wildlife which includes the sage-grouse as a covered species. The HCP proposes to conserve all existing sage-grouse habitat on LADWP lands for the life of the permit (i.e., 10 years) and possibly longer if the permit is renewed (see further discussion on the development of this HCP in the “Conservation Efforts” section below). The largest block of private lands not owned by LADWP lies adjacent to occupied sage-grouse habitat west of Crowley Lake. The remainder of private lands in the South Mono PMU are rangeland with potential for commercial, residential, or recreational development. Several meadows with important summer brood-rearing habitat within two private parcels in the South Mono PMU (Sagehen (16.2 ha (40 ac)) and Gaspipe (16.2 ha (40 ac)) Meadows) have recently been significantly affected by development (Taylor 2008, pers. comm.).

The Town of Mammoth Lakes, California, and the surrounding area in the South Mono PMU is a desirable recreational destination (although most recreational development and activity in Mono County is in the Eastern Sierra Nevada (Burns 2013, pers. comm.)) and has been growing in population size (Town of Mammoth Lakes 2007a, p. 4-220). In 2007, the Town adopted measures allowing more development on private lands (Town of Mammoth Lakes 2007b, entire); however, the overall amount of private land is limited and the majority of it is within the confines of the Town of Mammoth Lakes. Therefore, actual direct loss of sage-grouse habitat

due to adoption of these measures is potentially small, but increased indirect effects due to associated human growth are expected. An example is the proposed expansion of the Mammoth Yosemite Airport located within the South Mono PMU (Long Valley). While only approximately 1.6 ha (4 ac) of occupied sage-grouse habitat surrounding the Airport is zoned for development, commercial traffic has increased to eight winter flights per day since 2008 (Mammoth Yosemite Airport 2012). The Airport had regional commercial air service from 1970 until the mid-1990s (Federal Aviation Administration 2008, p. 1-5), and it currently supports about 400 flights per month of primarily single-engine, private aircraft (Town of Mammoth Lakes 2005, p. 4-204). All sage-grouse in the Long Valley portion of the South Mono PMU occur in close proximity to the Airport and are exposed to commercial and private air traffic. The change in public use of Long Valley has not been quantified, but anecdotally the numbers of people and user days appear to be increasing (Nelson 2008, pers. comm.; Taylor 2008, pers. comm.). The area is frequently visited by anglers and bicyclists, and used for other general recreational activities including camping and hot spring visits. Long-term effects of increasing commercial flight traffic and people that the South Mono PMU sage-grouse population will be exposed to remain undetermined.

Currently, Mono County is updating their General Plan, and the County is expecting to develop policies promoting the avoidance of sage-grouse habitat and to provide best management practices for the conservation of sage-grouse for activities within sage-grouse habitat (Burns 2013, pers. comm.). On average, the County issues about 30 development permits per year, and the majority of development occurs within established communities. Mono County also has a Land Tenure Adjustment Program that is designed to get isolated pockets of private land moved closer to communities (via land exchanges or conservation easements) so that they become incorporated into public land ownership or are covered under a conservation easement for resource management (Burns 2013, pers. comm.).

Much of the White Mountains PMU is publicly owned. However, there is potential for future development on the limited private lands present in this PMU based on the recently expanded housing developments near Chiatovich Creek on the Nevada side of the PMU (Bi-State Lek Surveillance Program 2012, p. 38). This area is approximately 8 km (5 mi) south of two recently identified leks and development has led to direct habitat loss, as well as likely further affecting connectivity between the northern and southern portions of this PMU. Additional fragmentation of this corridor area may further limit connectivity between the White Mountains PMU and Adobe Valley in the South Mono PMU.

Sagebrush vegetation conversion to agricultural land can result in loss of habitat availability and habitat quality. This conversion has occurred in the past and continues currently, but the rate remains difficult to quantify. The actual effect depends on the amount of sagebrush lost, the type of seasonal habitat affected, and the arrangement of habitat lost (large blocks or small patches) (Knick *et al.* 2011, pp. 208–211). Direct impacts to sage-grouse depend on the timing of conversion (e.g., loss of nests, eggs). Indirect effects within adjoining sagebrush habitats include increased predation with reduced nest success (Connelly *et al.* 2004, p. 7-23), increased human presence, and habitat fragmentation. For example, Rights-of-Way (ROW) granted across public lands for roads, utility lines, sewage treatment plants, and other public purposes (see

“Infrastructure” section below) are needed and typically granted to support development activities on adjacent private parcels.

Traditional land uses in the Bi-State area were primarily farming and ranching operations, and these operations have both beneficial and detrimental roles in sage-grouse conservation. Continuing farming and ranching operations have limited development of exurban subdivisions in the Bi-State area, but they have also maintained or increased reductions in sagebrush extent. They have also influenced the current frequent dependence of sage-grouse on irrigated pastures during the brood-rearing season. This situation presents challenges to sage-grouse population growth currently and in the future, as these pastures are less suitable for chick production than native meadow systems. Furthermore, functionality of these pastures can vary annually. For example, in the Mount Grant PMU higher fuel costs for pumping have influenced the extent to which pastures have been irrigated (Bi-State LAWG 2012, pers. comm.). In Smith Valley, Nevada, near complete conversion of sagebrush to ranching and agricultural purposes began over 100 years ago and this valley likely provided the most significant migratory connection between the Pine Nut and Desert Creek-Fales PMUs historically. More recently (in the past decade), land conversion from sagebrush to pasture has occurred in the Desert Creek-Fales PMU, and this action may have influenced the recent abandonment of a lek within several hundred meters of this site (Espinosa 2008, pers. comm.).

Current and anticipated future fragmentation caused by conversion of private lands may be ameliorated by fee acquisition of these properties or enrollment of these lands into programs (e.g., conservation easements) that potentially minimize habitat loss and functionality to sage-grouse. We estimate that approximately 5,058 ha (12,500) ac of private land, which provide suitable habitat for sage-grouse in the Bi-State DPS, are currently enrolled in various easement programs. The majority of these easement lands (3,374 ha (8,338 ac)) are located in the Bodie PMU, with the remainder of easements occurring in the Desert Creek-Fales, South Mono, and White Mountains PMUs. Of the approximately 133,170 ha (329,000 ac) of private land within the Bi-State area, approximately 3.8 percent are under easements. An additional 2,538 ha (6,272 ac) or approximately 1.9 percent of private land within the Bi-State DPS has been acquired by State and Federal agencies over the past decade. State acquired lands (494 ha, 1,220 ac) are to be managed for wildlife benefit, while federally-managed acquisitions have no specific covenants restricting use.

Human population growth that results in development of sagebrush habitats in the future will likely reduce sage-grouse persistence. In modeling sage-grouse persistence, Aldridge *et al.* (2008, pp. 991–992) determined that human density in 1950 was the best predictor of sage-grouse extirpation among the human population metrics considered. Extirpation was more likely in areas having a moderate human population density of at least four people per 1 km<sup>2</sup> (four people per 0.4 mi<sup>2</sup>). Further increase in human populations from this moderate level did not infer a greater likelihood of extirpation, likely because much of the additional growth occurred in areas no longer suitable for sage-grouse (Aldridge *et al.* 2008, pp. 991–992). Aldridge *et al.* (2008, p. 990) also reported that sage-grouse require a minimum of 25 percent sagebrush for persistence in an area; a high probability of persistence required 65 percent sagebrush or more.

In addition, Wisdom *et al.* (2011, p. 463) reported that human density was 26 times greater in extirpated sage-grouse areas than in currently occupied range.

To further examine the potential likelihood of population changes that may influence urbanization and habitat conversion in the future, we examined the most recent U.S. Census Bureau data (U.S. Census Bureau 2012) and found three counties in the Bi-State area have documented declines in the number of people present between 2000 and 2010: Alpine County, California, and Mineral and Esmeralda Counties in Nevada. These counties contain small portions of the Pine Nut and White Mountains PMUs and the majority of the Mount Grant PMU. In addition, these three counties generally support less than four people per 1 km<sup>2</sup> (four people per 0.4 mi<sup>2</sup>). The remaining counties in the Bi-State area have seen human population increases over the past decade, ranging from 0 to 5 percent for Inyo County, California; from 5 to 15 percent for Mono County, California, and Douglas and Carson City Counties, Nevada; and greater than 25 percent for Lyon County, Nevada (U.S. Census Bureau 2012). These five counties encompass the majority of five PMUs in the Bi-State including the Pine Nut, Desert Creek-Fales, Bodie, South Mono, and White Mountains PMUs. Although we do not have specific information on possible future developments from each of these counties with documented human population increases, we are aware that recent development levels are reduced as compared to the past.

#### Summary of Urbanization and Habitat Conversion Impacts

Historical and recent conversion of sagebrush habitat on private lands for agriculture, housing, and associated infrastructure within the Bi-State area has likely negatively affected sage-grouse distribution and population extent in the Bi-State DPS, thus limiting current and future recovery opportunities in the Bi-State area. These alterations to habitat have been most pronounced in the Pine Nut and Desert Creek-Fales PMUs and to a lesser extent the Bodie, South Mono, and White Mountains PMUs. Although only a subset of the 8 percent of suitable sage-grouse habitat that occurs on private lands could potentially be developed, conservation actions on adjacent public lands could be compromised due to the high percentage of late brood-rearing habitat that occurs on the private lands. Sage-grouse display strong site fidelity to traditional seasonal habitats and loss of specific sites (such as mesic meadow or spring habitats that are typically private lands in the Bi-State area) can have pronounced population impacts. The influence of land development and habitat conversion on the population dynamics of sage-grouse is greater than a simple measure of spatial extent because of the indirect effects from the associated increases in human activity. These threats are not universal across the Bi-State area, but localized areas of impacts have been realized and additional future impacts are anticipated.

#### *Infrastructure*

We characterize infrastructure as features that assist or are required for the pursuit of human development or an associated action. We focus on five infrastructure features that are impacting the Bi-State DPS: three linear features (roads, power lines, and fences) and two site-specific features (landfills and communication towers). While there may be other features that could be characterized as infrastructure (such as railroads or pipelines), these are not present in the Bi-State area and we are unaware of any information suggesting they would impact the Bi-State

DPS in the future. Infrastructure can have direct impacts on sage-grouse (such as mortality through collision (see “Power lines” and “Fences” sections below) or indirect impacts (such as habitat fragmentation or habitat loss leading to a reduction in population size).

Habitat fragmentation is the separation or splitting apart of previously contiguous, functional habitat components of a species. Fragmentation can result from direct habitat losses that leave the remaining habitat in non-contiguous patches or from alteration of habitat areas that render the altered patches unusable (i.e., functional habitat loss). Functional habitat losses include disturbances that change a habitat’s successional state or remove one or more habitat functions, physical barriers that preclude use of otherwise suitable areas, and activities that prevent species from using suitable habitat patches due to behavioral avoidance.

Fragmentation of sagebrush habitats has been cited as a primary cause of the decline of sage-grouse populations because the species requires large expanses of contiguous sagebrush (Patterson 1952, pp. 192–193; Connelly and Braun 1997, p. 4; Braun 1998, p. 140; Johnson and Braun 1999, p. 78; Connelly *et al.* 2000a, p. 975; Miller and Eddleman 2000, p. 1; Schroeder and Baydack 2001, p. 29; Johnsgard 2002, p. 108; Aldridge and Brigham 2003, p. 25; Beck *et al.* 2003, p. 203; Pedersen *et al.* 2003, pp. 23–24; Connelly *et al.* 2004, p. 4-15; Schroeder *et al.* 2004, p. 368). For example, studies have documented negative effects of fragmentation specifically from oil and gas development and its associated infrastructure on lek persistence, lek attendance, winter habitat use, recruitment, yearling annual survival rate, and female nest site choice (Holloran 2005, p. 49; Aldridge and Boyce 2007, pp. 517–523; Walker *et al.* 2007a, pp. 2,651–2,652; Doherty *et al.* 2008, p. 194). Additional examples of the negative effects that result from fragmented habitat are related to a variety of human developments including roads, energy development, power lines, and other factors that are associated with sage-grouse extirpations (Wisdom *et al.* 2011, p. 463). Estimating the impact of habitat fragmentation on sage-grouse is complicated by time lags in species response to habitat changes (Garton *et al.* 2011, p. 371), particularly since these relatively long-lived birds continue to return to altered breeding areas (leks, nesting areas, and early brood-rearing areas) due to strong site fidelity despite nesting or productivity failures (Wiens and Rotenberry 1985, p. 666).

Sagebrush communities exhibit a high degree of variation in their resistance and resilience to change, beyond natural variation. Resistance (the ability to withstand disturbing forces without changing) and resilience (the ability to recover once altered) generally increase with increasing moisture and decreasing temperatures, and also can be linked to soil characteristics (Connelly *et al.* 2004, p. 13-6). However, most extant sagebrush habitat has been altered since European settlement of the West (Baker *et al.* 1976, p. 168; Braun 1998, p. 140; Knick *et al.* 2003, p. 612; Connelly *et al.* 2004, p. 13-6), and sagebrush habitat continues to be fragmented and lost (Knick *et al.* 2003, p. 614) through the specific impacts described below. The cumulative effects of habitat fragmentation have not been quantified within the Bi-State area or over the range of sagebrush, and most habitat fragmentation cannot be attributed to specific land uses (Knick *et al.* 2003, p. 616). Thus, changes to the sagebrush vegetation community from infrastructure have occurred in the Bi-State area and the ultimate impacts caused by these features may have yet to be realized. Furthermore, these factors likely act in concert with other impacts, thus causing the recovery of the sagebrush community to be challenging. The specific infrastructure within the

Bi-State area potentially impacting the Bi-State DPS include roads, power lines, fences, landfills, and communication towers.

## 1. Roads

Impacts to animals from roads include direct habitat loss, direct mortality, barriers to migration corridors or seasonal habitats, facilitation of predators, and spread of invasive plant species, and other indirect influences such as noise (Forman and Alexander 1998, pp. 207–231). Sage-grouse mortality from vehicle collisions does occur (Patterson 1952, p. 81), including in the Bi-State area (Wiechman 2008, p. 3), but mortalities are typically not monitored or recorded.

Roads can provide corridors for predators to move into previously unoccupied areas. For some mammalian species, dispersal along roads has greatly increased their distribution (Forman and Alexander 1998, p. 212; Forman 2000, p. 33). Corvids (e.g., ravens (*Corvus* spp.)) also use linear features like roads as travel routes, expanding into new regions (Knight and Kawashima 1993, p. 268; Connelly *et al.* 2004, p. 12-3). Bui (2009, p. 31) documented ravens following roads in oil and gas fields during foraging. Associated with roads are highway rest areas, which provide a source of food and perches for corvids and raptors, and facilitate their movements into surrounding areas (Connelly *et al.* 2004, p. 7-25). Specific road impact data has been collected for Gunnison sage-grouse in Colorado where road development was shown to impede movement of local populations between the resultant habitat patches, with road avoidance presumably a behavioral means to limit exposure to predation (Oyler-McCance *et al.* 2001, p. 330).

Inevitably, roads will increase human access and resulting disturbance effects in remote areas (Forman and Alexander 1998, p. 221; Forman 2000, p. 35; Connelly *et al.* 2004, pp. 7-6 to 7-25). For example, roads built into sagebrush habitats have been documented to facilitate increases in legal and illegal hunting of sage-grouse across their range (Hornaday 1916, p. 183; Patterson 1952, p. vi). Roads also facilitate access for rangeland habitat treatments such as disking or mowing (Connelly *et al.* 2004, pp. 7-25), resulting in subsequent direct losses of sagebrush habitats.

Road networks contribute to the spread of nonnative invasive plants via introduced road fill, vehicle transport, and road maintenance activities (Forman and Alexander 1998, p. 210; Forman 2000, p. 32; Gelbard and Belnap 2003, p. 426; Knick *et al.* 2003, p. 619; Connelly *et al.* 2004, p. 7-25). Invasive species are not restricted to roadsides, but also encroach into surrounding habitats (Forman and Alexander 1998, p. 210; Forman 2000, p. 33; Gelbard and Belnap 2003, p. 427). For example, Gelbard and Belnap (2003, p. 426) reported that converting unpaved four-wheel drive roads to paved roads increased cover of nonnative invasive plant species within the interior of adjacent plant communities. This effect was associated with road construction and maintenance activities and vehicle traffic, and not differences in site characteristics (Gelbard and Belnap 2003, p. 426). The incursion of nonnative invasive plants into native sagebrush systems can negatively affect sage-grouse through habitat losses and ecosystem conversions.

Additional indirect effects of roads to sage-grouse may result from the bird's behavioral avoidance of road areas because of noise or visual disturbance. The absence of vegetation in arid and semiarid regions to buffer these impacts exacerbates this effect (Suter 1978, p. 6). Holloran



(2005, p. 40) showed that male sage-grouse lek attendance declined within 3 km (1.9 mi) of a road with traffic volume exceeding one vehicle per day in Wyoming. Male sage-grouse are also dependent on acoustical signals to attract females to leks (Gibson and Bradbury 1985, p. 82; Gratson 1993, p. 692). Therefore, if noise interferes with mating displays, and thereby female attendance, younger males will not be drawn to the lek and eventually leks could become inactive (Amstrup and Phillips 1977, p. 26; Braun 1986, pp. 229–230). While traffic volume varies substantially across all roads in the Bi-State area, locations associated with mineral development (e.g., Aurora and East Walker River Valley areas in Mount Grant PMU), recreational activity (Bodie State Park, Bodie and South Mono PMUs), and major travel corridors (Highway 395 and Nevada State Route 338, Desert Creek-Fales PMU) have the most significant daily road traffic.

Female sage-grouse breeding activity is also affected by the presence of roads. In Wyoming, sage-grouse hens that bred on leks within 3 km (1.9 mi) of roads traveled twice as far to nest as did hens bred on leks greater than 3 km (1.9 mi) from roads (Lyon and Anderson 2003, p. 489). Also, nest initiation rates for hens bred on leks close to roads were lower (65 versus 89 percent), ultimately lowering population recruitment by 10 percent (Lyon 2000, p. 33; Lyon and Anderson 2003, pp. 489–490). Braun *et al.* (2002, p. 5) suggested that daily vehicular traffic along road networks can impact sage-grouse breeding activities based on lek abandonment patterns. Following are examples of studies that examined abandonment of leks or suitable habitat over time:

- Connelly *et al.* (2004, p. 13-12) conducted a study of 804 leks within 100 km (62.5 mi) of Interstate 80 in Wyoming and Utah and discovered there were no leks within 2 km (1.25 mi) of the Interstate and only 9 leks between 2 and 4 km (1.25 and 2.5 mi) from the Interstate. The number of active leks also increased with increasing distance from the Interstate. Analysis of changes between 1970 and 2003 showed that leks closest (within 7.5 km (4.7 mi)) to the Interstate declined at a greater rate (Connelly *et al.* 2004, p. 13-13).
- Wisdom *et al.* (2011, p. 463) determined that across the western U.S. extirpated sage-grouse range is 60 percent closer to highways (mean = 5 km (3.1 mi)) and that extirpated sites were generally closer to secondary roads.
- Johnson *et al.* (2011, p. 449) reported attendance at leks within 18 km (11 mi) of interstate, Federal, or state highways declined with increasing road density even though road construction predated the time period from which lek counts were obtained (1997–2007). This suggests a continuing impact from highways, possibly due to increased traffic levels, which have been identified as reducing numbers of sage-grouse occupying leks.

Minimal information is available on the potential impacts of road density within sage-grouse habitat. Aldridge *et al.* (2008, p. 992) did not find road density to be an important factor affecting sage-grouse persistence or rangewide patterns in sage-grouse extirpation. However, the authors did not model intensity of road use, and their analyses may have been influenced by inaccuracies in spatial road data sets, particularly for secondary roads (Aldridge *et al.* 2008, p. 992). Wisdom *et al.* (2011, p. 18) reported that extirpated range has a 25 percent higher road

density than occupied range. This recent rangewide analysis supports the results of local studies (Lyon and Anderson 2003, entire; Aldridge and Boyce 2007, entire) showing that roads have both direct and indirect impacts on sage-grouse distribution and individual fitness.

An extensive road network occurs throughout the Bi-State area. Roads vary from paved, multi-lane highways to rough jeep trails, but the majority of road miles are unpaved, dirt two-track roads. As stated above, traffic volume varies significantly in the Bi-State area, as do individual populations' exposure. Our analysis of the best available data in the Bi-State area documents that all known leks are within 3 km (1.8 mi) or less of an existing road and between 35 and 45 percent of annually-occupied leks are within 5 km (3.1 mi) of highways (Service 2013, unpublished data).

- In the Pine Nut PMU, an extensive road network exists. Generally much of this area is not accessible to vehicle traffic until early summer due to winter conditions, but its proximity to urban settings and the increasing prevalence of off-highway vehicles (OHV) has expanded the timeframe and degree of exposure (Bi-State LAWG 2012, pers. comm.).
- In the Desert Creek-Fales PMU, all leks are in close proximity to dirt two-track roads and seven of eight consistently occupied leks in recent years are in close proximity (less than 2.5 km (1.5 mi)) to well-traveled highways (Bi-State Local Planning Group 2004, p. 54).
- For the Bodie and Mount Grant PMUs, roads (although abundant) have not been identified as a broad scale risk factor but may be causing local degradations (Bi-State Local Planning Group 2004, pp.137). However, aside from leks located in the Wassuk Range, where access is controlled by the DOD, most leks (with one or two exceptions) are generally accessible via well-traveled roads during average spring weather conditions. Also, vehicle traffic due to recent mining activity in the Mount Grant PMU has increased significantly with the potential for additional increases due to other proposed mining operations (Bi-State TAC 2012, p. 36).
- In the South Mono PMU, essentially all leks are accessible during average spring conditions along well-maintained roads, although access is controlled at three sites by the BLM, which prevents vehicle traffic directly to the leks during the strutting season. Two leks that were less than 300 m (1,000 ft) from California Highway 120 have not been active since 2009 (CDFW 2012, unpublished data).
- In the White Mountains PMU lek locations are poorly known and road access is relatively restricted with spring weather conditions generally precluding access. However, the 2004 Bi-State Plan (Bi-State Local Planning Group 2004, pp. 120, 124) identified existing roads and the potential for new roads as a concern in this PMU.

In the Bi-State area, all Federal lands have restrictions limiting off-road vehicular travel. In addition, road closures and rehabilitation of redundant roads are also occurring to benefit Bi-State DPS conservation, such as the following:

- The INF and HTNF recently mapped existing roads and trails on Forest Lands as part of the USFS Travel Management planning efforts, including identification of designated routes (USFS 2009, entire; USFS 2010, entire); these planning efforts variously affect all PMUs. For the INF, this added approximately 1,600 km (1,000 mi) of previously

unauthorized routes to the National Forest System, while proposing to close approximately 1,125 km (700 mi) (USFS 2009, p. 1). The HTNF planning effort adopted approximately 360 km (225 mi) of previously unauthorized routes to the National Forest System, while proposing to close approximately 310 km (193 mi) of unauthorized routes (USFS 2010, pp. 4–5). Many of the unauthorized routes adopted into the National Forest System have been in use for decades; thus, potential future negative impacts to sage-grouse would be from indirect effects such as invasive species, predators, and increased vehicle traffic.

- The BLM's Bishop Field Office closed—permanently or seasonally—several miles of roads to minimize lek disturbance during the breeding season (BLM 2005a, p. 3). In addition, they are rehabilitating several miles of redundant routes to consolidate use and minimize habitat degradation and disturbance for these same lek complexes (BLM 2005a, p. 3).

Overall, it is evident through examination of data, literature, maps, and aerial imagery that an extensive network of roads and trails currently occurs throughout the range of the Bi-State DPS. We anticipate limited additional road and trail development will occur within suitable and potentially suitable habitat in the Bi-State area based on recent USFS travel management plans and our current understanding of BLM travel management direction. However, because an extensive road and trail network already occurs throughout the Bi-State area and roads are known to result in both direct and indirect impacts to sage-grouse, we anticipate some impacts to birds and leks in the future, although we are uncertain to what degree these potential impacts will affect populations in the Bi-State area. Of greatest concern is our already limited ability to recover the Bi-State DPS in various areas due to the existing extensive road network.

## 2. Power Lines

Power lines (including geographic groups of power lines called power grids) were first constructed in the United States in the late 1800s. Demand for electricity has grown as human population and industrial activities have expanded (Manville 2002, p. 5), resulting in more than 804,500 km (500,000 mi) of power lines (lines carrying greater than 115 kilovolts (kV) (115,000 volts) by 2002 (Manville 2002, p. 4). Power lines are common to nearly every type of anthropogenic (human-influenced) habitat use. Power lines can directly affect sage-grouse by posing collision and electrocution hazards (Braun 1998, pp. 145–146; Connelly *et al.* 2000a, p. 974) and can have indirect effects by decreasing lek recruitment (Braun *et al.* 2002, p. 10), increasing predation (Connelly *et al.* 2004, p. 13-12), fragmenting habitat (Braun 1998, p. 146), facilitating the invasion of nonnative invasive annual plants (Knick *et al.* 2003, p. 612; Connelly *et al.* 2004, p. 7-25), and potentially acting as a barrier to movement (Pruett *et al.* 2009, pp. 1255–1256). Due to the potential spread of invasive species and predators as a result of power line construction, the indirect influence power lines can have on vegetation community dynamics and species occurrence often extends out further than the physical footprint (Knick *et al.* 2011, p. 219). Following are examples of collision and predation impacts to sage-grouse from power lines:

- In one of the first records of collision reported (1939), three adult sage-grouse died after colliding with a telegraph line (Borell 1939, p. 85). Subsequently, both Braun (1998, p.

145) and Connelly *et al.* (2000a, p. 974) reported an unspecified number of sage-grouse collisions with power lines. An unpublished collision observation was reported in 2003 by Aldridge and Brigham (2003, p. 31) and, in 2009, two sage-grouse died in the Bi-State area from electrocution after colliding with a power line (Gardner 2009, pers comm.).

- In areas with low vegetation and relatively flat terrain, power poles provide hunting perches, roosting perches, and nesting stratum for raptors and corvids (Steenhof *et al.* 1993, p. 27; Connelly *et al.* 2000a, p. 974; Manville 2002, p. 7; Vander Haegen *et al.* 2002, p. 503), which in turn can result in increased predation of sage-grouse. Power poles increase a raptor's range of vision, allow for greater speed during attacks on prey, and serve as territorial markers (Steenhof *et al.* 1993, p. 275; Manville 2002, p. 7). In southern Idaho and Oregon, raptors and ravens began nesting on the support poles within 1 year of construction of a 596-km (372.5-mi) power line (Steenhof *et al.* 1993, p. 275); after 10 years, 133 pairs of raptors and ravens were nesting along this line (Steenhof *et al.* 1993, p. 275). In Nevada, raven counts increased by approximately 200 percent along the Falcon-Gondor power line within 5 years of construction (Atamian *et al.* 2007, p. 2). In Utah, Ellis (1985, p. 10) reported that golden eagle (*Aquila chrysaetos*) predation of sage-grouse increased from 26 to 73 percent of the total lek predation after construction of a power line within 200 meters (m) (220 yards (yd)) of an active lek; the lek was eventually abandoned, and Ellis (1985, p. 10) concluded that the line changed sage-grouse dispersal patterns and fragmented the habitat. In Wyoming, leks within 0.4 km (0.25 mi) of new power lines had significantly lower growth rates (measured by recruitment of new males onto the lek), presumed to be from increased raptor predation (Braun *et al.* 2002, p. 10).

Based on presence of power lines and associated increased presence of predators, sage-grouse and other related birds have been observed to shift their use of habitat away from these areas. Braun (1998, p. 146) discovered that sage-grouse use of suitable habitat near power lines increased as distance from the power line increased for up to 600 m (660 yd) and reported that power lines may limit sage-grouse use within 1 km (0.6 mi). Pruett *et al.* (2009, pp. 1255–1256) discovered that lesser and greater prairie-chickens (*Tympanuchus pallidicinctus* and *T. cupido*, respectively) avoided otherwise suitable habitat near power lines. In addition, both lesser and greater prairie-chickens crossed power lines less often than nearby roads, which suggests that power lines are a particularly strong barrier to movement (Pruett *et al.* 2009, pp. 1255–1256). However, in sage-grouse this behavioral barrier to movement is not readily apparent. For example, a long-term study assessing the impacts of a newly constructed power line on a sage-grouse population in Nevada did not detect noticeable avoidance of the power line by marked individuals. While measuring avoidance was not a specific objective of the study, preliminary assessment did not indicate avoidance was occurring (Nonne *et al.* 2013, p. 31). Sage-grouse may also avoid the electromagnetic fields produced by power lines (Wisdom *et al.* 2011, p. 467). Electromagnetic fields alter behavior, physiology, endocrine systems and immune function in birds, with negative consequences on reproduction and development (Fernie and Reynolds 2005, p. 135). Fernie and Reynolds (2005, p. 135) note that birds vary in their sensitivities to electromagnetic fields, with domestic chickens being very sensitive and many raptor species less affected.

Power lines can also facilitate the spread of nonnative invasive plant species (such as cheatgrass (*Bromus tectorum*)), as reported by Gelbard and Belnap (2003, pp. 424–426), Knick *et al.* (2003, p. 620), and Connelly *et al.* (2004, p. 1-2). However, we are unaware of any scientific or commercial information regarding the amount of invasive species incursions as a result of power line construction.

In a comparative study between extirpated and extant sage-grouse populations, Wisdom *et al.* (2011, p. 463) found distance to power lines was a strong explanatory variable inferring extirpation, and that extirpated populations were on average within 6 km (3.7 mi) of a power line. Furthermore, LeBeau (2012, p. 79–82) found nest and brood success was negatively influenced by proximity to power lines associated with wind development in central Wyoming. Alternatively, a Nevada study failed to find a correlation between distance to power lines and nesting success in sage-grouse (Nonne *et al.* 2013, p. 23). In addition, Johnson *et al.* (2011, p. 440) did not find that lek counts conducted between 1997 and 2007 were affected by power line proximity. However, the researchers caveat their results because most of the power lines used in their analysis were constructed prior to the time period from which the lek counts were conducted, thus changes in lek counts may have already occurred before 1997 (Johnson *et al.* 2011, p. 449). While power lines on a landscape may affect sage-grouse in a number of ways, ultimately our understanding of the influence that power lines have on sage-grouse occurrence or vital rates is not complete. Johnson *et al.* (2011, p. 427) did report that other anthropogenic towers (i.e., communication towers) negatively affected lek counts and that construction of these features largely overlapped with the lek count time period (1997–2007). Thus, while it appears reasonable that sage-grouse would respond similarly to different tower types, there may be differences that are not yet apparent.

Power lines occur in all Bi-State PMUs, but the impacts these existing power lines may have on the Bi-State DPS varies by location.

- In the Pine Nut PMU, power lines border the North Pine Nut lek complex (i.e., the only active complex in this PMU) on two sides (Bi-State Local Planning Group 2004, p. 28). The distance between this lek complex and the power lines ranges from approximately 1.2 to 2.9 km (0.74 to 1.8 mi). One existing line also bisects the limited nesting habitat in this PMU.
- In the Desert Creek-Fales PMU, power lines may impact sage-grouse through displacement and habitat fragmentation (Bi-State Local Planning Group 2004, p. 54). Local biologists speculate that observed population declines in 1981 near Burcham and Wheeler Flats may be related to power line construction and associated land uses (Bi-State Local Planning Group 2004, p. 54). This area continues to experience residential development, which will likely create a need for additional distribution lines.
- In the Bodie PMU, numerous small distribution lines are present in occupied sage-grouse habitats (Bi-State Local Planning Group 2004, p. 81). Development of new lines to service private property in the Bodie PMU is also expected (Bi-State Local Planning Group 2004, pp. 81–82). Reduced sage-grouse activity at one lek adjacent to a new utility line has been reported (Bi-State Local Planning Group 2004, p. 81); however,

numbers of birds at this lek have rebounded since 2004. There are no existing high-voltage transmission lines in the Bodie PMU or designated transmission corridors in existing land use plans (Bi-State Local Planning Group 2004, p. 82). Furthermore, one power line is currently being removed (Nelson 2012, pers. comm.), and this should prove beneficial.

- In the Mount Grant PMU, a high-voltage power line traverses the PMU from north to south, with two or three additional smaller distribution lines extending west from Hawthorne, Nevada, into the PMU. The high-voltage power line is in a corridor recently incorporated into the West-wide Energy Corridor (BLM and DOE 2009, p.7), and additional development within this corridor is anticipated. There are two leks that likely represent a lek complex within approximately 2 km (1.2 mi) of this power line that have been sporadically active over recent years. Anecdotal information suggests these leks have changed locations, possibly in response to the power line construction (Espinosa 2010, pers. comm.). Shifts in lek locations may partially account for the reported sporadic inactivity at the two known leks in recent years. The Mount Grant PMU has a strong potential for geothermal energy and mineral development that will then require additional distribution lines (Renewable Energy Transmission Access Advisory Committee (RETAAC) (2007, Figure 2); see the “Renewable Energy Development” section below). Of significant concern is the potential for additional distribution lines near Aurora, Nevada, and within the East Walker River Valley where existing geothermal leases are in an area that supports the largest lek in the Mount Grant PMU and that is about 2.5 km (1.5 mi) from the existing power line corridor.
- In the South Mono PMU, multiple high-voltage power lines and several smaller distribution lines currently exist and may be impacting birds on a year round basis, including three to four leks that are within 2–3 km (1.2–1.9 mi) of existing power lines (Bi-State Local Planning Group 2004, p. 169). Future geothermal development may also result in expansion of power lines in the South Mono PMU (Bi-State Local Planning Group 2004, p. 169).
- In the White Mountains PMU, power lines are relatively restricted to the housing developments near Chiatovich Creek, Nevada. Future development is possible and most likely through the Queen Valley or California Highway 168 corridor as transmission of power to southern California is needed.

Data on the total extent (lengths and alignments) of existing power lines and future transmission projects within currently occupied sage-grouse habitats are not available for the entire Bi-State area. However, existing power lines are present in many areas within the range of the species, as indicated in the individual PMU narratives above. Overall, between 40 and 50 percent of annually occupied leks in the Bi-State area are within approximately 5 km (3.1 mi) or less of existing transmission lines (Service 2013, unpublished data), thus providing situations where sage-grouse can be negatively impacted by these facilities both now and in the future. In addition, we anticipate that power lines will potentially increase in the future based on the current proposed and ongoing development activities within the Bi-State area, particularly given the increasing development of renewable energy resources (see “Renewable Energy

Development” section below) and expansion of urbanization on a portion of the private lands within and around the Bi-State area. The anticipated increase in power line development is also supported by the November 2009 Memorandum of Understanding signed by nine Federal agencies to expedite building new power lines on Federal lands (U.S. Department of Agriculture *et al.* 2009, entire). If these power lines are in or adjacent to occupied habitats, sage-grouse may be negatively affected beyond the impacts the species currently faces within its range.

It is evident through examination of data, literature, and aerial imagery that a variety of power lines (transmission and distribution) currently occur throughout the range of the Bi-State DPS, although their footprint is less than for roads and trails. We anticipate power line development will expand within the currently suitable and potentially suitable sage-grouse habitat in the Bi-State area based on our forecast for additional housing and commercial developments, as well as to satisfy the need to move power across State lines. Since a power line network already occurs throughout the Bi-State area and power lines are known to result in both direct and indirect impacts to sage-grouse, we anticipate impacts to the Bi-State DPS will continue in the future, although we are uncertain to what degree these impacts will affect populations. Of greatest concern is: (1) Any additional power line development in the Bodie and South Mono PMUs since they are currently the strongest populations to support the overall recovery of the Bi-State DPS, and (2) our already limited ability to recover the Bi-State DPS in various areas due to the existence of an established power line network.

### 3. Fences

Fences are used to delineate property boundaries and for livestock management (Braun 1998, p. 145; Connelly *et al.* 2000a, p. 974). The effects of fencing on sage-grouse include direct mortality through collisions, creation of predator (raptor and corvid) perch sites, creation of predator corridors (particularly if roads are adjacent to fences), incursion of nonnative invasive species along the fencing corridor (particularly if roads are adjacent to fences), and habitat fragmentation (Call and Maser 1985, p. 22; Braun 1998, p. 145; Connelly *et al.* 2000a, p. 974; Beck *et al.* 2003, p. 211; Knick *et al.* 2003, p. 612; Connelly *et al.* 2004, p. 1-2). Fences present a risk to sage-grouse in all Bi-State PMUs (Bi-State Local Planning Group 2004, pp. 54, 80, 120, 124, 169) due to known fence collisions and their potential to fragment and degrade habitat quality.

Sage-grouse frequently fly low and fast across sagebrush flats, and fences create a collision hazard (Call and Maser 1985, p. 22). In Utah, 36 sage-grouse carcasses were discovered along a 3.2-km (2-mi) fence within 3 months of its construction (Call and Maser 1985, p. 22). In Wyoming, 21 fence collision mortalities were reported in 2003 (Connelly *et al.* 2004, p. 13-12), while another study confirmed 146 sage-grouse fence strike mortalities over a 31-month period along a 7.6-km (4.6-mi) stretch of 3-wire fence (Christiansen 2009, p. 1). In Idaho, 56 sage-grouse collisions with fences were documented in the spring of 2010 (Stevens *et al.* 2012, p. 299). In the Bi-State area, the BLM Bishop Field Office reported increased sage-grouse mortality and decreased use of leks near fences (Nelson 2008, pers comm.). No research has assessed how fence collisions may impact sage-grouse demography across the range of the species, and it is unclear whether this source of mortality is additive or compensatory to natural

mortality. Thus, population level impacts likely depend on the size of the population and the relative number of male and female fatalities.

Not all fences present the same direct mortality collision risk to sage-grouse. Collision risk factors include fencing design, landscape topography, and spatial relationship with seasonal habitats (Christiansen 2009, p. 2). Stevens *et al.* (2012, p. 301) discovered that lek size and lek proximity to fence influenced collision rates during the breeding season in Idaho; fences in proximity to leks (< 2 km (< 1.2 mi)) presented the greatest collision hazard. We are unaware of information to assess collision mortality from fences in other seasonal habitats. However, fences are ubiquitous across the Bi-State area, and collisions are a recognized source of mortality for sage-grouse (Braun 1998, p. 145; Connelly *et al.* 2000a, p. 974; Oyler-McCance *et al.* 2001, p. 330; Connelly *et al.* 2004, p. 7-3).

Recently, visual markers have been employed to make fences more readily seen by birds, thus reducing mortality due to collision. Stevens *et al.* (2012, p. 301) note that this method reduced the fence collision rate during the sage-grouse breeding season by 83 percent. However, this relatively inexpensive marking method does not entirely alleviate the likelihood of mortality. Markers have been installed on a total of approximately 8 km (5 mi) of fence in the Desert Creek-Fales, Mount Grant, Bodie, and South Mono PMUs.

In addition to direct mortality from collisions, fence posts create perches for raptors and corvids, which may increase their ability to prey upon sage-grouse (Braun 1998, p. 145; Oyler-McCance *et al.* 2001, p. 330; Connelly *et al.* 2004, p. 13-12). The effect on sage-grouse populations from the creation of predator perches and predator corridors from fence lines in sagebrush habitats is likely similar to that of power lines (Braun 1998, p. 145; Connelly *et al.* 2004, p. 7-3). Furthermore, sage-grouse avoidance of habitat adjacent to fences, presumably to minimize predation risk, effectively results in habitat fragmentation even if the actual habitat is not removed (Braun 1998, p. 145). Thus, apparently suitable habitat may act as a functional population sink due to predation or as nonhabitat due to behavioral avoidance.

Fences and associated roads may also influence predator movements and facilitate the spread of invasive plants that replace sagebrush (Braun 1998, p. 145; Connelly *et al.* 2000a, p. 973; Gelbard and Belnap 2003, p. 421; Connelly *et al.* 2004, p. 7-3). For some mammalian species, dispersal along roads has greatly increased their distribution (Forman and Alexander 1998, p. 212; Forman 2000, p. 33). Corvids are similar in that they are known to use linear features like roads as travel routes (expanding into new regions) and as hunting grounds (Knight and Kawashima 1993, p. 268; Connelly *et al.* 2004, p. 12-3; Bui 2009, p. 31). In addition, road occurrence can contribute to nonnative plant invasions through soil disturbance, vehicle use, and maintenance activities (Forman and Alexander 1998, p. 210; Forman 2000, p. 32; Gelbard and Belnap 2003, p. 426; Knick *et al.* 2003, p. 619; Connelly *et al.* 2004, p. 7-25). Thus, the indirect impacts fences may have on sage-grouse persist and potentially increase following fence installation.

Fences can be valuable rangeland management tools to improve habitat conditions for sage-grouse if they are properly sited and designed. For example, near several leks in the Long Valley area (South Mono PMU), the BLM and LADWP are using “let down” fences to manage cattle



(Nelson 2012, pers. comm). A “let down” fence utilizes permanent metal fence posts, but the horizontal wire strands can be effectively removed (let down) during the sage-grouse breeding season or when cattle are not present. While this does not ameliorate all negative aspects of fence presence (e.g., posts for predator perches), it presumably reduces the likelihood of sage-grouse collisions during the period of time when the wire strands are removed. While the use of this fence design may not be feasible at a landscape scale it could be employed strategically, especially when new fences are built.

Data on the total extent (length and distribution) of existing fences and new fence construction projects are not available for the Bi-State area. It is evident through examination of data, literature, and aerial imagery that existing fencing occurs throughout the range of the Bi-State DPS. While we expect fencing (as a source of mortality and habitat fragmentation) to continue and possibly expand in the future within every PMU in the Bi-State area, efforts are currently ongoing (and expected to continue into the future) to ameliorate some of their impacts, including additional use of let down fences, fence marking, and removal of fences (Bi-State TAC 2012, p. 5). While direct mortality through collision may be minimized by these approaches, indirect impacts caused by predation and other forms of habitat degradation may remain. The overall severity of these impacts to the Bi-State DPS throughout its range is not known, but based on the best available data the impacts are widespread but thought to be minor.

#### 4. Communication Towers

Millions of birds are killed annually in the United States through collisions with communication towers (including cellular towers) and their associated structures (e.g., guy wires, lights) (Shire *et al.* 2000, p. 5; Manville 2002, p. 10), although most documented mortalities are of migratory songbirds. Cellular towers have specifically been identified to potentially cause sage-grouse mortality via collisions, to influence movements through avoidance of a tall structure (Wisdom *et al.* 2011, p. 463), and to influence predation risk by providing perches for corvids and raptors (Steenhof *et al.* 1993, p. 275; Connelly *et al.* 2004, p. 13-7).

Within the range of the Bi-State DPS, eight communication towers have been constructed in recent years (Federal Communications Commission (FCC) 2012, unpublished data). In general, these installation sites have been associated with existing communication tower facilities, and each PMU has at least one such facility located within occupied sage-grouse habitat. These 8 sites are likely an under representation of the actual number of tower sites within the Bi-State area as tower facilities shorter than 61 m (199 ft) above ground level are not required to register with the FCC (FCC 2012, unpublished data). We are unable to determine if any sage-grouse mortalities have occurred as a result of collisions with communication towers or their supporting structures, as most towers are not monitored, and those that are monitored lie outside the range of the species (Kerlinger 2000, p. 2; Shire *et al.* 2000 p. 19).

In a comparison of sage-grouse locations in extirpated areas of their range (as determined by museum species and historical observations) and currently occupied habitats, proximity to cellular towers was a strong indicator of extirpation, and the distance to cellular towers was nearly twice as far from grouse locations in currently occupied habitats than extirpated areas (Wisdom *et al.* 2011, p. 463). These results may have been influenced by location as many

cellular towers are close to human development. However, such associations between cellular towers and other indicators of human development were low (Wisdom *et al.* 2011, p. 467). High levels of electromagnetic radiation within 500 m (1,640 ft) of towers have been linked to decreased populations and reproductive performance of some bird and amphibian species (Wisdom *et al.* 2011, pp. 467–468 and references therein). Similar to power lines, we are unaware of any information that documents if sage-grouse are negatively impacted by electromagnetic radiation or if their avoidance of towers is a response to increased predation risk.

We do not have any information to suggest the likelihood or location of future placements of cellular towers in the Bi-State area. However, we anticipate that existing communication towers will remain in place, new communication towers will be added at existing tower sites, and additional communication towers will be constructed at new sites based on past trends in site development. It is also probable that new communication towers will be located along existing Federal Highways and State Routes. Thus, future communication tower placements will most likely affect the Desert Creek-Fales, Bodie, and South Mono PMUs, potentially affecting between 5 and greater than 10 leks (10 to more than 25 percent of total leks within the Bi-State DPS) depending on tower locations.

## 5. Landfills

Municipal solid waste landfills and associated roads contribute to increases in synanthropic predators (i.e., predator species adapted to conditions created or modified by people) (Knight *et al.* 1993, p. 470; Restani *et al.* 2001, p. 403; Webb *et al.* 2004, p. 523). For example, common raven numbers have increased dramatically across the West (see “Predation” section below), commonly in association with human developments, and ravens are a sage-grouse nest predator that restrain sage-grouse population growth in some locations (Batterson and Morse 1948, p. 14; Autenrieth 1981, p. 45; Coates 2007, p. 26). In one Nevada study, corvids (i.e., ravens) were responsible for more than 50 percent of nest depredations (Coates 2007, pp. 26–30).

One landfill exists in the Bi-State area. The Benton Crossing Landfill in Mono County is located north of Crowley Lake in Long Valley on a site leased from the LADWP. Common ravens and California gulls (*Larus californicus*) heavily use the landfill (Coates 2008, pers. comm.). Kolada *et al.* (2009b, p. 1,344) reported that sage-grouse nest success in Long Valley (South Mono PMU) was significantly lower than in other PMUs within the Bi-State area, which may be attributable to increased avian predators subsidized by landfill operations (Casazza 2008, pers. comm.). While the population in Long Valley appears stable, we are unaware of information to determine if limited nest success is suppressing the carrying capacity of this population. There are 10 years remaining on the facility’s lease, and currently LADWP does not intend to renew it (Courtney 2013, pers. comm.). There is support for relocating the landfill from the sage-grouse conservation community, although its current location is supported by the community of Mammoth Lakes (Dublino 2011, pers. comm.), and there are logistical challenges associated with relocation. At this time, the future of the landfill is uncertain, but any action on relocation is unlikely before the lease expires in 2023.

## Summary of the Potential Impacts From Infrastructure

In the Bi-State area, linear infrastructure impacts each PMU both directly and indirectly to varying degrees. Existing roads, power lines, and fences degrade and fragment sage-grouse habitat, and contribute to direct mortality through collisions. In addition, roads, power lines, and fences influence sage-grouse use of otherwise suitable habitats adjacent to current active areas, and increase predators and invasive plants. The impact caused by these indirect effects extends beyond the immediate timeframe associated with the infrastructure installation (i.e., the existence of an extended road system, power lines, and fencing already limit our ability to recover the Bi-State DPS in various areas throughout its range). We do not have consistent and comparable information on miles of existing roads, power lines, or fences, or densities of these features within PMUs or for the Bi-State area as a whole. Wisdom *et al.* (2011, p. 463) reported that across the entire range of the greater sage-grouse, the mean distance to highways and transmission lines for extirpated populations was approximately 5 km (3.1 mi) or less. In the Bi-State area, between 35 and 45 percent of annually occupied leks are within 5 km (3.1 mi) of highways, and between 40 and 50 percent are within this distance to existing transmission lines (Service 2013, unpublished data). Therefore, the similarity apparent between these Bi-State DPS lek locations and extirpated greater sage-grouse populations suggests that persistence may be influenced by their juxtaposition with these anthropogenic features.

The geographic extent, density, type, and frequency of linear infrastructure disturbance in the Bi-State area have changed over time. While new development of some of these features (highways) will likely remain static, other infrastructure features have the likelihood of increasing (secondary roads, power lines, fencing, and communication towers). Furthermore, while development of new highways is unlikely, road improvements are possible and traffic volume will likely increase, and in certain areas these actions may be more important than road development itself. For example, with the proliferation of OHVs, the potential impact to the Bi-State DPS and its habitat caused by secondary or unimproved roads may become of greater importance as traffic volume increases rates of disturbance and spread of nonnative invasive species in areas that traditionally have been traveled sporadically.

The potential impacts caused by cellular towers (all PMUs) and the landfill site (South Mono PMU) appear variable. At least eight cellular tower locations are currently known to exist within occupied habitat in the Bi-State area. Wisdom *et al.* (2011, p. 463) determined that cellular towers are highly influential in explaining population extirpation, and additional installations will likely occur in the near future as development continues. The landfill in Long Valley is likely influencing demography in the area as nest success is comparatively low and subsidized avian nest predators numbers are high (Kolada *et al.* 2009b, p. 1,344). While this core population of sage-grouse in the Bi-State area currently appears stable, recovery following any potential future perturbations affecting alternative vital rates (brood survival, adult survival) will be hampered by this limited nesting success.

Overall, impacts from infrastructure occur in various forms throughout the Bi-State DPS's range and are considered significant threats to the species both currently and in the future. This is based on a variety of rangewide impacts that are currently occurring and expected to continue or increase in the future that result in habitat fragmentation; limitations for sage-grouse recovery

actions due to an extensive road network, power lines, and fencing; and a variety of direct and indirect impacts such as direct loss of individuals from collisions or structures that promote increased potential for predation. Collectively, these threats may result in perturbations that influence both demographic vital rates of sage-grouse (e.g., reproductive success and adult sage-grouse survival) and habitat suitability in the Bi-State area.

### *Mining*

Surface and subsurface mining for mineral resources (gold, silver, aggregate, and others) results in direct loss of habitat if occurring in sagebrush habitats. The direct impact from surface mining is usually greater than from subsurface activity. Habitat loss from both types of mining can be exacerbated by the storage of overburden (soil removed to reach subsurface resource) in otherwise undisturbed habitat. Construction of mining infrastructure can result in additional direct loss of habitat from establishment of structures, staging areas, roads, railroad tracks, and power lines. Sage-grouse and their nests could be directly affected by trampling or vehicle collision. Sage-grouse also can be impacted indirectly from an increase in human presence, land use practices, ground shock, noise, dust, reduced air quality, degradation of water quality and quantity, and changes in vegetation and topography (Moore and Mills 1977, entire; Brown and Clayton 2004, p. 2). Some impacts resulting from mining activities are described as follows:

- Water contamination could occur from leaching of waste rock, overburden, and nutrients from blasting chemicals and fertilizer (Moore and Mills 1977, pp. 115, 133). Altering water regimes through diversions or groundwater pumping can lead to decreased surface water for maintaining essential seasonal habitats. Local water quality deterioration or dewatering may influence mesic habitats and result in a loss of brood-rearing habitat.
- Invasion of nonnative invasive and noxious weed species could occur following alteration of habitat, which typically results in unsuitable habitat conditions for sage-grouse (Moore and Mills 1977, pp. 125, 129). Once mining activities are completed, rehabilitation of sites is generally required; however, restoration of sagebrush is difficult to achieve and disturbed sites may never return to suitable conditions for sage-grouse (Pyke 2011, p. 544).
- Dust resulting from heavy equipment operations and vehicle use of unpaved roads can interfere with plant photosynthesis and insect populations (Moore and Mills 1977, entire). This can result in a reduction in habitat extent. Most large surface mines are required to control dust; a single, large-scale surface mine currently exists in the Bi-State area, and we are unaware of any regulatory requirements to control dust at this mine. On occasion, we have witnessed significant dust-caused haze encompassing the East Walker River Valley in the Ninemile Flat area (Abele 2012, pers. obs.).
- Noise and ground shock could occur as a result of blasting to remove overburden or the target mineral, and repeated use of explosives could potentially result in lek or nest abandonment (Moore and Mills 1977, p. 137). Noise from mining activity could mask male vocalizations resulting in reduced female attendance and yearling recruitment, as seen in sharp-tailed grouse (*Pedioecetes phasianellus*) (Amstrup and Phillips 1977, pp.

23, 25–27), since sage-grouse depend on acoustical signals to attract females to leks (Gibson and Bradbury 1985, pp. 81–82; Gratson 1993, pp. 693–694).

Varying impacts of mining activities to sage-grouse leks outside the Bi-State area have been documented. In Colorado, there was a reduction in males attending leks within 2 km (0.8 mi) of three coal mines and existing leks failed to recruit yearling males, but overall population numbers were not reduced (Braun 1986, pp. 229–230; Remington and Braun 1991, pp. 131–132). New leks formed farther away from the mining disturbance (Remington and Braun 1991, p. 131), while some abandoned leks adjacent to mine areas reestablished when mining ceased suggesting this disturbance was the limiting factor (Remington and Braun 1991, p. 132). In Wyoming, hen survival did not decline near large surface coal mines, and nest success did not appear to be affected (Brown and Clayton 2004, p. 1).

Mineral extraction has a long history throughout the Bi-State area, and mining continues today to a limited extent in four PMUs and is expected to continue into the future. Although mining represents a year-round risk to the Bi-State DPS, direct loss of key seasonal habitats or population disturbances during critical seasonal periods are of greatest impact. Currently, the PMUs with the greatest exposure are Bodie, Mount Grant, Pine Nut, and to a lesser degree South Mono (Bi-State Local Planning Group 2004, pp. 89, 137, 178).

- In the Bodie PMU, mining impacts were pronounced in the late 1800's and early 1900's when as many as 10,000 people inhabited the area (California State Parks 2013, unpublished data). The area is currently open to mineral development, and exploration is likely to continue; however, there are currently no operating or proposed large scale operations (Bi-State Local Planning Group 2004, pp. 89–90; Nelson 2013, pers. comm.). Current mining operations in the Bodie Hills are small-scale gold and silver exploration and sand and gravel extraction activities with minimal impacts (Bi-State Local Planning Group 2004, p. 90). An exception may develop from recent exploratory drilling near the historical Paramount Mine, approximately 8 km (5 mi) north of Bodie, California, within an existing WSA. The exploration was successful (i.e., the gold resource was present), but the WSA designation precludes development, and therefore the mining proponents are currently seeking to have the WSA withdrawn (Taylor 2012, pers. comm.), which requires an act of the U.S. Congress. If mine development proceeds at this site it may negatively influence sage-grouse movement and use of breeding and summer habitats near Big Flat, and adversely influence connectivity between the Bodie and Mount Grant PMUs. There is one relatively large active lek at Big Flat.
- In the Mount Grant PMU, two open pit mines exist, one of which is currently active. This active mine has recently added a power line to service the mine operations, and vehicle traffic has increased substantially in this portion of the PMU (Bi-State TAC 2012, p. 36). Mining is largely concentrated around the Aurora Historic District and typically located on private lands, although a proposed clay mine near the East Fork Walker River and a proposed silica mine near Lucky Boy Pass are also pending decisions (USFS 2012a, *in litt*). Each site is generally located on the periphery of sage-grouse range within the PMU, but some overlap with occupied habitat occurs. It is likely that mining will continue and may increase during periods when prices for precious metals are high

as has been the case for the past several years (recently, prices have been falling), thus potentially negatively affecting the sage-grouse populations in those areas. Four active leks, one inactive lek, and two historical leks are within approximately 4.8–8 km (3–5 mi) of the operating open pit mine or associated infrastructure (roads, power lines). Of greatest concern are the potential impacts to the Aurora lek complex, located approximately 3.2 km (2 mi) from the actual mine site on private land. It is the largest remaining lek in the Mount Grant PMU and potentially connects breeding populations in the Bodie Hills with breeding populations in the remainder of the Mount Grant PMU.

- In the Pine Nut PMU, there has been a long history of mining activity. A limited number of small operations on private lands are currently active, but there are no new, proposed, or expanding mines requiring a Plan of Operation on BLM lands. In general, Plan of Operations are required when disturbance exceeds 2 ha (5 ac), thus exploration may be occurring which does not exceed this threshold and as such is difficult to track. Three new proposals for mineral entry are being considered by the BLM's Carson City District Office (BLM 2012a, *in litt.*); each proposal overlaps with occupied sage-grouse habitat, and two of these proposals are in relatively close proximity (1.6–4 km (1–2.5 mi)) to the single active lek in the north end of this PMU.
- In the South Mono PMU, mining is limited to small scale saleable minerals such as sand and gravel. While these operations are generally small (several acres) they still use some machinery and produce periodic increases in vehicle traffic. Although we are unaware of the specific locations of these operations, it is possible that several leks and nesting habitat could be impacted to an unknown degree within the South Mono PMU.

In summary, additional mineral developments occurring in sagebrush habitats in any of these PMUs will likely negatively influence the distribution of sage-grouse and the connectivity among breeding complexes. There is potential for additional mineral developments to occur in the Bi-State area in the future based on mineral resources in the Bodie and Mount Grant PMUs and at least three recent preliminary inquiries for entry within the Pine Nut PMU (BLM 2012a, *in litt.*). While all PMUs have the potential for mineral development, based on current land designations and past activity, it appears the Pine Nut and Mount Grant PMUs are most likely to experience new and additional activity. Currently operational mines are not within the core population areas of the Bi-State DPS, although existing inactive mining sites and potential future developments could impact important lek complexes and connectivity between at minimum the Bodie and Mount Grant PMUs.

### *Renewable Energy Development*

Renewable energy development and associated infrastructure are identified risks for sage-grouse in the Bi-State area (Bi-State Local Planning Group 2004, pp. 30, 178; Bi-State TAC 2012, pp. 19, 36, 41, 49). Renewable energy facilities (including geothermal facilities, wind power facilities, and solar arrays) require power lines and roads for construction and operation, and avoidance of such features by sage-grouse and other prairie grouse is documented (Holloran 2005, p. 1; Pruett *et al.* 2010, pp. 1,255–1,256; see discussions regarding power lines and roads in the “Infrastructure” section above). There has been minimal direct habitat loss in the South

Mono PMU based on the currently operating geothermal facility in Long Valley, but we anticipate additional loss in the Mount Grant PMU due to currently leased locations (BLM 2006, entire). Indirect and direct impacts to the Bi-State DPS and its habitat are also expected as a result of habitat fragmentation through not only roads and power lines, but also noise and increased human presence (Connelly *et al.* 2004, pp. 7-40 to 7-41), all of which are expected to be similar to those impacts discussed in the “Infrastructure” section above.

The Energy Policy Act (Public Law 109–58, August 8, 2005) establishes a goal for the Secretary of the Interior to approve 10,000 megawatts of electricity from non-hydropower renewable energy projects located on public lands. The State of Nevada, through the Renewable Portfolio Standard, has mandated that investor-owned utilities generate, acquire, or save 20 percent of their produced electricity from renewable systems by 2015. The State of California, has mandated that 33 percent of electrical power be derived from renewable energy sources by 2020. Nevada is predicted to experience the greatest increase in geothermal growth across the United States—doubling production from geothermal sources by 2025 (BLM and USFS 2008b, p. 2-35). Within the Bi-State area, the Mount Grant PMU currently has the greatest immediate potential for new/future geothermal development as several sections of land have already been leased and the USFS recently completed a programmatic Environmental Impact Statement (EIS), which allows for the consent to lease much of the National Forest administered lands in this area and within the Desert Creek-Fales PMU (USFS 2012b, Appendix A, Figure 4). Associated stipulations targeting sage-grouse conservation were addressed in the EIS, but the effectiveness of these conservation mitigation practices is unknown at this time. In addition, development requires a lease from the BLM, who maintains regulatory authority over fluid minerals, as well as site-specific analysis in compliance with the National Environmental Policy Act (NEPA) before development can occur.

Geothermal energy production requires surface exploration, exploratory drilling, field development, plant construction, and operation. Direct habitat loss occurs from development of well pads, structures, roads, pipelines, and transmission lines. Intensive human activity is required during field development, but relatively reduced levels of human activity occur during operation. Accessing a thermal source can take 3–8 weeks of continuous well drilling (Suter 1978, p. 3) and can potentially cause toxic gas releases depending on the geological formation (Suter 1978, pp. 7–9). Water is necessary for drilling operations and later for condenser cooling at the generation plants, which are similar in size to coal- or gas-fired plants. Thus, local water depletions may be a concern for sage-grouse if they result in the loss of brood-rearing habitat. The BLM and USFS completed a programmatic EIS for geothermal leasing and operations across much of the western United States in 2008 (BLM and USFS 2008b, entire). Best management practices were included for minimizing the effects of geothermal development and operations on sage-grouse, but they are guidance only and general in nature (BLM and USFS 2008b, pp. 4.82–4.83).

The only currently operating geothermal plants in the Bi-State area are two plants on private land immediately east of U.S. 395 at Casa Diablo in the South Mono PMU. This Mammoth-Pacific Geothermal Power Plant facility is under evaluation by the USFS and BLM for expansion on public lands nearby (Casa Diablo IV Geothermal Development Project; BLM *et al.* 2012, entire).

Elsewhere within the South Mono PMU about 3,884 ha (9,600 ac) are under geothermal lease to the west of U.S. 395 and immediately north of Highway 203. The existing facility, as well as leased locations, are largely outside or on the periphery of occupied sage-grouse habitat in Long Valley. These currently operational geothermal plants are approximately 4 km (2.5 mi) from the nearest inactive lek and nearly 9 km (5.5 mi) from the nearest active lek, thus disturbance to breeding activity is likely minimal. However, they do overlap and sit adjacent to nesting habitat, so displacement from or functional loss of suitable habitat may have occurred.

Potential future geothermal operations could occur within the Desert Creek-Fales PMU, where an active lease through 2017 covers 2,071 ha (5,120 ac) of lands on the north end of the Pine Grove Hills near Mount Etna. This location is generally on the periphery of currently known occupied sage-grouse habitat and approximately 8 km (5 mi) from the nearest known lek. In addition, approximately 14 sections within the Mount Grant PMU are currently leased and several more areas are proposed for geothermal leasing. The leases within the Desert Creek-Fales and Mount Grant PMUs fall within the boundary delineated for geothermal development proposed by RETAAC (2007, Figure 2). One of the leased areas on USFS land (1,035 ha (2,560 ac)) in the Mount Grant PMU is in year-round sage-grouse habitat and essentially overlaps or lies within 1.6 km (1 mi) of three active leks. Another leased area (3,366 ha (8,320 ac)) in the Mount Grant PMU around the Aurora Historic District contains at least 776 ha (1,920 ac) of sagebrush communities, and two known leks are within approximately 1.6 km (1 mi). Further, these locations are generally situated in the most likely corridor connecting sage-grouse populations in the Bodie PMU with the Mount Grant PMU. The USFS has also signed a Record of Decision for the consent to lease the majority of lands contained within the Bi-State portion of Bridgeport Ranger District (Mount Grant and Desert Creek-Fales PMUs) (USFS 2012b, entire). While consent to lease does not represent an irretrievable commitment of resources (because the lease must still be provided by the BLM), it does suggest the potential for future development in the Mount Grant and Desert Creek-Fales PMUs is high, and this development will likely prove detrimental to sage-grouse and sagebrush habitats in these areas through direct habitat loss and additional fragmentation and isolation of populations, especially (but not limited to) the area between the Bodie and Mount Grant PMUs.

Wind power facilities can both directly and indirectly impact sage-grouse and its habitat. Direct loss of habitat (primarily from construction of access roads) and indirect loss (due to avoidance) results from installation of individual wind turbine units despite their small footprints from a landscape perspective. Spacing turbines improves their efficiency, but expands the overall footprint of the field, thus resulting in larger blocks of habitat being impacted. Research conducted in Wyoming suggests that in the short-term, avoidance of habitat in proximity to wind facilities by sage-grouse is not apparent, although these results may be confounded by variation in habitat quality or site fidelity (LeBeau 2012, pp. 28–35). However, LeBeau (2012, p. 79) determined that fitness parameters can be influenced by proximity to wind energy facilities (i.e., while adult female survival was not impacted by proximity to wind facilities, both nest success and brood survival were negatively impacted).

No gallinaceous bird (grouse) deaths were reported in a comprehensive review of avian collisions at wind farms in the United States (Johnson *et al.* 2000, pp. ii–iii; Erickson *et al.* 2001,



pp. 8, 11, 14–15); average tower heights, flight elevations of grouse, and diurnal migration habitats minimize the risk of collision. However, sage-grouse can be killed by flying into turbine rotors or towers (Erickson *et al.* 2001, entire). One dead sage-grouse was found near a turbine over a 3-year monitoring period at a wind facility in Wyoming (Young *et al.* 2003, Appendix C, p. 61). Preliminary data from research in Wyoming has indicated that direct mortality from collision occurs and may be greater than previously anticipated (Deibert 2012, pers. comm.).

Sage-grouse could be impacted by increased noise levels and behavioral modifications resulting from rotating wind turbine blades. First, noise is produced by wind turbine mechanical operations (gear boxes, cooling fans) and airfoil interaction with the atmosphere. Adjusting for manufacturer type and atmospheric conditions, the audible operating sound of a single wind turbine is typical of background levels of a rural environment (BLM 2005b, p. 5-24). However, commercial wind facilities have multiple turbines with a much larger noise footprint. Second, data exist that document how low-frequency vibrations created by rotating blades produce annoyance responses in humans (van den Berg 2004, p. 955), although the effect on birds is unknown. Moving turbine blades also produce a phenomenon called “shadow flicker” (American Wind Energy Association (AWEA) 2008, p. 5-33), which could mimic predator shadows and elicit an avoidance response in birds during daylight hours. However, sage-grouse hens with broods have been observed under wind turbines (Young 2004, pers comm), and use of habitat by sage-grouse did not appear to be influenced by turbine proximity (LeBeau 2012, p. 29). However, LeBeau (2012, pp. 33–34) cautions against definitive conclusions based on these short-term data; because of demonstrated fidelity to seasonal habitats by sage-grouse there should be an anticipated time lag in avoidance response. Therefore, while the best available data do not currently indicate noise or turbine presence influence sage-grouse habitat use or behavior in the near-term, it may influence population dynamics by affecting recruitment.

The best available data indicate that several locations in the Bi-State area (Pine Nut and South Mono PMUs) have wind resources suitable for development based on recent leasing and inquiries by facility developers, but currently there are no active leases. The Pine Nut Mountains had previously been designated as a renewable energy “wind zone” by Nevada’s RETAAC (2007, Figure 2). A single lease involving the ridgeline of the Pine Nut Mountains had been active for several years, but the BLM decided that this lease will not be renewed (BLM 2012a, *in litt.*). If wind power development occurs in the Pine Nut PMU in the future, it could have a significant impact on connectivity within this small population and greatly restrict access to nesting and brooding habitat. Within the South Mono PMU, we are aware of at least one recent inquiry into wind development, but the INF declined this application based largely on sage-grouse concerns (USFS 2012c, *in litt.*). We are uncertain of the probability of future development of wind energy in the Pine Nut PMU or across the remainder of the Bi-State area.

Solar array development requires similar infrastructure as other renewable and nonrenewable energy sources. Direct habitat loss can be significant because much of a solar project site would have vegetation removed. The topography in the Bi-State area is generally not conducive to solar development based on existing technology. Further, the BLM recently completed a programmatic EIS on solar development in six southwestern States including Nevada and California, and through this process identified exclusion areas or areas where solar development

would not be allowed (BLM 2012b, p. ES-7). The EIS only affects utility-scale developments (greater than 20 megawatts) occurring on BLM-managed lands, but recognized occupied sage-grouse habitat as a criterion for exclusion (BLM 2012b, p. ES-8). While small developments or developments on other federally-managed or privately-owned lands have the potential to occur, future commercial development of solar energy in the Bi-State area appears unlikely.

In summary, minimal direct habitat loss has occurred in the South Mono PMU due to an operating geothermal facility, but the likelihood of additional renewable energy facility development, especially geothermal, in the Bi-State area is high based on current leases. Inquiries by energy developers (geothermal, wind) have increased in the past several years (Dublino 2011, pers. comm.). There is strong political and public support for energy diversification in Nevada and California, and the energy industry considers the available resources in the Bi-State area to warrant investment (RETAAC 2007, p. 8). Renewable energy development and expansion, if realized, could pose significant challenges to sage-grouse populations in the Bi-State area through direct loss of habitat and indirect impacts affecting population viability. Based on our current assessment of the probability of new or expanding development, it appears the Mount Grant PMU and to a lesser degree the Desert Creek-Fales PMU are likely to be most negatively affected. However, interest by developers changes rapidly, making it difficult to predict potential outcomes.

### *Grazing and Rangeland Management*

Livestock grazing has a long history in sagebrush ecosystems. Initially, native vegetation communities within the sagebrush-steppe ecosystem evolved in the absence of significant grazing (Mack and Thompson 1982, p. 768). With European settlement of western States (1860-early 1900's), unregulated numbers of cattle, sheep, and horses rapidly increased, peaking at the turn of the century (Oliphant 1968, p. vii; Young *et al.* 1976, pp. 194–195; Carpenter 1981, p. 106; Donahue 1999, p. 15) with an estimated 19.6 million cattle and 25 million sheep. Excessive livestock grazing along with severe drought significantly impacted sagebrush ecosystems (Knick *et al.* 2003, p. 616). Animal Unit Months (AUMs; amount of forage required to feed 1 cow with calf, 1 horse, 5 sheep, or 5 goats for 1 month) for cattle and sheep on all Federal land have declined since the early 1900's (Laycock *et al.* 1996, p. 3), although long-term effects from overgrazing persist, including changes in plant communities and soils (Knick *et al.* 2003, p. 116).

Livestock grazing continues to be the most widespread land use across the sagebrush biome (Connelly *et al.* 2004, p. 7-29; Knick *et al.* 2003, p. 616; Knick *et al.* 2011, p. 219), including within the Bi-State area. Links between grazing practices and population levels of sage-grouse are not well studied (Braun 1987, p. 137; Connelly and Braun 1997, p. 231). Aldridge *et al.* (2008, p. 990) did not find any relationship between sage-grouse persistence and livestock densities, but concluded that other aspects of livestock management (intensity, duration, and distribution) may be more influential on rangeland conditions than livestock density.

Suitability of sage-grouse nesting habitat and nesting success can be impacted by livestock grazing activities. Sage-grouse need significant grass and shrub cover for protection from predators during the nesting season, and females will preferentially choose nest sites based on these qualities (Hagen *et al.* 2007, p. 46). Gregg *et al.* (1994, p. 165) suggest that the reduction

of grass heights from grazing in nesting and brood-rearing areas negatively affects nesting success when cover is reduced below the 18 cm (7 in) height needed for predator avoidance. In the Bi-State area specifically, nest success of sage-grouse on average is comparable to the rest of the species' range (Kolada *et al.* 2009b, p. 1,344), but varies among PMUs. Studies suggest that grazing or maintaining residual grass cover may not influence nest success in the Bi-State area as much as in other regions (Kolada *et al.* 2009b, pp. 1,343–1,344). This is expected because the most influential nest predator in the Bi-State area, the common raven, is potentially less influenced by grass cover than mammalian predators (such as American badgers (*Taxidea taxus*) (Coates *et al.* 2008, entire)) that are more prevalent in other regions.

In general, livestock grazing reduces food availability for sage-grouse and may act in direct competition. Cattle feed mostly on grasses, but seasonally use forbs and shrubs like sagebrush (Vallentine 1990, p. 226). Domestic sheep consume large volumes of grass, shrubs (including sagebrush (Vallentine 1990, pp. 240–241)), and forbs in occupied sage-grouse habitat (Pederson *et al.* 2003, p. 43). Because forbs provide essential calcium, phosphorus, and protein for pre-laying hens (Barnett and Crawford 1994, p. 117), the absence of sufficient forbs can impact a hen's nutritional condition, thus affecting nest initiation rate, clutch size, and subsequent reproductive success (Barnett and Crawford 1994, p. 117; Coggins 1998, p. 30). More specifically, livestock grazing can reduce the available food sources needed during breeding and brood-rearing periods (Braun 1987, p. 137; Dobkin 1995, p. 18; Connelly and Braun 1997, p. 231; Beck and Mitchell 2000, pp. 998–1,000). Livestock grazing reduces water infiltration rates, reduces cover of herbaceous plants and litter, compacts soils, and increases soil erosion (Braun 1998, p. 147; Dobkin *et al.* 1998, p. 213). These impacts change the proportions of shrubs, grasses, and forbs in affected areas, and increase the propensity for invasion by nonnative invasive plant species (Mack and Thompson 1982, p. 761; Miller and Eddleman 2000, p. 19; Knick *et al.* 2011, p. 232; Reisner *et al.* 2013, p. 10). However, grazing by sheep and goats has been used strategically in sage-grouse habitat to control invasive weeds (Merritt *et al.* 2001, p. 4; Olsen and Wallander 2001, p. 30; Connelly *et al.* 2004, p. 7-49) and woody plant encroachment (Riggs and Urness 1989, p. 358), although some research found no evidence that controlling cheatgrass through grazing was evident (Reisner *et al.* 2013, p. 10). In addition to nonnative plant impacts, Aldridge and Brigham (2003, p. 30) suggest that poor livestock management in mesic sites can reduce forbs and grasses available to sage-grouse chicks, thereby affecting chick survival. However, Evans (1986, p. 67) reported that sage-grouse used grazed meadows significantly more during late summer because grazing had stimulated the regrowth of forbs. Klebenow (1981, p. 121) noted that sage-grouse used openings in meadows created by cattle. Limited grazing in the Bi-State area may be benign or even beneficial to some seasonal sage-grouse habitats, but when conducted improperly livestock grazing can have negative effects on sage-grouse habitat and individuals.

Livestock presence can cause hens to abandon nests, and trampling is known to destroy nests (Rasmussen and Griner 1938, p. 863; Patterson 1952, p. 111; Call and Maser 1985, p. 17; Holloran and Anderson 2003, p. 309; Coates 2007, p. 28). For example, Coates (2007, p. 28) documented nest abandonment following partial nest depredation by a cow in Nevada. In general, all recorded encounters between livestock and grouse nests resulted in hens flushing from nests (Coates 2008b, p. 462), which could expose the eggs to predation. There is strong

evidence that visual predators like ravens use hen movements to locate sage-grouse nests (Coates 2007, p. 33); this is a concern for the Bi-State DPS given that ravens are the primary predators of sage-grouse in the Bi-State area. Livestock also trample nests and sagebrush bushes and seedlings, thereby impacting future sage-grouse food and cover (Connelly *et al.* 2004, p. 7-31). Trampling by livestock can also influence soil properties making areas susceptible to cheatgrass invasion (Mack and Thompson 1982, p. 764; Young and Allen 1997, p. 531; Reisner *et al.* 2013, p. 10). Cheatgrass is already widespread in the Pine Nut PMU and occurs at lower densities throughout the remaining PMUs.

Extensive rangeland management has been conducted by Federal agencies and private landowners to reduce shrub cover and improve forage conditions for livestock in the sagebrush-steppe ecosystem (Connelly *et al.* 2004, p. 7-28; Knick *et al.* 2011, p. 220; Pyke 2011, p. 534). The deliberate elimination of sagebrush was generally followed with rangeland seedings of nonnative grasses, such as *Agropyron cristatum* (crested wheatgrass) on public lands (Connelly *et al.* 2004, p. 7-28). These treatments and seedings reduced or eliminated many native grasses and forbs (Hull 1974, p. 217), thereby affecting the sage-grouse through the loss of native forbs that serve as food and loss of native grasses that provide cover (Connelly *et al.* 2004, p. 4-4). By the 1970's, over 2 million ha (5 million ac) of sagebrush were mechanically treated, sprayed with herbicides, or burned across the West to increase herbaceous forage and grasses for livestock consumption (Crawford *et al.* 2004, p. 12). Braun (1998, p. 146) concluded that, since European settlement of western North America, all sagebrush habitats used by sage-grouse have been treated in some way to reduce shrub cover. Chemical control of sagebrush was initiated in the 1940's and intensified in the 1960's and early 1970's (Braun 1987, p. 138). Crawford *et al.* (2004, p. 12) hypothesized that reductions in sage-grouse habitat quality (and possibly sage-grouse numbers) in the 1970's may have been associated with extensive rangeland treatments to increase forage for domestic livestock. The following are examples of impacts to sage-grouse and their habitat as a result of chemical control and mechanical rangeland treatments (both of which are conducted in the Bi-State area to an unknown extent):

- Chemical control of sagebrush has resulted in declines of sage-grouse breeding populations (Connelly *et al.* 2000a, p. 972). Treatments also can result in sage-grouse emigration from affected areas (Connelly *et al.* 2000a, p. 973) and have negative effects on nesting, brood carrying capacity (Klebenow 1970, p. 399), winter food, and thermal cover (Connelly *et al.* 2000a, p. 973). However, impacts to sage-grouse and their habitat as a result of chemical control of sagebrush can be minimized or possibly beneficial. Braun (1998, p. 147) noted that small treatments interspersed with non-treated sagebrush habitats did not affect sage-grouse use. Also, Autenrieth (1981, p. 65) determined that application of herbicides in early spring to reduce sagebrush cover may enhance some brood-rearing habitats by increasing the coverage of herbaceous plant foods.
- Mechanical treatments remove the aboveground portion of the sagebrush plant (mowing, roller chopping, roto-beating, and burning) or uproot the plant (grubbing, bulldozing, chaining, cabling, raking, and plowing) (Connelly *et al.* 2004, p. 17-47). These treatments began in the 1930's and continued at relatively low levels into the late 1990's (Braun 1998, p. 147). Although carefully designed and executed mechanical treatments

can be beneficial to sage-grouse by improving herbaceous cover, forb production, and sagebrush re-sprouting (Braun 1998, p. 147), adverse effects have been documented (Connelly *et al.* 2000a, p. 973). For example, in Montana numbers of breeding males declined by 73 percent after 16 percent of a 202 km<sup>2</sup> (78 mi<sup>2</sup>) study area was plowed (Swenson *et al.* 1987, p. 128). Braun (1998, p. 147) documented that mechanical treatments in blocks greater than 100 ha (247 ac), or of any size seeded with nonnative invasive grasses, degrade sage-grouse habitat by altering the structure and composition of the vegetative community.

The ability to restore or rehabilitate overgrazed areas depends on the condition of the area relative to its site potential (Knick *et al.* 2011, p. 232). In areas with a balanced mix of shrubs and native understory vegetation, a change in grazing management can restore the habitat to its potential vigor (Pyke 2011, p. 538). Rest from grazing is known to have a better perennial grass response than other treatments (Wambolt and Payne 1986, p. 318). Active restoration is required where the native understory is reduced (Pyke 2011, p. 539). If an area has soil loss or invasive species, returning the native plant community may be impossible (Daubenmire 1970, p. 82; Knick *et al.* 2011, p. 232; Pyke 2011, p. 539).

Ongoing removal or control of sagebrush in the Bi-State area is limited. The BLM (2012, *in litt.*) and USFS (2012, *in litt.*) have stated that with rare exceptions, they no longer convert sagebrush to other habitat types, and that treatments on BLM lands currently focus on improving the diversity of the native plant community, reducing conifer encroachment, or reducing the risk of large wildfires. Our understanding of sagebrush treatments on private lands in the Bi-State area is poorly informed. Known instances of the elimination of sagebrush by chemical and mechanical means are apparent but their extent remains to be quantified. For example, the recent conversion of sagebrush vegetation to agricultural land in the Desert Creek-Fales PMU may have influenced the apparent discontinued use of a lek located less than several hundred meters from this activity (Abele 2012, pers. obs.). We estimate historical conversion of sagebrush vegetation on private lands has been most pronounced in the Pine Nut, Desert Creek-Fales, and Mount Grant PMUs (Service 2013, unpublished data).

Water developments (e.g., springs, tanks guzzlers) for livestock and wild ungulates in upland shrub-steppe habitats are common on public lands (Connelly *et al.* 2004, p. 7-35). Development of springs and other water sources can artificially concentrate domestic livestock and wild ungulates in mesic areas, thereby exacerbating grazing and trampling impacts to sage-grouse nesting and brood-rearing areas (Braun 1998, p. 147; Knick *et al.* 2011, p. 230). In addition, diverting water sources has the secondary effect of changing the habitat present at the water source, potentially resulting in the loss of riparian or wet meadow habitat that sage-grouse depend upon as sources of forbs and insects. However, water developments can also be beneficial to sagebrush vegetation communities, assuming livestock grazing is occurring, as this can potentially minimize concentrated impacts of livestock grazing by dispersing activity across a wider area. Water developments also can become mosquito breeding habitat and thus facilitate the spread of West Nile virus (WNV) in avian populations, although we are unaware of evidence that this is occurring in the Bi-State area.

In the Bi-State area, over 100 livestock grazing allotments are active across all PMUs and most grazed lands are managed by the BLM and USFS, although much of the meadow habitats are located on private lands (Bi-State Local Planning Group 2004, entire). While there are public allotments or portions of allotments exhibiting adverse impacts from current or historical livestock grazing (such as in the Pine Nut and Mount Grant PMUs where understory vegetation is largely absent), our understanding of the degree of impact is rudimentary. This understanding is confounded by a general lack of data, lack of control sites that are not currently grazed, and compatibility of data due to varying survey methods and approaches used to categorize vegetation condition and determine causality. However, we estimate based on available data that 15 to 30 percent of locations surveyed exhibit vegetation conditions outside of those desired by land managers and a portion of this deviation is attributable to livestock activity. In general, this deviation is influenced by condition of upland understory vegetation (lack of grass and forb) and meadow condition. The majority of allotments in the Bi-State area are in fair to good condition (Axtell 2008, pers. comm; Murphy 2008, pers. comm.; Nelson 2008, pers. comm.), and livestock grazing is generally thought to have a limited impact on sage-grouse habitat (Bi-State TAC 2012, entire). Livestock grazing will continue into the indefinite future within the Bi-State area at its current or slightly decreased level, and thus remain a discretionary action where Federal agencies have the ability to alter use when renewing grazing permits. Also, it appears that Federal land managers are moving in a direction that affords greater discretion to sage-grouse habitat needs when evaluating livestock management (Nelson 2008, pers. comm.). However, implementation of this discretion has traditionally been challenging as a result of internal and external pressures related to changes in grazing prescriptions.

In addition to domestic livestock, feral horses can negatively impact meadows and brood-rearing habitats used by sage-grouse (Connelly *et al.* 2004, p. 7-37; Crawford *et al.* 2004, p. 11). Feral horses have utilized sagebrush communities since they were brought to North America at the end of the 16th century (Wagner 1983, p. 116; Beever 2003, p. 887). Horses are generalists, but seasonally their diets can be almost entirely grasses (Wagner 1983, pp. 119–120). Areas without horse grazing can have 1.9 to 2.9 times more grass cover and higher grass density (Beever *et al.* 2008, p. 176), whereas sites with horse grazing have less shrub cover and more fragmented shrub canopies (Beever *et al.* 2008, p. 176), less plant diversity, altered soil characteristics, and 1.6 to 2.6 times greater abundance of cheatgrass (Beever *et al.* 2008, pp. 176–177). Therefore, horse presence may negatively affecting sagebrush vegetation communities and habitat suitability for sage-grouse by decreasing grass cover, fragmenting shrub canopies, altering soil characteristics, decreasing plant diversity, and increasing the abundance of invasive cheatgrass.

Sage-grouse habitat is impacted differently by horses as compared to cows as a result of a variety of biological and behavioral characteristics (Beever 2003, pp. 888–890). A horse forages longer and consumes 20 to 65 percent more forage than a cow of equivalent body mass (Wagner 1983, p. 121; Menard *et al.* 2002, p. 127). Horses can crop vegetation closer to the ground, potentially limiting or delaying recovery of plants (Menard *et al.* 2002, p. 127). Horses also seasonally move to higher elevations, spend less time at water, and range farther from water sources than cattle (Beever and Aldridge 2011, p. 286). In areas utilized by both horses and cattle, it is unknown whether grazing impacts are synergistic or additive (Beever and Aldridge 2011, p. 286).

There are seven designated Wild Horse Territories (WHT) or Herd Management Areas (HMA) that overlap the Bi-State PMUs, plus a single Wild Horse Unit. The most significant impacts from feral horses in the Bi-State area occur in the Pine Nut, Mount Grant, and White Mountains PMUs (Axtell 2008, pers. comm.; Bi-State TAC 2012, pp. 19, 37, 41), although they are also known to occur within the Bodie and South Mono PMUs.

- Pine Nut PMU: The Pine Nut HMA is the only HMA in the Pine Nut PMU. The targeted management level is 119–179 horses (BLM 2012a, *in litt.*), and the current estimate is 293 horses based on data from a 2010 horse gather (BLM 2012a, *in litt.*).
- Mount Grant PMU: The Wassuk HMA and Powell Mountain WHT occur in the Mount Grant PMU. Within the Wassuk HMA the targeted management level is 110–165 horses, and the current estimate is 597 horses (BLM 2012a, *in litt.*). The Powell Mountain WHT had an estimated 40 horses in 2012 (USFS 2012a, *in litt.*). The appropriate management level (AML) for the Powell Mountain WHT is 29 horses (USFS 2012a, *in litt.*).
- Bodie and South Mono PMUs: Both the Bodie and South Mono PMUs have no official HMAs or WHTs. Although horses frequent the Bodie PMU, these horses are likely from the Powell Mountain WHT (Bi-State Local Planning Group 2004, pp. 86–87). Horses from the adjacent Montgomery Pass WHT in the White Mountains PMU have begun to shift their distribution to the northern portion of the South Mono PMU.
- White Mountains PMU: One WHT and three HMAs occurs in the White Mountains PMU, although an additional wild horse management plan exists for the White Mountains Wild Horse Unit (not a formally designated WHT) (USFS 2012c, *in litt.*). The current number of horses in the Montgomery Pass WHT is not known, but use appears to have shifted to lands managed by the BLM and private lands located in Adobe Valley (South Mono PMU). Herd size of the White Mountains Wild Horse Unit was established at 70 animals in 1976 (USFS 2012c, *in litt.*), and 79 animals were documented during 2010 (USFS 2012c, *in litt.*). Current estimates of wild horse numbers in the White Mountains PMU are not available, but horse use across this PMU was noted as potentially degrading the habitat, specifically in relation to meadow sites (USFS 2012c, *in litt.*). The remaining three HMAs (Fish Lake Valley, Piper Mountain, Marietta Burro Range) occur on the western and southern edges of the White Mountains PMU; current horse numbers are unknown, although numbers are anticipated to be low due to lack of water.

We are unaware of the specific severity and scope of impacts caused by feral horses on the Bi-State DPS and sage-grouse habitat, although localized areas of concern in all PMUs are apparent. Most important are probable impacts to mesic areas within the Pine Nut, Mount Grant, and White Mountains PMUs. Management of herd size by Federal agencies is an ongoing challenge as horses reproduce rapidly and management is expensive. Based on this understanding, we anticipate future impacts caused by wild horses to increase.

Native ungulates co-exist with sage-grouse and livestock in sagebrush ecosystems. Mule deer (*Odocoileus hemionus*) browse sagebrush during the winter and can cause sagebrush mortality in small patches from heavy winter use. Pronghorn antelope (*Antilocarpo americana*) overlap sage-grouse habitat year around, consuming grasses and forbs during the summer and browsing

sagebrush in the winter. The best available data do not indicate native ungulates are causing significant impacts on sage-grouse or sage-grouse habitat currently or will in the future, including within the Bi-State area.

### Summary of Potential Grazing and Rangeland Management Impacts

Grazing and domestic livestock management have the potential to result in sage-grouse habitat degradation. Grazing can adversely impact nesting and brood-rearing habitat by decreasing vegetation used for concealment from predators. Grazing also compacts soils, decreases herbaceous vegetation abundance, increases soil erosion, and increases the probability of invasion of nonnative invasive plant species. Livestock management and associated infrastructure (such as water developments and fencing) can degrade important nesting and brood-rearing habitat, reduce nesting success, and facilitate the spread of WNV. In addition, some research suggests there may be direct competition between sage-grouse and livestock for plant resources (Vallentine 1990, p. 226). However, despite numerous documented negative impacts, some research suggests that under specific conditions grazing domestic livestock can benefit sage-grouse (Klebenow 1981, p. 121). Similar to domestic livestock, feral horses have the potential to negatively affect sage-grouse habitats by decreasing grass cover, fragmenting shrub canopies, altering soil characteristics, decreasing plant diversity, and increasing the abundance of invasive plant species. Native ungulates co-exist with sage-grouse in the Bi-State area, but we are not aware of significant impacts from these species on sage-grouse populations or sage-grouse habitat. Cattle, horses, mule deer, and pronghorn antelope each use the sagebrush ecosystem somewhat differently, and the combination of multiple species may produce a different result than simply more of a single species.

Overall, impacts from past grazing and rangeland management occur within localized areas throughout the Bi-State DPS's range (i.e., all PMUs, although it is more pronounced in some PMUs than others). These impacts have resulted in ongoing habitat degradation that significantly affects sage-grouse habitat indirectly and cumulatively in the Bi-State area, resulting in less-than-optimal conditions (i.e., lack of understory plants) of upland sagebrush communities, especially in the Pine Nut and Mount Grant PMUs. We have specific concerns over current habitat conditions in the Pine Nut and Mount Grant PMUs as both PMUs generally have less resilience to additional stressors. Across the remainder of the PMUs, localized areas of meadow degradation are apparent, and these conditions may influence sage-grouse populations through altering nesting and brood-rearing success. Currently, there is little direct evidence linking grazing effects and sage-grouse population responses. Analyses for grazing impacts at landscape scales important to sage-grouse are confounded by the fact that almost all sage-grouse habitat has at one time been grazed and thus no ungrazed control areas exist for comparisons (Knick *et al.* 2011, p. 232). Our broader concern as we look to the future is the potential facilitation of cheatgrass occurrence influenced by livestock management within the Bi-State DPS.



## *Nonnative and Native Invasive Plants*

### Nonnative Invasive Plants

Nonnative invasive plants negatively impact sagebrush ecosystems by altering plant community structure and composition, productivity, nutrient cycling, and hydrology (Vitousek 1990, p. 7) and may cause declines in native plant populations through competitive exclusion and niche displacement, among other mechanisms (Mooney and Cleland 2001, p. 5,446). They can create long-term changes in ecosystem processes, such as fire cycles (see “Wildfires and Altered Fire Regime” section below) and other disturbance regimes that persist even after an invasive plant is removed (Zouhar *et al.* 2008, p. 33). A variety of nonnative annuals and perennials are invasive to sagebrush ecosystems (Connelly *et al.* 2004, pp. 7-107 to 7-108; Zouhar *et al.* 2008, p. 144). Cheatgrass (which is not considered controllable and is on the U.S. Department of Agriculture’s noxious weed list) is considered most invasive in Wyoming big sagebrush communities (including the Bi-State area), while *Taeniatherum caput-medusae* (L.) Nevski (medusahead rye) fills a similar niche in more mesic communities with heavier clay soils (Connelly *et al.* 2004, p. 5-9). Some other problematic rangeland weeds that occur in sage-grouse habitat (and the Bi-State area) include *Euphorbia esula* (leafy spurge), *Centaurea solstitialis* (yellow starthistle), (*C. maculosa* (spotted knapweed), *C. diffusa* (diffuse knapweed), and a number of other *Centaurea* species (DiTomaso 2000, p. 255; Davies and Svejcar 2008, pp. 623–629).

Nonnative invasive plant species are abundant within sagebrush habitat, intermingling with and negatively impacting native brush and forb species that sage-grouse rely on. Sage-grouse depend on a variety of native forbs and the insects associated with them for chick survival (Connelly *et al.* 2000a, p. 971), as well as sagebrush species that are used exclusively by sage-grouse throughout the winter for food and cover (Connelly *et al.* 2000a, p. 972). Nonnative plants typically replace vegetation essential to sage-grouse and fragment existing sage-grouse habitat (Miller *et al.* 2011, pp. 160–164). Because nonnative invasive plants are present in the Bi-State area, sage-grouse are potentially impacted both seasonally (loss of forbs and associated insects) and long-term (sagebrush displacement and habitat fragmentation).

A variety of nonnative invasive plants are present in all PMUs within the Bi-State area, although cheatgrass is of greatest concern because it is widely dispersed across all the PMUs. Wisdom *et al.* (2003, pp. 4-3 to 4-13) reported that 44 percent of existing sagebrush habitat in Nevada is at moderate or high risk of displacement by cheatgrass. Rowland *et al.* (2003, p. 40) discovered that 48 percent of sage-grouse habitat on lands administered by the BLM Carson City District Office is at low risk of cheatgrass replacement, about 39 percent is at moderate risk, and about 13 percent is at high risk. Both assessments, however, included large portions of land outside the Bi-State area. Although cheatgrass is present throughout the Bi-State area, its relative abundance is variable. Averaged across the entire Bi-State, percent cover of cheatgrass is generally low (Peterson 2003, entire), and conversion to an annual grass dominated community is currently limited to only a few locations. Anecdotal reports suggest Peterson’s (2003) assessment remains generally true although it is apparent that the abundance and distribution of cheatgrass has increased over the past decade. For example, 3 to 5 years ago in the Bodie PMU, cheatgrass appeared greatly restricted to disturbed areas and travel corridors. After several years of favorable growing conditions, it is now found throughout the Wyoming big sagebrush vegetation

community in the Bodie Hills, representing approximately 5 percent of the understory (Abele 2013, pers. obs.). Areas of greatest immediate concern are in the Pine Nut PMU because cheatgrass abundance is greatest and post-fire restoration challenges are becoming apparent.

Occurrence of cheatgrass has generally been restricted to elevations below approximately 1,700 m (5,500 ft) above mean sea level (Bradley 2010, p. 202). However, in the Bi-State area cheatgrass occurs at elevations thought to be relatively immune based on the grass's ecology. This suggests that in the near future few locations in the Bi-State area will be immune from cheatgrass invasion. Climate change may strongly influence the spread of this species; the available climate data suggest that future conditions will be most influenced by precipitation and winter temperatures (Bradley 2009, p. 200). Predictions on the timing, type, and amount of precipitation contain the greatest uncertainty. In the Bi-State area, model scenarios that result in the greatest expansion of cheatgrass suggest much of the area remains suitable to cheatgrass presence with some additional high elevation sites in the Bodie Hills, White Mountains, and Long Valley becoming more suitable than they are today (Bradley 2009, p. 204). On the opposite end of the spectrum, model scenarios that result in the greatest contraction in cheatgrass range suggest low elevation sites such as Desert Creek-Fales and Mount Grant PMUs become less suitable for this invasive species but high elevation sites (i.e., Bodie and White Mountains PMUs) where habitat conditions are generally marginal today become more suitable in the future. Please see the "Climate Change" section below for further discussion on potential impacts related to climate change predictions.

Many efforts are ongoing to restore or rehabilitate sage-grouse habitat affected by nonnative invasive plant species. The common rehabilitation techniques include: (1) Reducing the density of invasives using herbicides; (2) defoliating via grazing, pathogenic bacteria, or another form of bio-control; (3) conducting a prescribed fire (Tu *et al.* 2001, entire; Larson *et al.* 2008, p. 250; Pyke 2011, p. 543); and (4) reseedling with grass and forb mixes, and sometimes planting sagebrush plugs. Despite ongoing efforts to transform lands dominated by invasive annual grasses into quality sage-grouse habitat, restoration and rehabilitation techniques are mostly unproven and experimental (Pyke 2011, pp. 543–544).

Several components of the restoration process (to remove cheatgrass and other nonnative invasive grasses) are being investigated with varying success (Pyke 2011, p. 543). For example, Pyke (2011, p. 543) discovered that use of the herbicide Imazapic to control cheatgrass is promising, although determining the effectiveness is challenging because it will take time for sagebrush to establish and mature in areas that were dominated by annual grasses. Another challenge with restoration efforts is that they are hindered by cost and the inability to procure the necessary equipment and seed (Pyke 2011, p. 544). Furthermore, restoration of sage-grouse habitat requires partnerships across multiple ownerships in order to restore and maintain a network of intact vegetation (Pyke 2011, p. 548). Regardless, restoration is occurring and localized weed treatments have been applied within all the Bi-State PMUs. Currently, the Pine Nut PMU proves to be the greatest restoration challenge specifically because cheatgrass is widely distributed and relatively abundant, and fire events facilitating additional invasion and dominance are relatively frequent. However, cheatgrass is currently present at relatively low levels across all the PMUs and active treatments are logistically difficult. The greatest defense

against cheatgrass and other nonnative invasive species is to maintain habitat in a competitive condition by ensuring native understory species remain healthy and viable, especially following disturbance events such as fire and drought.

Based on our understanding and past experience with nonnative invasive species in the Great Basin Region, we anticipate a worsening scenario into the future. Climatic conditions will likely influence the dominance of specific nonnative invasive species (see “Climate Change” section below), as will adaptation expressed by these species and actions that facilitate their introduction and spread. While cheatgrass represents the most immediate concern, species such as medusahead rye and red brome (*Bromus rubens*, a cheatgrass relative) present similar and even more concern. These three species inhabit a range of climatic conditions, adapt rapidly, and remain a challenge to manage at a landscape scale. Therefore, regardless of future climate shifts, impacts caused by nonnative species will continue to occur.

### Native Invasive Plants

In addition to nonnative plant invasions within sagebrush habitat, some native tree species are invading sagebrush habitat and impacting the suitability of the habitat for the various life processes of the sage-grouse. Pinyon-juniper woodlands are a native vegetation community dominated by pinyon pine and various juniper species that can encroach upon, infill, and eventually replace sagebrush habitat. The root cause of this conversion from shrubland to woodland is debatable but variously influenced by livestock grazing, fire suppression which has altered the natural fire disturbance regime, and changes in climate and levels of atmospheric carbon dioxide that influences sites suitability to tree establishment and tree competitiveness (see “Climate Change” section below). Some portions of the Bi-State DPS’s range are also impacted by *Pinus jeffreyi* (Jeffrey pine) encroachment. Regardless of the type of woodland encroachment, sage-grouse response has been negative, as demonstrated by the following:

- (1) Commons *et al.* (1999, p. 238) found that the number of male Gunnison sage-grouse on leks doubled after pinyon-juniper removal and mechanical treatment of Wyoming big sagebrush and deciduous brush.
- (2) Doherty *et al.* (2008, p. 187) reported a strong avoidance of conifers by female sage-grouse in the winter.
- (3) Freese (2009, pp. 84–85, 89–90) found that sage-grouse used areas with less than 5 percent juniper cover more often in the breeding and summer seasons.

Therefore, forest or woodland encroachment into occupied sage-grouse habitat reduces, and likely eventually eliminates, sage-grouse occupancy.

Land managers in the Bi-State area consider pinyon-juniper encroachment a significant threat to sage-grouse because it impacts habitat quality, quantity, and connectivity, and increases the risk of avian predation to sage-grouse populations (Bi-State Local Planning Group 2004, pp. 20, 39, 96; Bi-State TAC 2012, pp. 18, 25, 30, 36, 40, 47). Previously occupied sage-grouse locations throughout the Bi-State area are thought to have been abandoned due to woodland succession (Bi-State TAC 2012, pp. 18, 25, 30, 36, 40, 47). Pinyon-juniper encroachment is occurring to some degree within all PMUs in the Bi-State area, with the greatest loss and fragmentation of

occupied sagebrush habitat in the Pine Nut, Desert Creek-Fales, Mount Grant, Bodie, and White Mountains PMUs (USFS 1966, p. 22; Bi-State Local Planning Group 2004, pp. 20, 39, 96, 133, 137, 167). Across the Bi-State area approximately 40 percent of the historically available sagebrush habitat has been usurped by woodland succession over the past 150 years (USGS 2012b, unpublished data). The extent of this conversion varies by PMU, with the South Mono PMU being the least impacted (approximately 13 percent loss) and the Pine Nut PMU being the most influenced (approximately 50 percent loss). The remainder of the PMUs (White Mountains, Mount Grant, Desert Creek-Fales, and Bodie) are each estimated to have experienced approximately a 40 percent loss of historical sagebrush vegetation to woodland succession. In total, over the past 150 years an estimated 390,000 ha (963,000 ac) of sagebrush habitat has converted to woodland vegetation resulting in a loss of availability of sagebrush habitat from slightly over 1,000,000 ha (2,580,000 ac) in 1850 to approximately 650,000 ha (1,600,000 ac) today across the Bi-State DPS (USGS 2012b, unpublished data).

The pattern and rate of woodland expansion into sagebrush habitat are difficult to measure and vary according to landscape gradients such as topography and productivity, as well as climate patterns that favor tree establishment (Weisberg *et al.* 2007, p. 123). Studies generally support the concept that expansion is dominated by in-filling and less by a woodland movement extending out from a habitat edge (Lyford *et al.* 2003, p. 580; Weisberg *et al.* 2007, p. 123). The conditions necessary for tree establishment are relatively restricted, however, once established mortality rates are low and species such as pinyon pine and juniper can be very persistent and capable of survival under environmental conditions not conducive for establishment. Hence, the advance of trees from sagebrush/woodland habitat edge can be slow, followed by periodic pulses of long distance dispersal events during periods of favorable climate conditions (Weisberg *et al.* 2007, p. 123). In-filling behind the advancing front proceeds rapidly because trees themselves modify their environment through altered microclimate, and in the case of pinyon-juniper woodland, elimination of understory plant species that compete with tree seedlings. Expansion of woodland has been estimated between approximately 0.5 and 1.5 percent annually (Soule *et al.* 2003, p. 51; Weisberg *et al.* 2007, p. 120). Extrapolating these estimates to current woodland acreage in the Bi-State area suggests from 2,159 to 6,479 ha (5,535 to 16,000 ac) of sagebrush habitat is affected by woodland expansion annually.

A variety of techniques (e.g., mechanical, herbicide, cutting, burning) are being implemented to remove conifers in sage-grouse habitat. Treatment effectiveness varies with the technique used and proximity to invasive plant infestations, among other factors. We are not aware of any study documenting a direct correlation between these treatments and sage-grouse population response; however, we infer some level of positive response based on Commons *et al.*'s (1999) Gunnison sage-grouse study and the documented avoidance or reduced use by sage-grouse of areas with pinyon-juniper encroachment (Doherty *et al.* 2008, p. 187; Freese 2009, pp. 84–85, 89–90). Approximately 22 woodland thinning or removal projects over the past decade have been completed in the Bi-State area, removing more than 6,475 ha (16,000 ac) of woodland (Bi-State TAC 2012, p. 5). In most cases it is still too early to measure a population-level response of sage-grouse to these treatments (ODFW 2008, p. 3); however, there are several locations in the Bi-State area where anecdotal observations indicate that these actions are resulting in the addition of suitable habitat in some instances (Nelson 2012, pers. comm.). Planning and

implementation of additional woodland treatment projects are also underway over the next several years covering several thousand acres.

Using the best available data, we estimate that the rate of woodland expansion currently outpaces treatment efforts on the order of three to nine times (Service 2012, unpublished data). However, we believe that in the coming decade this disparity will narrow based on current land manager interest and the fact that expansion rates should slow as woodland extent is reduced. However, climate projections (see “Climate Change” section below) suggest warming temperatures in the future, which will facilitate upslope movement of woodlands. Therefore, we remain optimistic that woodland succession is a manageable risk, but restoring historical connectivity and preventing further loss of suitable habitat will require years of focused effort.

### Summary of Nonnative and Native Invasive Plants

Both nonnative and native invasive plants are impacting the sage-grouse and its habitat in the Bi-State area. In general, nonnative plants are not abundant throughout the Bi-State area, with the exception of cheatgrass that occurs in all PMUs but is most extensive and of greatest concern in the Pine Nut PMU. Cheatgrass is a nonnative annual species that will likely continue to expand throughout the Bi-State region in the future and increase the adverse impact that currently exists to sagebrush habitats and sage-grouse through outcompeting beneficial understory plant species and altering the fire ecology of the area. Land managers have had little success preventing cheatgrass invasion in the West, and elevational barriers to occurrence are becoming less restrictive. The best available data suggest that future conditions that could promote expansion of cheatgrass will be most influenced by precipitation and winter temperatures (Bradley 2009, p. 200). Cheatgrass is a serious challenge to the sagebrush shrub community and its spread will be detrimental to sage-grouse in the Bi-State area. In addition, the encroachment of native woodlands (particularly pinyon-juniper) into sagebrush habitats is occurring throughout the Bi-State area, and continued isolation and reduction of suitable habitats will adversely influence both short- and long-term persistence of sage-grouse. We predict that future woodland encroachment will continue, but this may be manageable given sufficient resources and ongoing interest in treatments.

Overall, nonnative and native invasive species occur throughout the Bi-State DPS’s range and are significant threats to the species both currently and in the future. This is based on the extensive amount of pinyon-juniper encroachment and cheatgrass invasion that is occurring throughout the range of the species and the interacting impact these invasions have on habitat quality (e.g., reduces foraging habitat, increases likelihood of wildfire) and habitat fragmentation.

### *Wildfires and Altered Fire Regime*

#### Wildfire and its History in Sagebrush Ecosystems

Wildfire is the principal disturbance mechanism affecting sagebrush communities, although the nature of historical fire patterns, particularly in big sagebrush, is not well understood and was historically infrequent (Miller and Eddleman 2000, p. 16; Zouhar *et al.* 2008, p. 154; Baker

2011, pp. 189, 196). Most sagebrush species have not developed evolutionary adaptations such as re-sprouting and heat-stimulated seed germination found in other shrub-dominated systems, such as chaparral that are exposed to relatively frequent fire events. Baker (2011, p. 196) suggests natural fire regimes and landscapes were shaped by a few infrequent large fire events that occurred at intervals approaching the historical fire rotation (50 to 200 years in mountain big sagebrush communities and 200 to 350 years in Wyoming big sagebrush communities). The historical sagebrush systems likely consisted of extensive sagebrush habitat dotted by small areas of grassland, maintained by long interludes of numerous small fires accounting for little burned area, and punctuated by large fire events (Baker 2011, p. 197). In general, fire extensively reduces sagebrush within burned areas and big sagebrush varieties, the most widespread species of sagebrush can take decades to re-establish and even longer to return to pre-burn conditions (Braun 1998, p. 147; Cooper *et al.* 2007, p. 13; Lesica *et al.* 2007, p. 264; Baker 2011, pp. 194–195).

#### Wildfire Frequency Within Sage-grouse Range

Fire rotation (i.e., the average time it takes to burn once through a particular landscape) is difficult to quantify because sagebrush is killed by fire and does not record evidence of prior burns (i.e., fire scars) (Baker 2011, p. 189). Depending on the species of sagebrush and other site-specific characteristics, fire return intervals derived from data across the western United States range from 10 to well over 300 years (McArthur 1994, p. 347; Peters and Bunting 1994, p. 33; Miller and Rose 1999, p. 556; Kilpatrick 2000, p. 1; Zouhar *et al.* 2008, p. 154; Baker 2011, pp. 191–192). Mean fire return intervals in low lying, xeric big sagebrush communities range from over 200 to 350 years, and return intervals decrease from 50 to over 200 years in more mesic areas, at higher elevations, during wetter climatic periods, and in locations associated with grasslands (Baker 2006, p. 181; Mensing *et al.* 2006, p. 75; Baker 2011, pp. 191–192; Miller *et al.* 2011, p. 166). Within the range of the greater sage-grouse, the natural fire regime has been modified to such an extent that the threat of increased fire intervals and decreased fire intervals can both impact to the species and its habitat. While no specific studies have been conducted within the Bi-State area to inform our knowledge of fire rotation, we expect this pattern to be similar to those described above for the remainder of the species' range. However, based on current vegetation condition and vegetation community composition it appears across much of the Bi-State area the lack of fire or lengthening of the fire return interval has created conditions favoring tree establishment.

When intervals between wildfire events become unnaturally long in sagebrush communities (as compared to a natural fire interval as described above), woodlands have the ability to expand when they are adjacent to or are present (in small quantities) within sagebrush habitat. Conifer woodlands have expanded into sagebrush ecosystems throughout the sage-grouse range over the last century (Miller *et al.* 2011, p. 162). Woodlands can encroach into sagebrush communities when the interval between fires allows seedlings to establish and trees to mature (Miller *et al.* 2011, p. 167). In recent times, a suite of causes acting in concert with active wildfire suppression (i.e., putting out fires) may explain the dramatic expansion of conifer woodlands into sagebrush habitats that we see today including: domestic livestock grazing (reduced competition from native grasses and forbs and facilitation of tree regeneration by increased shrub cover and

enhanced seed dispersal), climatic fluctuations favorable to tree regeneration, enhanced tree growth due to increased water use efficiency associated with carbon dioxide fertilization, and recovery from past disturbance (natural and anthropogenic) (Baker 2011, p. 200; Miller *et al.* 2011, pp. 167–169). Each of these factors have likely influenced the current pattern of vegetation in the Bi-State area today and leading to an estimated 40 percent decline in sagebrush extent due to woodland succession and additional fragmentation of sage-grouse populations across the DPS (see “Native Invasive Plants” above). Active wildfire suppression is occurring throughout the Bi-State DPS, as land managers implement a full suppression policy.

A shortened fire frequency interval within sagebrush habitat can result in the invasion of nonnative invasive annual grasses, such as cheatgrass and medusahead rye; once these nonnatives are established, wildfire frequency within sagebrush ecosystems can increase (Zouhar *et al.* 2008, p. 41; Miller *et al.* 2011, p. 167; Balch *et al.* 2013, p. 178). For example, Link *et al.* (2006, p. 116) showed that risk of fire increases from approximately 46 to 100 percent as ground cover of cheatgrass increases from 12 to 45 percent or more. Cheatgrass readily invades sagebrush communities, especially disturbed sites, and shortens historical fire patterns by providing an abundant and easily ignitable fuel source that facilitates fire spread (Balch *et al.* 2013, pp. 180–181). Cheatgrass recovers within 1–2 years of a wildfire event (Young and Evans 1978, p. 285), which leads to a recurring wildfire cycle that prevents sagebrush reestablishment (Eiswerth *et al.* 2009, p. 1,324). For example in the Snake River Plain of Idaho, wildfire rotation due to cheatgrass establishment is documented to be as low as 3–5 years (Whisenant 1990, p. 4). It is difficult and usually ineffective to restore sagebrush after annual grasses become established due to the positive feedback with fire, invasive species seed bank establishment, and alterations to soil and hydrologic processes (Paysen *et al.* 2000, p. 154; Connelly *et al.* 2004, pp. 7-44 to 7-50; Pyke 2011, p. 539). Thus, habitat loss from wildfire can be detrimental to a sage-grouse population if a large proportion of extant sagebrush is consumed; but more importantly, habitat loss is even more detrimental if the subsequent invasion by nonnative annual grasses occurs because recovery is then significantly challenged (Connelly *et al.* 2000c, p. 93, Beck *et al.* 2012, p. 452).

#### Potential Impacts of Fire on Sage-grouse and its Habitat

While multiple factors can influence sagebrush persistence, wildfire can cause large-scale habitat losses that lead to fragmentation and isolation of sage-grouse populations. In addition to loss of habitat and its influence on sage-grouse population persistence, fragmentation and isolation of populations presents a higher probability of extirpation in disjunct areas (Knick and Hanser 2011, p. 395; Wisdom *et al.* 2011, p. 469). This is a concern within the Bi-State area, specifically throughout the Pine Nut and portions of the South Mono PMUs where burned habitat may be influencing already small and disjunct populations. Extinction is currently more probable than colonization for many sage-grouse populations such as those in the Bi-State area because of their low abundance and isolation coupled with fire and human influence (Knick and Hanser 2011, pp. 401–404). As areas become isolated through disturbances such as wildfire, populations are exposed to additional stressors and persistence may be hampered by the limited ability of individuals to disperse into areas that are otherwise not self-sustaining. Thus, while direct loss of habitat due to wildfire has been shown to be a significant factor associated with

population persistence for sage-grouse (Beck *et al.* 2012, p. 452), the indirect effect posed by loss of connectivity among populations may greatly expand the influence of this threat beyond the physical fire perimeter.

Wildfire is associated with sage-grouse population declines across the West (Connelly and Braun 1997, p. 232; Connelly *et al.* 2000a, p. 973; Connelly *et al.* 2000c, p. 93; Miller and Eddlemen 2000, p. 24; Johnson *et al.* 2011, p. 424; Knick and Hanser 2011, p. 395). First, in nesting and wintering areas, fire causes direct loss of habitat due to reduced cover and forage (Call and Maser 1985, p. 17). Rowland and Wisdom (2002, p. 28) reported that prescribed fires in mountain sagebrush caused a short-term increase in certain forbs, but reduced sagebrush cover, making the habitat less suitable for nesting. Similarly, Nelle *et al.* (2000, p. 586) and Beck *et al.* (2009, p. 400) reported nesting habitat loss from fire due to loss of canopy cover. Second, research indicates that the simple presence of fire within 54 km (33.6 mi) of a lek is a primary factor in predicting lek extirpation (Knick and Hanser 2011, p. 395). Even small increases in burned habitat surrounding a lek can have a large influence on lek abandonment (Knick and Hanser 2011, p. 401). Thus, fire has been documented to have a negative effect on lek trends (Johnson *et al.* 2011, p. 424). As a result, disturbances such as fire that remove sagebrush extent and limit habitat availability (cover and forage), appears to strongly influence the probability of local population persistence (Beck *et al.* 2012, p. 452).

Herbaceous understory vegetation plays a critical role throughout the breeding season as forage and cover for sage-grouse hens and chicks. The response of herbaceous understory vegetation to fire varies with species composition, pre-burn site condition, fire intensity, and pre- and post-fire patterns of precipitation. In general, any short-term flush of understory perennial grasses and forbs within burned sites is essentially lost after only a few years (Cook *et al.* 1994, p. 298; Fischer *et al.* 1996, p. 196; Crawford 1999, p. 7; Wroblewski 1999, p. 31; Nelle *et al.* 2000, p. 588; Paysen *et al.* 2000, p. 154; Wambolt *et al.* 2001, p. 250). Therefore, any short-term benefits gained by releasing understory vegetation from competition with a shrub overstory are negated by the loss of overstory structure essential to sage-grouse life history needs.

Fires can influence insect populations (Schroeder *et al.* 1999, p. 5), but study results have been mixed. Ants (Hymenoptera), grasshoppers (Orthoptera), and beetles (Coleoptera) are essential components of juvenile sage-grouse diets, especially in the first 3 weeks (Johnson and Boyce 1991, p. 90). In one study (Bock and Bock 1991, p. 165), grasshoppers declined 60 percent the first year post-burn, but differences disappeared the second year; while Fischer *et al.* (1996, p. 197) discovered significantly lower overall insect abundance 2–3 years post-burn. Pyle (1992, p. 14) reported no effects from prescribed burning to beetles; and Crawford and Davis (2002, p. 56) reported arthropods did not decline following wildfire. Nelle *et al.* (2000, p. 589) reported the abundance of beetles and ants was significantly greater one year post-burn, but returned to pre-burn levels by years three to five. These data suggest that any potential short-term benefits gained by increases in insect abundance following a fire event are typically negated by the loss of sagebrush overstory structure essential to sage-grouse life history needs.

The few studies that have suggested fire may be beneficial for sage-grouse were primarily conducted in mesic areas used for brood-rearing (Klebenow 1970, p. 399; Pyle and Crawford 1996, p. 323). Small fires may maintain a suitable habitat mosaic by reducing shrub



encroachment and encouraging understory growth. However, without available nearby sagebrush cover, the utility of these sites is questionable (Woodward 2006, p. 65). For example, Slater (2003, p. 63) reported that sage-grouse using burned areas were rarely found more than 60 m (200 ft) from the edge of the burn and may preferentially use the burned and unburned edge habitat. However, Byrne (2002, p. 27) reported avoidance of burned habitat by nesting, brood-rearing, and broodless females. Both Connelly *et al.* (2000c, p. 90) and Fischer *et al.* (1996, p. 196) found that prescribed burns did not improve brood-rearing habitat in Wyoming big sagebrush, as forbs did not increase and insect populations declined. Hence, fires in these locations may negatively affect brood-rearing habitat rather than improve it (Connelly and Braun 1997, p. 11). In upland Wyoming big sagebrush communities, fire is used as a tool to break-up fuel continuity and prevent large fires in otherwise undisturbed habitat). This method may offer utility, but in areas with limited sagebrush habitat or sites that are exposed to invasive species, the negative aspects of this approach outweigh the positive (Baker 2011, p. 201). The most important and widespread sagebrush species for sage-grouse (i.e., big sagebrush) are killed by fire and require decades to recover (Knick *et al.* 2011, p. 233). Prior to recovery, these sites are of limited to no use to sage-grouse (Fischer *et al.* 1996, p. 196; Connelly *et al.* 2000c, p. 90; Nelle *et al.* 2000, p. 588; Beck *et al.* 2009, p. 400).

#### Potential Recovery of Sagebrush Habitat Following Wildfire

Sagebrush recovery rates following wildfire are highly variable, and precise estimates are often hampered by limited data from older burns. Factors contributing to the rate of shrub recovery include the amount of and distance from unburned habitat, abundance and viability of seed in soil seed bank (sagebrush seeds are typically viable for one to three seasons depending on species), rate of seed dispersal, and pre- and post-fire weather, which influences seedling germination and establishment (Young and Evans 1989, p. 204; Maier *et al.* 2001, p. 701; Ziegenhagen and Miller 2009, p. 201). Baker (2011, pp. 194–195) reports that full recovery to pre-burn conditions in *Artemisia tridentata* ssp. *vaseyana* (mountain sagebrush) communities ranges between 25 and 100 years, and in *A. t.* ssp. *wyomingensis* (Wyoming big sagebrush) communities potentially ranges between 50 and 120 years. By 25 years post-fire, Wyoming big sagebrush typically has less than 5 percent pre-fire canopy cover (Baker 2011, p. 195). The Bi-State area is largely comprised of these two sagebrush subspecies, and we anticipate similar recovery times as those derived from studies across the West as described above.

A variety of techniques have been employed to restore sagebrush communities following wildfires (Cadwell *et al.* 1996, p. 143; Quinney *et al.* 1996, p. 157; Livingston 1998, p. 41). The extent and efficacy of restoration is variable and complicated by limitations in capacity (personnel, equipment, funding, seed availability, and limited seeding window), incomplete knowledge of appropriate methods, invasive plant species, and abiotic factors (e.g., weather) that are largely outside the control of land managers (Hemstrom *et al.* 2002, pp. 1,250–1,251; Pyke 2011, pp. 544–545).

When wildfires occur across Federal lands, evaluating habitat impacts and determining the most appropriate rehabilitation treatments are initiated via the Burned Area Emergency Stabilization and Rehabilitation (BAER) Program on USFS managed lands and Emergency Stabilization and Rehabilitation (ESR) on BLM managed lands. The main purpose of these two programs is to

stabilize soils and maintain site productivity (Pyke 2011, p. 542). Consequently, in areas that experience active post-fire restoration efforts, emphasis is often placed on introduced grasses that establish quickly. Only recently has a modest increase in use of native species for rehabilitation been reported (Richards *et al.* 1998, p. 630; Pyke 2011, p. 542). Further complicating our understanding of the effectiveness of these treatments is that most land managers do not systematically collect and track monitoring data (U.S. Government Accountability Office 2003, p. 5). Assuming complete success of restoration efforts on targeted areas, however unlikely, the return of a shrub dominated community such as sagebrush will still require several decades, and landscape restoration may require centuries or longer (Knick 1999, p. 55; Hemstrom *et al.* 2002, p. 1,252). Even longer time periods may be required for sage-grouse to use recovered or restored landscapes (Knick *et al.* 2011, p. 233).

In addition to wildfires occurring in sagebrush habitat throughout the range of sage-grouse, land managers are using prescribed fire to obtain desired management objectives for a variety of wildlife species and domestic livestock. While the efficacy of such treatments in sagebrush habitats to enhance sage-grouse populations is questionable (Peterson 1970, p. 154; Swensen *et al.* 1987, p. 128; Connelly *et al.* 2000c, p. 94; Nelle *et al.* 2000, p. 590; WAFWA 2009, p. 12; Connelly *et al.* 2011c, p. 552), as with wildfire, an immediate and potentially long-term result is the loss of habitat (Beck *et al.* 2009, p. 400). However, prescribed fire treatments reduce fire risk in the presence of housing developments or intact expanses of sagebrush habitat and in these instances benefits may be gained. In the Bi-State area, prescribed fire use has not been extensive and generally limited to woodland sites and to reduce fire risk near communities. In the past decade, prescribed fire has been used in the Pine Nut and Desert Creek-Fales PMUs; the efficacy of these actions to restore a sagebrush community has not yet been determined. There remains the potential for future use of prescribed fire (or other methods of sagebrush treatment) across the Bi-State area, as all management agencies retain this tool. Future use will be dependent on NEPA analysis and likely limited to situations that minimize potential loss of residential developments.

#### Impact of Wildfires and an Altered Fire Regime Within the Bi-State Area

Wildfire is considered a relatively high risk across all the PMUs in the Bi-State area due to its ability to affect large landscapes in a short period of time (Bi-State TAC 2012, pp. 19, 26, 32, 37, 41, 49). Furthermore, the future potential of this risk is exacerbated by the presence of people, invasive species, and climate change. While dozens of wildfires have occurred in the Pine Nut, Desert Creek-Fales, Bodie, and South Mono PMUs (fewer in the Mount Grant and White Mountains PMUs) over the past 20 years, to date there have been relatively few large scale events (Table 3). In general, current data also do not indicate an increase of wildfires in the PMUs over time with the significant exception of the Pine Nut PMU where fire occurrence is more frequent (Service 2013, unpublished data). Furthermore, cheatgrass has a more substantial presence in the Pine Nut PMU, which appears to mirror (much more than the rest of the Bi-State area) the damaging fire and invasive species cycle impacting sagebrush habitat across much of the southern Great Basin.

**Table 3.** Twenty-year history of wildfires larger than 202 hectares (ha) (500 acres (ac)) across the Bi-State area, California and Nevada.

<b>PMU</b>	<b>Estimated PMU Area Burned ha (ac)</b>	<b>Estimated Number of Fire Events (1992–2012)</b>
<b>Pine Nut</b>	33,754 (83,409)	23
<b>Desert Creek-Fales</b>	13,482 (33,315)	5
<b>Mount Grant</b>	475 (1,173)	1
<b>Bodie</b>	277 (685)	1
<b>South Mono</b>	12,658 (31,281)	8
<b>White Mountains</b>	232 (575)	1
<b>TOTAL</b>	<b>60,878 (150,438)</b>	<b>39</b>

Changes in fire ecology over time have resulted in an altered fire regime in the Bi-State area, presenting future wildfire risk in all PMUs (Bi-State TAC 2012, pp. 19, 26, 32, 37, 41, 49). A reduction in fire occurrence has facilitated the expansion of woodlands into montane sagebrush communities in all PMUs (see “Nonnative and Native Invasive Plants” section below). Furthermore, a pattern of overabundance in wildfire occurrence in sagebrush communities is becoming apparent in the Pine Nut PMU. Each of these alterations to wildfire regimes has contributed to fragmentation of habitat and the isolation of the sage-grouse populations (Bi-State Local Planning Group 2004, pp. 95–96, 133).

The loss of habitat due to wildfire across the West is anticipated to increase due to the intensifying synergistic interactions among fire, people, invasive species, and climate change (Miller *et al.* 2011, p. 184). The recent past- and present-day fire regimes across the sage-grouse’s range have changed with a demonstrated increase of wildfires in the more arid Wyoming big sagebrush communities and a decrease of wildfire across many mountain sagebrush communities (Miller *et al.* 2011, pp. 167–169). Both altered fire regime scenarios have caused significant losses to sage-grouse habitat through facilitating conifer expansion at high-elevation interfaces and nonnative invasive weed encroachment at lower elevations (Miller *et al.* 2011, pp. 167–169). In the face of climate change, both scenarios are anticipated to worsen (Baker 2011, p. 200; Miller *et al.* 2011, p. 179), including in the Bi-State area. Predicted changes in temperature, precipitation, and carbon dioxide (see “Climate Change” section below) are all anticipated to influence vegetation dynamics and alter fire patterns resulting in increasing loss and conversion of sagebrush habitats (Neilson *et al.* 2005, p. 157). Further, many climate scientists suggest that in addition to the predicted change in climate toward a warmer and generally drier Great Basin, variability of interannual and interdecadal wet-dry cycles will likely

increase and act in concert with fire, disease, and invasive species to further stress the sagebrush ecosystem (Neilson *et al.* 2005, p. 152). See the “Overall Summary of Species Status and Impacts” section below for further discussion of synergistic effects. The anticipated increase in suitable conditions for wildland fire will likely further interact with people and infrastructure. Human-caused fires have increased and are correlated with road presence across the sage-grouse range, and there is indication that a similar pattern exists in the Bi-State area (Miller *et al.* 2011, p. 171).

Fire is one of the primary factors linked to population declines of sage-grouse across the West because of long-term loss of sagebrush and frequent conversion to monocultures of nonnative invasive grasses (Connelly and Braun 1997, p. 7; Johnson *et al.* 2011, p. 424; Knick and Hanser 2011, p. 395). Within the Bi-State area, the BLM and USFS currently manage the area to limit loss of sagebrush habitat. Based on the best available information, historical wildfire events have not removed a significant amount of sagebrush habitat across Bi-State area and conversion of sagebrush habitat to a nonnative invasive vegetation community has been restricted (Pine Nut PMU withstanding). It does appear that a lack of historical fire has facilitated the establishment of woodland vegetation communities and loss of sagebrush habitat. Both the too little and too much fire scenarios present challenges for the Bi-State DPS. The former influences the current degree of connectivity among sage-grouse populations in the Bi-State DPS and the extent of available sagebrush habitat, likely affecting sage-grouse population size and persistence. The latter, under current conditions, now has the potential to quickly alter significant percentages of remaining sagebrush habitat. Restoration of sagebrush communities is challenging, requires many years, and may be ineffective in the presence of nonnative invasive grass species. Sage-grouse are slow to recolonize burned areas even if structural features of the shrub community have recovered (Knick *et al.* 2011, p. 233). While it is not currently possible to predict the extent or location of future fire events in the Bi-State area, we anticipate fire frequency to increase in the future due to the increasing presence of cheatgrass and people, and the projected effects of climate change.

Overall, this threat of wildfire and the existing altered fire regime occurs throughout the Bi-State DPS's range and is considered a significant threat to the species both currently and in the future. This is based on a continued reduced fire frequency that exacerbates pinyon-juniper encroachment into sagebrush habitat in some locations, but also an increased fire frequency that promotes the spread of cheatgrass and other invasive species that in turn can hamper recovery of sagebrush habitats in other locations.

### *Climate*

### Drought

Sage-grouse are affected by drought through the loss of vegetative habitat components, reduced insect production (Connelly and Braun 1997, p. 9), and potentially exacerbation of WNV exposure. Drought, defined relative to an average set of conditions has occurred periodically but not regularly in sagebrush habitats (Miller *et al.* 2011, p. 173). Drought reduces vegetation cover (Milton *et al.* 1994, p. 75; Connelly *et al.* 2004, p. 7-18), potentially resulting in increased soil erosion and subsequent reduced soil depths, decreased water infiltration, and reduced water

storage capacity. Drought can also exacerbate other natural events such as defoliation of sagebrush by insects. For example, approximately 2,544 km<sup>2</sup> (982 mi<sup>2</sup>) of sagebrush shrublands died in Utah in 2003 as a result of drought and infestations with the webworm moth (*Aroga* sp.) (Connelly *et al.* 2004, p. 5-11). These habitat component losses can result in declining sage-grouse populations due to increased nest predation and early brood mortality associated with decreased nest cover and food availability (Braun 1998, p. 149; Moynahan 2007, p. 1,781).

Sage-grouse populations declined during the 1930's period of drought (Patterson 1952, p. 68; Braun 1998, p. 148). Drought conditions in the late 1980's and early 1990's also coincided with historically low sage-grouse population levels (Connelly and Braun 1997, p. 8). From 1985 through 1995, the entire range of sage-grouse experienced severe drought (as defined by the Palmer Drought Severity Index) with the exceptions of north-central Colorado (MZ II) and southern Nevada (MZ III). Abnormally dry to severe drought conditions still persist in Nevada (University of Nebraska 2008).

Aldridge *et al.* (2008, p. 992) determined that the number of severe droughts from 1950 to 2003 had a weak negative effect on patterns of sage-grouse persistence. However, they cautioned that drought may have a greater influence on future sage-grouse populations as temperatures rise over the next 50 years, and synergistic effects of other threats affect habitat quality (Aldridge *et al.* 2008, p. 992). A study in central Nevada showed strong evidence that recruitment was highly influenced by annual precipitation and further that adult survival was negatively correlated with summer temperatures (Blomberg *et al.* 2012, p. 10). These results support the importance of water balance in sagebrush systems to sage-grouse population dynamics (Blomberg *et al.* 2012, p. 14). Furthermore, the study (Blomberg *et al.* 2012, p. 10) demonstrated a strong interaction between climate variables and the presence of invasive annual grasses (cheatgrass). Meaning that documented recruitment pulses during years of favorable weather conditions were tempered or nonexistent when the habitat surrounding a lek site was impacted by conversion to nonnative invasive grasses following wildfire.

Climate change projections in the Great Basin suggest a hotter and stable to declining level of precipitation and a shift in precipitation events to the summer months; fire frequency is expected to accelerate, fires may become larger and more severe, and fire seasons will be longer (Brown *et al.* 2004, pp. 382–383; Neilson *et al.* 2005, p. 150; Chambers and Pellant 2008, p. 31; Global Climate Change Impacts in the United States 2009, p. 83). Increased evapotranspiration in a warmer climate is also anticipated to shift herbaceous communities to more drought adapted species and elevated levels of carbon dioxide in the environment is thought to favor cheatgrass occurrence (Ziska *et al.* 2005, p. 1,329). If alterations to annual water balance positively influence the occurrence of nonnative invasive species, we may expect a reduction in preferable habitat and a lowered frequency and magnitude of periodic pulses in sage-grouse recruitment (Blomberg *et al.* 2012, p. 15). The interaction of these variables along with the exposure inherent in small or isolated populations suggests populations on the periphery of the range may have a higher risk of extirpation, especially during a severe and prolonged drought (Wisdom *et al.* 2011, p. 469).

In the Bi-State area, drought is a natural part of the sagebrush ecosystem and we are unaware of any information to suggest that drought has influenced population dynamics of sage-grouse

under historical conditions. There are known occasions, however, where reduced brood rearing habitat condition due to drought have resulted in little to no recruitment within certain PMUs (Bodie, Pine Nut) (Gardner 2009, pers. comm.; Coates 2012, pers. comm.). Given the relatively small and restricted extent of this population, if these conditions were to persist longer than the typical adult life span, drought could have significant ramifications on population persistence. Further, drought impacts on the sage-grouse may be exacerbated when combined with other habitat impacts that reduce cover and food (Braun 1998, p. 148).

### Climate Change

The Intergovernmental Panel on Climate Change (IPCC) has concluded that warming of the climate is unequivocal, and that continued greenhouse gas emissions at or above current rates will cause further warming (IPCC 2007, p. 30). Eleven of the 12 years from 1995 through 2006 rank among the 12 warmest years in the instrumental record of global surface temperature since 1850 (ISAB 2007, p. 6). Climate-change scenarios estimate that the mean air temperature could increase from 2.1 °C to over 6 °C (3.8 °F to >10.8 °F) by 2100 (IPCC 2007, p. 46; Miller *et al.* 2011, p. 175; Finch 2012, p.1). Modeling scenarios also project that there will likely be regional increases in drought risk, frequency of hot extremes, heat waves, and heavy precipitation, as well as increases in atmospheric carbon dioxide (IPCC 2007, pp. 36, 46; Strzepek *et al.* 2010, p. 5).

In our analysis, we rely primarily on synthesis documents (e.g., IPCC 2007, entire; Global Climate Change Impacts in the United States 2009, entire) that present the consensus view of a large number of experts on climate change from around the world. We have discovered that these synthesis reports and scientific papers used in those reports or resulting from those reports represent the best available scientific information to inform our decision and we rely upon them and provided citations within our analysis. In addition, where possible we use projections specific to the western United States within the range of the sage-grouse and regional assessments that attempt to further scale down these projections within the Bi-State area. We also use projections of the effects of climate change to sagebrush where appropriate; however, we note that the uncertainty of climate change effects increases when applying those potential effects to a habitat variable like sagebrush, and then increases again when the impacts to the habitat variable are applied to the species.

Projected climate change and its associated consequences have the potential to affect sage-grouse, and potentially the Bi-State DPS, and may increase its risk of extinction, as the impacts of climate change interact with other stressors such as disease, invasive species, prey availability, moisture, vegetation community dynamics, disturbance regimes, and other habitat degradations and loss that are already affecting the species (Global Climate Change Impacts in the United States 2009, p. 81; Miller *et al.* 2011, pp. 174–179; Walker and Naugle, 2011, entire; Finch 2012, pp. 60, 80). In arid regions such as the Great Basin, weather patterns are likely to become hotter and drier, fire frequency is expected to accelerate, and fires may become larger and more severe (Brown *et al.* 2004, pp. 382–383; Neilson *et al.* 2005, p. 150; Chambers and Pellant 2008, p. 31; Global Climate Change Impacts in the United States 2009, p. 83).

The anticipated effects of climate change (such as alterations in the timing and amount of precipitation, changes in the amount of atmospheric carbon, and the upward shift in seasonal

high and low temperatures, as well as changes in average temperatures) are anticipated to alter distributions of individual species and ecosystems significantly (Bachelet *et al.* 2001, p. 174; Bradley 2010, pp. 198, 205; Finch 2012, pp. 1–2). Under projected future temperature and precipitation conditions, the amount of sagebrush habitat across the west is anticipated to decline (Shafer *et al.* 2000, p. 209; Neilson *et al.* 2005, p. 154; Chambers and Pellant 2008, p. 30; Bradley 2010, p. 205). Warmer temperatures and greater concentrations of atmospheric carbon dioxide create conditions favorable to cheatgrass, thus continuing the positive feedback cycle between the invasive annual grass and fire frequency that poses a significant challenge to sagebrush habitats and to sage-grouse (Chambers and Pellant 2008, p. 32; Global Climate Change Impacts in the United States 2009, p. 83). Fewer frost-free days also favor frost-sensitive woodland vegetation, which facilitates expansion of woodlands into the sagebrush biome, especially in the southern Great Basin (Neilson *et al.* 2005, p. 154). Nielson *et al.* (2005, p. 154) forecast that 12 percent of sagebrush habitat in the Great Basin will be lost to woodland succession per 1°C (1.8 °F) of temperature increase. In addition, Comer *et al.* (2012, pp. 142–143) forecast that low elevation sites in the Great Basin will be susceptible to conversion to drier or novel vegetation communities, such as salt desert scrub or Mohave Desert communities. Thus, sagebrush habitats in the Great Basin will likely be lost at more southerly latitudes and low elevation sites and upper elevation areas will be more susceptible to woodland succession and cheatgrass invasion.

Temperature and precipitation both directly influence potential for WNV transmission (see “Disease or Predation” section below) (Walker and Naugle 2011, p. 131). In sage-grouse, WNV outbreaks appear to be most severe in years with higher summer temperatures (Walker and Naugle 2011, p. 131) and under drought conditions (Epstein and Defilippo, p. 105). This relationship is due to the breeding cycle of the WNV vector *Culex tarsalis* being highly dependent on warm water temperature for mosquito activity and virus amplification (Walker and Naugle 2011, p. 131). Therefore, current climate change projections for higher summer temperatures, more frequent or severe drought, or both make more severe WNV outbreaks likely in low-elevation sage-grouse habitats where WNV is already endemic, and also make WNV outbreaks possible in higher elevation sage-grouse habitats that have been WNV-free due to relatively cold conditions.

Increasing emissions of carbon dioxide are expected to provide favorable growth conditions for invasive nonnative plants that are more susceptible to wildfire conditions. Emissions of carbon dioxide, considered to be the most important anthropogenic greenhouse gas, increased by approximately 80 percent between 1970 and 2004 due to human activities (IPCC 2007, p. 36). Future carbon dioxide emissions from energy use are projected to increase by 40–110 percent between 2000 and 2030 (IPCC 2007, p. 44). An increase in the atmospheric concentration of carbon dioxide has important implications for sage-grouse, beyond those associated with warming temperatures, because higher concentrations of carbon dioxide are favorable for the growth and productivity of cheatgrass (Smith *et al.* 1987, p. 142; Smith *et al.* 2000, p. 81), which is an invasive plant that negatively impacts sage-grouse habitat. Although most plants respond positively to increased carbon dioxide levels, many invasive nonnative plants, including cheatgrass, respond with greater growth rates than native plants (Smith *et al.* 1987, p. 142; Smith *et al.* 2000, p. 81; Global Climate Change Impacts in the United States 2009, p. 83). Laboratory

research results illustrate that cheatgrass grown at carbon dioxide levels representative of current climatic conditions mature more quickly, produce more seed and greater biomass, and produce significantly more heat per unit biomass when burned as compared to cheatgrass grown at “pre-industrial” carbon dioxide levels (Blank *et al.* 2006, pp. 231, 234). These responses to increasing carbon dioxide may have increased the flammability in cheatgrass communities during the past century (Ziska *et al.* 2005, p. 1330; Blank *et al.* 2006, p. 234), thus resulting in increased flammability of sagebrush communities that harbors this invasive plant.

Based on the current and predicted increased atmospheric carbon dioxide levels, the challenges posed to sage-grouse conservation by cheatgrass from both sagebrush habitat degradation (through loss of native understory species) and severe wildfires will become exacerbated in the future (Smith *et al.* 1987, p. 143; Smith *et al.* 2000, p. 81; Brown *et al.* 2004, p. 384; Neilson *et al.* 2005, pp. 150, 156; Chambers and Pellant 2008, pp. 31–32). Field studies demonstrate that *Bromus* species (including cheatgrass) display significantly higher plant density, biomass, and seed rain (dispersed seeds) at elevated carbon dioxide levels relative to native annuals (Smith *et al.* 2000, pp. 79–81). The researchers determined that the results from this field study confirm experimentally (in an intact ecosystem) that elevated carbon dioxide may enhance the invasive success of brome grasses in arid ecosystems, suggesting that this enhanced success will then expose these areas to more frequent fire events (Smith *et al.* 2000, p. 81). Chambers and Pellant (2008, p. 32) also suggest that higher carbon dioxide levels are likely increasing cheatgrass fuel loads due to increased productivity, with a resulting increase in fire frequency and extent. Therefore, beyond the potential changes in vegetation communities induced by alterations in temperature and precipitation regimes, increases in carbon dioxide concentrations represent a threat to the sagebrush biome and an indirect threat to sage-grouse (including within the Bi-State DPS) through habitat degradation and loss (Miller *et al.* 2011, p. 179).

Predicted movement or conversion of native sagebrush-steppe habitat into one dominated by nonnative invasive species suggest these communities may either expand or contract under climate change, depending on the current and projected future range of environmental conditions tolerated by a particular invasive plant species (Bradley 2009, p. 204; Bradley *et al.* 2009, p. 1,517; Bradley and Wilcove 2009, p. 718). These studies developed a suite of bioclimatic envelope model scenarios for cheatgrass across the range of the sage-grouse based on maps of invaded range derived from remote sensing. The best predictors of cheatgrass occurrence were summer, annual, and spring precipitation, followed by winter temperature (Bradley 2009, p. 200). Depending primarily on future precipitation conditions, the model predicts cheatgrass is likely to shift northwards or up in elevation (Bradley 2009, p. 202). Therefore, the threat posed to sage-grouse rangewide by the greater frequency and geographic extent of wildfires and other associated negative impacts from the presence of cheatgrass is expected to continue into the future and likely impact areas that currently have limited exposure. In the Bi-State area, these model scenarios suggest a range of outcomes depending on the realized environmental condition resulting from climate change. Again, environmental changes in the amount and timing of precipitation events and winter temperature appear most influential. Under scenarios that result in the greatest expansion of cheatgrass, much of the Bi-State remains suitable to cheatgrass presence with some additional high elevation sites in the Bodie Hills, White Mountains, and Long Valley becoming more suitable than they are today (Bradley 2009, p. 204). On the



opposite end of the spectrum, scenarios that result in the greatest contraction in cheatgrass range suggest much of the Bi-State area will become less suitable for this invasive species. However, there will remain locations (such as high elevation sites in the Bodie Hills and White Mountains) where habitat conditions become more suitable for cheatgrass invasion (i.e., areas where this invasive is currently limited).

Bradley (2009, p. 205) stated that the bioclimatic model she used is an initial step in assessing the potential geographic extent of cheatgrass because climate conditions only affect invasion on the broadest regional scale. Other factors relating to land use, soils, competition or topography may affect suitability of a given location for cheatgrass and likely other invasive nonnative plants. Bradley *et al.* (2009, pp. 1,517–1,518) concludes that the potential for climate to shift away from suitability for cheatgrass in the future may offer an opportunity for restoration of the sagebrush biome in these areas; however, the authors note that these locations may become more susceptible to invasion by red brome, a relative of cheatgrass that is more tolerant of higher temperatures. We anticipate that areas that become unsuitable for cheatgrass across the range of the sage-grouse may transition to other vegetation over time; however, we are unaware of information to determine if transition back to sagebrush as a dominant landcover or to other native or nonnative vegetation is more likely.

In a study that modeled potential impacts to sagebrush species (specifically *Artemisia tridentata*) due to climate change, Shafer *et al.* (2001, pp. 200–215) used response surfaces to describe the relationship between bioclimatic variables and the distribution of tree and shrub taxa in western North America. Species distributions were simulated using scenarios generated by three general circulation models: HADCM2, CGCM1, and CSIRO. Each scenario produced similar results, simulating future bioclimatic conditions that would reduce the size of the overall range of sagebrush and change where sagebrush may occur (Shafer *et al.* 2001, p. 209). These simulated changes were the result of increases in the mean temperature of the coldest month, which the authors speculated may interact with soil moisture levels to produce the simulated impact (Shafer *et al.* 2001, pp. 210–211). Each model predicted that climate suitability for big sagebrush would shift north into Canada (Shafer *et al.* 2001, p. 209). Shafer *et al.* (2001, p. 209) concludes that areas in the sage-grouse current range (including the Bi-State DPS area) would become less suitable climatically, and would potentially cause significant contraction. Shafer *et al.* (2001, p. 211) also point out that increases in fire frequency under the simulated climate projections would leave big sagebrush more vulnerable to fire impacts.

Contractions in the current distribution of sagebrush due to projected changes in climate have been proposed by several other researchers (Neilson *et al.* 2005, p. 155; Bradley 2010, p. 204; Comer *et al.* 2012, p. 142; Finch 2012, p. 10). In the Bi-State area, these studies suggest substantial changes in vegetation communities occurring between 2025 and 2100. Alterations of Bi-State DPS habitat include loss of low elevation sagebrush sites that are converted to salt desert and Mohave scrub communities, and loss of mid- to high-elevation sagebrush sites to woodland succession (Bradley 2010, p. 205; Comer *et al.* 2012, pp. 142–143).

The results derived from climate models are inherently challenged by uncertainty, especially changes that are most influenced by precipitation. However, recent research has attempted to minimize this uncertainty by using results derived from several climate change models

simultaneously or an ensemble approach (Bradley *et al.* 2009, p. 1,517; Bradley 2010, p. 206). Still, caveats to conclusions drawn by this research remain. Shafer *et al.* (2001, p. 213) explicitly state that their approach should not be used to predict the future range of a species, and that the underlying assumptions of the models they used are “unsatisfying” because they presume a direct causal relationship between the distribution of a species and particular environmental variables. A variety of factors are not included in climate space models, including: (1) The effect of elevated carbon dioxide on the species’ water-use efficiency, (2) knowing the physiological effect (with confidence) of exceeding the assumed (modeled) bioclimatic limit on the species, (3) the life stage at which the limit affects the species (seedling versus adult), (4) the life span of the species, and (5) the movement of other organisms into the species range (Shafer *et al.* 2001, p. 207). These variables would likely help determine how climate change would affect species distributions, including the Bi-State DPS. Shafer *et al.* (2001, p. 213) concludes that while more empirical studies are needed on what determines a species and multi-species distributions, those data are often lacking; in their absence, climatic space models can play an important role in characterizing the types of changes that may occur so that the potential impacts on natural systems can be assessed.

Global climate change is expected to affect the Bi-State area (Lenihan *et al.* 2003, p. 1674; Diffenbaugh *et al.* 2008, p. 3; Lenihan *et al.* 2008, p. S223, Comer *et al.* 2012, pp. 142, 145). Potential impacts are generally well defined (such as loss of sagebrush habitat that is replaced by woodlands, and drier vegetation communities), but precise predictions are problematic due to the coarse nature of the climate models and relatively small geographic extent of the area. In general, model predictions tend to agree on an increasing temperature regime (Cayan *et al.* 2008, pp. S38–S40). Of greater uncertainty is the influence of climate change on local precipitation (Diffenbaugh *et al.* 2005, p. 15776; Cayan *et al.* 2008, p. S28). This variable is an important predictor of sagebrush occurrence as well as to greater sage-grouse, as timing and quantity of precipitation greatly influences plant community composition and extent, specifically forb production, which in turn affects nest and chick survival. Across the west, models predict a general stable or decrease in precipitation but suggest a generally drier environment due to elevated temperature and increased rates of evapotranspiration (Neilson *et al.* 2005, p. 150). Scaled-down predictions for the Bi-State area show an overall decrease in annual precipitation ranging from under 2.54 cm (1 in) up to 7.6 cm (3 in) over the next 50 years (TNC Climate Wizard 2012). In addition to the uncertainties related to local precipitation levels, there are also uncertainties regarding how climate change will affect insect populations, which are important for the Bi-State DPS as a food source and also as pollinators for its habitat.

A warming trend in the mountains of western North America is expected to decrease snow pack, accelerate spring runoff, and reduce summer stream flows (Intergovernmental Panel on Climate Change (IPCC) 2007, p. 11). These events will likely impact sagebrush and meadow habitats, affect fire frequency and intensity, and potentially alter WNV outbreaks in the Bi-State area. In the Sierra Nevada Mountains, March temperatures have warmed over the last 50 years resulting in more rain than snow precipitation, which translates into earlier snowmelt (Chambers and Pellant 2008, p. 30). This trend is likely to continue and accelerate into the future (Kapnick and Hall 2009, p. 11). This change in the type of precipitation and the timing of snow melt will likely influence reproductive success by altering the availability of understory vegetation and

meadow habitats, and potentially influence insect abundance (Casazza *et al.* 2011, p. 162). Increased summer temperature is also expected to increase the frequency and intensity of wildfires, as demonstrated by Westerling *et al.* (2009, pp. 10–11) who modeled potential wildfire occurrences as a function of land surface characteristics in California. Their model predicts an overall increase in the number of wildfires and acreage burned by 2085 (Westerling *et al.* 2009, pp. 17–18). Changes in a particular location's susceptibility to invasive annual grass and increases in WNV outbreaks are reasonably anticipated (IPCC 2007, p. 13; Lenihan *et al.* 2008, p. S227).

Based on the best available scientific and commercial information, the threat of climate change is not known to currently impact the Bi-State DPS to such a degree that the viability of the species is at stake. However, while it is reasonable to assume the Bi-State area will experience vegetation changes into the future (as presented above), we do not know with precision the nature of these changes or ultimately the effect this will have on the Bi-State DPS. A recent analysis conducted by NatureServe, which incorporates much of the information presented above, suggests a substantial contraction of both sagebrush and sage-grouse range in the Bi-State area by 2060 (Comer *et al.* 2012, pp. 142,145). Furthermore, Gardali *et al.* (2012, p. 8) ranked sage-grouse as the most vulnerable to climate change in comparison to other at-risk California bird species. It is likely the area will become generally less suitable to invasion by cheatgrass. It is similarly likely that the current extent of suitable shrub habitat will decrease, as the conditions that make the reduction in cheatgrass possible also suggest a less suitable climate condition for sagebrush and improved suitability for woodland and drier vegetation communities, which are not favorable to sage-grouse in the Bi-State DPS. In addition, it is reasonable to assume that changes in atmospheric carbon dioxide levels, temperature, precipitation, and timing of snowmelt will act synergistically with other threats such as wildfire and invasive nonnative species to produce yet unknown but likely negative effects to sage-grouse populations in the Bi-State area. Based on this information it is reasonable to assume that climate change (acting both alone and in concert with impacts such as disease and nonnative invasive species) could be pervasive throughout the range of the Bi-State DPS, potentially degrading habitat to such a degree that all populations would be negatively affected. Therefore, given the scope and potential severity of climate change when interacting with other threats in the future, the overall impact of climate change to the Bi-State DPS at this time is considered moderate.

### *Overutilization Impacts*

#### Commercial Hunting

The sage-grouse was heavily exploited by commercial hunting in the late 1800's and early 1900's (Patterson 1952, pp. 30–32; Autenrieth 1981, pp. 3–11). Hornaday (1916, pp. 179–221) and others noted the risk of extinction of the species from overharvest. The impacts of hunting on sage-grouse may have been exacerbated by impacts from human expansion into sagebrush-steppe habitats (Girard 1937, p. 1). Sage-grouse have not been commercially harvested in the Bi-State area since the 1930s and they are not expected to be commercially harvested in the future. Therefore, commercial hunting is not impacting the continued existence of the Bi-State sage-grouse.

## Recreational Hunting

The allowance of limited recreational hunting, based on the concepts of compensatory and additive mortality, were allowed across most of the species' range with the increase of sage-grouse populations by the 1950's (Patterson 1952, p. 242; Autenrieth 1981, p. 11). The compensatory mortality hypothesis contends if sage-grouse produce more offspring than can survive to sexual maturity, individuals lost to hunting represent losses that would have occurred otherwise from some other source (e.g., starvation, predation, or disease). Hunting mortality is deemed additive if it exceeds natural mortality and ultimately results in a decline of the spring breeding population.

In recent years, hunting as a form of compensatory mortality for upland game birds (which includes sage-grouse) has been questioned (Connelly *et al.* 2005, pp. 660, 663; Reese and Connelly 2011, p. 111). Historically, harvest levels of upland game birds, based on the compensatory mortality hypothesis, assumed that productivity and overwinter mortality was high (Reese and Connelly 2011, p. 102). However, annual sage-grouse productivity is relatively low and overwinter survival is relatively high (approximately 2 percent) compared to other grouse species (Connelly *et al.* 2000b, p. 229). This suggests that populations of sage-grouse are more sensitive to harvest mortality than previously thought. In addition, there are several life history and ecological factors that influence the likelihood of hunting becoming an additive source of mortality in sage-grouse populations. For example, due to WNV, sage-grouse population dynamics may be increasingly affected by mortality that is density independent (i.e., mortality that is independent of population size). There is also growing concern among managers across the West regarding wide-spread habitat degradation and fragmentation from various sources, such as development, fire, and the spread of noxious weeds, resulting in density independent mortality, which increases the probability that harvest mortality will be additive (Reese and Connelly 2011, p. 111).

A greater number of female sage-grouse are typically harvested compared to males, and this directly relates to adult female survivorship, which is a key element of population productivity. The potential for negative effects on populations by harvesting reproductive females has long been recognized and harvest of hens for many upland game birds (e.g., ring-necked pheasant (*Phasianus colchicus*)) is frequently prohibited. Connelly *et al.* (2000b, pp. 228–229) calculated that 42 percent of all documented female mortality of sage-grouse was attributable to hunting while for males it was 15 percent. In Nevada, from 1996 to 2008, on average 63 percent of adult hunting mortalities were females (range 58 to 73 percent) (NDOW 2009b, unpublished data). Because sage-grouse are relatively long-lived, have moderate reproductive rates, and are polygynous, their populations are likely sensitive to adult female survival (Schroeder 1999, pp. 2, 13; Saether and Bakke 2000, p. 652; Connelly 2005, p. 9). Adult females have higher nest initiation rates, higher nest success, and higher chick survival rates than yearling females (Connelly *et al.* 2011a, pp. 63–65). If high adult female mortality occurs in sage-grouse populations, there is the potential for negative lag effects as future populations become overrepresented by yearling females (Moynahan *et al.* 2006, p. 1537); thus, sage-grouse population productivity can be negatively impacted.

Results of studies to determine whether hunting mortality in sage-grouse is compensatory or additive have been contradictory (Crawford 1982, p. 376; Crawford and Lutz 1985, p. 72; Braun 1987, p. 139; Johnson and Braun 1999, p. 83; Connelly *et al.* 2003, p. 337; Sedinger *et al.* 2010, p. 329). Braun (1987, p. 139) determined that harvest levels of 7 to 11 percent had no effect on subsequent spring breeding populations based on lek counts, which suggests harvest mortality was compensatory. Johnson and Braun (1999, p. 83) determined that overwinter mortality correlated with harvest intensity, and hypothesized that hunting mortalities may be additive. In addition, contradictory study results have occurred that are likely due to differing methods, lack of experimental data, and differing effects of harvest due to a relationship between harvest and habitat quality. For example, Connelly *et al.* (2003, pp. 256–257) evaluated data for areas experiencing different levels of harvest (no harvest, 1-bird season, 2-bird season) and discovered that populations with no hunting season had faster rates of population increase than populations with a light to modest harvest. The effect was particularly pronounced in xeric habitats near human populations, which suggests that the impact of hunting on sage-grouse can depend on habitat quality.

An appropriate harvest rate has not been determined for sage-grouse populations but there is general recognition that this rate should vary by population, given the degree of impact exerted by this factor and how it acts in concert with other impacts such as habitat degradation (Reese and Connelly 2011, p. 111). Autenrieth (1981, p. 77) suggested sage-grouse could sustain harvest rates of up to 30 percent annually, while Braun (1987, p. 139) suggested a rate of 20 to 25 percent of the population was sustainable. While it is currently unknown the threshold at which harvest mortality tips toward an additive source of mortality, the amount of harvest across the range of the species has generally moved toward a more conservative and limited approach in the past several decades. Currently, State wildlife agencies attempt to keep harvest levels below 5 to 10 percent of the fall population based on recommendations in Connelly *et al.* (2000a, p. 976). This harvest level of the fall populations appears to be the adopted standard among States and, in general, species experts agree this level is compatible with conservation (Reese and Connelly 2011, entire).

In the Nevada portion of the Bi-State area, NDOW regulates hunting of sage-grouse. Most hunting of sage-grouse in the Nevada portion of the Bi-State area is closed. NDOW closed the shotgun and archery seasons for sage-grouse in 1997 and the falconry season in 2003 (NDOW 2012, *in litt.*). Hunting of sage-grouse may occur on tribal allotments located in the Pine Nut PMU where the Washoe Tribe of Nevada & California has authority. There are anecdotal reports of harvest by tribal members, but currently the Washoe Tribe Hunting and Fishing Commission does not issue harvest permits for greater sage-grouse (Warpea 2009, pers. comm).

In the California portion of the Bi-State area, CDFW regulates hunting of sage-grouse. Hunting historically occurred and continues to occur in the Long Valley (South Mono PMU) and Bodie Hills (Bodie PMU) areas, the South Mono and North Mono Hunt Units, respectively. Prior to 1983, California instituted changes in hunting seasons and bag limits including periodic closures in these units based on estimated population size. In 1983, CDFW closed the hunting season and in 1987 reopened the hunting season and instituted a quota system (Bi-State Local Planning Group 2004, pp. 73–74). Between 1987 and 1997, CDFW annually issued between 100 and 450

single-bird permits for both Hunt Units. In 1998, Gibson (1998, unpublished data; 2011, p. 312) determined that from the late-1960s to late-1990s hunting had suppressed the isolated Long Valley population well below the apparent carrying capacity but had no measurable impact on the Bodie Hills population, which is contiguous with populations in Nevada. As a result of the documented population declines and Gibson's (1998) work, CDFW significantly reduced the number of permits issued (Bi-State Local Planning Group 2004, pp. 74–75; Gardner 2008, pers. comm.). Since 1998, CDFW has annually issued between 20 to 35 single-bird hunting permits for the North and South Mono Hunt Units, respectively (Bi-State Local Planning Group 2004, p. 173; CDFW 2012, *in litt.*). The estimated harvest from these permits averages approximately 40 total birds annually; 20 birds for the North Mono and 20 birds for the South Mono Hunt Units.

Comparing the recent (2011 and 2012) estimated harvest levels to the estimated fall population in California over the past decade, harvest has been on the order of 2 to 4 percent of the estimated fall population in each of the Bodie and South Mono PMUs (CDFW 2012, *in litt.*). As currently instituted, the permit system employed by CDFW and the estimated harvest rate is below the currently accepted harvest rate of 5 to 10 percent of the fall population. This harvest rate is compatible with a compensatory mortality paradigm and therefore, likely has a negligible impact on the population.

Other potential sources of mortality for sage-grouse in the Bi-State area include illegal harvest (poaching) or the accidental taking of sage-grouse by hunters pursuing other upland game birds. Gibson (2001, p. 4) mentioned that a low level of known poaching occurred in Long Valley. However, neither the CDFW nor NDOW have any information regarding the degree or scope of illegal harvest or accidental taking of sage-grouse that may be occurring throughout the Bi-State area. Consequently, though we acknowledge that poaching or the accidental taking of sage-grouse in the Bi-State area may happen, we are unaware of any information to indicate that it is occurring to such a degree that it is having a negative impact on a particular PMU or the population.

The future impact of harvest from recreational hunting in the Bi-State area is unknown. Each State recognizes the heightened concern over conservation within the Bi-State DPS but also balances mandates to provide hunting opportunities to the sportsman user groups, while recognizing the benefits gained through education and dollars received through license sales and taxes associated with hunting equipment some of which are subsequently re-invested in sage-grouse habitat. States set hunting regulations independently of one another but generally apply guidelines derived from the scientific community as adopted by the Western Association of Fish and Wildlife Association. Currently, these guidelines recommend harvest be eliminated if a local breeding population is represented by less than 100 males counted on leks (Connelly *et al.* 2000a, p. 976). Each of the Nevada PMUs (or portion thereof) is below or slightly above this level. Therefore, in Nevada, the current closure will likely remain in place until such time the populations appear robust enough to support harvest. In California, it is likely CDFW will continue utilizing the current, and generally conservative, permit system as long as sage-grouse populations in the South Mono and Bodie PMUs remain stable. While we do not know with certainty the future potential for harvest across the Bi-State area, we consider the strategy with

the greatest likelihood of implementation will be one that is conservative and closely monitored to ensure harvest does not trend toward an additive source of mortality.

In summary, recreational hunting of sage-grouse could have a negative impact on the population if harvest mortality shifts from a compensatory to additive source of mortality. However, there are several life history and ecological conditions that may affect the level at which harvest mortality becomes an additive source of mortality. Consequently, State wildlife agencies have taken a more conservative approach and attempt to keep harvest levels below 5 to 10 percent of the fall population. The only location within the Bi-State area where hunting has been shown to be an additive source of mortality is in Long Valley, the South Mono PMU (Gibson 2011, p. 312). Upon recognition of this, the CDFW has altered their approach to harvest in this location and today employs a relatively conservative approach to harvest. A similar harvest approach is employed by the CDFW in the Bodie PMU, even though historical harvest has not been shown to have influenced this PMU's population size. The State of Nevada has not allowed recreation hunting in the Bi-State area for over a decade. Given the current level and location of harvest, and the expected use of a conservative management approach into the future, the impact this factor has on population persistence appears negligible.

### *Recreation*

Non-consumptive recreational activities occur throughout the range of the sage-grouse, including throughout the Bi-State DPS area. These activities can degrade wildlife resources, water, and land by distributing refuse, disturbing and displacing wildlife, increasing animal mortality, and simplifying plant communities (Boyle and Samson 1985, pp. 110–112). Sage-grouse response to disturbance may be influenced by the type of activity, recreationist behavior, predictability of activity, frequency and magnitude, activity timing, and activity location (Knight and Cole 1995, p. 71). A variety of recreational activities are pursued across the Bi-State area, including traditional activities such as fishing, hiking, horseback riding, and camping as well as more recently popularized activities, such as OHV use and mountain biking.

Disruption of sage-grouse during vulnerable periods at leks, or during nesting or early brood rearing, could affect reproduction and survival (Baydack and Hein 1987, pp. 537–538). Baydack and Hein (1987, p. 537) reported displacement of male sharp-tailed grouse at leks from human presence resulting in loss of reproductive opportunity during the disturbance period; female sharp-tailed grouse were only observed at undisturbed leks. Disturbance of incubating female sage-grouse could cause displacement from nests, increased predator risk, and loss of nests.

Sage-grouse avoidance of activities associated with development (such as Holloran 2005, pp. 43, 53, 58; Doherty *et al.* 2008, p. 194) suggests they are disturbed by persistent human presence. Aldridge *et al.* (2008, p. 988) reported that the density of humans in 1950 was the best predictor of extirpation of sage-grouse. The authors also determined that sage-grouse were extirpated in virtually all counties reaching a human population density of 25 people/km<sup>2</sup> (65 people/mi<sup>2</sup>) by 1950. However, their analyses did not separate recreational activities from other human activities and infrastructure. The presence of free roaming dogs associated with recreational activity in proximity to sage-grouse can result in sage-grouse mortality or disturbance, and increases in garbage from recreationists can attract predators and maintain their numbers at

increased levels. Leu *et al.* (2008, p. 1133) reported that slight increases in human densities in ecosystems with low biological productivity (such as sagebrush) may have a disproportionately negative impact on these ecosystems due to the potentially reduced resiliency to anthropogenic disturbance.

Indirect effects to sage-grouse from recreational activities include impacts to vegetation and soils, and facilitating the spread of invasive species. Payne *et al.* (1983, p. 329) studied OHV impacts to rangelands and discovered long-term (2-year) reductions in sagebrush shrub canopy cover as the result of repeated trips. Increased sediment production and decreased soil infiltration rates were observed after disturbance by motorcycles and four-wheel drive trucks on two desert soils in southern Nevada (Eckert *et al.* 1979, p. 395), and noise from these activities can also cause additional disturbance (Knick *et al.* 2011, p. 219). Unpaved roads fragment sagebrush landscapes as well as subsidize predators adapted to humans and provide disturbed surfaces that facilitate the spread of invasive plant species (Knick *et al.* 2011, p. 219).

In the western United States, greater than 27 percent of the human population used OHVs for recreation between 1999 and 2004 (Knick *et al.* 2011, p. 217). Any high-frequency human activity along established corridors can affect wildlife through habitat loss and fragmentation (Knick *et al.* 2011, p. 219). The effects of OHV use on sagebrush and sage-grouse have not been directly studied (Knick *et al.* 2011, p. 219). The Bi-State Plan (Bi-State Local Planning Group 2004, pp. 27, 137–138) specifically discusses the risk associated with off-road vehicles in the Pine Nut and the Mount Grant PMUs and more generally discusses off-road vehicles in the context of all types of recreational activities (motorized and non-motorized) for the Bodie and South Mono PMUs (Bi-State Local Planning Group 2004, pp. 91–92, 170–171).

Off-road vehicle use has indirect impacts to sage-grouse habitat; it is known to reduce or eliminate sagebrush canopy cover through repeated trips in an area, degrade meadow habitat, increase sediment production, and decrease soil infiltration rates through compaction (Service 2005, p. 2278). In the Bi-State area there are areas of concern for off-road vehicle use, especially in brood rearing and wintering habitats. In winter, off-road vehicle or snowmobile use in occupied areas may increase stress on birds and displace sage-grouse to less optimal habitats (Bi-State Local Planning Group 2004, p. 91). We did not locate any scientific information documenting instances where snow compaction as a result of snowmobile traffic precluded sage-grouse use or affected their survival in wintering areas. However, during heavy snow years, essentially the entire population of birds in the South Mono PMU (Long Valley) may congregate in a very small area (Gardner 2008, pers. comm.).

Potential disturbance caused by non-motorized forms of recreation (fishing, camping, hiking, big game hunting, dog training) are most prevalent in the South Mono and Bodie PMUs. These PMUs are also exposed to tourism-associated activity centered on Mono Lake and the towns of Mammoth Lakes and Bodie. The exact amount of recreational activity or user days occurring in the area is not known, however, the number of people in the area appears to increase annually (Nelson 2008, pers. comm.; Taylor 2008, pers. comm.). In addition, with the recent reestablishment of commercial air service to the Mammoth Yosemite Airport during the winter, sage-grouse in the South Mono PMU will potentially be exposed to more recreational visitors during the breeding season than previously experienced. The early nesting season (in addition to



the already busy summer months) will present the most significant new overlap between birds and human activity in the area. The greatest concern is the relatively concentrated recreation occurring in the South Mono PMU, which overlaps with a core population of sage-grouse in the Bi-State area. Given the likelihood of a continuing influx of people into Mono County, especially in proximity to Long Valley, largely created by opportunities to access public lands, we anticipate effects from recreational activity will continue to increase.

There are very likely impacts caused by recreation but currently there are little quantifiable data available to assess the degree of this impact. Anecdotally, recreational activity in the Long Valley portion of the South Mono PMU is consistently increasing. Typically, recreational activity in this location is more pedestrian in nature (fishing, biking, hot springs, camping), although these forms of activity have still been demonstrated to have negative impacts on wildlife and wildlife habitats. Recreational activities throughout the remainder of the PMUs in the Bi-State are generally more vehicular (OHV, cars, trucks) in nature and there are known areas of habitat degradation caused by these activities. These sites are relatively limited in extent but may be influential, especially in locations where seasonal habitats are restricted. However, we are unaware of any information to suggest this is impacting specific breeding populations. Furthermore, the level of activity associated with a specific road or occurring in a specific PMU is not known. Although, anecdotal information suggests that the level of activity (i.e., OHV numbers) is generally increasing. All the PMUs are relatively close to urban centers, thus we anticipate recreational activity will continue and likely increase, however there are a number of sites within the Bi-State area that may become designated wilderness. If this occurs, vehicular traffic will presumably diminish in these locations.

Sage-grouse are subject to a variety of non-consumptive recreational uses such as bird watching or tour groups visiting leks, general wildlife viewing, and photography. Daily human disturbances on sage-grouse leks could cause a reduction in mating and some reduction in total production (Call and Maser 1985, p. 19). Across the range of sage-grouse, a relatively small number of leks in each State receive regular viewing use by humans during the strutting season and most States report no known impacts from this use (Apa 2008, pers. comm.; Christiansen 2008, pers. comm.; Gardner 2008, pers. comm.; Northrup 2008, pers. comm.). Only Colorado has collected data regarding the effects of non-consumptive use, and analyses suggest that controlled lek visitation has not impacted sage-grouse (Apa 2008). However, Oregon reported anecdotal evidence of negative impacts of unregulated viewing to individual leks near urban areas that are subject to frequent disturbance from visitors (Hagen 2008, pers. comm.).

Similarly, within the Bi-State area, anecdotal data suggests a relatively small number of leks receive regular viewing during the strutting season (CDFW 2012, unpublished data; NDOW 2012, *in litt.*). State wildlife agencies and Federal land managers provide interested persons directions to the largest and most easily accessible leks and guidelines to minimize viewing disturbance on a case-by-case basis but do not attempt to track actual visitation. Requests for lek locations vary annually but to date appear not to have been excessive (CDFW 2012, unpublished data, NDOW 2012, *in litt.*). Although visitation is generally not well understood, leks contained within the South Mono, Bodie, and Desert Creek-Fales PMUs are most readily accessible and thought to receive the most attention. The leks in the other three PMUs are more remote and

generally difficult to access; it is unlikely these leks receive frequent visitation. Across the Bi-State DPS, we estimate that approximately 15 to 20 percent of lek sites are visited with any regularity.

Disturbance may be occurring, however, we are unaware of any information that this type of recreational activity is having a negative impact on local populations or contributing to population trends of sage-grouse in the Bi-State area (Gardner 2008, pers. comm.; Espinosa 2008, pers. comm.). A single exception may apply, as anecdotal information from one frequently visited lek site within the Desert Creek-Fales PMU, suggests strutting activity may be shifting location and this site represents the largest of four active leks in the Nevada portion of this PMU (Espinosa 2012, pers. comm.). Still, aside from this potential behavioral disruption, the lek remains active and the local population appears generally stable (NDOW 2012, *in litt.*). Furthermore, in an attempt to limit disturbance to this lek, the Federal managing land agency restricted road access and limited travel to pedestrian traffic in 2012 (USFS 2012a, *in litt.*). Foot traffic may be more disturbing to strutting birds, as people walking appear more disruptive to birds than vehicles. Despite the potential disruption to birds from foot traffic, it is anticipated that restricting road access will limit the overall number of visitors to this lek.

The future impact of recreational viewing on the Bi-State DPS is unknown. While we do not know the degree of impact this potential stressor may pose to local breeding populations in the future, it is reasonable to assume interest will likely increase with increasing human population growth and the likelihood that information on lek locations will be more widely distributed. We anticipate that the largest and most easily accessible leks (i.e., those within South Mono, Desert-Creek Fales, and Bodie PMUs) will likely continue to receive increased visitation. However, it is possible that if visitation increases at the more well-known leks, this may lead to increased visitation at remote or smaller leks. Ideally, this potential stressor, if elevated in the future, could be effectively managed and is thus considered negligible.

In summary, lek locations in the Bi-State area are generally well known by the local community but it is not apparent that this information is widely disseminated. Currently, it appears that a relatively limited number of leks are frequently visited. These leks are generally restricted to the South Mono and Desert Creek-Fales PMUs, although certain leks within the Bodie PMU also are attractive for viewing. Although visitation rates are not tracked, we are unaware of any information that indicates the current level of visitation is having a negative impact on the population. In addition, measures have been taken to minimize disturbance to the one lek in the Desert-Creek Fales PMU that is potentially being impacted by frequent visitation. Finally, we cannot predict how recreational viewing may change in the future. It is likely that recreational viewing will increase in the future as the human population increases and information regarding lek locations becomes more widely distributed.

### *Scientific and Educational Uses*

Mortality and behavioral impacts to sage-grouse may occur as a result of scientific research activities. Sage-grouse in the Bi-State area have been subject to several scientific research efforts over the past decade involving capture, handling, and subsequent banding or radio-marking. Several hundred birds have been captured and handled by researchers. Casazza *et al.*

(2009, p. 45) indicated that, in 3 years of study of radio-marked sage-grouse (n=145), the deaths of 4 birds (approximately 1 percent per year) in the Bi-State area were attributed to handling by researchers. Within the Bi-State area, ongoing research in the Pine Nut PMU and several additional scattered locations has not reported any mortality attributable to handling. Across the range of sage-grouse, mortality rate associated with capture, handling, and subsequent banding or radio-marking was estimated at 2.7 percent in 2005, similar to results documented in the Bi-State area (Service 2010, p. 13965). We are not aware of any studies that suggest this level of mortality has affected any sage-grouse population in the Bi-State area or throughout the range of the sage-grouse.

Marking of sage-grouse individuals may influence aspects of the species life history such as behavior or propensity to breed, which may alter population dynamics. Data are largely limited to assess “researcher effect”; however, a recent investigation in Nevada suggests that males marked with traditional necklace-style radio-transmitters were less likely to be detected on leks and in addition these devices may be influencing survival, albeit to a lesser degree (Nonne *et al.*, in review, p. 12). Potential explanation as to why collared males are less likely to be detected on leks may stem from males foregoing strutting activity, spending less time on leks, or strutting on the periphery of leks. The behavioral changes detected in collared males may infer that collars are adding an additional energetic challenge or that collars are inhibiting successful display. Limited data investigating the later concept suggest that collared male vocalization is apparently altered (Nonne *et al.*, in review, pp. 14–15). Regardless of the cause affecting a reduction in detection rate, these results suggest that collared males may be less successful breeders.

A reduction in the propensity of collared males to breed may be a concern if a significant number of males in a population are collared or if a substantial number of dominant males are collared. Generally, researchers are less interested in understanding male biology and more interested in understanding females and thus typically do not collar many males. This is primarily due to the greater influence females have on population dynamics. Thus, in the Bi-State area we do not have substantial concern over this potential impact because we do not believe it will influence population dynamics. However, there may be local Bi-State DPS populations that have a limited number of males (Parker Meadows in the South Mono PMU, Pine Nut PMU) where caution by researchers should be afforded. Currently, few males have been collared in these locations and future research direction is primarily directed toward females, thus males will not likely be a focus and thus potential impacts would likely be minimal.

Impacts on females by research activity are also poorly understood. This understanding is challenged because of the lack of a control group or a group of unmarked females that can be monitored in tandem with marked females. One aspect of female life history, which has been investigated somewhat, is the influence that visitation to nests to check activity affects nesting success. Traditionally, researchers have attempted to minimize this impact by adopting minimally invasive methods such as not flushing females. More recently, assessing the impact of visitation on nest survival can be understood by incorporating this factor into statistical models. Results using this modeling approach have not been conclusive and have likely been confounded by other factors such as the predator community where the research occurs. In Nevada, Noone *et al.* (2012, unpublished data.) determined that visitation did indeed increase the

probability of nest failure at an individual nest but that this influence was minor and did little to change the average nest survival rate across the population.

An additional avenue for potential impact from research activity comes from emerging technologies. GPS transmitters are beginning to replace traditional VHF transmitters in sage-grouse research as costs come down. GPS transmitters are rump mounted (over the tail) and attached via elastic straps around the birds legs. The transmitters are slightly heavier than traditionally methods and solar powered, which requires a reflective solar panel. We currently have little understanding of the impact that this technology has on sage-grouse vital rates (survival, reproductive success). However, preliminary results from an ongoing study in Wyoming suggest annual survival rates of birds marked by rump-mounted equipment may be half that of birds collared by traditional necklace style transmitters (Blomberg 2013, pers. comm.). In addition, research in the Bi-State area, where a limited number of these transmitters have been deployed, suggest nesting success may be negatively affected. Speculation as to the cause of this effect suggests the reflective solar panel surface associated with these devices may increase the likelihood of detection of birds on nests by predators (Blomberg 2013, pers. comm.). Ultimately, we will not be able to ascertain the impact this new technology has on sage-grouse vital rates because we lack a control group; however, we will be able to compare these new technologies to the traditional necklace style transmitters to better understand a relative degree of impact. Within the Bi-State area, both approaches are being employed and in the next few years, as sample sizes increase, researchers should be able to determine the relative impact inferred by the two separate approaches of marking individuals.

Over the next several years, interest in researching sage-grouse within the Bi-State DPS will likely remain. This will entail the capture and marking of approximately 30 to 50 individuals annually. Assuming the rate of mortality from handling birds remains the same or increases slightly, only one to two birds per year would be anticipated to be lost. Alone, this amount of loss would not be anticipated to impact population dynamics in the Bi-State area due to the low rate of mortality among marked individuals and the small percentage of the populations that is actually marked. While there are very likely impacts to nesting success caused by these activities, we have little information to inform the significance of this impact. The number of GPS transmitters deployed remains relatively low (less than 10 units), largely due to cost. It is unlikely that a significant number (greater than 40) of these transmitters will ever be deployed. Thus, while there is likely loss of individuals due to research activity and affects to survival and nesting success it does not appear this level of loss will translate into population level effects.

In summary, much remains unknown about the impacts of research on sage-grouse population dynamics. The available information indicates that very few individuals die as a result of handling and marking. In addition, visitation by researchers may negatively impact nesting success, and marking sage-grouse may alter their behavior and decrease their survival rates. However, these impacts are likely minor and do not occur across the entire range of the Bi-State DPS. Consequently, the impact research has on population persistence appears negligible both currently and into the future. Furthermore, the information gained through research activities provides significant value to understanding and ameliorating alternative population stressors.

## *Disease or Predation*

### Disease

The best available data indicate that parasites and disease in general are not significant concerns in the Bi-State area. However, sage-grouse are known to be hosts for a variety of parasites and diseases (as outlined in the following paragraphs) including macroparasitic arthropods, helminthes, and microparasites (protozoa, bacteria, viruses and fungi) (Thorne *et al.* 1982, p. 338; Connelly *et al.* 2004, pp. 10-4 to 10-7; Christiansen and Tate, 2011, p. 114).

- Internal parasites documented in sage-grouse include protozoans (*Sarcosystis* spp. and *Tritrichomonas simonyi*), blood parasites (including avian malaria (*Plasmodium* spp.), *Leucocytozoon* spp., *Haemoproteus* spp., and *Trypanosoma avium*), tapeworms (*Raillietina centroceri* and *R. cesticillus*), gizzard worms (*Habronema* spp. and *Acuaria* spp.), cecal worms (*Heterakis gallinarum*), and filarid nematodes (*Ornithofilaria tuvensis*) (Hones 1955, pp. 1–2; Hepworth 1962, p. 6; Thorne *et al.* 1982, p. 338; Connelly *et al.* 2004, pp. 10-4 to 10-6; Petersen 2004, p. 50; Christiansen and Tate, 2011, pp. 119–123). None of these parasites are known to cause mortality in sage-grouse (Christiansen and Tate, 2011, pp. 119–123); their sub-lethal effects have not been studied.
- External parasites that sage-grouse are documented to host include lice, ticks, and dipterans (midges, flies, mosquitoes, and keds) (Connelly *et al.* 2004, pp. 10-6 to 10-7). Most ectoparasites do not produce disease, but can serve as disease vectors or cause mechanical injury and irritation (Thorne *et al.* 1982, p. 231). Ectoparasites can be detrimental, particularly when a bird is stressed by inadequate habitat or nutritional conditions (Petersen 2004, p. 39). Some studies suggest that lice infestations can affect sage-grouse mate selection (Boyce 1990, p. 266; Spurrier *et al.* 1991, p. 12; Deibert 1995, p. 37), but population impacts are not known (Connelly *et al.* 2004, p. 10-6).

It is unknown whether or not parasites have a role in population declines (Connelly *et al.* 2004, p. 10-3; Christiansen and Tate, 2011, p. 114). Early studies suggested that sage-grouse populations were negatively impacted by parasitic infections (Batterson and Morse 1948, p. 22). Parasites also have been implicated in sage-grouse mate selection, with effects on genetic diversity (Boyce 1990, p. 263; Deibert 1995, p. 38). However, Connelly *et al.* (2004, p. 10-6) note that, while these relationships may be important to the long-term ecology of sage-grouse, they have not been shown to be significant to the immediate population status across the range of the species. However, Connelly *et al.* (2004, p. 10-3) and Christiansen and Tate (2011, p. 126) suggest that diseases and parasites may limit isolated sage-grouse populations as it interacts with other demographic parameters such as reproductive success and immigration, and thus the effects of emerging diseases require additional study.

A few mortalities from parasitic infections and bacterial infections have been documented in sage-grouse populations, including the protozoan *Eimeria* spp. (coccidiosis) (Connelly *et al.* 2004, p. 10-4) and possibly ixodid ticks (*Haemaphysalis cordeilishas*); *Escherichia coli*, and *Salmonella* spp.; none of these have occurred in the Bi-State area. Furthermore, one case of

aspergillosis, a fungal disease, has been documented in sage-grouse, but there is no evidence to suggest it limits sage-grouse populations (Connelly *et al.* 2004, p. 10-8; Petersen 2004, p. 45). Sage-grouse habitats are generally incompatible with the ecology of this disease due to arid conditions.

Viruses (such as coronavirus and West Nile virus (WNV)) can cause serious diseases in grouse species and death, potentially influencing population dynamics (Petersen 2004, p. 46). Prior to 2002, only avian infectious bronchitis (caused by a coronavirus) had been identified in sage-grouse. WNV has spread across North America since 1999 (Marra *et al.* 2004, p. 394), and currently is the disease most likely to impact the Bi-State area. This virus is thought to have caused millions of wild bird deaths since its introduction (Walker and Naugle 2011, p. 128), but most WNV mortality goes unnoticed or unreported (Ward *et al.* 2006, p. 101). The virus persists largely within a mosquito-bird-mosquito infection cycle (McLean 2006, p. 45). However, direct bird-to-bird transmission has been documented in several species (McLean 2006, pp. 54, 59), including sage-grouse (Cornish 2009a, pers. comm.; Walker and Naugle 2011, p. 132). The frequency of direct transmission has not been determined (McLean 2006, p. 54). Impacts of WNV on the bird host vary by species with some experiencing mortality rates of up to 68 percent (e.g., American crow (*Corvus brachyrhynchos*)) (Walker and Naugle 2011, p. 129, and references therein). Sage-grouse are considered to have a high susceptibility to WNV, with corresponding high levels of mortality (Clark *et al.* 2006, p. 19; McLean 2006, p. 54).

Efficacy and transmission of WNV in sagebrush habitats is primarily regulated by environmental factors including temperature, precipitation and anthropogenic water sources, such as stock ponds and coal-bed methane ponds that support mosquito vectors (Reisen *et al.* 2006, p. 309; Walker and Naugle 2011, pp. 131–132). Cold ambient temperatures generally preclude mosquito activity and virus amplification, so transmission to and in sage-grouse is most prevalent in summer (mid-May to mid-September) (Naugle *et al.* 2005, p. 620; Zou *et al.* 2007, p. 4), with a peak in July and August (Walker and Naugle 2011, p. 131). However, delayed WNV transmission in sage-grouse has occurred in years with lower summer temperatures (Naugle *et al.* 2005, p. 621; Walker *et al.* 2007b, p. 694). Furthermore, the primary vector of WNV in sagebrush ecosystems is a mosquito (*Culex tarsalis*) (Naugle *et al.* 2004, p. 711; Naugle *et al.* 2005, p. 617; Walker and Naugle 2011, p. 129). Individual mosquitoes may disperse as much as 18 km (11.2 mi) (Miller 2009, pers. comm.; Walker and Naugle 2011, p. 129) and this species is capable of overwinter survival. Infected adult mosquitoes can emerge the following spring, thereby increasing the probability of early-season occurrence and potentially reducing survival of chicks either directly or indirectly by affecting survival of hens with dependant broods (Walker and Naugle 2011, p. 130 and references therein). Overwintering may also increase the occurrence of WNV in higher elevation sage-grouse populations, where ambient temperatures would otherwise be insufficient to sustain the entire virus cycle. In non-sagebrush ecosystems, high temperatures associated with drought conditions increase WNV transmission by allowing more rapid larval mosquito development and shortening virus incubation periods (Shaman *et al.* 2005, p. 134; Walker and Naugle 2011, p. 131). Sage-grouse congregate in mesic habitats in mid- to late-summer (Connelly *et al.* 2000a, p. 971), thereby increasing exposure to mosquitoes. If WNV outbreaks coincide with drought conditions that aggregate birds near water sources, the risk of exposure will be elevated (Walker and Naugle 2011, p. 131).

Sage-grouse deaths resulting from WNV have been detected in 10 States and 1 Canadian Province and was first detected as a cause of mortalities in 2002 (Walker and Naugle 2011, p. 133). Since this time, mortalities have been documented annually in marked and unmarked individuals, with some data available to infer mortality rates. For example, in 2005, mortality rates of radio-marked birds from WNV in northeastern Wyoming and southeastern Montana were between 2.4 (estimated minimum) and 28.9 percent (estimated maximum) (Walker *et al.* 2007b, p. 693). In 2006, mortality rates in northeastern Wyoming ranged from 5 to 15 percent of radio-marked females (Walker and Naugle 2011, p. 135). A confirmed WNV outbreak in South Dakota in 2007 contributed toward a 44 percent mortality rate among radio-marked females and a mortality rate for radio-marked juvenile sage-grouse ranged between 6.5 and 71 percent in the same year, reducing recruitment the subsequent spring by 2-4 percent (Kaczor 2008, pp. 63-65). Sage-grouse mortalities from WNV also were reported in the Bi-State area, as well as other locations in Nevada, Utah, and Alberta in 2005, but no mortality rates were calculated (Walker and Naugle 2011, p. 135). In 2006, large sage-grouse mortality events, likely the result of WNV, were reported in the Jordan Valley and near Burns, Oregon (over 60 birds), and in several areas of Idaho and along the Idaho-Nevada border (over 55 birds) (Walker and Naugle 2011, p. 135). Twenty-six percent of radio-marked females in northeastern Montana died during a 2-week period immediately following the first detection of WNV in mosquitoes; two females were confirmed dead from WNV (Walker and Naugle 2011, p. 135). In the Powder River Basin, WNV-related mortality among 85 marked females was between 8 and 21 percent (Walker and Naugle 2011, p. 135).

Mortality from WNV occurs at a time of year when survival is otherwise typically high for adult sage-grouse (Schroeder *et al.* 1999, p. 14; Aldridge and Brigham 2003, p. 30) and the disease has been shown to cause population declines in populations throughout the West. Data from four studies in the eastern half of the sage-grouse range (Alberta, Montana, and Wyoming) showed survival in these populations declined 25 percent in July and August of 2003 as a result of the WNV infection (Naugle *et al.* 2004, p. 711). Sage-grouse in exposed populations were 3.4 times more likely to die during July and August, the peak of WNV occurrence, than birds in non-exposed populations (Connelly *et al.* 2004, p. 10-9; Naugle *et al.* 2004, p. 711). Subsequent declines in male and female lek attendance in infected areas in 2004 suggest outbreaks could contribute to local population extirpation (Walker *et al.* 2004, p. 4). One outbreak in 2003 was associated with the subsequent extirpation of the local breeding population, with five leks becoming inactive within 2 years (Walker and Naugle 2011, pp. 134-135). Lek surveys in northeastern Wyoming in 2004 indicated that regional sage-grouse populations did not decline, suggesting that the initial effects of WNV were localized (WGFD 2004). A 52-percent decline in the number of males attending leks in North Dakota between 2007 and 2008 also were associated with WNV mortality in 2007 (North Dakota Game and Fish Department 2008, entire; Robinson 2009, pers. comm.). The Duck Valley Indian Reservation along the border of Nevada and Idaho has experienced continued population declines resulting from WNV with a drop of 50.3 percent in average males per lek from 2005 to 2008 (Dick 2008, p. 2; Gossett 2008, pers. comm.). Therefore, these female and male deaths may be an additive source of mortality, thus potentially reducing population growth (Naugle *et al.* 2005, p. 621).

Although sage-grouse exposure to WNV typically results in death, some (albeit minimal) survival can occur. In 2005, we reported there was little evidence that sage-grouse survive WNV infection (Service 2005, p. 2270). This conclusion was based on the lack of sage-grouse found to have antibodies to the virus and from laboratory studies in which all sage-grouse exposed to the virus, at varying doses, died within 8 days (Service 2005, p. 2270; Clark *et al.* 2006, p. 17). These data suggested that sage-grouse do not develop resistance to the virus, and death is certain once an individual is exposed (Clark *et al.* 2006, p. 18). However, 6 of 58 females (10.3 percent) captured in the spring of 2005 in Wyoming and Montana were seropositive for neutralizing antibodies, which suggests they were exposed to the virus the previous fall and survived. Additional but significantly fewer (2 of 109, or 1.8 percent) seropositive females were found in the spring of 2006 (Walker *et al.* 2007b, p. 693). Of approximately 1,400 serum tests on sage-grouse from South Dakota, Montana, Wyoming and Alberta, only 8 tested positive for exposure to WNV (Cornish 2009b, pers. comm.), suggesting that survival is extremely low. Seropositive birds have not been reported from other parts of the species' range (Walker and Naugle 2011, p. 136) but the extent and distribution of testing remains largely limited and generally unknown.

Duration of WNV immunity conferred by surviving an infection is unknown (Walker and Naugle 2011, p. 136), and it is unclear whether sage-grouse have sub-lethal or residual effects resulting from an infection. Potential residual effects could include reduced productivity or overwinter survival (Walker *et al.* 2007b, p. 694). Other bird species infected with WNV have been documented to suffer from chronic symptoms, including reduced mobility, weakness, disorientation, and lack of vigilance (Marra *et al.* 2004, p. 397; Nemeth *et al.* 2006, p. 253), all of which may affect survival, reproduction, or both (Walker and Naugle 2011, p. 136).

Several variants of WNV have emerged since the original identification of the disease in the United States in 1999. One variant, termed NY99, has proven to be more virulent than the original strain, increasing the frequency of disease cycling (Miller 2009, pers. comm.). This constant evolution of the virus could limit resistance development in the sage-grouse. We are unaware of any evidence these variants have occurred in sage-grouse or within the Bi-State DPS, however, there is no indication that the species is less susceptible than other bird taxa to changes in the virus.

Walker and Naugle (2011, p. 137) modeled variability in sage-grouse population growth using vital rate means and variances from across the species range for the next 20 years based on current conditions under three WNV impact scenarios. These scenarios included: (1) No mortalities from WNV, (2) WNV-related mortality based on rates of observed infection and mortality rate data from 2003 to 2007, and (3) WNV-related mortality with increasing resistance to the disease over time. The addition of WNV-related mortality (scenario 2) resulted in a reduction of population growth (Walker and Naugle 2011, pp. 137–139). The proportion of resistant individuals in the modeled population increased marginally over the 20-year projection periods, from 4 to 15 percent, under the increasing resistance scenario (scenario 3). While this increase in the proportion of resistant individuals did reduce the projected WNV rates, the presence of neutralizing antibodies in live birds does not always indicate that these birds would be resistant to infection and disease (Walker and Naugle 2011, p. 140). Additional models predicting the prevalence of WNV suggest that new sources of anthropogenic surface waters,



increasing ambient temperatures, and a mosquito parasite that reduces the length of time the virus is present in the vector before the mosquito can spread the virus will likely result in increased impacts of this disease to sage-grouse across the range of the species (Miller 2008, pers. comm.).

Scientists have expressed concern regarding the potential for exacerbating WNV persistence and spread due to the proliferation of surface water features (Friend *et al.* 2001, p. 298; Zou *et al.* 2006, p. 1040; Walker *et al.* 2007b, p. 695; Walker and Naugle 2011, p. 140). Human-created water sources in sage-grouse habitat known to support breeding mosquitoes that transmit WNV include overflowing stock tanks, stock ponds, irrigated agricultural fields and coal-bed natural gas discharge ponds (Zou *et al.* 2006, p. 1035). In addition, water developments installed in arid sagebrush landscapes to benefit a variety of wildlife species are common including within the Bi-State area. Walker *et al.* (2007a, p. 694) concluded that impacts from WNV will depend less on resistance to the disease than on temperatures and changes in vector distribution.

The long-term response of different sage-grouse populations to WNV infections is expected to vary markedly depending on factors that influence exposure and susceptibility, such as temperature, land uses, and sage-grouse population size (Walker and Naugle 2011, p. 140). Small, isolated, or genetically limited populations are at higher risk as an infection may reduce population size below a threshold where recovery is no longer possible, as observed in an extirpated population in Wyoming (Walker and Naugle 2011, p. 140). Larger populations may be able to absorb impacts resulting from WNV as long as the quality and extent of available habitat supports positive population growth (Walker and Naugle 2011, p. 140). However, impacts from this disease may act synergistically with other stressors resulting in reduction of population size, bird distribution, or persistence (Walker *et al.* 2007a, p. 2652). WNV persists on the landscape after it first occurs as an epizootic, suggesting this virus will remain a long-term issue in affected areas (McLean 2006, p. 50).

As indicated above, WNV appears to be the only identified disease that warrants concern for sage-grouse in the Bi-State area. Small populations, such as the subpopulations within the Bi-State area, may be at high risk of extirpation simply due to their low population numbers and the additive mortality WNV causes (Christiansen and Tate, 2011, pp. 125–126). The documented loss of four sage-grouse to WNV in the Bodie (n=3) and Desert Creek-Fales (n=1) PMUs (Casazza *et al.* 2009, p. 45) has heightened our concerns about the potential impact of this disease in the Bi-State area. These mortalities represented only 4 percent of the total sage-grouse mortalities observed in the Bi-State area, but additional mortality attributed to predation could have been due in part to disease-weakened individuals. Mortality caused by disease acts in a density independent or additive manner. The fact that it can act independently of habitat and suppress a population below carrying capacity makes it a concern. Existing and developing models suggest that the occurrence of WNV is likely to increase throughout the range of the species and based on projected increases in temperature caused by changes in climate, occurrence in the Bi-State may also increase.

Much of the Bi-State area occurs at relatively high elevations with short summers, representing conditions that likely limit the extent of mosquito and WNV occurrences or possibly limit outbreaks to the years with above-average temperatures. However, the Bi-State area represents

the highest known elevation (about 2,300 m (7,545 ft) at which sage-grouse have been infected with WNV (Walker and Naugle 2011, p. 131). Casazza *et al.* (2009) captured birds in the California portions of the White Mountains, South Mono, Bodie, and Desert Creek-Fales PMUs and documented mortality as a result of WNV in two of these PMUs (Bodie and Desert Creek-Fales). The presumed low levels of mortalities caused by WNV in these locations may not be representative of the Bi-State area as a whole, as other sage-grouse subpopulations occur at lower elevations.

The impact of WNV reported by Casazza *et al.* (2009) during 2003 to 2005 in the Bi-State area may further be an underrepresentation of current conditions because WNV was first documented in California in 2003 (Reisen *et al.* 2004, p. 1369) and may not have had the opportunity to become established in the area during the course of the researchers activity. From 2004 to 2012, the U.S. Geological Survey reported 83 cases of WNV in birds (species undefined) from Mono, Douglas, Lyon, and Mineral Counties (USGS 2012c). An additional 231 cases were reported over this period in the Bi-State area in alternative hosts as well as in collected mosquitoes. While WNV appears annually present in proximity to the Bi-State area, we do not currently know if the prevalence of occurrence has been changing through time. The extent that WNV influences sage-grouse population dynamics in the Bi-State area is unknown and barring a severe outbreak, natural variations in survival and reproductive rates that drive population growth may be masking the true impact of the disease. The number of reported incidences of WNV across the Bi-State area is substantially higher in Lyon and Douglas Counties, Nevada (Pine Nut and Desert Creek-Fales PMUs). It is not clear if this is due to greater prevalence or simply reflects greater reporting or sampling rates. The majority of sage-grouse occurring in these counties are primarily associated with irrigated pasture lands during the time of year when WNV would be most prevalent. While sage-grouse are not actively monitored for the disease, no anecdotal sightings of mortalities have been reported by individual pasture landowners to date.

In summary, sage-grouse are host to a wide variety of diseases and parasites, although few have resulted in population-level effects, with the exception of WNV. Substantial new information on WNV and impacts on sage-grouse has emerged in the past six to seven years. The virus is now distributed throughout the species' range, and affected sage-grouse populations experience high mortality rates, often with large reductions in affected local population numbers. Limited information suggests that sage-grouse may be able to survive an infection; however, because of the apparent low level of immunity and continuing changes within the virus, widespread resistance is unlikely. The most significant environmental factors affecting the persistence of WNV within the range of sage-grouse are ambient temperatures and surface water abundance and development.

Available data do not suggest that WNV is currently having a population level effect on sage-grouse in the Bi-State area. Although WNV is a significant mortality factor for sage-grouse when an outbreak occurs, a complex set of environmental and biotic conditions that support the WNV cycle must coincide for an outbreak to occur. Based on our current knowledge of the virus, the relatively high elevations and cold temperatures common in much of the Bi-State area likely reduce the chance of a DPS-wide outbreak. However, there may be localized areas suitable for outbreaks such as the Desert Creek-Fales and Mount Grant PMUs that could influence these

subpopulations. And the impact on individual subpopulations from WNV outbreaks may influence the dynamics of the Bi-State DPS as a whole through the loss of redundancy to the overall population and the associated challenges of recolonizing extirpated sites through natural emigration.

The development or maintenance of anthropogenic water sources in the Bi-State area, some of which likely provide suitable conditions for breeding mosquitoes, potentially increases the likely prevalence of the virus above that which could be sustained naturally by existing water bodies such as streams and meadows. We anticipate that WNV will persist within Bi-State sage-grouse habitats indefinitely and may be exacerbated in the future by factors (e.g., climate change) that increase ambient temperatures.

### Predation

Predation of sage-grouse as a food item is the most commonly identified cause of direct mortality during all life stages (Schroeder *et al.* 1999, p. 9; Connelly *et al.* 2000b, p. 228; Casazza *et al.* 2009, p. 45; Connelly *et al.* 2011a, p. 65). However, sage-grouse have co-evolved with a variety of predators, and their cryptic plumage and behavioral adaptations have allowed them to persist (Schroeder *et al.* 1999, p. 10; Coates 2007, p. 69; Coates and Delehanty 2008, p. 635; Hagen 2011, p. 96). Until recently, there has been little published information that indicates predation is a limiting factor for the sage-grouse (Connelly *et al.* 2004, p. 10-1), particularly where habitat quality has not been compromised (Hagen 2011, p. 96). Although many predators consume sage-grouse, none specialize on the species (Hagen 2011, p. 97). However, generalist predators may have a significant effect on ground nesting birds because predator numbers are independent of prey density (Coates 2007, p. 4).

Predation of sage-grouse can occur at all life cycle stages. Major predators of adult sage-grouse include many species of diurnal raptors (especially the golden eagle), coyotes (*Canis latrans*), red foxes (*Vulpes vulpes*), and bobcats (*Lynx rufus*) (Hartzler 1974, pp. 532–536; Schroeder *et al.* 1999, pp. 10–11; Schroeder and Baydack 2001, p. 25; Rowland and Wisdom 2002, p. 14; Hagen 2011, p. 97). Juvenile sage-grouse also are killed by many raptors as well as common ravens (*Corvus corax*), badgers, red foxes, coyotes and weasels (*Mustela* spp.) (Braun 1995, entire; Schroeder *et al.* 1999, p. 10). Nest predators include badgers, weasels, coyotes, common ravens, American crows, and magpies (*Pica* spp.); sage-grouse eggs have also been consumed by elk (*Cervus canadensis*) (Holloran and Anderson 2003, p. 309) and domestic cows (*Bovus* spp.) (Coates *et al.* 2008, pp. 425–426). Ground squirrels (*Spermophilus* spp.) have also been identified as nest predators (Patterson 1952, p. 107; Schroeder *et al.* 1999, p. 10; Schroeder and Baydack 2001, p. 25), but recent data show that they are physically incapable of puncturing eggs (Holloran and Anderson 2003, p. 309; Coates *et al.* 2008, p. 426; Hagen 2011, p. 97). Several other small mammals and snakes (e.g., Great Basin gopher snakes (*Pituophis catenifer deserticola*)) have visited sage-grouse nests in Nevada, but none resulted in predation events (Coates *et al.* 2008, p. 425).

Mortality risk due to predation varies seasonally and between genders. Adult male sage-grouse are very susceptible to predation while on leks (Schroeder *et al.* 1999, p. 10; Schroeder and Baydack 2000, p. 25; Hagen 2011, p. 97), presumably because they are forgoing concealment to

facilitate female attraction during their conspicuous mating displays. Because leks are attended daily by numerous birds during the breeding season, predators may be attracted to these areas (Braun 1995, entire). Connelly *et al.* (2000b, p. 228) determined that 83 percent of the mortality among 40 radio-collared males was due to predation, with 42 percent occurring during the lekking season (March-June). Adult female sage-grouse are susceptible to predators while on the nest, but mortality rates are low (Hagen 2011, p. 97). Hens will abandon nests when disturbed by predators (Patterson 1952, p. 110), likely reducing mortality (Hagen 2011, p. 97). Connelly *et al.* (2000b, p. 228) reported that among 77 radio-collared adult hens that died, 52 percent of the mortality was due to predation, and 52 percent of those mortalities occurred between March and August, which includes the nesting and brood-rearing periods. Because sage-grouse are highly polygynous with only a few males breeding per year, sage-grouse populations are likely more sensitive to predation of females (Sedinger *et al.* 2011, p. 317). Predation of adult sage-grouse is generally thought to be low outside the lekking, nesting, and brood-rearing season (Connelly *et al.* 2000b, p. 230; Naugle *et al.* 2004, p. 711; Moynahan *et al.* 2006, p. 1536; Hagen 2011, p. 97). However, there is indication that mortality risk varies both temporally and spatially outside of the breeding season and is sufficient to affect population dynamics (Sedinger *et al.* 2011, p. 325).

In the Bi-State, there are a few studies that allow inference into adult survival. These efforts did not attempt to differentiate causes of mortality, thus comparison with predation specific studies is slightly confounded. However, given that predation is principally responsible for mortality (Schroeder *et al.* 1999, p. 9) studies assessing adult survival remain informative and afford context. From 2003 to 2005 in the California portion of the Bi-State, Farinha (2011, p. 37) discovered that survival varied by age, season, and subpopulation. The researcher reported that subadults had higher survival rates than adults and that survival was greatest during the winter. Both of these results are generally consistent with the other results across the range of the species (Connelly *et al.* 2011a, p. 65). Annual survival among subpopulations varied. Three breeding complexes including Long Valley, Parker Meadows, and Jackass Flat in the Sweetwater Mountains had estimated annual survival rates that ranged between 61 and 70 percent. The estimates are generally within but on the low side of the range of annual survival estimates reported across the range of the species (Connelly *et al.* 2011a, p. 65). Two additional breeding complexes, Bodie Hills and Fales, however, had significantly lower annual adult survival rates of 41 and 14 percent, respectively. An additional study in the Nevada portion of the Desert Creek-Fales PMU reported a similar annual survival rate of 16 percent, although this latter study had a restricted sample size ( $n=6$ ) (Sedinger *et al.* 2011, p. 324). The results of these studies suggest annual survival is low for these locations relative to other populations of sage grouse, and in the case of the Desert Creek-Fales PMU would not be consistent with a stable population (Sedinger *et al.* 2011, p. 324). An additional study conducted between 2010 and 2011 across many of the same California subpopulations as Farinha (2011), reported annual survival rates for females of 86 percent in the Bodie Hills, 47 percent in Long Valley, and 100 percent in Parker Meadows (Tebbenkamp *et al.* 2012, p. 36). The number of birds used in this analysis was relatively restricted, especially with respect to Parker Meadows, and the results are reported as apparent survival. Apparent survival is generally biased high and this bias can be as great as 90 percent (Kolada *et al.* 2009b, p. 1,345); however, in this instance the extent of this bias is undeterminable.

Range-wide, annual survival of breeding-age sage-grouse varies from 37 to 78 percent for females and 30 to 65 percent for males, with the majority of mortality attributable to predation (Schroeder and Baydack 2001, p. 25; Connelly *et al.* 2011a, p. 65). The best data available for the Bi-State DPS population estimates annual adult survival at 8 to 68 percent for males and 15 to 76 percent for females (Farinha 2011, p. 37; Sedinger *et al.* 2011, p. 324). Estimates of adult survival vary among subpopulations in the Bi-State area and while annual adult survival in most subpopulations generally falls within the expected range based on rangewide estimates, in the Desert Creek-Fales PMU adult survival is below that considered sustainable (Farinha 2011, p. 37; Sedinger *et al.* 2011, p. 324). Where good quality habitat is not a limiting factor, research suggests it is unlikely that predation influences the persistence of the species. Thus, we consider the low estimates of adult survival in the northern half of the Bi-State area to be a manifestation of habitat degradation or other anthropogenic factors that can alter natural predator-prey dynamics such as introduced nonnative predators or human-subsidized native predators.

Sage-grouse nest depredation can be total (all eggs destroyed) or partial (one or more eggs destroyed). However, hens abandon nests in either case (Coates 2007, p. 26). Gregg *et al.* (1994, p. 164) reported that over a 3-year period in Oregon, 106 of 124 nests (84 percent) were depredated; and the nests that escaped depredation had greater grass and forb cover. In Wyoming, Patterson (1952, p. 104) reported nest depredation rates of 41 percent; and Holloran and Anderson (2003, p. 309) reported a depredation rate of 12 percent (3 of 26). In a 3-year study involving four study sites in Montana, Moynahan *et al.* (2007, p. 1777) attributed 131 of 258 (54 percent) of nest failures to predation, but the rates may have been inflated by the study design (Connelly *et al.* 2011a, p. 64). In the Bi-State area, Kolada *et al.* (2009b, p. 1,344) estimated nest success as ranging from 68 to 21 percent among subpopulations. The lowest estimate was from data for Long Valley in the South Mono PMU. Tebbenkamp *et al.* (2012, p. 37) reported an average apparent nest success of 30 percent for the Bodie Hills subpopulation and a 45 percent nest success rate for the Long Valley subpopulation. While predation apparently accounted for the majority of nest loss, the authors did not assess the portion of loss attributable to abandonment. The difference in nest success among some subpopulations in the Bi-State area may be attributable to the apparent differences in the abundance of nest predators (i.e., common ravens). In Long Valley, a local landfill readily supports large numbers of common ravens and California gulls (Abele 2012, pers. obs.). A review by Connelly *et al.* (2011a, p. 58) and primarily consisting of studies reporting apparent nest success concludes that nest success varies by habitat quality and averages 51 percent in unaltered habitats and 37 percent in altered or degraded habitats. Re-nesting efforts may compensate for the loss of nests due to predation (Schroeder 1997, p. 938), but re-nesting rates are highly variable and as such is unlikely to offset losses due to predation (Connelly *et al.* 2011a, pp. 64, 67).

Estimates of predation rates on juveniles are limited (Aldridge and Boyce 2007, p. 509; Hagen 2011, p. 98). Chick mortality due to predation ranged from 10 to 51 percent in three study sites (Gregg *et al.* 2003a, p. 15; 2003b, p. 17). Mortality due to predation during the first few weeks after hatching was estimated at 82 percent (Gregg *et al.* 2007, p. 648). Crawford *et al.* (2004, p. 4 and references therein) reported survival of juveniles to their first breeding season was approximately 10 percent, and predation was one of several factors affecting juvenile survival. However, Connelly *et al.* (2011a, p. 64) note that this juvenile survival estimate is likely biased

low because some of the studies were from areas with fragmented or otherwise marginal habitat. Dahlgren *et al.* (2010, pp. 1,289–1,290) reported that predation accounted for 32 percent of juvenile mortalities and estimated that chick survival to 42 days was 50 percent. Limited data on brood success is available for the Bi-State and these studies do not differentiate between causes of mortality. Brood survival to 28 and 60 days in the Bodie Hills was 100 percent and 43 percent, respectively in 2010 (Tebbenkamp *et al.* 2012, p. 37). During 2010 and 2011 in Long Valley, brood survival averaged 82 percent and 73 percent at 28 and 60 days, respectively. In the Pine Nut PMU brood success in 2012 was 62 percent at 50 days post-hatch (USGS 2012a, p. 7).

Nesting success of sage-grouse are dependent on habitat quality. Nesting success is positively correlated with the presence of greater amounts of sagebrush, grass, and forb cover (Connelly *et al.* 2000a, p. 971) and females actively select nest sites with these qualities (Schroeder and Baydack 2001, p. 25; Hagen *et al.* 2007, p. 46). Loss of nesting cover from any source (e.g., grazing, fire) can reduce nest success and adult hen survival. Similarly, habitat alteration that reduces cover for young chicks can increase their rate of predation (Schroeder and Baydack 2001, p. 27). Connelly *et al.* (2011a, p. 17) reported that nesting success was greater in unaltered habitats. Where sage-grouse habitat has been altered, the influx of predators can decrease annual recruitment into a population (Gregg *et al.* 1994, p. 164; Braun 1995, entire; 1998, entire; DeLong *et al.* 1995, p. 91; Schroeder and Baydack 2001, p. 28; Coates 2007, p. 2; Hagen 2011, p. 100). Ritchie *et al.* (1994, p. 125), Schroeder and Baydack (2001, p. 25), Connelly *et al.* (2004, p. 7-23), and Summers *et al.* (2004, p. 523) reported that agricultural development, landscape fragmentation, and human populations have the potential to increase predation pressure on all life stages of sage-grouse by forcing birds to nest in less suitable or marginal habitats, increasing travel time through habitats where they are vulnerable to predation, and increasing the diversity and density of predators.

Abundance of red fox and corvids (e.g., ravens) has increased in association with human-altered landscapes (Sovada *et al.* 1995, p. 5). In the Strawberry Valley of Utah, low survival of sage-grouse may have been due to an unusually high density of red foxes, which apparently were attracted to that area by anthropogenic activities (Bambrough *et al.* 2000). Ranches, farms, and housing developments have resulted in the introduction of nonnative predators including domestic dogs (*Canis domesticus*) and cats (*Felis domesticus*) into sage-grouse habitats (Connelly *et al.* 2004, p. 7-23). Local attraction of ravens to nesting hens may be facilitated by loss and fragmentation of native shrublands, which increases exposure of nests to potential predators (Aldridge and Boyce 2007, p. 522; Bui 2009, p. 32). The presence of ravens is negatively associated with grouse nest and brood fate (Bui 2009, p. 27). Thus, the presence of high numbers of predators within a sage-grouse nesting area may negatively affect sage-grouse productivity without causing direct adult mortality.

Raven abundance has increased as much as 1,500 percent in some areas of western North America since the 1960's (Coates and Delhanty 2010, p. 244 and references therein). Human-made structures in the environment increase the effect of raven predation, particularly in low canopy cover areas, by providing ravens with perches (Braun 1998, pp. 145–146; Coates 2007, p. 155; Bui 2009, p. 2). Reduction in patch size and diversity of sagebrush habitat, as well as the

construction of fences, power lines, landfills, and other infrastructure also are likely to encourage the presence of the common raven (Coates *et al.* 2008, p. 426; Bui 2009, p. 4). Holloran (2005, p. 58) attributed increased sage-grouse nest depredation to high corvid abundances, which resulted from anthropogenic food and perching subsidies in areas of natural gas development in Wyoming. Bui (2009, p. 31) also found that ravens used road networks for foraging activities. Raven abundance was strongly associated with sage-grouse nest failure in northeastern Nevada, with resultant negative effects on sage-grouse reproduction (Coates and Delehanty 2010, p. 243). The authors' report that an increase of 1 raven per 10 km (6 mi) survey transect was associated with a 7.4 percent increase in nest failure. Coates (2007, pp. 85-86) suggested that ravens may reduce the time spent off the nest by female sage-grouse, thereby potentially compromising their ability to secure sufficient nutrition to complete the incubation period.

Leu and Hanser (2011, p. 270) determined that the influence of the human footprint in sagebrush ecosystems may be underestimated due to varying quality of spatial data. Therefore, the influence of ravens and other predators associated with human activities may also be underestimated. As suitable grouse habitat is lost to industrial conversion, woodlands, agriculture, and other exurban development, grouse nesting and brood-rearing become increasingly spatially restricted (Bui 2009, p. 32). High nest densities which result from habitat fragmentation or disturbance associated with the presence of edges, fencerows, or trails may increase predation rates by making foraging easier for predators (Holloran 2005, p. C37). In some areas low but consistent raven presence can have a major impact on sage-grouse reproductive behavior (Bui 2009, p. 32).

Predator removal efforts have sometimes shown short-term gains that may benefit seasonal survival rates, but there is little support of these efforts influencing population growth (Cote and Sutherland 1997, p. 402; Hagen 2011, p. 9; Leu and Hanser 2011, p. 27). Predator removal may have greater benefits in areas with low habitat quality, but predator numbers quickly rebound without continual control (Hagen 2011, p. 99). Red fox removal in Utah appeared to increase adult sage-grouse survival and productivity, but the study did not include non-removal control areas, so inferences are limited (Hagen 2011, p. 99). Slater (2003, p. 133) demonstrated that coyote control failed to have an effect on sage-grouse nesting success in Wyoming. However, coyotes may not be an important predator of sage-grouse. Johnson and Hansen (1979, p. 954) showed that sage-grouse and bird egg shells made up a very small percentage (0.4-2.4 percent) of analyzed scat samples. In addition, coyote removal can have unintended consequences resulting in the release of mesopredators, many of which, like the red fox, may have greater negative impacts on sage-grouse (Mezquida *et al.* 2006, p. 752). Removal of ravens from an area in northeastern Nevada caused only short-term reductions in raven populations (less than 1 year) as apparently transient birds from neighboring sites repopulated the removal area (Coates 2007, p. 151). Badger predation also appeared to partially compensate for decreases in ravens (Coates 2007, p. 152). Connelly *et al.* (2004, p. 10-1) noted that only two of nine studies examining survival and nest success indicated that predation had limited a sage-grouse population by decreasing nest success, and both studies indicated low nest success due to predation was ultimately related to poor nesting habitat. Bui (2009, pp. 36-37) suggested removal of anthropogenic subsidies (e.g., landfills, tall structures) may be an important step to reducing the presence of sage-grouse predators. Leu and Hanser (2011, pp. 270-271) also argue

that reducing the effects of predation on sage-grouse can only be effectively addressed by precluding these features.

Overall, predation is currently known to occur throughout the Bi-State DPS's range. It is facilitated by habitat fragmentation (fences, power lines, and roads) and other human activities that may be altering natural population dynamics in specific areas throughout the Bi-State DPS's range. By itself it is not considered a significant impact at this time, but is a concern currently and in the future based on data suggesting certain populations are exhibiting deviations in vital rates below those anticipated, including potential impacts to the Long Valley population, which is one of the two largest (core) populations for the Bi-State DPS.

In summary, sage-grouse are prey for a variety of terrestrial and avian predators but they are adapted to minimize predation by cryptic plumage and behavior; where habitat is not limited and is of good quality, predation is not a threat to the persistence of the species. However, sage-grouse may be increasingly subject to levels of predation that would not normally occur in the historically contiguous unaltered sagebrush habitats. The impacts of predation on sage-grouse can increase where habitat quality has been compromised by anthropogenic activities (Coates 2007, pp. 154, 155; Bui 2009, p. 16; Hagen 2011, p. 100). Based on this assumption, the Bodie and White Mountains PMUs are likely least affected and the remaining PMUs more susceptible. Landscape fragmentation, habitat degradation and human populations have likely increased predator populations through increasing ease of securing prey and subsidizing food sources and nest or den substrates. Thus, otherwise suitable habitat may change into a habitat sink for sage-grouse populations (Aldridge and Boyce 2007, p. 517). Anthropogenic influences on sagebrush habitats that increase suitability for ravens may limit sage-grouse populations (Bui 2009, p. 32). Current land-use practices in the intermountain West (including the Bi-State area) favor high predator (in particular, common raven) abundance relative to historical numbers (Coates *et al.* 2008, p. 426).

In addition to adult mortality, predation is typically the principal cause of nest loss and a key determinant in sage-grouse population dynamics (Schroeder *et al.* 1999, p. 15). Nest success across the California portion of the Bi-State area is within the normal range, with some locations even higher than previously documented (Kolada 2009a, p. 1,344). Thus, the potential negative impact to population growth caused by changes in this vital rate is not currently apparent. However, the lowest estimates occur in Long Valley (South Mono PMU; 21 percent; Kolada 2009a, p. 1,344), which is of concern as this is a core population for the species in the Bi-State area and is also the population most likely exposed to the greatest amount of nest predators (Kolada *et al.* 2009b, p. 1,344). Although significantly more birds were present in the past, the Long Valley population (South Mono PMU) appears stable. The negative impact from reduced nesting success in this location is presumably being offset by other demographic statistics such as high chick or adult survival. We do not currently have estimates of nest success from areas within the Nevada portion of the Bi-State DPS.

Data are limited that definitively link sage-grouse population trends with predator abundance; however, where habitats have been altered by human activities, it is possible that predation could be limiting local sage-grouse populations. This may be occurring across the entire Bi-State area but based on available information the PMUs that are known or suspected to be at least partially



influenced include: Pine Nut, Desert Creek-Fales, and South Mono. The degree of nest depredation is variable among Bi-State area subpopulations and potentially influenced by the extent of human-subsidized predators. As more habitats face development (including roads, power lines and other anthropogenic features such as landfills, airports and urbanization), even dispersed development, we expect the risk of increased predation to spread, possibly with negative effects on the sage-grouse population trends.

#### *Small Population Size and Population Structure*

Sage-grouse have comparatively low reproductive rates and high annual survival (Schroeder *et al.* 1999, pp. 11, 14; Connelly *et al.* 2000a, pp. 969-970), resulting in slower potential or intrinsic population growth rates than is typical of other game birds. Therefore, recovery of populations after a decline may require years. Also, as a consequence of their site fidelity to seasonal habitats (Lyon and Anderson 2003, p. 489), measurable population effects may lag behind negative habitat impacts (Wiens and Rotenberry 1985, p. 666). Sage-grouse populations have classically been described as exhibiting multi-annual fluctuations; meaning, that some mechanism or combination of mechanisms is causing populations to fluctuate through time. Fedy and Doherty (2010, entire) demonstrated these fluctuations represented true cycles and document duration of seven to eight years for each cycle in Wyoming. Furthermore, Blomberg *et al.* (2012, p. 9) showed annual rates of population growth in sage-grouse was strongly influenced by the weather, especially annual rainfall that generally support vegetation and insect production and presumably improves recruitment. Generally, in long-lived species selective pressures tend to stabilize survival, which in turn leads to adaptations that minimize survival costs associated with reproducing in years of limited resources. These studies suggest that ultimately population maintenance in sage-grouse, a generally long-lived and low reproductive species, depends on relatively stable adult survival rate, punctuated by periodic pulses of recruitment (Blomberg *et al.* 2012, pp. 11–12). While these natural history characteristics would not limit sage-grouse populations across large geographic scales under historical conditions of extensive habitat, they may contribute to local population declines or extirpations when populations are small or weather patterns, habitats or mortality rates are altered.

In the Bi-State area, Farinha (2011, p. 37) determined that adult survival varied among subpopulation within the California portion of the Bi-State DPS. The researcher reports that annual adult female survival for the breeding complexes located near Sonora Junction, California (Desert Creek-Fales PMU) and in the Bodie Hills (Bodie PMU) averaged 18 and 47 percent, respectively from 2003 to 2005. Annual adult survival (males and females combined) for these same two breeding complex averaged 14 and 41 percent. Sedinger *et al.* (2011, p. 324) derived a similar adult survival estimate (16 percent) for the Nevada portion of the Desert Creek-Fales PMU. Survival estimates for all three locations are low in comparison to rangewide estimates and the two breeding complexes contained within the Desert Creek-Fales PMU are considered to be unusually low and would not be consistent with a stable population (Sedinger *et al.* 2011, p. 324). Within three additional breeding complexes (Sweetwater Mountains, Parker Meadow, and Long Valley annual adult female survival ranged from 64 to 76 percent and annual adult survival ranged from 59 to 72 percent (Farinha 2011, p. 37). These estimates fall more comfortably within range of survival estimates reported elsewhere. However, Wiechman (2013, p. 94)

determined that female survival did not differ between subpopulation and estimated average adult female survival in the South Mono PMU (Long Valley) and Bodie PMU (Bodie Hills) as 43 percent. These data, collected from 2007 to 2009 compare well with Fahrina's results in the Bodie PMU. However, Wiechman's (2013, p. 94) estimate of 43 percent annual adult female survival is substantially lower than the estimated 74 percent for this subpopulation reported by Fahrina (2011, p. 37).

In addition to adult survival, nesting success in sage-grouse populations is influential in population growth (Connelly *et al.* 2011a, pp. 64–65). In the Bi-State area, Kolada *et al.* (2009b, p. 1,344) developed model estimates of nest success and reported a range from 68 to 21 percent among subpopulations, with the lowest estimate derived from data for Long Valley in the South Mono PMU. Furthermore, Tebbenkamp *et al.* (2012, p. 37) reported an average apparent nest success of 30 percent for the Bodie Hills subpopulation and a 45 percent nest success rate for the Long Valley subpopulation. And, preliminary results from the Pine Nut PMU suggest apparent nest success based on 15 females is 33 percent (USGS 2012a, p. 7). A review by Connelly *et al.* (2011, p. 58) and primarily consisting of studies reporting apparent nest success concludes that nest success varies by habitat quality and averages 51 percent in unaltered habitats and 37 percent in altered or degraded habitats. Connelly *et al.* (2011a, pp. 66–67) suggest that given average nest success (46 percent), number of non-nesting females (18 to 22 percent), and typical rate of renesting (20 to 30 percent), combined with the fact that sage-grouse produce only one brood per season and generally have low chick survival makes it unlikely to produce rapidly increasing populations, even under the best circumstances.

Based on radio-telemetry and genetic data, sage-grouse subpopulations in the Bi-State area appear to be isolated to varying degrees from one another (Casazza *et al.* 2009, entire; Oyler-McCance and Casazza 2011, p. 10; Tebbenkamp 2012, p. 66). Birds in the White Mountains PMU as well as those in the South Mono PMU are largely isolated from sage-grouse subpopulations in the remainder of the Bi-State DPS and apparently from one another (Casazza *et al.* 2009, pp. 34, 41; Oyler-McCance and Casazza 2011, p. 10; Tebbenkamp 2012, p. 66). The isolation of populations occurring to the north of Mono Lake is less clear. Telemetry data demonstrate birds in the Bodie and Mount Grant PMUs share habitat during parts of the year, as do birds in both the Nevada and California portions of the Desert Creek-Fales PMU (Casazza *et al.* 2009, pp. 13, 21). However, movement of birds between Mount Grant and Desert Creek-Fales or Bodie and Desert Creek-Fales PMUs appears more restricted (Tebbenkamp 2012, p. 66). Traditionally the Pine Nut PMU was presumed isolated; however, recent GPS telemetry data show birds (n=2) are capable of moving south into the Sweetwater Mountains in the Desert Creek-Fales PMU and even further south into the Bodie PMU. The porosity of this corridor is not currently known nor is the degree to which dispersal events are successful. Based on about 150 marked individuals, no dispersal events were documented among any of the PMUs, suggesting that even though some populations were mixing during certain times of the year, there was no documented integration among breeding individuals (Farinha 2008, pers. comm.). While adults are unlikely to switch breeding subpopulations, it is likely that genetic material is transferred among these northern populations through the natural movements of young of the year birds, as long as there are established populations available to emigrate into. Telemetry studies do not frequently mark subadult birds but generally sage-grouse populations are most

influenced by birth and death rates and dispersal is considered to be infrequent (Connelly *et al.* 2011a, pp. 59–61).

Sage-grouse have one of the most polygamous mating systems observed among birds (Deibert 1995, p. 92). Asymmetrical mate selection (where only a few of the available members of one sex are selected as mates) should result in reduced effective population sizes (Deibert 1995, p. 92), meaning the actual amount of genetic material contributed to the next generation is smaller than predicted by the number of individuals present in the population. Furthermore variation in female reproductive success, fluctuating population size, and unequal sex ratios all reduce effective population size (Frankham 1995, p. 796; Stiver *et al.* 2008, p. 473). Traditionally, a limited percentage of males in a population were assumed to breed each year (approximately 10 to 15 percent) (Aldridge and Brigham 2003, p. 30); however recent evidence of off-lek copulations by subordinate males, as well as multiple paternity within a clutch suggests that the percentage of the male population successfully breeding may be closer to 50 percent (Connelly *et al.* 2004, p. 8-2; Bush 2009, p. 108). In addition, sage-grouse populations are known to fluctuate (Fedy and Doherty 2010, entire), there is variation in female reproductive success (both annually and among age classes) (Connelly *et al.* 2011a, p. 63), and there is typically assumed a female skewed sex ratio ranging from one to three females per male (Connelly *et al.* 2011a, p. 66). Each of these influencing factors on effective population size occurs in the Bi-State DPS and suggests population sizes in sage-grouse must be greater than in non-lekking bird species to maintain long-term genetic diversity.

Effective population size is defined as the size of the idealized population of breeding adults that would experience the same rate of loss of heterozygosity, change in the average inbreeding coefficient, or change in variance in allele frequency through genetic drift as the actual population (Frankham *et al.* 2002, pp. 312–317). As effective population size decreases, the rate of loss of genetic diversity increases. The consequences of this loss of genetic diversity, reduced fitness through inbreeding depression and reduced adaptive (evolutionary) potential, are thought to elevate extinction risk (Frankham 2005, p. 135). Captive studies suggest effective population size should exceed 50 to 100 individuals to avoid short term extinction risk caused by inbreeding depression and mathematical models suggest that effective population size should exceed 500 individuals to retain evolutionary potential and avoid long-term extinction risk. However, some estimates of effective population size necessary to retain evolutionary potential are as high as 5,000 individuals (Lande 1995, p. 789).

The effective population size of a wildlife population is often much less than its actual size. We are unaware of specific data or literature that definitively identifies the number of sage-grouse needed to maintain an effective population size of birds that would also result in a viable population. However, some literature exists to help us understand the complexities of answering this question for the Bi-State DPS or any other region within the range of the greater sage-grouse. Aldridge and Brigham (2003, p. 30) estimated that up to 5,000 individual sage-grouse may be necessary to maintain an effective population size of 500 birds. Their estimate was based on individual male breeding success, variation in reproductive success of males that do breed, and the death rate of juvenile birds. Similarly, Trail *et al.* (2010, p. 32) concluded from a meta-analysis based on a wide array of species that a minimum viable population size (actual

population size) necessary for long-term persistence should be on the order of 5,000 adult individuals, though others have argued a minimum viable population from 2 to 10 times this figure (Franklin and Frankham 1998, p. 70; Lynch and Lande 1998, p.72). However, Flather *et al.* (2011, entire) counter that there is no magic minimum population size number and extinction risk depends on a complex interaction between life history strategies, environmental context and threat. Empirical data from Colorado showed the effective population size in Gunnison sage-grouse to be about 20 percent of actual population size (Stiver *et al.* 2008, p. 478). We are unaware of any other published estimates of minimal population sizes necessary to maintain genetic diversity and long-term population sustainability in sage-grouse and specifically for the Bi-State DPS.

For the purposes of this analysis, we estimated the effective population size of the Bi-State DPS using a formula developed by Sewall Wright (1938):

$$N_e = \frac{1}{\frac{1}{N_m} + \frac{1}{N_f}}$$

Where  $N_e$  is effective population size,  $N_m$  = number of successfully breeding males, and  $N_f$  = number of successfully breeding females. We assumed Bush's (2009, p. 108) estimate that the number of successfully breeding males was 46 percent of the population and that the percent of successfully breeding females in the population was 43 percent (Kolada 2009a, p. 1,344). In addition, we adopted the approach used by NDOW and CDFW to estimate population size ( $N$ ) based on annual lek counts, which assumes the number of males counted on leks represents 75 percent of actual males in the population, an assumed sex ratio of 2 adult female per adult male and a lek detection rate that varies between 75 and 95 percent. For example, 418 males were counted on leks in Long Valley (South Mono PMU) in 2012. Dividing 418 by 0.75 provides a total male estimate of 557 for the subpopulation. Multiplying this number by 46 percent (breeding males; Bush 2009, p. 108) provides an estimate of  $N_m = 256$ . For females we used the total male estimate and multiply by 2 (sex ratio) to derive a total female population size of 1,115. Multiplying this number by 43 percent (nest success; Kolada 2009a, p. 1,344) provides an estimate of  $N_f = 479$ . Using the equation above we derive an effective population estimate for Long Valley of  $N_e = 167$ .

Isolated populations are typically at greater risk of extinction due to genetic and demographic concerns such as inbreeding depression, loss of genetic diversity, and Allee effect (the difficulty of individuals finding one another), particularly where populations are small (Lande 1988, pp. 1456–1457; Stephens *et al.* 1999, p. 186; Frankham *et al.* 2002, pp. 312–317). Over the past decade, estimates of the Bi-State DPS spring breeding population has ranged between approximately 1,860 and 7,160 individuals annually (CDFW 2012, *in litt.*; NDOW 2012, *in litt.*). Using the equation above to determine effective population size in the Bi-State area, the estimated annual effective population size (for the entire Bi-State area) is estimated to be about 200 to 700 sage-grouse (Service 2012, unpublished data). Genetic and radio-telemetry studies, however, suggest that some sage-grouse populations in the Bi-State area are isolated suggesting that the effective population size is actually less (Table 4). Based on these data, we used the

equation above to calculate the effective population size for five generally discrete populations in the Bi-State to provide context surrounding long-term genetic viability of these units (Table 4)

The Bi-State DPS is relatively small and both geographically and genetically isolated from the remainder of the greater sage-grouse distribution (see the “Historical Range/Distribution” section above). As with isolated populations of sage-grouse across their range, this scenario presents challenges to population persistence through increased risk caused by genetic, demographic, or stochastic environmental events. However, available data suggest genetic diversity in the Bi-

**Table 4.** Range in population size and effective population size estimates by Population Management Unit (PMU) between 2002 and 2012 for the Bi-State area, Nevada and California.

<b>PMU</b>	<b>Estimated population size range 2002–2012</b>	<b>Estimated effective population size range 2002–2012</b>
<b>Pine Nut</b>	50–331	4–25
<b>Desert Creek-Fales</b>	317–1,268	29–95
<b>Mount Grant and Bodie</b>	635–3,812	59–259
<b>South Mono</b>	859–2,005	81–170
<b>White Mountains</b>	No Data	No Data

State area is currently high (Oyler-McCance and Quinn 2011, p. 18). Thus, we currently have no indication that genetic factors such as inbreeding depression, hybridization, or loss of genetic diversity place the Bi-State DPS at immediate risk. However, recent genetic analysis shows that subpopulations in the Bi-State area have unique detectable qualities that allow differentiation from one another (Oyler-McCance and Casazza 2011, p. 12; Tebbenkamp 2012, p. 66). Also, the Parker Meadows area (a single isolated lek system located in the South Mono PMU) is experiencing a disproportionately high degree of nest failures due to nonviable eggs (Gardner 2009, pers. comm.) suggesting a possible manifestation of genetic challenges and indeed this small breeding complex has the lowest reported genetic diversity in the Bi-State area. While concerns over genetic diversity may or may not be apparent today, the estimated effective population sizes for the Bi-State DPS are small and below theoretical thresholds suggested necessary for long-term persistence. Conservation and enhancement of the current genetic diversity levels is likely important for long-term viability of the Bi-State DPS.

In addition to the potential negative effects to small populations due to genetic considerations, small populations such as those found in the Bi-State area are at greater risk from stochastic events such as disease epidemics, prey population crashes, or environmental catastrophes. Interactions between climate change, drought, wildfire, WNV, and the limited potential to

recover from population downturns or extirpations place significant challenges to the persistence of the Bi-State DPS of sage-grouse.

The Bi-State DPS is comprised of approximately 43 active leks representing 4 to 8 relatively discrete populations (see “Species Information” section above and the “Current Range/Distribution and Population Estimates/Annual Lek Counts”. Research has shown fitness and population size within the Bi-State DPS are strongly correlated and smaller populations are more subject to environmental and demographic stochasticity (Keller and Waller 2002, pp. 239-240; Reed 2005, p. 566). Each population is relatively small and below theoretical minimum for long-term persistence as is the entire DPS on average. Our estimates of effective population size suggest that genetic challenges will likely influence long-term viability if connectivity among populations does not improve. When coupled with mortality stressors related to human activity and significant fluctuations in annual population size, long-term persistence of small populations (in general) is unlikely (Traill *et al.* 2010, entire). The Pine Nut PMU has the smallest number of sage-grouse of all Bi-State area PMUs (usually less than 100 individuals, and ranging from 50 to 331 individuals as observed from data collected between 2002 and 2012 (Table 1), representing approximately 5 percent of the DPS). However, each population in the Bi-State DPS is relatively small and below theoretical minimum threshold (as interpreted by species experts and not statistically proven) for long-term persistence, as is the entire DPS on average (estimated 1,833 to 7,416 individuals).

Overall, this threat occurs throughout the Bi-State DPS’s range and is considered a significant threat to the species both currently and in the future. This is based on our understanding of the overall DPS population size and the apparent isolation among populations contained within the DPS, as inferred from demographic and genetic investigations. This understanding combined with the collective literature available that demonstrates both long-term population persistence and evolutionary potential is challenged in small populations. This literature shows that thousands of individuals are required for a population to have an acceptable degree of resilience in the face of environmental fluctuations and catastrophic events, and ensuring the continuation of evolutionary process.

### *Pesticides and Herbicides*

We are unaware of information to suggest that pesticides and herbicides are significantly impacting the Bi-State DPS currently (if at all) or expected to do so in the future. However, a few studies have examined the effects of pesticides to sage-grouse, and direct mortality as a result of pesticide applications (such as insecticides and pesticides applied via cropland spraying) has been documented from two studies. Two separate incidences involving organophosphorus insecticides (methamidophos and dimethoate) resulted in mortality events ranging from 5 to 41 percent of the sage-grouse exposed (Blus *et al.* 1989; p. 1142, Blus and Connelly 1998, p. 23). Both methamidophos and dimethoate remain registered for use in the United States (Christiansen and Tate 2011, p. 125). Cropland spraying may affect populations that are not adjacent to agricultural areas, given the distances traveled by females with broods from nesting areas to late brood-rearing areas (Knick *et al.* 2011, p. 211). The actual footprint of this effect cannot be estimated, because the distances traveled to reach irrigated and sprayed fields are unknown

(Knick *et al.* 2011, p. 211). Similarly, mortalities from pesticides may be underestimated if sage-grouse disperse from agricultural areas after exposure.

Mortality of sage-grouse following probable pesticide exposure has been documented. In 1950, rangelands treatments with toxaphene and chlordane bait to control grasshoppers resulted in game bird mortality of 23.4 percent (Christian and Tate 2011, p. 125). Forty-five sage-grouse deaths were recorded, 11 of which were most likely related to the pesticide (Christiansen and Tate 2011, p. 125, and references therein). Other sage-grouse mortality from vehicle collisions and mowing machines in the same area was likely related to pesticide ingestion (Christian and Tate 2011, p. 125). Neither of these chemicals has been registered for grasshopper control since the early 1980's (Christiansen and Tate 2011, p. 125, and references therein).

Game birds that ingest sub-lethal levels of pesticides exhibit abnormal behavior that may lead to a greater risk of predation (Dahlen and Haugen 1954, p. 477; McEwen and Brown 1966, p. 609; Blus *et al.* 1989, p. 1141). McEwen and Brown (1966, p. 689) reported that wild sharp-tailed grouse poisoned by malathion and dieldrin exhibited depression, dullness, slowed reactions, irregular flight, and uncoordinated walking. No research has explicitly studied the indirect levels of mortality from sub-lethal doses of pesticides (e.g., predation of impaired birds), but it is assumed to be the reason for additional mortality among study birds (McEwen and Brown 1966 p. 609; Blus *et al.* 1989, p. 1142; Connelly and Blus 1991, p. 4). Post (1951, p. 383) and Blus *et al.* (1989, p. 1142) located depredated sage-grouse carcasses in areas that had been treated with insecticides. Sage-grouse mortalities also were documented in a study where they were exposed to strychnine bait used to control small mammals (Schroeder *et al.* 1999, p. 16). Currently strychnine is registered for use only below ground as a bait application to control pocket gophers (*Thomomys* sp.; Environmental Protection Agency (USEPA) 1996, p. 4).

Much of the research related to pesticides with either lethal or sub-lethal effects on sage-grouse was conducted on pesticides that have been banned or that have had use restrictions in place for more than 20 years (e.g., dieldrin, strychnine). We are unaware of any information that banned pesticides are having negative impacts to sage-grouse populations through either illegal use or residues in the environment.

Reductions in insect populations resulting from insecticide application can potentially affect nesting sage-grouse females and chicks (Willis *et al.* 1993, p. 40; Schroeder *et al.* 1999, p. 16). Eng (1952, pp. 332, 334) noted that after pesticide spraying to reduce grasshoppers, songbird and corvid nestling deaths ranged from 50 to 100 percent depending on the chemical used, and it appeared that nestling development was negatively impacted due to the reduction in grasshoppers. Potts (1986 as cited in Connelly and Blus 1991, p. 93) determined that reduced food supply resulting from the use of pesticides ultimately resulted in high starvation rates of partridge chicks (*Perdix perdix*). In a similar study on partridges, Rands (1985, pp. 51–53) found that pesticide application negatively impacted brood size and chick survival by reducing chick food supplies.

Three approved insecticides (i.e., carbarayl, diflubenzuron, and malathion) are currently available for application across the extant range of sage-grouse as part of implementation of the Rangeland Grasshopper and Mormon Cricket Suppression Control Program under the direction

of the Animal and Plant Health Inspection Service (APHIS) (APHIS 2004, entire). Carbaryl is applied as bait, while diflubenzuron and malathion are sprayed. APHIS requires that application rates be in compliance with EPA regulations, and APHIS has general guidelines for buffer zones around sensitive species habitats. These pesticides are only applied for grasshopper and Mormon cricket (*Anabrus simplex*) control when requested by private landowners (APHIS 2004, entire). Due to delays in developing nationwide protocols for application procedures, APHIS did not perform any grasshopper or Mormon cricket suppression activities in 2006, 2007, or 2008 (Gentle 2008, pers. comm.).

In the Rangeland Grasshopper and Mormon Cricket Suppression Program Final Environmental Impact Statement, APHIS (2002, p. 10) concluded that there “is little likelihood that the insecticide APHIS would use to suppress grasshoppers would be directly or indirectly toxic to sage-grouse. Treatments would typically not reduce the number of grasshoppers below levels that are present in non-outbreak years.” APHIS (2002, p. 69) stated that although “malathion is also an organophosphorus insecticide and carbaryl is a carbamate insecticide, malathion and carbaryl are much less toxic to birds” than other insecticides associated with effects to sage-grouse or other wildlife. The APHIS (2002, pp. 122–184) risk assessment for this EIS determined that the grasshopper treatments would not directly affect sage-grouse. As to potential effects on prey abundance, APHIS noted that during “grasshopper outbreaks when grasshopper densities can be 60 or more per square meter, grasshopper treatments that have a 90 to 95 percent mortality still leave a density of grasshoppers (3 to 6) that is generally greater than the average density found on rangeland, such as in Wyoming, in a normal year.”

Herbicide applications are also known to kill sagebrush and forbs important as food sources for sage-grouse (Call and Maser 1985, p. 14). The greatest impact resulting from a reduction of either forbs or insect populations is for nesting females and chicks due to the loss of potential protein sources that are critical for successful egg production and chick nutrition (Johnson and Boyce 1991, p. 90; Schroeder *et al.* 1999, p. 16). A comparison of applied levels of herbicides with toxicity studies of grouse, chickens, and other game birds concluded that herbicides applied at recommended rates should not result in sage-grouse poisonings (Call and Maser 1985, p. 15). To date, no large mortality events have been reported in the Bi-State area that could be assumed caused by pesticide application.

In summary, pesticides can result in direct mortality of individuals and also can reduce the availability of food sources (insects and forbs), which in turn could contribute to mortality of sage-grouse. We could find no information to indicate that the use of these chemicals within the Bi-State area, at current levels, negatively affects sage-grouse population numbers, nor are they expected to do so in the future. Many of the pesticides that have shown effects on sage-grouse have been banned or otherwise restricted in the United States for more than 20 years. As previously noted, we currently do not have any information to show that these pesticides or herbicides are presently having negative impacts to sage-grouse populations through either illegal use or residues in the environment within the Bi-State area. Further we are unaware of any information to suggest the level of pesticide and herbicide use will increase in the future.



## *Contaminants*

Sage-grouse exposure to various types of environmental contaminants (concentrated salts, petroleum products, or other industrial chemicals) may occur as a result of agricultural and rangeland management practices, mining, energy development and pipeline operations, and transportation of hazardous materials along highways and railroads. In the Bi-State area, exposure to contaminants associated with mining is the most likely to occur (see “Mining” section above). Limited operating mines occur within the occupied range of sage-grouse populations in the Bi-State area. Exposure to contaminated water in wastewater pits or evaporation ponds could cause mortalities or morbidity of sage-grouse. However, the number of sage-grouse in the immediate vicinity of these facilities would be small due to the typically intense human activity, the lack of cover around these ponds, and because sage-grouse do not require free water. Most bird mortalities recorded in association with industrial artificial ponds are water-dependent species (e.g., waterfowl); dead ground-dwelling birds are rarely found (Domenic 2008, pers. comm.). However, if wastewater pits are not appropriately screened, sage-grouse may access them and ingest contaminated water or become immersed while pursuing insects. Currently, it appears unlikely that the Bi-State DPS is impacted by contaminants, although if there are any impacts that might occur they would be limited to the Pine Nut and Mount Grant PMUs based on the location of and type of current mining practices (see “Mining” section above). Future impacts are undeterminable but mineral operations typically have associated waste facilities and the greatest likelihood of additional development will occur in the Pine Nut and Mount Grant PMUs.

## *Existing Regulatory Mechanisms*

This section examines whether threats to the greater sage-grouse are adequately addressed by existing regulatory mechanisms. Existing regulatory mechanisms that could provide some protection for greater sage-grouse include: (1) Local land use laws, processes, and ordinances; (2) State laws and regulations; and (3) Federal laws and regulations. Regulatory mechanisms, if they exist, may preclude the need for listing if such mechanisms are judged to adequately address the threats to the species such that listing is not warranted. Conversely, threats on the landscape continue to affect the species and may be exacerbated when not addressed by existing regulatory mechanisms, or when the existing mechanisms are not adequate (or not adequately implemented or enforced). We cannot predict when or how local, State, or Federal laws, regulations, and policies will change; however, most Federal land use plans are valid for at least 20 years.

### Local Regulatory Mechanisms

Approximately 8 percent of the land in the Bi-State area is privately owned or owned by a State or County (Bi-State Local Planning Group 2004, pp. 11, 32, 63, 102, 127, 153). County-level master plans and ordinances sometimes contain certain policies or provisions which impart deference to wildlife species (such as sage-grouse) and wildlife habitat, potentially influencing local decisions concerning land use. Although they may provide direct or indirect conservation benefits to sage-grouse and their habitats now or in the future, the majority of these are of a non-regulatory nature and, as such, they are not being evaluated for their inadequacy as regulatory mechanisms. The local land use laws, processes, and

ordinances that we evaluated are identified in Appendix C. The jurisdictions covered include: Alpine and Mono Counties, California, and Carson City, Douglas, Esmeralda, Lyon, Mineral, and Storey Counties, Nevada.

When County regulations identify the need for natural resources conservation, they are to be commended for their vision. To our knowledge, County policies and ordinances have not precluded development but have, at times, limited development through restrictions on parcel subdivisions and the extent of development that can occur. For example, a recent 48-ha (120-ac) parcel subdivision potentially affecting the Fales breeding complex in the Desert Creek-Fales PMU was restricted by Mono County to three 16-ha (40-ac) parcels and, the County further limited the number of buildings that could be established on each subdivided parcel. Despite these zoning restrictions, a residential home was constructed in 2011 within several hundred meters of one of two extant leks in the area. Beyond zoning restrictions, actual habitat loss is generally not regulated or monitored; therefore, conversion of sagebrush habitat (i.e., to pasture) would not come before a county zoning commission. In the above example, it remains to be known the impact this level of development will have on sage-grouse use of the area. In other locations such as the Pine Nut PMU and adjacent to the Desert Creek breeding complex (Desert Creek-Fales PMU), more intensive residential development has occurred. It is not known the degree to which these developments were constrained by County regulations, but development has influenced sage-grouse use of these areas. Thus, while there may be minimization measures available to County zoning commissions, it is not apparent that local restrictions can be enacted to a degree that would minimize habitat loss.

### State Regulatory Mechanisms

State agencies directly manage approximately 1 percent of the total sagebrush landscape in the Bi-State area. State laws and regulations provide: (1) Specific authority for sage-grouse conservation on State lands; broad authority to regulate and protect wildlife on all lands within their borders; and a mechanism for indirect conservation through regulation of threats (e.g., noxious weeds) to the species. Both Nevada and California have State laws and regulations that identify the need to conserve wildlife populations and habitat, including sage-grouse (Connelly *et al.* 2004, pp. 2-2 to 2-6). However, these laws and regulations are general in nature, do not provide specific direction to State wildlife agencies, or afford regulatory authority over habitat preservation. Therefore, they afford limited protection to sage-grouse habitat. Also, the interpretation of these provisions is prone to change based on direction provided through their respective Governors' Offices.

### California Fish and Game Codes (CFGC)

It is the policy of the State of California to “encourage the preservation, conservation, and maintenance of wildlife resources” (CFGC, Title 14, Part 1, Chapter 8, section 1801). CFGC section 1301 states that “it is the policy of the State to acquire and restore to the highest possible level, and maintain in a state of high productivity, those areas that can be most successfully used to sustain wildlife and which will provide adequate and suitable recreation. To carry out these purposes, a single and coordinated program for the acquisition

of lands and facilities suitable for recreational purposes, and adaptable for conservation, propagation, and utilization of the fish and game resources of the State, is established.” This regulation allows for State land purchases and State easements with private landowners in California. CFGC section 3684 specifically funds acquisitions and easements of upland game bird habitat. Land acquisitions in excess of 5,650 ha (14,000 ac) have been completed that provide some utility to sage-grouse in the Bi-State area. For example, CDFW recently purchased 470 ha (1,160 ac) in the Desert Creek-Fales PMU largely for the conservation of sage-grouse (Taylor 2008, pers. comm.). We consider these activities to have great benefit and recognize that they are used strategically. However, given the capacity to purchase lands is relatively limited and few acquisitions have been completed to date, the degree to which these policies and regulations and their application can offset sage-grouse habitat loss throughout the Bi-State area remains uncertain.

Under CFGC sections 3682 and 3683, greater sage-grouse in the Bi-State area are managed by CDFW as resident native game birds. The game bird classification allows the direct taking of greater sage-grouse during hunting seasons authorized and conducted under State laws and regulations. Sage-grouse are currently hunted on the California side of the Bi-State DPS. Sage-grouse are hunted under a limited quota permit system in two zones in the Bi-State DPS where populations are most robust and healthy: North Mono Hunt Unit (Bodie Hills portion of the Bodie PMU) and South Mono Hunt Unit (Long Valley portion of the South Mono PMU). Sage-grouse are not hunted in the Desert Creek-Fales PMU, the White Mountains PMU, or in the Mono Basin portions (Parker Creek, Granite Mountain, and Adobe Valley) of the South Mono PMU.

The current permit system allows CDFW to closely control harvest of sage-grouse. In past decades, unlimited numbers of hunters led to several closures of the sage-grouse season in California, the most recent of which was from 1983 to 1986 (Gardner 2008, pers. comm.). Hunting resumed in California under the permit system in 1987, which was based on intensive lek counts to estimate the annual size of the breeding population. Since then, CDFW has continued to propose increasingly conservative numbers of permits and reduce hunt zones to areas with the largest populations. Current regulations are designed to keep the harvest at less than five percent of the projected fall population (Gardner 2012, pers. comm.). Despite population increases in each of the hunt zones between 2010 and 2012, no increases have been made in the number of permits since the 2009 season (CDFW 2012, in litt.). Actual harvest in recent years is generally about 20 birds per Hunt Unit and usually less than 3 percent of the projected fall population (CDFW 2012, in litt.). Hunting and other State regulations that deal with issues such as harassment provide adequate protection for individual birds, but do not protect habitat; therefore, the protection afforded through the aforementioned State regulatory mechanisms are limited in their scope.

#### Nevada Revised Statutes (NRS)

NRS 501.100 states “preservation, protection, management and restoration of wildlife within the State contribute immeasurably to the aesthetic, recreational and economic aspects of these natural resources.” NRS 321.5977 provides the following objectives in administering Nevada

public lands: “The public lands of Nevada must be administered in such a manner as to conserve and preserve natural resources, wildlife habitat, wilderness areas, ... and to permit the development of compatible public uses for recreation, agriculture, ranching, mining and timber production and the development, production and transmission of energy and other public utility services under principles of multiple use which provide the greatest benefit to the people of Nevada.” Multiple use objectives were not established to ensure that Nevada public lands are managed for conservation of sage-grouse or sagebrush habitats.

The State of Nevada Board of Wildlife Commissioners, under the authority of NRS sections 501.181, 503.090, 503.140, and 503.245, adopts regulations (seasons, bag limits, and special regulations) for the management of upland game birds, such as sage-grouse. In the Bi-State area and throughout Nevada, greater sage-grouse are managed as resident native game birds by NDOW. The game bird classification allows the direct taking of greater sage-grouse during hunting seasons authorized and conducted under State laws and regulations. However, sage-grouse have not been hunted in the Nevada portion of the Bi-State area since 1997.

Under NRS 501.181 3(c), the Commissioners also establish policies for acquisition of lands, water rights, easements, and other property for the management, propagation, protection, and restoration of wildlife. No land acquisitions or easements have been made in the Bi-State area by the State of Nevada for sage-grouse or other wildlife to date.

### **Executive Orders**

On September 26, 2008, the Governor of Nevada signed an Executive Order (EO 2008-19) calling for the preservation and protection of sage-grouse habitat in the State of Nevada (Nevada Executive Order 2008, entire). The EO directs NDOW to continue to work with State and Federal agencies and the interested public to implement the Nevada sage-grouse conservation plan (Nevada Executive Order 2008, p. 1). The EO also directs other State agencies to coordinate with NDOW in these efforts (Nevada Executive Order 2008, p. 1). The EO does not outline specific measures that will be undertaken to reduce threats and ensure conservation of sage-grouse in Nevada.

On March 30, 2012, the Governor of Nevada signed EO 2012-09 establishing a Greater Sage-Grouse Advisory Committee (Nevada Executive Order 2012a, entire). The Committee was tasked with developing recommendations on policies and actions that could form the basis for a State-wide strategy to preclude the need to list the species under the Act. This Committee completed the task in July 2012 (Greater Sage-Grouse Advisory Committee 2012, entire). The Committee was solely advisory, and it is not clear how these recommendations will be adopted, mandated, or enforced. Therefore, the protection afforded through this effort is currently undefined.

On November 19, 2012, the Governor of Nevada signed EO 2012-19 establishing a Sagebrush Ecosystem Council (Nevada Executive Order 2012b, entire). The Council was

tasked with implementing a conservation strategy for sage-grouse based on recommendation developed by the Greater Sage-Grouse Advisory Committee. We are encouraged by the steps taken by the State of Nevada, but currently specific detail has not been developed. Therefore, until a conservation strategy can be developed and implemented, the protection afforded through this effort is currently undefined.

### **Nevada State Senate Bill 394**

In 2009, Senate Bill 394 became law in Nevada (NV Senate Bill 394). This law requires the registration and the visual identification for all OHVs sold in Nevada after the date of July 1, 2011. The effective date of this Bill was extended to July 1, 2012, during the 76th Legislative Session to allow additional time for the Nevada Department of Motor Vehicles (DMV) to prepare for the specified vehicle registration process. Proceeds from this OHV registration, minus agency administrative costs, are deposited in a new State fund entitled the “Fund for Off-Highway Vehicles.” As administered by the Commission on OHVs, the distribution of these collected funds is limited to: Law enforcement of State vehicle laws; studies or planning for off-highway trails or facilities; mapping and signing for off-highway trails or facilities; acquisition of land for off-highway trails or facilities; enhancement, maintenance, and construction of off-highway trails or facilities; restoration of areas that have been damaged by OHVs; and public education and safety training for OHV use.

Potential benefits to sage-grouse from this law may be gained by a better educated and conscientious user group. Further, funding can be used to better manage and coordinate OHV use, ideally to reduce impacts to sagebrush habitats. Finally, the law provides a mechanism by which law enforcement can identify vehicle owners in instances where state or Federal laws pertaining to OHV access or use are violated. While we recognize the potential conservation benefit gained through education and restoration of habitats impacted by OHV use, we are unaware of information supporting benefits to the Bi-State DPS from enacting this law.

### **California Environmental Quality Act (CEQA)**

The California Environmental Quality Act (CEQA) (Public Resources Code sections 21000–21177) requires full disclosure of the potential environmental impacts of projects proposed by State and local agencies. The public agency with primary authority or jurisdiction over the project is responsible for conducting an environmental review of the project, and consulting with the other agencies concerned with the resources affected by the project. Section 15065 of the CEQA guidelines requires a finding of significance if a project has the potential to “reduce the number or restrict the range of a rare or endangered plant or animal.” Species that are eligible for listing as rare, threatened, or endangered but are not so listed are given the same protection as those species that are officially listed with the State. However, once significant effects are identified, the lead agency has the option to mitigate the effects through changes in the project, or decide that overriding considerations, such as social or economic considerations, make mitigation infeasible (CEQA section 21002). In the latter case, projects may be approved that cause significant environmental damage, such as

destruction of endangered species, and their habitat. Therefore, protection of listed species through CEQA is dependent upon the discretion of the agency involved.

#### Federal Laws and Regulations

##### **Federal Land Policy and Management Act of 1976 (FLPMA) (43 U.S.C. 1701 *et seq.*)**

Approximately 54 percent of sagebrush habitat within the sage-grouse Bi-State area is BLM-administered land; this includes approximately 1 million ha (2.5 million ac). The Federal Land Policy and Management Act of 1976 (FLPMA) (43 U.S.C. 1701 *et seq.*) is the primary Federal law governing most land uses on BLM lands, and directs development and implementation of RMPs which direct management at a local level. The sage-grouse is designated as a sensitive species on BLM lands in the Bi-State area (Sell 2010, pers. comm.). Further, BLM policies direct management to consider candidate species on public lands under their jurisdiction. The management guidance afforded species of concern and candidate species under BLM Manual 6840 – Special Status Species Management (BLM 2008) states that “Bureau sensitive species will be managed consistent with species and habitat management objectives in land use and implementation plans to promote their conservation and to minimize the likelihood and need for listing under the ESA” (BLM 2008, p. .05V). BLM Manual 6840 further requires that RMPs should address sensitive species, and that implementation “should consider all site-specific methods and procedures needed to bring species and their habitats to the condition under which management under the Bureau sensitive species policies would no longer be necessary” (BLM 2008, p. 2A1). As a designated sensitive species under BLM Manual 6840, sage-grouse conservation must be addressed in the development and implementation of RMPs on BLM lands.

RMPs are the basis for all actions and authorizations involving BLM-administered lands and resources. They authorize and establish allowable resource uses, resource condition goals and objectives to be attained, program constraints, general management practices needed to attain the goals and objectives, general implementation sequences, intervals and standards for monitoring and evaluating RMPs to determine effectiveness, and the need for amendment or revision (43 CFR 1601.0-5(k)). The RMPs also provide a framework and programmatic direction for implementation plans, which are site-specific plans written to regulate decisions made in a RMP. Examples include allotment management plans (AMPs) that address livestock grazing, fluid mineral development, travel management, and wildlife habitat management. Implementation plan decisions normally require additional planning and NEPA analysis.

Three RMPs in the Bi-State area include sage-grouse habitat, each of which contain specific measures or direction pertinent to management of sage-grouse or their habitats. However, the nature of these measures and direction vary widely, with some measures directed at a particular land use category (e.g., grazing management), and others relevant to specific habitat use categories (e.g., breeding habitat). If an RMP contains specific direction regarding sage-grouse habitat, conservation, or management, it represents a regulatory mechanism that has the potential to ensure that the species and its habitats are protected during permitting and other decision making on BLM lands. This section describes our understanding of how RMPs are currently implemented in relation to sage-grouse conservation.

#### Bishop RMP (BLM 1993), as amended

Sage-grouse conservation has been a management focus for the BLM's Bishop Field Office for over 20 years and was a key issue during development of the Bishop RMP in 1993 (BLM 1993, entire). In 2012, the Bi-State DPS of sage-grouse was designated specifically as a California BLM Sensitive Species (BLM 2012, entire). BLM Sensitive Species are defined under BLM Manual 6840–Special Status Species Management as species that will be “... managed consistent with species and habitat management objectives in land use and implementation plans to promote their conservation and to minimize the likelihood and need for listing under the Endangered Species Act.” (BLM 2008, p. 05V). As a BLM designated Sensitive Species, sage-grouse are provided the same level of protection as listed species pursuant to land use decisions prescribed in the Bishop RMP (BLM 1993, p. 18). The Bishop RMP includes several land use decisions and best management practices (guidelines and standard operating procedures (SOPs)) designed specifically to conserve sage-grouse and their habitats in the Bi-State area. Of most significance, the RMP provides for “yearlong protection of endangered, threatened, candidate, and sensitive plants and animal habitats” (BLM 1993, p. 18). Yearlong protection is defined as “no discretionary action which would adversely affect target resources would be allowed. Existing uses and casual use would be managed to prevent disturbance which would adversely affect target resources. Locatable mineral exploration and development could continue, with appropriate mitigation” (BLM 1993, p. 18).

In 1999, the Bishop RMP was amended by the Central California Standards for Rangeland Health and Guidelines for Livestock Grazing Management (Central California S&Gs) (BLM 1999, entire). The Central California S&Gs provide additional direction for the management of permitted livestock grazing on public lands administered by the Bishop Field Office. Standards were set for soil, species, riparian, and water quality and metrics by which the achievement of these standards could be measured were established. This affects sage-grouse conservation by enabling BLM to manage livestock grazing to ensure “special status species and other local species of concern are healthy and in numbers that appear to ensure stable to increasing populations; habitat areas are large enough to support viable populations or are connected adequately with other similar habitat areas.”

In 2005, the Bishop RMP was amended by the Bishop Fire Management Plan (FMP; BLM 2005c, entire). The Bishop FMP provides additional direction for the management of wildland fire incidents and fuels management projects on public lands administered by the Bishop Field Office including objectives, management coordination, and use of resource advisors. The intent within the sagebrush vegetation community is to limit habitat loss and degradation and minimize disturbance during suppression activities. The Bishop FMP benefits sage-grouse by increasing early awareness of responders to the presence of sage-grouse habitat, limiting disturbances that create favorable conditions for nonnative vegetation, and also increasing the likelihood of appropriate habitat restoration measures after a wildfire.

#### Carson City Field Office Consolidated RMP (BLM 2001), as amended.

The Carson RMP incorporates National BLM Policy (BLM Manual Section 6840 – Special Status Species Management; BLM 2008, entire) on Candidate and Sensitive Species including

sage-grouse. National policy states BLM shall carry out management, consistent with the principles of multiple use, for the conservation of candidate species and their habitats, and shall ensure that actions authorized, funded, or carried out do not contribute to the need to list any candidate species (BLM 2008, entire). The Carson RMP includes some land decisions and SOPs specifically for managing sage-grouse habitat (BLM 2001, entire). Several land use decisions and SOPs for general wildlife apply to sage-grouse management (*e.g.*, seasonal restrictions on activities, wildlife-friendly structures such as fences, maintaining or improving the habitat condition of meadow and aquatic areas, limiting vehicle traffic to designated roads and trails in the higher elevations of the Pine Nut Mountains, revegetation of disturbed areas) (BLM 2001, pp. SOP 1, SOP 2, SOP 3, WLD 1, WLD2, WLD 7, WLD 8, SSS 1, SSS 2, SSS 3, SSS 4). The Carson City District has initiated development of a revised RMP (BLM 2012a, *in litt.*; (77 FR 11152, February 24, 2012)). Further, they are also engaging in an amendment to the existing RMP in conjunction with the HTNF to address the Bi-State DPS, which is currently scheduled to be completed by the fall of 2013 (BLM 2012a, *in litt.*). Until such time these efforts are completed, the Carson City District Office is operating under a new Instruction Memorandum (IM NV–2013–061) (see discussion below regarding Instruction Memoranda), which provides interim policies and procedures to be applied to ongoing and proposed authorizations and activities that affect the Bi-State DPS (BLM 2012c, entire). The intent of the IM is to maintain, enhance, and restore Bi-State sage-grouse habitat and applies to all BLM programs.

#### Tonopah RMP (BLM 1997)

Sage-grouse are recognized as BLM Sensitive Species in the State of Nevada. The Tonopah RMP (1997) includes some land use decisions and BMPs (guidelines and SOPs) written specifically for sensitive species including sage-grouse and their habitat (*e.g.*, seasonal timing restrictions). The Tonopah Field Office is currently under the jurisdiction of the Battle Mountain District Office. The Battle Mountain District Office is currently revising their RMP, which will supersede the existing Tonopah RMP (BLM 2010, entire). The new RMP will likely include specific guidance to conserve the Bi-State DPS and its habitat in the Bi-State area, but we are currently unaware of the specifics of this guidance. The completion of the Battle Mountain RMP revision is scheduled for 2014. Until such time, the Tonopah Field Office is operating under a new Instruction Memorandum, which provides interim policies and procedures to be applied to ongoing and proposed authorizations and activities that affect the Bi-State DPS (IM NV–2013–061, entire). The intent of the memorandum is to maintain, enhance, and restore Bi-State sage-grouse habitat and applies to all BLM programs.

In addition to land use planning, BLM uses Instruction Memoranda (IM) to provide instruction to district and field offices regarding specific resource issues. Implementation of IMs is required unless the IM provides discretion (Buckner 2009, pers. Comm.). However, IMs are short duration (1-2 years) and are intended to immediately address resource concerns or provide direction to staff until a threat passes or the resource issue can be addressed in a long-term planning document. Because of their short duration, their utility and certainty as a long-term regulatory mechanism may be limited if not regularly renewed. Several BLM IMs relevant to sage-grouse conservation include:



- National Sage-Grouse Habitat Conservation Strategy (BLM IM-2005-024).
- Grasshopper and Mormon Cricket Treatments within Greater Sage-grouse Habitat (BLM IM-2010-084).
- Managing Structures for the Safety of Sage-grouse, Sharp-tailed grouse, and Lesser Prairie chicken (BLM IM-2010-022).
- General Wildlife Guidance for Authorization of Meteorological Tower (MET) Right-of-Way Applications and Wildlife Monitoring Protocols for Wind Energy Development (BLM IM NV-2010-024).
- Gunnison and Greater Sage-grouse Management Considerations for Energy Development (Supplement to National Sage-Grouse Habitat Conservation Strategy) (BLM IM-2010-071).
- 2008/2009 Wildfire Season and Sage-grouse Conservation (BLM IM-2008-142 (Change 1)). This IM was replaced by IM-2010-149.
- Sage-grouse Conservation Related to Wildland Fire and Fuels Management (BLM IM-2010-149). This IM was replaced by IM-2011-138. Sage-grouse Conservation Related to Wildland Fire and Fuels Management (BLM IM-2011-138).
- BLM Interim Management Policy for Lands Under Wilderness Review (BLM Manual H-8550-1, BLM 1995).
- Identification and Uniform Mapping of Wildlife Corridors and Crucial Habitat Pursuant to a Memorandum of Understanding with the Western Governors' Association (BLM IM 2012-039).
- Bi-State Distinct Population Segment of Greater Sage-Grouse Interim management Policy and Procedures (BLM IM NV-2012-061). This IM applies to lands managed by the Carson City District and the Tonopah Field Offices in Nevada.

The BLM has discretionary regulatory authority over most activity occurring on Federal lands including livestock grazing, OHV travel and human disturbance, infrastructure development, fire management, and energy development through FLPMA and associated RMP implementation and the Mineral Leasing Act (MLA) (30 U.S.C. 181 *et seq.*). Generally, hard rock mining activity is the only action considered nondiscretionary and is governed by the Mining Act of 1872 with subsequent amendments. The RMPs provide a framework and programmatic guidance for AMPs that address livestock grazing. In addition to FLPMA, BLM has specific regulatory authority for grazing management provided at 43 CFR 4100 (Regulations on Grazing Administration Exclusive of Alaska). Livestock grazing permits and leases contain terms and conditions determined by BLM to be appropriate to achieve management and resource condition objectives on the public lands and other lands

administered by the BLM, and to ensure that habitats are, or are making significant progress toward being restored or maintained for BLM special status species (43 CFR 4180.1(d)). Terms and conditions that are attached to grazing permits are generally mandatory but agreed upon in coordination with grazing permittees.

Across the range of sage-grouse, each BLM state office is required to adopt rangeland health standards and guidelines by which they measure allotment condition (43 CFR 4180.2(b)). Each state office develops their own standards and guidelines based on habitat type and other local considerations. The rangeland health standards must address restoring, maintaining, or enhancing habitats of BLM special status species to promote their conservation, and maintaining or promoting the physical and biological conditions to sustain native populations and communities (43 CFR 4180.2(e)(9) and (10)). BLM is required to take appropriate corrective action no later than the start of the next grazing year upon determining that existing grazing practices or levels of grazing use are significant factors in failing to achieve the standards and conform with the guidelines (43 CFR 4180.2(c)). However, actions are not necessarily implemented until the permit renewal process is initiated for the noncompliant allotment, resulting in a significant time lag. Although RMPs, AMPs, and the permit renewal process provide an adequate regulatory framework, whether or not these regulatory mechanisms are being implemented in a manner that conserves sage-grouse is unclear. BLM data indicate that there are lands within the range of the Bi-State DPS that are not meeting the rangeland health standards necessary to conserve sage-grouse habitats where corrective actions have not been implemented (BLM 2012a, *in litt.*). However, there was general lack of consistency in data provided by the BLM on rangeland health that precluded us from making generalizations on habitat conditions. Therefore, we lack the information necessary to assess how this regulatory mechanism effects sage-grouse conservation.

The BLM uses regulatory mechanisms to address invasive species concerns, particularly through the NEPA process. On BLM lands, the BLM has the authority to identify and prescribe best management practices for weed management that must be incorporated into project design and implementation. Common BMPs for weed management include surveying for noxious weeds, identifying problem areas, training contractors regarding noxious weed management and identification, providing cleaning stations for equipment, limiting off-road travel, and reclaiming disturbed lands immediately following ground disturbing activities, among other practices. The effectiveness of these measures is not documented.

Herbicides also are commonly used on BLM lands to control invasive species. In 2007, the BLM completed a programmatic EIS (72 FR 35718) and Record of Decision (ROD) (72 FR 57065) for vegetation treatments on BLM lands in the western United States. This guides the use of herbicides for field-level planning, but does not authorize any specific on-the-ground actions; site-specific project NEPA analysis is still required.

The BLM conducts habitat treatments on BLM lands, the most common being reseeding through the Emergency Stabilization and Burned Area Rehabilitation Programs. Generally, seed mix requirements (as stated in RMPs, emergency stabilization and rehabilitation, and other plans) were sufficient to provide suitable sage-grouse habitat (e.g., seed containing sagebrush and forb

species) (Carlson 2008, pers. Comm.). However, a sufficient seed mix is not mandated and if used does not ensure that restoration goals will be met; many other factors (e.g., precipitation) influence the outcome of restoration efforts.

### **National Forest Management Act (NFMA)**

The USFS manages approximately 35 percent of the land base in the Bi-State area or approximately 600,000 ha (1.5 million ac). Management of activities on national forest system lands is guided principally by the NFMA (16 U.S.C. 1600-1614, August 17, 1974, as amended 1976, 1978, 1980, 1981, 1983, 1985, 1988 and 1990). The NFMA specifies that the USFS must have a land and resource management plan (LRMP) (16 U.S.C. 1600) to guide and set standards for all natural resource management activities on each National Forest or National Grassland. The two existing LRMPs (USFS 1986, 1988) in the Bi-State area that guide the management of sage-grouse habitats on USFS lands were developed using the 1982 implementing regulations for land and resource management planning (1982 Rule, 36 CFR 219).

The greater sage-grouse is designated as a USFS Sensitive Species in the Intermountain (R4) and Pacific Southwest (R5) Regions, which include the HTNF Bridgeport Ranger District and the INF in the Bi-State area. Designated sensitive species require special consideration during land use planning and activity implementation to ensure the viability of the species on USFS lands and to preclude any population declines that could lead to a Federal listing (USFS 2008, p. 21). In addition, sensitive species designations require analysis for any activity that could have an adverse impact to the species, including analysis of the significance of any adverse impacts on the species, its habitat, and overall population viability (USFS 2008, p. 21). The specific protection that sensitive species status confers to sage-grouse on USFS lands is largely dependent on LRMPs and site-specific project analysis and implementation. The INF and HTNF also identify sage-grouse as an MIS, which requires the USFS to establish objectives for the maintenance and improvement of habitat for the species during all planning processes, to the degree consistent with overall multiple use objectives (1982 Rule, 36 CFR 219.19(a)). Both Sensitive Species and MIS designations potentially afford an additional degree of consideration when evaluating actions conducted on USFS managed lands as it mandates for a full effect analysis for all projects occurring in sage-grouse habitat; however, neither of these designations preclude activities that may negatively affect conservation.

### **Humboldt-Toiyabe National Forest Land and Resource Management Plan (1986)**

The Humboldt-Toiyabe National Forest LRMP (USFS 1986, entire) identified several standards for monitoring sage-grouse and managing their habitats, including protections for designating priority areas, direction for protecting the spatial integrity of habitat, and instructions for choosing vegetation for restoration (HTNF 1986, entire). Additional protections based on conservation actions/guidance derived from NDOW and the Nevada Governor's Sage-Grouse Conservation Team (e.g., *Nevada Energy Standards to Conservation of Greater Sage-grouse and Their Habitats*) (Nevada Governor's Sage-Grouse Conservation Team 2010), USGS (e.g., protecting nesting area within a three-mile buffer of leks), and the U.S. Fish and Wildlife Service have more recently been included in relevant projects as design features, mitigations, and stipulations; although adherence to these voluntary guidelines and recommendations are

contingent on their incorporation into relevant NEPA documents. Currently, the HTNF is engaging in an amendment to the existing LRMP to address the Bi-State DPS, which is currently scheduled to be completed by the fall of 2013 (USFS 2012a, *in litt.*). We anticipate the amendment will more fully address conservation of the Bi-State area and more formally incorporate current voluntary management intent but until completed, this remains unknown.

Inyo National Forest Land and Resource Management Plan (USFS 1988), as amended.

The INF LRMP identifies several standards and guidelines for managing sage-grouse habitats (USFS 1988, entire). These guidelines represent what the INF identified as management actions that needed to be specifically addressed to maintain and improve sage-grouse habitat throughout the forest, which includes the Bi-State DPS. Further guidance on implementation of proposed projects has also been added as design features (USFS 2012c, *in litt.*), specifically within livestock grazing and vegetation treatment environmental analyses.

In December 2007, the INF LRMP was amended by the Sierra Nevada Forests Management Indicator Species Amendment, Record of Decision (USFS 2007a, entire). This amendment updated the species listed as MIS, and sage-grouse remained a MIS for sagebrush habitats on the INF. The INF initiated the process to develop a revised LRMP with an anticipated completion date of January 2016, (USFS 2012c, *in litt.*). In addition, the INF adopted an Interim Management Policy specific to the Bi-State DPS to improve regulatory effectiveness and consistency for discretionary actions that may affect sage-grouse and its habitat (USFS 2012c, *in litt.*). While the Interim Policy affords greater deference to sage-grouse during the course of land use decision, given its recent adoption, the effectiveness of this policy into the future is unknown.

Essentially all habitats that support sage-grouse on USFS lands in the Bi-State area are open to livestock grazing (USFS 2012a, *in litt.*; USFS 2012c, *in litt.*). Under the Range Rescissions Act of 1995 (Public Law 104-19), the USFS must conduct NEPA analysis to determine whether grazing should be authorized on an allotment, and what resource protection provisions should be included as part of the authorization (USFS 2008, p. 33). The USFS reports using sage-grouse habitat guidelines (Connelly *et al.* 2000, entire) to develop desired condition and livestock use standards at the project or allotment level. However, the degree to which the recommended sage-grouse conservation and management guidelines are incorporated and implemented under Forest Plans varies (USFS 2008, p. 45). We do not have a complete inventory of rangeland health assessments or other information regarding the status of all USFS lands with sage-grouse habitat in the Bi-State area and, therefore, cannot assess the efficacy of these regulatory mechanisms in conserving the Bi-State DPS. However, data provided by the INF identifies allotments not meeting standards and contends grazing modification and restrictions are to be applied until such time rangelands meet objectives (USFS 2012c, *in litt.*).

As part of the USFS Travel Management planning effort, the INF and HTNF have completed Motorized Travel Managements Plans (USFS 2009; 2010). In addition to route designations and closures, these plans call for the permanent prohibition on cross country travel off designated authorized roads (USFS 2009; 2010). These recent efforts may offer conservation value by limiting disturbance to sage-grouse and their habitat in the Bi-State area. However, we are

unaware of the degree to which these actions are being enforced. In addition, until such time unauthorized roads are restored to a natural vegetation community, they may still affect sage-grouse and sage-grouse predator movements.

Energy and mineral developments occur on USFS and BLM lands. Through NFMA, LRMPs, FLPMA, RMPs, and the On-Shore Oil and Gas Leasing Reform Act (1987; implementing regulations at 36 CFR 228, subpart E), land managing agencies have the authority to manage, restrict, or attach protective measures to mineral extraction, wind development, and other energy permits on Federal lands. Stipulations are conditions that are made part of a public land lease when the environmental planning record demonstrates the need to accommodate various resources such as the protection of specific wildlife species. Stipulations advise the lease holder that a species needing special management may be present in the leased area, and certain protective measures may be required in order to develop the mineral resource. Stipulations must have waiver, exception or modification criteria, and the least restrictive constraint to meet the resource protection objective should be used (BLM 2005d, Appendix C, pp. 23–24). Waivers are permanent exemptions to stipulations, modifications are changes in the terms of stipulations, and exceptions are one-time exemptions to stipulations. The BLM (2008i) reports the issuance of waivers and modifications is rare.

Existing protective stipulations identified in land use plans are typically limited and general in nature. Therefore, land use plans generally allow for stipulations to be adopted, which are informed by more up to date research. However, there is generally a time-lag of several years associated with integrating research results into land manager decisions. For example, in 2007 the HTNF signed a decision record making 14 sections of land in the Mount Grant PMU available for geothermal leasing (USFS 2007b, entire). Several stipulations on development were attached to the decision including a “No Surface Occupancy” restriction within 0.96 km (0.6 mi) of any known leks (USFS 2007b, Appendix B), which restricts development of above ground infrastructure within the delineated area. In 2012, the HTNF signed a decision record making 25 additional sections in the same location within the Mount Grant PMU available for geothermal leasing (USFS 2012d, entire). Stipulations attached to these leases were more restrictive and included an No Surface Occupancy restriction within 4.8 km (3 mi) of any known lek (USFS 2012d, p. 11). Stipulations associated with the 2012 decision align more closely with research on sage-grouse (which has been available since 2005) and the identified sensitivity of this species to development. Furthermore, this example illustrates the general time-lag between adopted stipulations associated with management decision and research results.

#### **Sikes Act Improvement Act of 1997 (Sikes Act) (16 U.S.C. 670a)**

The Sikes Act required each military installation that includes land and water suitable for the conservation and management of natural resources to complete an integrated natural resource management plan (INRMP) by November 17, 2001. An INRMP integrates implementation of the military mission of the installation with stewardship of the natural resources found on the base. Each INRMP includes: (1) An assessment of the ecological needs on the installation, including the need to provide for the conservation of listed species; (2) a statement of goals and

priorities; (3) a detailed description of management actions to be implemented to provide for these ecological needs; and (4) a monitoring and adaptive management plan. Among other things, each INRMP must, to the extent appropriate and applicable, provide for fish and wildlife management; fish and wildlife habitat enhancement or modification; wetland protection, enhancement, and restoration where necessary to support fish and wildlife; and enforcement of applicable natural resource laws. The Service consults with the military on the development and implementation of INRMPs for installations with listed species.

There are two Department of Defense (DOD) military installations located within the range of the Bi-State DPS. The Hawthorne Army Depot has lands within the Mount Grant PMU; these DOD lands represent less than 1 percent of the range of the Bi-State DPS. However, these lands provide relatively high quality habitat (Nachlinger 2003, p. 38) and likely provide some of the best greater sage-grouse habitat remaining in the Mount Grant PMU because of the exclusion of livestock grazing and the public (Bi-State Local Planning Group 2004, p. 149). The Hawthorne Army Depot has a draft INRMP that they are implementing, but the INRMP has not been finalized and approved by the Service. The U.S. Marine Corps' Mountain Warfare Training Center (MWTC) has lands within the Desert Creek - Fales PMU. Some MWTC lands were recently acquired, and although the total DOD-owned acreage (approximately 243 ha (600 ac)) is below the Sikes Act criterion, the MWTC has initiated preparation of an INRMP (Brillenz 2013, pers. comm.). As neither INRMP is finalized, the Service cannot evaluate their adequacy as regulatory mechanisms.

#### Summary of Existing Regulatory Mechanisms

Bi-State sage-grouse conservation has been addressed in some local, State, and Federal plans, laws, regulations, and policies. County regulations including those identified above, at times, identify the need for natural resource conservation and are to be commended for these efforts. To our knowledge, however, County policy and ordinances have not precluded development but have, at times, potentially minimized its impact through zoning restrictions. In addition, habitat loss is not regulated or monitored; therefore conversion of habitat would not come before a county zoning commission. Thus, while there may be minimization measures available to County zoning commissions, it is not apparent that these restrictions can be enacted to a degree that would affect habitat loss. Similarly, State laws and regulations are general in nature, do not provide specific direction to State wildlife agencies, or afford regulatory authority over habitat preservation. Therefore, they afford limited protection to sage-grouse habitat necessary to protect the species. Furthermore, the interpretation of these provisions is prone to change based on direction provided through their respective Governors' Offices.

The Bi-State area is largely comprised of federally-managed lands. Existing land use plans, as they pertain to sage-grouse, are typically general in nature and afford relatively broad latitude to land managers. This latitude influences whether measures available to affect conservation of greater sage-grouse are incorporated during decision making, and implementation is prone to change based on managerial discretion. While we recognize the benefits of management flexibility, we also recognize that such flexibility with regard to implementation of land use plans can result in land use decisions that negatively affect the Bi-State DPS. Therefore, we consider most existing Federal mechanisms[SF1] are sufficiently vague as to offer limited

certainty as to managerial direction pertaining to sage-grouse conservation, particularly as they relate to addressing the threats that are significantly impacting the Bi-State DPS (i.e., nonnative and native invasive plants, wildfire and altered wildfire regime, infrastructure, and rangeland management). Regulations in some counties identify the need for natural resource conservation and attempt to minimize impacts of development through zoning restrictions, but to our knowledge neither preclude development nor do they provide for monitoring of the loss of sage-grouse habitats. Similarly, State laws and regulations are general in nature and provide flexibility in implementation, and do not provide specific direction to State wildlife agencies, although they can occasionally afford regulatory authority over habitat preservation (e.g., creation of habitat easements and land acquisitions).

## CONSERVATION EFFORTS

A variety of management efforts directed at conservation of the Bi-State DPS have been implemented since approximately 2000, such as vegetation restoration and habitat remediation projects. Many additional conservation efforts are ongoing or under development, including some associated with the *2012 Bi-State Action Plan* (Bi-State TAC 2012, entire). Most recently, the *2013 Greater Sage-grouse Conservation Objectives Team (COT) Final Report* was completed to guide management efforts for the greater sage-grouse in each state across its range, including the Bi-State DPS in Nevada and California (Service 2013, entire). Examples of past and ongoing management efforts in the Bi-State area are presented below, followed by summaries of conservation strategies outlined in the 2012 Bi-State Action Plan and the 2013 Greater Sage-grouse COT Report.

It is important to note that sagebrush habitat is difficult to restore (see biological information in the “Sagebrush Ecosystem” discussion above under the “Habitat” section, as well as the “Potential Recovery of Sagebrush Habitat Following Wildfire” section above). In general, restoration of disturbed sagebrush habitat is challenging due to the large range of abiotic variation, the minimal short-lived seed banks, and the long generation time of sagebrush. The disruption of primary patterns, processes, and components of sagebrush ecosystems has been ongoing since EuroAmerican settlement (Knick *et al.* 2003, p. 612; Miller *et al.* 2011, p. 147). Not all areas previously dominated by sagebrush can be restored because alteration of vegetation, nutrient cycles, topsoil, and living (cryptobiotic) soil crusts has exceeded recovery thresholds (Knick *et al.* 2003, p. 620). In addition, processes to restore sagebrush ecology are relatively unknown (Knick *et al.* 2003, p. 620). Active restoration activities in sagebrush ecosystems are often limited by financial and logistic resources (Knick *et al.* 2003, p. 620; Miller *et al.* 2011, p. 147). Meaningful restoration for sage-grouse requires landscape, watershed, or eco-regional scale context rather than individual, unconnected efforts (Knick *et al.* 2003, p. 623, and references therein; Wisdom *et al.* 2011, p. 471). Restoration to suitable habitat conditions for sage-grouse requires decades or centuries (Knick *et al.* 2003, p. 620, and references therein). Landscape restoration efforts require a broad range of partnerships (private, State, and Federal) due to landownership patterns (Knick *et al.* 2003, p. 623). Except for areas where active restoration is attempted following disturbance (e.g., mining, wildfire), management efforts in sagebrush ecosystems are usually focused on maintaining the remaining sagebrush (Miller *et al.* 2011, p. 147). Very little sagebrush within its extant range is undisturbed or unaltered from its

condition prior to EuroAmerican settlement in the late 1800s (Knick *et al.* 2003, p. 612, and references therein).

### *Past and Ongoing Management Efforts*

The Bi-State Plan (Bi-State Local Planning Group 2004, entire) represents more than 2 years of collaborative analysis by numerous local biologists, land managers, nongovernmental organizations, land users, and private land owners who share a common concern for sage-grouse in western Nevada and eastern California. The intent of the plan was to identify factors that negatively affect sage-grouse populations in the Bi-State area as well as conservation measures likely to ameliorate these threats and maintain this population. These recommended conservation measures (which include both voluntary actions and some required to meet specific local, State, or Federal policies) are in various stages of development and depend on the voluntary cooperation and participation of interested parties and agencies.

*Nevada Energy and Infrastructure Development Standards To Conserve Greater Sage-grouse Populations and Their Habitat* (April 2010) was prepared by the Nevada Governor's Sage-Grouse Conservation Team and focuses on renewable energy potential in Nevada, its overlap with sage-grouse habitat, and recommends to both avoid and minimize impacts to sage-grouse populations and their habitat. The Governor's Sage-Grouse Conservation Team was originally established in 2000 by then Nevada Governor Kenneth Guinn. The intent of this team was to establish an open and collaborative forum working toward sage-grouse conservation in the State of Nevada. The recommendations developed by this Team also apply to non-renewable energy development and have been used to inform discussions pertaining to resource extraction projects, such as mining. While recommendations are voluntary, State and Federal agencies often use these recommendations to evaluate and modify proposed projects that could affect sage-grouse. Examples of conservation actions implemented to date, including those identified in the Bi-State Plan (Bi-State Local Planning Group 2004), are targeted at various perceived stressors and include (but are not limited to):

#### 1. Urbanization

More than 4,303 ha (10,634 ac) of sage-grouse habitat were preserved at approximately nine conservation easements acquired between 2001 and 2008 across the Bi-State area (Desert Creek-Fales, Bodie, South Mono, and White Mountains PMUs). An additional 2,389 ha (5,904 ac) of sage-grouse habitat have been placed under easement since 2010, the year the Service determined the Bi-State DPS was warranted but precluded for listing under the Act (Service 2010, 13910). In addition to conservation easements, land acquisitions of approximately 2,538 ha (6,272 ac) by BLM, USFS, CDFW, and DOD occurred across the Bi-State prior to 2010 and have resulted in public, State, or Federal ownership of seasonally occupied sage-grouse habitat (Bi-State TAC 2012, Appendix B), thus protecting large quantities of suitable sage-grouse habitat from further urbanization and all of which receive varying levels of management that provide conservation value to the Bi-State DPS. Since 2010, an additional 356 ha (880 ac) have been acquired by State or Federal entities. All of these land acquisitions have contributed to reducing urbanization impacts in the Bi-State area (see "Urbanization and Habitat Conversion" section above).



## 2. Infrastructure-Fences

Prior to 2010, six projects within the Bodie and South Mono PMUs have modified or removed fences affecting approximately 36 ha (90 ac) of sage-grouse habitat. Modifications included conversions of hog-wire style livestock enclosures to two strand barbed wire fence and traditional barbed wire to let down-style barbed wire fence (see the “Fences” discussion under the “Infrastructure” section above). The let down fence design allows for the removal of the horizontal barbed wire strands during periods of greatest sage-grouse presence. Since 2010, an additional 5.4 km (3.4 mi) of fence were removed within the Pine Nut and South Mono PMUs, and approximately 8 km (5 mi) of fence have been marked with flight diverters (to improve visibility of fences by sage-grouse during flight (Stevens *et al.* 2011, entire)) within the Desert Creek-Fales, Mount Grant, Bodie, and South Mono PMUs.

## 3. Infrastructure-Roads

Prior to 2010, permanent and seasonal road closures on BLM managed lands in the South Mono PMU have benefited approximately 971 ha (2,400 ac) of breeding habitat. Since 2010, the HTNF and INF have completed travel management planning that includes proposed closure of an additional approximately 418 km (260 mi) of roads in the Bi-State area. Physical closure of these National Forest roads is ongoing. All areas within PMUs are closed to off-road travel. See the “Roads” discussion under the “Infrastructure” section above.

## 4. Grazing-Livestock

Prior to 2010, livestock grazing permits on 30 allotments covering approximately 208,556 ha (515,354 ac) in the Bodie and South Mono PMUs were updated (Nelson 2012, pers. comm.; USFS 2012c, *in litt.*) to include terms and conditions that minimize impacts to sage-grouse and their habitat by adjusting season of use, modifying permit numbers, and limiting utilization levels in upland and meadow habitat (see “Grazing and Rangeland Management” section above). Since 2010, the terms and conditions associated with an additional 25 allotments covering approximately 199,510 ha (493,000 ac) were updated to minimize impacts to sage-grouse habitat. Approximately 12 meadows representing approximately 149 ha (370 ac) in the Bodie PMU have been fenced to exclude livestock. Escape ramps have been installed in the Pine Nut, Desert Creek-Fales, and Bodie PMUs at approximately 16 livestock water troughs to minimize drowning risk.

## 5. Grazing-Wild Horses

Prior to 2010, three feral horse gathers have occurred in the Pine Nut, Mount Grant, and White Mountains PMUs to return horse populations down to Appropriate Management Levels (AML) or the population size considered compatible with habitat maintenance (see potential impacts to meadow habitat in the “Grazing and Rangeland Management” section above). The most recent treatment used by Carson City BLM for horse herd population control was a combination gather and contraception, which was administered to mares in the Pine Nut Herd Management Area (HMA) in 2010.

#### 6. Invasive Species-Noxious Weeds

Since 2010, approximately 80 ha (200 ac) of weed treatment to eradicate and limit the spread of noxious weeds has occurred in the Desert Creek-Fales, Mount Grant, Bodie, and White Mountains PMUs (see the “Nonnative Invasive Plants” section above). *Lepidium latifolium* (Perennial pepperweed) control has been conducted along the East Walker River in Lyon County and in the Pine Nut PMU. *Acroptilon repens* (Russian knapweed) has been targeted in the Pine Nut and White Mountains PMUs. *Iris missouriensis* (Iris) control has been done in the Bodie PMU. INF has reduced populations of *Tamarix ramosissima* (salt cedar) and *Melilotus alba* (sweet clover) in the White Mountains PMU.

#### 7. Pinyon and Juniper Encroachment

Prior to 2010, approximately 1,808 ha (4,470 ac) of rangeland encroached with conifer woodlands have been treated at six project sites to remove trees and reestablish sagebrush habitat within the Pine Nut, Desert Creek-Fales, and Bodie PMUs. Since 2010, an additional 4,672 ha (11,546 ac) have been treated at 16 sites to remove trees and reestablish sagebrush habitat on public and private lands within the Pine Nut, Desert Creek-Fales, Mount Grant, Bodie, and South Mono PMUs. See further discussion in the “Native Invasive Plants” section above.

#### 8. Wildfire Fuel Reduction and Rehabilitation

Fuels reduction treatments in the wildland/urban interface reduce the threat of catastrophic wildfires spreading from urban areas into the wildlands (see “Wildfires and Altered Fire Regime” section above). Prior to 2010, seven fuel reduction projects were completed on approximately 470 ha (1,116 ac) in the Pine Nut PMU to reduce ignition risks on the treated areas and also reduce the risk of wildfire in adjacent habitats. Since 2010, an additional treatment was conducted on approximately 435 ha (1,075 ac) in the Pine Nut PMU. The BLM has implemented guidance that prioritizes sage-grouse habitat for suppression efforts (WO-IM-2011-138; WO-IM-2012-043; NV-IM-2012-061).

Prior to 2010, approximately 1,368 ha (3,382 ac) of public and private land on three areas that were burned by wildfire within the Pine Nut PMU were reseeded with native and adapted species to reduce the threat of sagebrush habitat conversion to nonnative invasive species (see “Nonnative Invasive Plants” section above) and reestablish sagebrush habitat. Currently, not enough time has passed to establish efficacy of these treatments. Since 2010, 883 ha (2,182 ac) have been reseeded on three additional burned sites. Additionally, restriction of campfires has been implemented on LADWP lands in the South Mono PMU to reduce potential ignition of wildfires.

#### 9. Meadow and Sagebrush Habitat Condition

Prior to 2010, meadow habitat condition was improved on approximately 225 ha (557 ac) at five project locations within the Bodie and Desert Creek-Fales PMUs. Various treatments were used including mechanical removal of shrubs, chemical control of invasive species, and prescribed fire. Since 2010, an additional 102 ha (253 ac) of meadow habitat were treated to improve

conditions in the Bodie and Desert Creek-Fales PMUs, and approximately seven meadow sites in the Bodie PMU were fenced to exclude livestock.

(10) Disease or Predation

Regarding disease in the Bi-State area, two programs have been implemented to assist in our understanding of WNV (see “Disease” section above) in the Bi-State area. First, the Nevada Department of Agriculture has developed a surveillance program that is being implemented to monitor the reemergence and spread of WNV in the state to assist state and local agencies in reducing the impact of this disease (NV Dept. Ag. 2012). Second, the *California Mosquito-borne Virus Surveillance and Response Plan* (2012) includes a comprehensive mosquito-borne disease surveillance program that is implemented by several California State agencies. This program has been monitoring mosquito abundance and mosquito-borne virus activity since 1969. Both efforts inform our understanding of disease in the Bi-State area.

Regarding predation in the Bi-State area, woodland and infrastructure removal in sage-grouse habitat has been occurring to reduce predation risks by removing avian predator perches (see “Predation” section above). In addition, NDOW currently holds a Federal Migratory Bird Depredation Permit that allows take of up to 2,000 common ravens for the protection of sage-grouse and other game bird species. Under the conditions of the permit, lethal take is not to be the primary means of control. Active hazing, harassment or other non-lethal techniques such as natural habitat improvement and modifications of anthropogenic artificial habitat provisions (such as transmission lines and landfills) must continue in conjunction with any lethal take of migratory birds.

(11) Monitoring/Research and Public Outreach

Since 2004, applied research studies (such as University and USGS led research efforts) have been conducted in the Desert Creek-Fales, South Mono, Bodie, Pine Nut, and White Mountains PMUs. Substantial funding has been provided by numerous sources; collectively, the results have been instrumental in guiding management practices and refining conservation strategies. These activities will greatly enhance our understanding of sage-grouse ecology in the Bi-State DPS, thereby informing more effective conservation actions.

Since 2010, public meetings and workshops regarding the Bi-State DPS and sage-grouse habitat have occurred in both Nevada and California, and public outreach and engagement to affect conservation continues on numerous fronts. In addition, informational kiosks have been established in the South Mono PMU to inform the public about sage-grouse conservation.

*Conservation Efforts On Private Lands*

Sage-grouse conservation has occurred on private lands in the Bi-State area that harbor both occupied sage-grouse habitat and currently unsuitable habitat. Private land conservation in the Bi-State area has benefited from active participation by numerous private citizens, local landowners, nongovernmental organizations, local governments, State agencies, and Federal partners including Wilderness Land Trust, Eastern Sierra Land Trust, American Land Conservancy, TNC, Boy Scout of America, Los Angeles Department of Water and Power,

California Department of Fish and Wildlife, Nevada Department of Wildlife, Nevada Department of Forestry, and the Natural Resources Conservation Service. Based on our evaluation of the best available data presented in this report, we estimate that approximately 6,692 ha (16,538 ac) of private land are currently enrolled in various easement programs. The majority of the lands (3,374 ha (8,338 ac)) are located in the Bodie PMU with the remainder of easements occurring in the Desert Creek-Fales, South Mono, and White Mountains PMUs. Of the approximately 133,170 ha (329,000 ac) of private land within the Bi-State area, easements currently occur on approximately 5 percent. Additional efforts on private lands to affect conservation includes approximately 607 ha (1,500 ac) of woodland treatments, 153 ha (380 ac) of meadow restoration treatments, enhance brood-rearing meadows, 485 ha (1,200 ac) of range management prescriptions, as well as several miles of fence marking and installation of several escape ramps in cattle watering troughs.

### *2012 Bi-State Action Plan*

The Bi-State Action Plan (Bi-State TAC 2012, entire) was finalized in 2012 and is similar in nature to the 2004 Bi-State Plan. The 2012 Bi-State Action Plan updated our current understanding of the Bi-State DPS and apparent stressors to the birds and their habitat, and includes a series of actions needed to alleviate impacts. Signatories to this plan include NDOW, CDFW, BLM, USFS, NRCS, USGS, and the Service, and the plan was vetted through Bi-State Local Working Group participants associated with the 2004 Bi-State Plan. While the 2012 Bi-State Action Plan remains non-regulatory, it provides a general strategic path forward toward conservation and affords a degree of confidence in implementation among stakeholders. Many of the examples provided above were the precursor to and a result of the 2012 Action.

### *2013 Conservation Objectives Team (COT) Report*

In 2012, the Service's Director asked each State within the range of the greater sage-grouse to join the Service in a collaborative approach that develops range-wide conservation objectives for the sage-grouse. This collaborative effort would inform the Service's upcoming decision on whether or not the greater sage-grouse is warranted for listing, as well as inform the collective conservation efforts of the many partners working to conserve the species. A Conservation Objectives Team (COT) was developed, consisting of State and Service representatives. Their task was to develop a recommendation regarding the degree to which threats need to be reduced or ameliorated to conserve the greater sage-grouse so that it would no longer be in danger of extinction or likely to become in danger of extinction in the foreseeable future. The *Greater Sage-grouse Conservation Objectives: Final Report* (Service 2013, entire) is a result of this collaborative effort.

A key component of the COT report is identification of Priority Areas of Conservation (PACs), which are key habitats that are crucial for sage-grouse conservation (Service 2013, pp. 13–14). The concept revolves around effective conservation strategies in key areas across the landscape that are necessary to maintain redundant, representative, and resilient populations (Service 2013, p. 13). Additional finer scale planning efforts by states may determine that additional areas outside of PACs are also essential in order to provide connectivity between PACs (genetic and habitat linkages), habitat restoration and population expansion opportunities, and flexibility for

managing habitat changes that may result from climate change (Service 2013, p. 36). The COT report identified all occupied habitat in the Bi-State area as PAC, delineating these as four separate PACs: North Mono Lake, South Mono Lake, Pine Nut, and White Mountains.

The highest level objective identified in the COT report is to minimize habitat threats to the species so as to meet the objective of the 2006 Western Association of Fish and Wildlife Agencies' (WAFWA) Greater Sage-grouse Comprehensive Conservation Strategy: reversing negative population trends and achieving neutral or positive population trends (Service 2013, entire). The Service's interpretation of this objective is that actions and measures should be put in place now that will eventually arrest what has generally been a continuing declining trend (Service 2013, entire). See the "Bi-State DPS Population Trends" section above for additional discussion on trends within the Bi-State area. Additional general conservation objectives outlined in the COT final report include the following:

- (1) Stop population declines and habitat loss.
- (2) Implement targeted habitat management and restoration.
- (3) Develop and implement State and Federal sage-grouse conservation strategies and associated incentive-based conservation actions and regulatory mechanisms.
- (4) Develop and implement proactive, voluntary conservation actions.
- (5) Develop and implement monitoring plans to track the success of State and Federal conservation strategies and voluntary conservation actions.
- (6) Prioritize, fund, and implement research to address existing uncertainties.

Specific conservation objectives were also identified in the COT final report for conserving the four PACs identified in the Bi-State area and addressing threat reduction. These are summarized below (and described in fuller detail in the COT final report (Service 2013, pp. 37–52)). Additional information on the threats specific to the Bi-State area is provided the "Impact Analysis" section above.

#### PACs

- (1) Retain sage-grouse habitats within PACs.
- (2) If PACs are lost to catastrophic events, implement appropriate restoration efforts.
- (3) Restore and rehabilitate degraded sage-grouse habitats in PACs.
- (4) Identify areas and habitats outside of PACs which may be necessary to maintain the viability of sage-grouse.
- (5) Re-evaluate the status of PACs and adjacent sage-grouse habitat at least once every 5 years, or when important new information becomes available.
- (6) Actively pursue opportunities to increase occupancy and connectivity between PACs.
- (7) Maintain or improve existing habitat conditions in areas adjacent to burned habitat.

#### Threat Reduction

- (1) Fire—Retain and restore healthy native sagebrush plant communities within the range of the species.
- (2) Nonnative, invasive plant species—Maintain and restore healthy, native sagebrush plant communities.

- (3) Energy development—Design to ensure these developments will not impinge upon stable or increase sage-grouse population trends.
- (4) Sagebrush removal—Avoid sagebrush removal or manipulation in sage-grouse breeding or wintering habitats.
- (5) Grazing—Conduct grazing management for all ungulates in a manner consistent with local ecological conditions that maintains or restores healthy sagebrush shrub and native perennial grass and forb communities, and conserves the essential habitat components for sage-grouse.
- (6) Range management structures—Avoid or reduce the impact of range management structures on sage-grouse.
- (7) Free-roaming equid (horse) management—Protect sage-grouse from the negative influences of grazing by free-roaming horses.
- (8) Pinyon-juniper expansion—Remove pinyon-juniper from areas of sagebrush that are most likely to support sage-grouse (post-removal) at a rate that is at least equal to the rate of pinyon-juniper incursion.
- (9) Agricultural conversion—Avoid further loss of sagebrush habitat for agricultural activities (both plant and animal production) and prioritize restoration.
- (10) Mining—Maintain stable to increase sage-grouse populations and no net loss of sage-grouse habitats in areas affected by mining.
- (11) Recreation—In areas subject to recreational activities, maintain healthy native sagebrush communities based on local ecological conditions and with consideration of drought conditions, and manage direct and indirect human disturbance (including noise) to avoid interruption of normal sage-grouse behavior.
- (12) Ex-urban development—Limit urban and exurban development in sage-grouse habitats and maintain intact native sagebrush plant communities.
- (13) Infrastructure—Avoid development of infrastructure within PACs.
- (14) Fences—Minimize the impact of fences on sage-grouse populations.

#### *Habitat Conservation Plans or Other Management Plans Under Development*

The LADWP is developing a Habitat Conservation Plan (HCP) with the Service and the CDFW, including the Bi-State DPS as a covered species. The HCP proposes to conserve all existing sage-grouse habitat on LADWP lands for the life of the permit (i.e., 10 years) and possibly longer if the permit is renewed. We anticipate the proposed conservation measures will include (at minimum) those management actions currently undertaken by the LADWP (see the “Urbanization and Habitat Conversion” section of the Threats Analysis above). The lands owned and managed by the LADWP represent 6 percent of the South Mono PMU, and less than 1 percent of the Bodie PMU. Furthermore, the LADWP has agreed to develop a conservation strategy to proactively manage sage-grouse that occur on their lands in the South Mono PMU and to co-sign with the Service a Memorandum of Understanding implementing that strategy (Tillemans 2013, pers. comm. 2013).

## OVERALL SUMMARY OF SPECIES STATUS AND IMPACTS

### *Summary of Species Status*

The Bi-State DPS of greater sage-grouse is genetically unique and markedly separated from the rest of the species' range. The species as a whole is long lived, reliant on sagebrush, highly traditional in areas of seasonal habitat use, and particularly susceptible to habitat fragmentation and alterations in their environment. Sage-grouse annually exploit numerous habitat types in the sagebrush ecosystem across broad landscapes to successfully complete their life cycle, thus spanning ecological and political boundaries. Populations are slow growing due to low reproductive rates, and they exhibit natural cyclical variability in abundance.

The Bi-State DPS has 6 PMUs representing from 4 to 8 demographically independent populations with a combined total of approximately 43 active leks. Each population is relatively small and below theoretical minimum criteria for long-term persistence, as is the entire DPS on average (estimated 1,833 to 7,416 individuals). Populations outside the two largest (i.e., Bodie Hills in the Bodie PMU and Long Valley in the South Mono PMU) are especially small. Sage-grouse abundance and sagebrush habitat reductions within the Bi-State area are both estimated to exceed 50 percent, with losses of each historically greater on the periphery of the DPS. Overall, the remaining habitat is reduced in quality and, thereby, sage-grouse carrying capacity. Thus, reductions in sage-grouse abundance proportionally exceed habitat loss. The residual limited connectivity of populations and habitats within and among the PMUs also continues to slowly erode.

Declining Bi-State DPS population trends continue for three peripheral PMUs (i.e., populations within the Pine Nut, Desert Creek-Fales, and Mount Grant PMUs), with an unknown trend for the other peripheral PMU (White Mountains). These trends are of critical concern at the DPS level because fluctuations in these small, less secure populations are likely to result in extirpations and loss of population redundancy within the DPS. Historical extirpations outside the existing boundaries of the six PMUs present a similar pattern of lost peripheral populations. Two range-wide assessments investigating patterns of sage-grouse population persistence suggest that PMUs on the northern and southern extents of the Bi-State DPS (i.e., Pine Nut, Desert Creek-Fales, and White Mountains PMUs) are similar to extirpated sites elsewhere within the range of greater sage-grouse, while the central PMUs (i.e., South Mono, Bodie, and Mount Grant PMUs) are similar to extant sites (Aldridge *et al.* 2008, entire; Wisdom *et al.* 2011, entire).

The Bodie and South Mono PMUs form the central core of the Bi-State DPS. They have the largest sage-grouse populations within the Bi-State area and encompass approximately 70 percent of existing Bi-State DPS individuals. These populations are relatively stable at present (estimates range between 522 to 2,400 individuals in the Bodie PMU and 859 to 2,005 individuals in the South Mono PMU), and the scope and severity of known impacts are comparatively less than in other PMUs. Although populations currently are relatively stable with overall fewer impacts as compared to the other four PMUs, both core PMUs have experienced prior habitat losses, population declines, and internal habitat fragmentation. Significant connectivity between these two PMUs is currently lacking, and both PMUs are increasingly vulnerable to cheatgrass and wildfire impacts. Together they represent less than 20 percent of

the historical range for the Bi-State DPS. While both core PMUs are projected by species experts to have moderate to high probabilities of persistence into the future, the Bodie PMU has generally had a negative long-term population trend. This PMU is expected to fall below 500 breeding adults within the next 30 years; thus, long-term viability is questionable. The long-term population trend for the South Mono PMU has been stable, but species experts predict an 80 percent chance of the population declining to less than 500 breeding adults in 30 years.

In summary, the Service anticipates the loss of sage-grouse populations in four of the six PMUs in the Bi-State DPS (i.e., Pine Nut, Desert Creek-Fales, Mount Grant, and White Mountains), with a fifth PMU (Bodie) having reduced viability within 30 years, and the sixth PMU (South Mono) persisting but with significant expectations of reduced population viability in the next 30 years. Following are brief summary accounts of each PMU.

(1) The Pine Nut PMU has the smallest number of sage-grouse of all Bi-State DPS PMUs (1 population comprising less than 100 individuals and representing less than 5 percent of the DPS). The population in the Pine Nut PMU has some level of connectivity with the Desert Creek-Fales PMU and potentially also with the Bodie and Mount Grant PMUs. Urbanization, grazing management, wildfire, invasive species, infrastructure, and mineral development are affecting this population, and the scope and severity of most of these impacts are likely to increase into the future based on the proximity of the PMU to expanding urban areas, agricultural operations, road networks, and power lines; altered fire regimes; new mineral entry proposals; and increasing OHV use on public lands. Because of the current small population size and the ongoing and potential future magnitude of habitat impacts, loss of the sage-grouse population in this PMU (i.e., the northern-most population within the range of the Bi-State DPS) appears likely.

(2) The Desert Creek-Fales PMU contains two populations. The Nevada portion of the Desert Creek-Fales PMU contains approximately 500 to 1,000 sage-grouse, and the California portion contains approximately 200 to 300 individuals. The populations in the Desert Creek-Fales PMU have some level of connectivity with the Pine Nut PMU and potentially also with the Bodie and Mount Grant PMUs. The most significant impacts in this PMU are wildfire, invasive species (specifically conifer encroachment), infrastructure, and urbanization. Private land acquisitions in California and conifer removal in Nevada and California have mitigated some of the impacts locally within this PMU. However, urbanization and woodland succession remain a concern based on the lack of permanent protection for important brood-rearing/summer habitat that occurs primarily on irrigated private pasture lands and continued pinyon-juniper encroachment that is contracting distribution of the populations and connectivity between populations. While some of these impacts are more easily mediated than others (i.e., conifer encroachment), the existing condition is not ideal and is likely to worsen going forward. This PMU has seen episodic sage-grouse population declines in the past, and the indicators of these declines remain. Long-term preservation of the sage-grouse populations in the Desert Creek-Fales PMU is unlikely without successful implementation of additional conservation measures.

(3) The Mount Grant PMU contains one population, and population estimates for this PMU over the past decade range from 85 to 1,412 individuals. The population in the Mount Grant PMU has some level of connectivity with the Bodie PMU and potentially also with the



Desert Creek-Fales and Pine Nut PMUs. Impacts in this PMU include woodland encroachment, renewable energy and mineral development, infrastructure, and the potential of wildfire. These impacts currently fragment habitat within this PMU and, in the future, may reduce or eliminate connectivity to the sage-grouse population in the Bodie PMU. Long-term preservation of the sage-grouse population in the Mount Grant PMU is uncertain.

(4) The Bodie PMU contains one population (Bodie Hills), which is one of the two core populations for the Bi-State DPS. Population estimates for this PMU over the past decade range from 552 to 2,400 individuals. This PMU typically has the highest number of active leks (i.e., 13) of all the PMUs. The population in the Bodie PMU has some level of connectivity with the Mount Grant PMU and potentially also with the Desert Creek-Fales and Pine Nut PMUs. Woodland succession is estimated to have caused a 40 percent reduction in sagebrush habitat throughout the Bodie PMU, and woodland encroachment into sagebrush habitat is expected to continue both from woodland edge expansion and infilling. The potential of future wildfire (largely unrealized currently) and subsequent widespread habitat loss by conversion to annual grasses is of great concern based on the increased understory presence of cheatgrass in Wyoming big sagebrush communities within the Bodie PMU (e.g., Bodie Hills). Furthermore, the potential for additional loss (largely restricted to date) of sage-grouse habitat to exurban development on unprotected private lands in the Bodie PMU is also a significant concern because these lands provide summer and winter use areas and connectivity between the Bodie, Mount Grant, and Desert Creek-Fales PMUs. Current impacts of infrastructure, grazing, and mineral extraction are of minimal severity in the Bodie PMU, but additional future impacts are anticipated.

(5) The South Mono PMU contains two populations (Long Valley and Parker Meadows). The Long Valley population is one of the two core populations for the Bi-State DPS. Population estimates for this PMU over the past decade range from 859 to 2,005 individuals. The South Mono PMU has typically had the highest estimated population size of all the PMUs. This PMU is considered to be completely isolated from the other PMUs. The most significant impacts in the South Mono PMU are from urbanization, infrastructure, and recreation, with the potential for increased wildfire. An important indirect impact of infrastructure to the sage-grouse population in Long Valley is predation likely associated with wildlife using the local landfill. Predation appears to significantly reduce sage-grouse nest success in Long Valley, although the population appears stable. The Parker Meadows population currently has 1 active lek and is quite small; from 2002 to 2010, male sage-grouse counts have ranged between 3 and 17. This population has the lowest reported genetic diversity in the Bi-State area, and it is experiencing high nest failure rates due to non-viable eggs (Gardner 2009, pers. comm.), potentially indicative of genetic challenges.

(6) The White Mountains PMU contains one population. No recent population estimate for this southern-most PMU is available and, overall, information on population status and impacts is limited. The area is remote and difficult to access and most data are from periodic observations rather than comprehensive surveys. The population in the White Mountains PMU is considered to be completely isolated from the other PMUs. Current impacts such as urbanization, grazing, recreation, and invasive species may be influencing portions of the population and are likely to increase in the future, but impacts largely remain unquantified and

are considered minimal due to the remote location. Potential future impacts from infrastructure (power lines, roads) and mineral developments could lead to the loss of the remote, contiguous nature of the habitat. Because the population in the White Mountains PMU is small and on the periphery of the range of the Bi-State DPS, it is vulnerable to extirpation if future impacts increase.

### *Summary of Threats Analysis*

Many of the impacts to sage-grouse populations and sagebrush habitats in the Bi-State DPS are present throughout the range and, while they currently affect the DPS to varying degrees, these impacts are likely to continue into the future. The populations and habitat in the northern extent of the Bi-State area including the Pine Nut, Desert Creek-Fales, and Mount Grant PMUs are now and will continue to be most at risk. We anticipate loss of some populations and contraction of the ranges of others in these three PMUs, which will leave them susceptible to extirpation from stochastic events such as wildfire, drought, and disease (each of which are currently acting upon certain populations within the Bi-State DPS). We expect that only two isolated populations in the Bodie and South Mono PMUs (i.e., the Bodie Hills and Long Valley populations, respectively) may remain in 30 years. The impacts that are of high current or potential scope and severity within the Bi-State DPS (i.e., significant impacts) include: Nonnative and native invasive species (e.g., pinyon-juniper encroachment, cheatgrass), wildfire and altered fire regime, infrastructure (e.g., fences, power lines, and roads), urbanization, small population size and population structure, and climate. Other impacts within the Bi-State DPS, which are considered to either have lesser and/or more localized current or future effects include: Grazing, predation, recreation, mining, and energy development. Negligible impacts within the DPS at this time may include disease and overutilization, while impacts from pesticides, herbicides, and contaminants are generally unknown. All of these impacts, including those that are currently considered negligible, can cumulatively be acting upon the DPS and, therefore, increase the risk of extinction.

The Bi-State DPS is experiencing multiple, identifiable interacting impacts (i.e., synergistic effects) to sage-grouse populations and sagebrush habitats that are ongoing in many areas throughout the species' range and imminent in certain portions of the species' range. Individually, each of these impacts is unlikely to affect persistence across the entire Bi-State DPS, but each may act independently to affect persistence of individual populations. The scope, severity, and timing of these impacts vary at the individual PMU level. While some of the impacts do not occur everywhere across the DPS at this time (such as habitat-based impacts from wildfire), where impacts are occurring in sage-grouse habitat, the risk they pose to the DPS may be exacerbated and magnified due to the small number, size, and isolation of populations within the DPS. We are unaware of information that identifies precise future locations of where some impacts will manifest on the landscape (such as effects of climate change, or locations of wildfires that in turn would most likely continue the spread of cheatgrass within the Bi-State area). Due to the scope of the impacts, current and anticipated future habitat degradation, fragmentation and loss, and isolation of already small populations, the potential severity of impacts to the entire Bi-State DPS is high.

## Urbanization and Habitat Conversion

Historical and recent conversion of sagebrush habitat on private lands for agriculture, housing, and associated infrastructure within the Bi-State area has negatively affected sage-grouse distribution and population extent in the Bi-State DPS, thus limiting current and future recovery opportunities in the Bi-State area. These alterations to habitat have been most pronounced in the Pine Nut and Desert Creek-Fales PMUs and to a lesser extent the Bodie, Mount Grant, South Mono, and White Mountains PMUs. Although only 8 percent of suitable sage-grouse habitat occurs on private lands in the Bi-State area, and only a subset of that could potentially be developed, conservation actions on adjacent public lands could be compromised due to the high percentage of late brood-rearing habitat that occurs on the private lands. Sage-grouse display strong site fidelity to traditional seasonal habitats and loss of specific sites (such as mesic meadow or spring habitats that typically occur on potentially developable private lands in the Bi-State area) can have pronounced population impacts. The influence of land development and habitat conversion on the population dynamics of sage-grouse is greater than a simple measure of spatial extent because of the indirect effects from the associated increases in human activity. These threats are not universal across the Bi-State area, but localized areas of impacts have been realized and additional future impacts are anticipated.

## Infrastructure

In the Bi-State area, linear infrastructure impacts each PMU both directly and indirectly to varying degrees. Existing roads, power lines, and fences degrade and fragment sage-grouse habitat, and contribute to direct mortality through collisions. In addition, roads, power lines, and fences influence sage-grouse use of otherwise suitable habitats adjacent to current active areas, and increase predators and invasive plants. The impact caused by these indirect effects likely extends beyond the immediate timeframe associated with the infrastructure installation (i.e., the existence of an extended road system, power lines, and fencing already limit our ability to recover the Bi-State DPS in various areas). We do not have consistent and comparable information on miles of existing roads, power lines or fences, or densities of these features within PMUs or for the Bi-State area as a whole. However, given current and future development (based on known energy resources), the Mount Grant, Desert Creek-Fales, Pine Nut, and South Mono PMUs are likely to be the most directly influenced by new power lines and associated infrastructure. Wisdom *et al.* (2011, p. 463) reported that across the entire range of the greater sage-grouse, the mean distance to highways and transmission lines for extirpated populations was approximately 5 km (3.1 mi) or less. In the Bi-State area, between 35 and 45 percent of annually occupied leks are within 5 km (3.1 mi) of highways, and between 40 and 50 percent are within this distance to existing transmission lines (Service 2013, unpublished data). Therefore, the similarity apparent between existing Bi-State conditions and extirpated populations elsewhere suggests that persistence of substantial numbers of leks within the Bi-State DPS will likely be negatively influenced by these anthropogenic features.

The geographic extent, density, type, and frequency of linear infrastructure disturbance in the Bi-State area have changed over time. While new development of some of these features (highways) will likely remain static, other infrastructure features have the potential and likelihood of increasing (secondary roads, power lines, fencing, and communication towers).

Furthermore, improvements to existing roads are possible and traffic volume will likely increase, which may be more important than road development itself. For example, with the proliferation of OHVs, the potential impact to the Bi-State DPS and its habitat caused by secondary or unimproved roads may become of greater importance as traffic volume increases rates of disturbance and spread of nonnative invasive species in areas that traditionally have been traveled relatively sporadically.

The potential impacts caused by cellular towers (all PMUs) and one landfill site (impacting the Long Valley populations within the South Mono PMU) appear variable. At least eight cellular tower locations are currently known to exist in occupied habitat in the Bi-State area. Wisdom *et al.* (2011, p. 463) determined this feature is highly influential in explaining population extirpation, and additional tower installations will likely occur in the near future as development continues. The lone landfill facility in Long Valley is likely influencing demography in the area as nest success is comparatively low and subsidized avian nest predators numbers are high (Kolada *et al.* 2009b, p. 1,344). While this core population of sage-grouse (in the Bi-State area) currently appears stable, recovery following any potential future perturbations affecting alternative vital rates (brood survival, adult survival) will be limited by nesting success.

### Mining

Currently, operational mining activities are not within the core population areas of the Bi-State DPS, although existing inactive mining sites and potential future developments could impact important lek complexes and connectivity areas between at minimum the Bodie and Mount Grant PMUs. Additional mineral developments occurring in sagebrush habitats in any PMU within the Bi-State DPS will likely negatively influence the distribution of sage-grouse and the connectivity among breeding complexes. There is potential for additional mineral developments to occur in the Bi-State area in the future based on known existing mineral resources and recent permit request inquiries with local land managers. While all six PMUs have the potential for mineral development, based on current land designations and past activity, the Pine Nut and Mount Grant PMUs are most likely to see new and additional activity.

### Renewable Energy Development

Minimal direct habitat loss has occurred in the Bi-State DPS due to energy development, specifically from the only operational geothermal facility in the Bi-State area, which is within the South Mono PMU. However, the likelihood of additional renewable energy facility development, especially geothermal, in the Bi-State area is high based on current Federal leases. Inquiries by energy developers (geothermal, wind) have increased in the past several years (Dublino 2011, pers. comm.). There is strong political and public support for energy diversification in Nevada and California, and the energy industry considers the available resources in the Bi-State area to warrant investment (RETAAC 2007, p. 8). Renewable energy development and expansion could result in direct loss of habitat and indirect impacts affecting population viability (e.g., fragmentation and isolation). Based on our current assessment of development probability, the Mount Grant PMU and to a lesser degree the Desert Creek-Fales PMU are most likely to be negatively affected. However, interest by developers changes rapidly, making it difficult to predict potential outcomes.

## Grazing and Rangeland Management

Livestock grazing and domestic livestock management have the potential to result in sage-grouse habitat degradation. Grazing can adversely impact nesting and brood-rearing habitat by decreasing grass cover and fragmenting shrub canopies used for concealment from predators. Grazing also compacts soils, decreases herbaceous abundance and plant diversity, alters soil characteristics and increases soil erosion, and increases the probability of occurrence of nonnative invasive plant species. Livestock management and associated infrastructure (such as water developments and fencing) can degrade important nesting and brood rearing habitat, reduce nesting success, and facilitate the spread of WNV. In addition, some research suggests there may be direct competition between sage-grouse and livestock for plant resources (Vallentine 1990, p. 226). Similar to domestic livestock, grazing and management of feral horses has the potential to negatively affect sage-grouse habitats. Despite numerous documented negative impacts, some research suggests that under specific conditions grazing domestic livestock can benefit sage-grouse (Klebenow 1981, p. 121). Native ungulates (mule deer and antelope) co-exist with sage-grouse in the Bi-State area, but we are not aware of significant impacts from these species on sage-grouse populations or sage-grouse habitat.

There are localized areas of habitat degradation in the Bi-State area attributable to past grazing practices that indirectly and cumulatively affect sage-grouse habitat. In general, upland sagebrush communities in the Pine Nut and Mount Grant PMUs deviate from desired conditions due to lack of understory plant species, while across the remainder of the PMUs localized areas of meadow degradation are apparent, and these conditions may influence sage-grouse populations through altering nesting and brood-rearing success. Currently, there is little direct evidence linking grazing effects and sage-grouse population responses. Analyses for grazing impacts at the landscape scales important to sage-grouse are confounded by the fact that almost all sage-grouse habitat has at one time been grazed and, thus, no ungrazed control areas exist for comparisons (Knick *et al.* 2011, p. 232). Across the Bi-State area we anticipate the future trend in rangeland management will be positive, although some aspects such as feral horses will remain difficult to manage. However, remaining impacts caused by historic practices will linger as vegetation communities and disturbance regimes recover. Change will likely occur slowly and alterations to climate and drought cycles will present additional stress on vegetation resources.

## Nonnative and Native Invasive Plants

Both nonnative and native invasive plants are impacting the sage-grouse and its habitat in the Bi-State area. In general, nonnative plants are not abundant throughout the Bi-State area, with the exception of cheatgrass that occurs in all PMUs but is most extensive and of greatest concern in the Pine Nut PMU. Cheatgrass will likely continue to expand and impact the entire Bi-State area in the future and increase the adverse impact that currently exists to sagebrush habitats and the greater sage-grouse through outcompeting beneficial understory plant species and altering the fire ecology. Alteration of the fire ecology of the Bi-State area is of greatest concern. Land managers have had little success preventing cheatgrass invasion in the West, and elevational barriers to occurrence are apparently becoming less restrictive. The best available data suggest

that future conditions that could promote expansion of cheatgrass will be most influenced by precipitation and winter temperatures (Bradley 2009, p. 200). Cheatgrass is a serious challenge to the sagebrush shrub community and its spread will be detrimental to sage-grouse in the Bi-State area. In addition, the encroachment of native woodlands (particularly pinyon-juniper) into sagebrush habitats is occurring throughout the Bi-State area, and continued isolation and reduction of suitable habitats will further adversely influence both short- and long-term persistence of sage-grouse. We predict that future woodland encroachment will continue across the entire Bi-State area, but recognize this is a potentially manageable stressor through management actions. To date, encroachment has outpaced restoration efforts. Thus, success will require additional resources.

### Wildfires and Altered Fire Regime

Wildfire is considered a relatively high risk across all the PMUs in the Bi-State area due to its ability to affect large landscapes in a short period of time (Bi-State TAC 2012, pp. 19, 26, 32, 37, 41, 49). Furthermore, the future risk of wildfire is exacerbated by the presence of people, invasive species, and climate change. While dozens of wildfires have occurred in the Pine Nut, Desert Creek-Fales, Bodie, and South Mono PMUs (fewer in the Mount Grant and White Mountains PMUs) over the past 20 years, to date there have been relatively few large scale events. In general, current data do not indicate an increase of wildfires in the Bi-State DPS over time with the significant exception of the Pine Nut PMU where fire occurrence is relatively frequent (Service 2013, unpublished data). Furthermore, cheatgrass has a more substantial presence in the Pine Nut PMU, which appears to mirror the damaging fire and invasive species cycle that affects sagebrush habitat across much of the southern Great Basin.

Changes in fire ecology over time have resulted in an altered fire regime in the Bi-State area, presenting future wildfire risk in all PMUs (Bi-State TAC 2012, pp. 19, 26, 32, 37, 41, 49). A reduction in fire occurrence has facilitated the expansion of woodlands into montane sagebrush communities in all PMUs (see “Nonnative and Native Invasive Plants” section). Meanwhile, a pattern of overabundance in wildfire occurrence in sagebrush communities is apparent in the Pine Nut PMU. Each of these alterations to wildfire regimes has contributed to fragmentation of habitat and the isolation of the sage-grouse populations Bi-State Local Planning Group 2004, pp. 95–96, 133).

The loss of habitat due to wildfire across the West is anticipated to increase due to the intensifying synergistic interactions among fire, people, invasive species, and climate change (Miller *et al.* 2011, p. 184). The recent past- and present-day fire regimes across the sage-grouse’s range have changed with a demonstrated increase of wildfires in the more arid Wyoming sagebrush communities and a decrease of wildfire across many mountain sagebrush communities (Miller *et al.* 2011, pp. 167–169). Both altered fire regime scenarios have caused significant losses to sage-grouse habitat through facilitating conifer expansion at high-elevation interfaces and nonnative invasive weed encroachment at lower elevations (Miller *et al.* 2011, pp. 167–169). In the face of climate change, both scenarios are anticipated to worsen (Baker 2011, p. 200; Miller *et al.* 2011, p. 179), including in the Bi-State area. Predicted changes in temperature, precipitation, and carbon dioxide (see “Climate Change” section) are all anticipated to influence vegetation dynamics and alter fire patterns resulting in the increasing loss and

conversion of sagebrush habitats (Neilson *et al.* 2005, p. 157). Many climate scientists suggest that in addition to the predicted change in climate toward a warmer and generally dryer Great Basin, variability of interannual and interdecadal wet-dry cycles will likely increase and act in concert with fire, disease, and invasive species to further stress the sagebrush ecosystem (Neilson *et al.* 2005, p. 152). See the “Synergistic Impacts” section below. The anticipated increase in suitable conditions for wildland fire will likely further interact with people and infrastructure. Human-caused fires have increased and are correlated with road presence across the sage-grouse range, and a similar pattern may exist in the Bi-State area (Miller *et al.* 2011, p. 171).

Fire is one of the primary factors linked to population declines of sage-grouse across the West because of long-term loss of sagebrush and frequent conversion to monocultures of nonnative invasive grasses (Connelly and Braun 1997, p. 7; Johnson *et al.* 2011, p. 424; Knick and Hanser 2011, p. 395). Within the Bi-State area, the BLM and USFS currently manage the area to limit sagebrush habitat loss. Based on the best available information, historical wildfire events have not removed a significant amount of sagebrush habitat across Bi-State area and conversion of sagebrush habitat to a nonnative invasive vegetation community has been restricted (Pine Nut PMU withstanding). It does appear that a lack of historical fire has facilitated the establishment of woodland vegetation communities and loss of sagebrush habitat. Both the too little and too much fire scenarios present challenges for the Bi-State DPS. The former influences the current degree of connectivity among sage-grouse populations in the Bi-State and the extent of available sagebrush habitat, likely affecting sage-grouse population size and persistence. The latter, under current conditions, now has the potential to quickly alter significant percentages of remaining sagebrush habitat. Restoration of sagebrush communities is difficult, requires many years, and may be ineffective in the presence of nonnative invasive grass species. Sage-grouse are slow to recolonize burned areas even if structural features of the shrub community have recovered (Knick *et al.* 2011, p. 233). While it is not currently possible to predict the extent or location of future fire events in the Bi-State area, we anticipate fire frequency to increase in the future due to the increasing presence of cheatgrass and people, and the projected effects of climate change. Given the fragmented nature and small size of the populations within the Bi-State DPS, increasing wildfires in sagebrush habitats would have a significant adverse effect on the overall viability of the DPS.

### Climate

Climate change is an additional consideration that will likely act synergistically with other impacts, further diminishing habitat and increasing isolation of populations, making them more susceptible to demographic and genetic challenges or disease. Predicting the impact of global climate change on sage-grouse populations is problematic due to the relatively small spatial extent of the Bi-State area. It is likely that vegetation communities will not remain static and the amount of sagebrush shrub habitat will decrease. Further, increased variation in drought cycles due to climate change will likely place additional stress on the populations. While sage-grouse evolved with drought, drought has been correlated with population declines and shown to be a limiting factor to population growth in areas where habitats have been compromised.

In the Bi-State area, drought is a natural part of the sagebrush ecosystem, and we are unaware of any information to suggest that drought has influenced population dynamics of sage-grouse

under historical conditions. There are known occasions, however, where reduced brood rearing habitat condition due to drought have resulted in little to no recruitment within certain PMUs (i.e., Bodie and Pine Nut PMUs) (Gardner 2009, pers. comm.; Coates 2012, pers. comm.). Given the relatively small and restricted extent of the Bi-State DPS, if these conditions were to persist longer than the typical adult life span, drought could have significant ramifications on population persistence. Further, drought impacts on the sage-grouse may be exacerbated when combined with other habitat impacts that reduce cover and food (Braun 1998, p. 148).

Based on the best available scientific and commercial information, the threat of climate change is not known to currently impact the Bi-State DPS to such a degree that the viability of the species is at stake. However, while it is reasonable to assume the Bi-State area will experience vegetation changes into the future (as presented above), we do not know with precision the nature of these changes or ultimately the effect this will have on the Bi-State DPS. A recent analysis conducted by NatureServe suggests a substantial contraction of both sagebrush and sage-grouse range in the Bi-State area by 2060 (Comer *et al.* 2012, pp. 142, 145). Under the NatureServe analysis it is likely the area will become generally less suitable to invasion by cheatgrass, that the current extent of shrub habitat will decrease, and that future conditions will be more suitable for woodland and drier vegetation communities, which are not favorable to sage-grouse in the Bi-State DPS. In addition, it is reasonable to assume that changes in atmospheric carbon dioxide levels, temperature, precipitation, and timing of snowmelt will act synergistically with other threats such as wildfire and invasive nonnative species to produce yet unknown but likely negative effects to sage-grouse populations in the Bi-State area. As a result of these predictions and given the potential scope and severity of climate change when interacting with other threats in the future, the overall impact of climate change to the Bi-State DPS at this time is considered moderate.

#### Overutilization and Scientific and Education Uses

Sport hunting is currently limited in the Bi-State DPS and within generally accepted harvest guidelines. It is unlikely that the scope and severity of hunting impacts will ever again reach historical levels that would act in an additive manner to natural mortality. In the Bi-State area hunting is limited to such a degree that it is not apparently restrictive to overall population growth. Furthermore, we are unaware of any information indicating poaching, non-consumptive uses, or scientific use significantly impact Bi-State sage-grouse populations. Impacts caused by recreational activities may be disturbing sage-grouse populations in the Bi-State area and there are known localized habitat impacts. However, we do not have a clear understanding of the severity of these impacts. Populations in the South Mono PMU, which are arguably exposed to the greatest degree of pedestrian recreational activity, appear relatively stable at present. We anticipate increases in the scope and severity of recreation use impacts within the Bi-State area but do not currently know the threshold beyond which disturbance may influence sage-grouse activity.

#### Disease or Predation

West Nile virus is known to have occurred within sage-grouse populations in the Bi-State DPS, but the impacts are likely underestimated due to lack of monitoring. The impact of this disease



in the Bi-State DPS is likely currently limited by ambient temperatures that do not allow consistent vector and virus maturation. Predicted temperature increases associated with climate change may result in this threat becoming more consistently prevalent. We have no indication that other diseases or parasites are impacting the Bi-State DPS.

Predation facilitated by habitat fragmentation (fences, power lines, and roads) and other human activities may be altering natural population dynamics in specific areas of the Bi-State DPS. Data suggest certain populations are exhibiting deviations in vital rates below those anticipated. For example, in Long Valley (South Mono PMU) nest predators associated with a county landfill may be lowering nesting success. In addition, low adult survival estimates from the Desert Creek-Fales PMU suggest predators may be influencing population growth there. However, we generally consider habitat alteration as the root cause of these results but teasing apart the interaction between predation rate and habitat condition is difficult. Thus, we do not know the current extent that predation independently has on population growth and stability.

#### Small Population Size and Population Structure

The Bi-State DPS is comprised of approximately 43 active leks representing 4 to 8 relatively discrete populations. Research has shown fitness and population size are strongly correlated and smaller populations are more subject to environmental and demographic stochasticity. When coupled with mortality stressors related to human activity and significant fluctuations in annual population size, long-term persistence of small populations is unlikely. The Pine Nut PMU has the smallest number of sage-grouse of all Bi-State area PMUs (less than 100 individuals, representing less than 5 percent of the DPS). However, each population in the Bi-State DPS is relatively small and below theoretical minimum criteria for long-term persistence, as is the entire DPS on average (estimated 1,833 to 7,416 individuals).

#### Pesticides and Herbicides

Although pesticides and herbicides can result in direct and indirect mortality of individual sage-grouse, we are unaware of information that would indicate the current usage or residues from past applications in the Bi-State area are having negative impacts on populations. Currently, we do not anticipate that the levels of use of such chemical will increase in the future.

#### Contaminants

Within the Bi-State DPS, sage-grouse exposure to potential contaminants is currently limited and most likely associated with a few existing mining operations in the Pine Nut and Mount Grant PMUs. Future impacts from contaminants would most likely occur in these same PMUs due to their potential for future mineral development, but the scope and severity of future impacts are undeterminable at the present time.

#### Existing Regulatory Mechanisms

Bi-State sage-grouse conservation has been addressed in some local, State, and Federal plans, laws, regulations, and policies. However, an examination of regulatory mechanisms for both the Bi-State DPS and sagebrush habitats revealed that while some mechanisms exist, the supporting

documents are sufficiently old as to not always be consistent with our current understanding of the species' life history requirements, reaction to disturbances, and currently understood conservation needs. Existing regulatory mechanisms vary across the Bi-State area, although managing agencies are beginning to work more collaboratively across jurisdictional boundaries. The degree to which existing regulatory mechanisms affect conservation for the DPS is largely dependent on current and future implementation.

The Bi-State area is largely comprised of federally-managed lands. Existing land use plans, as they pertain to sage-grouse, are typically general in nature and afford relatively broad latitude to land managers. This latitude influences implementation of measures available to affect conservation of greater sage-grouse during decision making, and application is prone to change based on internal and external pressure. While we recognize the benefits of affording flexibility, we also recognize that negative consequences can occur. Therefore, we consider most existing Federal mechanisms are sufficiently vague as to offer limited certainty as to managerial direction pertaining to sage-grouse conservation. Regulations in some Counties identify the need for natural resource conservation and attempt to minimize impacts of development through zoning restrictions, but to our knowledge do not preclude development or monitor loss of sage-grouse habitats. Similarly, State laws and regulations are general in nature, do not provide specific direction to State wildlife agencies, or afford regulatory authority over habitat preservation. Furthermore, the interpretation of these provisions is prone to change based on direction provided through their respective Governors' Offices.

### Synergistic Impacts

Many of the impacts described in this report may cumulatively or synergistically affect the Bi-State DPS beyond the scope of each individual stressor. For example, the future loss of additional significant sagebrush habitat due to wildfire in the Bi-State DPS is anticipated because of the intensifying synergistic interactions among fire, people and infrastructure, invasive species, and climate change. As another example, improper livestock grazing management alone may only affect a portion of the Bi-State DPS, but when combined with invasive species, drought, and wildfire, it may collectively result in substantial habitat loss, degradation, or fragmentation across large portions of the species' range. Predation may also increase as a result of increases in human disturbance and development. These are just a few scenarios of the numerous impacts that are likely acting cumulatively to further contribute to the challenges faced by many Bi-State DPS populations now and into the future.

### *Overall Summary*

Compounding impacts to habitat within the Bi-State area are interacting and resulting in increasingly fragmented habitat for a long-lived habitat specialist. Woodland encroachment is causing significant, measurable habitat loss throughout the range of the Bi-State DPS. While techniques to address this habitat impact are available and being implemented, the scale of such efforts is currently inadequate. Woodlands have expanded by an estimated 20,234 to 60,703 ha (50,000 to 150,000 ac) over the past decade in the Bi-State area, but woodland treatments have only been implemented on 6,475 ha (16,000 ac). Meanwhile, the existing and potential impacts of cheatgrass and wildfire are steadily increasing and will likely escalate further with climate

change, providing conditions that will likely result in rapid loss of significant quantities of suitable sage-grouse habitat. Similarly, impacts from infrastructure, urbanization, and recreation on already fragmented habitat within the Bi-State area are expected to gradually increase.

Taken cumulatively, the ongoing and future habitat-based impacts in all PMUs will likely act to fragment and further isolate populations within the Bi-State DPS. Current or future impacts caused by wildfire, urbanization, grazing, infrastructure, recreation, woodland succession, energy and mineral development, and climate change will likely persist and interact in the near term and most significantly influence the Pine Nut, Desert Creek-Fales, and Mount Grant PMUs. The Bodie and South Mono PMUs are larger and more stable and generally have fewer habitat pressures. The level of impacts within the White Mountains PMU remains largely unknown; this population is on the southern periphery of the DPS and is likely relatively small. While the South Mono, White Mountains, and Pine Nut PMUs appear to be largely isolated entities, the Bodie PMU interacts with the Mount Grant and to a lesser degree the Desert Creek-Fales PMUs, and the potential erosion of habitat suitability in these latter PMUs may influence the population dynamics and possibly the persistence of the breeding population occurring in the Bodie PMU.

When historical, existing, and future impacts such as predation, disease, recreation, and climate change (vegetation changes, drought) are considered in conjunction with other habitat stressors, it appears that preservation of sage-grouse populations in the northern half of the Bi-State area will be difficult. Given the Bi-State DPS's relatively low rate of growth and strong site fidelity, recovery and repopulation of extirpated areas will be slow and infrequent, making future recovery of extirpated populations within the Bi-State area challenging. Translocation of sage-grouse is difficult, and given the limited number of source individuals within the range of the Bi-State DPS, translocation efforts, if needed, will be logistically complicated. Within the next several decades, it is possible that sage-grouse in the Bi-State area will persist in two of the potentially eight populations in the Bi-State area, specifically the two populations located in the South Mono PMU (Long Valley) and the Bodie PMU (Bodie Hills). These two populations could also become isolated from one another as a result of the potential for loss of habitat connectivity due to exurban development on private lands in the Bodie PMU, as well as future habitat fragmentation from potential pinyon-juniper encroachment, wildfire, and cheatgrass impacts. Once further isolated, it is likely that both core PMUs would be at greater risk to stochastic events.

## REFERENCES CITED

- Aldrich, J.W. 1946. New subspecies of birds from western North America. *Proceedings of the Biological Society of Washington* 59:129–136.
- Aldridge, C.L., and M.S. Boyce. 2007. Linking occurrence and fitness to persistence: a habitat-based approach for endangered greater sage-grouse. *Ecological Applications* 17:508–526.
- Aldridge, C.L., and R.M. Brigham. 2003. Distribution, abundance, and status of the greater sage-grouse, *Centrocercus urophasianus*, in Canada. *Canadian Field-Naturalist* 117:25–34.
- Aldridge, C.L., S.E. Nielsen, H.L. Beyer, M.S. Boyce, J.W. Connelly, S.T. Knick, and M.A. Schroeder. 2008. Range-wide patterns of greater sage-grouse persistence. *Diversity and Distributions* 14:983–994.
- Alpine County. 2009. Alpine County General Plan. 264 pp.
- American Ornithologists' Union. 1957. Check-list of North American birds. 5th ed. The Lord Baltimore Press, Inc. Baltimore, Maryland. 139 pp.
- American Wind Energy Association. 2008. Wind Energy Siting Handbook. 183 pp.
- Amstrup, S.C., and R.L. Phillips. 1977. Effects of coal extraction and related development on wildlife populations: Effects of coal strip mining on habitat use, activities and population trends of sharp-tailed grouse (*Pedioecetes phasianellus*). Annual progress report. Denver Wildlife Research Center, U.S. Fish and Wildlife Service, Denver, Colorado. 37 pp.
- Animal and Plant Health Inspection Service (APHIS). 2002. U.S. Department of Agriculture. Rangeland grasshopper and mormon cricket suppression program. Final Environmental Impact Statement. Riverdale, MD. 283 pp.
- Animal and Plant Health Inspection Service. 2004. Site-specific environmental assessment: Rangeland grasshopper and mormon cricket suppression program. Draft for comment. EA Number: WY-04-01. Cheyenne, Wyoming. 40 pp.
- Anthony, R.G., and M.J. Willis. 2009. Survival rates of female greater sage-grouse in autumn and winter in southeastern Oregon. *Journal of Wildlife Management* 73:538–545.
- Atamian, M., J. Sedinger, and C. Frey. 2007. Dynamics of greater sage-grouse (*Centrocercus urophasianus*) populations in response to transmission lines in central Nevada. Progress Report Year 5. 39 pp.

- Autenrieth, R.E. 1981. Sage grouse management in Idaho. Wildlife Bulletin Number 9. Idaho Department of Fish and Game. 239 pp.
- Bachelet, D., R.P. Neilson, J.M. Lenihan, and R.J. Drapek. 2001. Climate change effects on vegetation distribution and carbon budget in the United States. *Ecosystems* 4:164–185.
- Baker, M.F., R.L. Eng, J.S. Gashwiler, M.H. Schroeder, and C.E. Braun. 1976. Conservation committee report on effects of alteration of sagebrush communities on the associated avifauna. *Wilson Bulletin* 88:165–171.
- Baker, W.L. 2006. Fire and restoration of sagebrush ecosystems. *Wildlife Society Bulletin* 34:177–185.
- Baker, W.L. 2011. Pre-Euroamerican and recent fire in sagebrush ecosystems. *Studies in Avian Biology* 38:185–201.
- Balch, J.K., B.A. Bradley, C.M. D'antonio, and J. Gomez-Dans. 2013. Introduced annual grass increases regional fire activity across the arid western USA (1980–2009). *Global Change Biology* 19:173–183.
- Bambrough, D.J., K.D. Bunnell, J.T. Flinders, J. Warder, and D. Mitchell. 2000. Red fox predation in Strawberry Valley, Utah. 22<sup>nd</sup> Western States Sage and Colombian Sharp-tailed Grouse Symposium, Redmond, Oregon.
- Barnett, J.K., and J.A. Crawford. 1994. Pre-laying nutrition of sage grouse hens in Oregon. *Journal of Range Management* 47:114–118.
- Batterson, W.M., and W.B. Morse. 1948. Oregon sage grouse. Oregon Fauna Series Number 1. Oregon State Game Commission. 29 pp.
- Baydack, R.K., and D.A. Hein. 1987. Tolerance of sharp-tailed grouse to lek disturbance. *Wildlife Society Bulletin* 15:535–539.
- Beck, J.L., and D.L. Mitchell. 2000. Influences of livestock grazing on sage grouse habitat. *Wildlife Society Bulletin* 28:993–1002.
- Beck, J.L., D.L. Mitchell, and B.D. Maxfield. 2003. Changes in the distribution and status of sage-grouse in Utah. *Western North American Naturalist* 63:203–214.
- Beck, J.L., J.W. Connelly, and K.P. Reese. 2009. Recovery of greater sage-grouse habitat features in Wyoming big sagebrush following prescribed fire. *Restoration Ecology* 17:393–403.
- Beck, T.D.I. 1977. Sage grouse flock characteristics and habitat selection in winter. *Journal of Wildlife Management* 41:18–26.

- Beck, J.L., J.W. Connelly, and C.L. Wamboldt. 2012. Consequences of treating Wyoming sagebrush to enhance wildlife habitats. *Rangeland Ecology and Management* 65:444–455.
- Beever, E.A. 2003. Management implications of the ecology of free-roaming horses in semiarid ecosystems of the western United States. *Wildlife Society Bulletin* 31:887–895.
- Beever, E.A., R.J. Tausch, and P.F. Brussard. 2008. Multi-scale responses of vegetation to removal of horse grazing from Great Basin (USA) mountain ranges. *Plant Ecology* 197:163–184.
- Beever, E.A., and C.L. Aldridge. 2011. Influences of free-roaming equids on sagebrush ecosystems, with focus on greater sage-grouse. *Studies in Avian Biology* 38:273–290.
- Benedict, N.G., S. J. Oyler-McCance, S.E. Taylor, C.E. Braun, and T.W. Quinn. 2003. Evaluation of the eastern (*Centrocercus urophasianus urophasianus*) and western (*Centrocercus urophasianus phaios*) subspecies of sage-grouse using mitochondrial control-region sequence data. *Conservation Genetics* 4:301–310.
- Berry, J.D., and R.L. Eng. 1985. Interseasonal movements and fidelity to seasonal use areas by female Sage-Grouse. *Journal of Wildlife Management* 49:237–240.
- Bi-State Lek Surveillance Program. 2012. Bi-State greater sage-grouse spring lek surveillance program. Part III: survey findings. 46 pp.
- Bi-State Local Planning Group. 2004. Greater Sage-Grouse Conservation Plan for the Bi-State Area of Nevada and Eastern California. Prepared in conjunction with the Nevada Governor’s Conservation Team. June 2004. 193 pp.
- Bi-State Technical Advisory Committee. 2012. Bi-State Action Plan. Past, Present, and Future Actions for Conservation of the Greater Sage-grouse Bi-State Distinct Population Segment. Prepared for the Bi-State Executive Oversight Committee for Conservation of Greater Sage-grouse. 108 pp. + appendices.
- Bi-State Technical Advisory Committee. 2012. Unpublished data. A spatially explicit habitat-suitability model developed for the Bi-State DPS that predicts location of suitable habitat.
- Blank, R.R., R.H. White, and L.H. Ziska. 2006. Combustion properties of *Bromus tectorum* L.: influence of ecotype and growth under four CO<sub>2</sub> concentrations. *International Journal of Wildland Fire* 15:227–236.
- Blomberg, E.J., J.S. Sedinger, M.T. Atamian, and D.V. Nonne. 2012. Characteristics of climate and landscape disturbance influence the dynamics of greater sage-grouse populations. *Ecosphere* 3(6):55. <http://dx.doi.org/10.1890/ES11-00304.1>. 20 pp.

- Blus, L.J., and J.W. Connelly. 1998. Radiotelemetry to determine exposure and effects of organophosphorous insecticides on sage grouse. Pages 21–29 *In* Brewer, L.W. and K.A. Fagerstone, eds. Proceedings Workshop Radiotelemetry Applications for Wildlife Toxicology Field Studies, January 5–8, 1993. Pacific Grove, California. Society of Environmental Toxicology and Chemistry, Pensacola, Florida. 224 pp.
- Blus, L.J., C.S. Staley, C.J. Henny, G.W. Pendleton, T.H. Craig, E.H. Craig, and D.K. Halford. 1989. Effects of organophosphorus insecticides on sage grouse in southeastern Idaho. *Journal of Wildlife Management* 53:1139–1146.
- Bock, C.E., and J.H. Bock. 1991. Response of grasshoppers (Orthoptera: Acrididae) to wildfire in a southeastern Arizona grassland. *American Midland Naturalist* 125:162–167.
- Borell, A.E. 1939. Telephone wires fatal to sage grouse. *Condor* 41:85–86.
- Boyce, M.S. 1990. The red queen visits sage grouse leks. *American Zoology* 30:263–270.
- Boyle, S.A., and F.B. Samson. 1985. Effects of nonconsumptive recreation on wildlife: a review. *Wildlife Society Bulletin* 13:110–116.
- Bradbury, J.W., R.M. Gibson, C.E. McCarthy, and S.L. Vehrencamp. 1989. Dispersion of displaying male sage grouse: II. The role of female dispersion. *Behavioral Ecology and Sociobiology* 24:15–24.
- Bradley, B.A. 2009. Regional analysis of the impacts of climate change on cheatgrass invasion shows potential risk and opportunity. *Global Change Biology* 15:196–208.
- Bradley, B.A., and D.S. Wilcove. 2009. When invasive plants disappear: transformative restoration possibilities in the Western United State resulting from climate change. *Restoration Ecology* 17:715–721.
- Bradley, B. A. 2010. Assessing ecosystem threats from global and regional change: hierarchical modeling of risk to sagebrush ecosystems from climate change, land use and invasive species in Nevada, USA. *Ecography* 33:198–208.
- Braun, C.E. 1995. Divisional correspondence from Clait E. Braun, Colorado Division of Wildlife, to those interested. Subject: Predation and sage-grouse. 3 pp.
- Braun, C.E. 1986. Changes in sage grouse lek counts with advent of surface coalmining. *Proc. Issues and Technology in the Management of Impacted Western Wildlife* 2:227–231.
- Braun, C.E. 1987. Current issues in sage grouse management. *Proceedings of Western Association of Fish and Wildlife Agencies* 67:134–144.
- Braun, C.E. 1998. Sage grouse declines in western North America: What are the problems? *Proceedings of Western Association of Fish and Wildlife Agencies* 78:139–156.

- Braun, C.E., M.F. Baker, R.L. Eng, J.W. Gashwiler, and M.H. Schroeder. 1976. Conservation committee report on effects of alteration of sagebrush communities on the associated avifauna. *The Wilson Bulletin* 88:165–171.
- Braun, C.E., O.O. Oedekoven, and C.L. Aldridge. 2002. Oil and gas development in western North America: Effects on sagebrush steppe avifauna with particular emphasis on sage-grouse. *Transactions of the North American Wildlife Natural Resources Conference* 67. 19 pp.
- Brown, K.G., and K.M. Clayton. 2004. Ecology of the greater sage-grouse (*Centrocercus urophasianus*) in the coal mining landscape of Wyoming's Powder River Basin. Final Technical Report, Thunderbird Wildlife Consultants, Inc. Wright, Wyoming. 19 pp.
- Brown, T.J., B.L. Hall, and A.L. Westerling. 2004. The impact of twenty-first century climate change on wildland fire danger in the western United States: an applications perspective. *Climate Change* 62:365–388.
- Bui, T.D. 2009. The effects of nest and brood predation by common ravens (*Corvus corax*) on greater sage-grouse (*Centrocercus urophasianus*) in relation to land use in western Wyoming. M.S. Thesis, University of Washington, Seattle, Washington. 48 pp.
- Bureau of Land Management (BLM). 1993. Record of Decision, Bishop Field Office Resource Management Plan. Bishop Field Office, Bishop, California
- Bureau of Land Management (BLM). 1997. Tonopah Resource Management Plan and Record of Decision. Tonopah Field Office, Tonopah, Nevada.
- Bureau of Land Management (BLM). 1999. Record of Decision Central California, Standards for Rangeland Health, Guidelines for Livestock Grazing Management. June 1999.
- Bureau of Land Management (BLM). 2001. Carson City Field Office Consolidated Resource Management Plan. Carson City Field Office, Carson City, Nevada.
- Bureau of Land Management (BLM). 2005a. Environmental Assessment and Finding of No Significant Impact, Sage Grouse Lek Protection and Recreational Access Management in the Long Valley Management Area - Whitmore Tubs and the Lek 1, Lek 5 and Lek 8 Vicinities. U.S. Department of the Interior, Bureau of Land Management. California State Office, Bishop Field Office, Bishop, California. CA-017-05-65. 21 pp.
- Bureau of Land Management (BLM). 2005b. Final programmatic environmental impact statement on wind energy development on BLM-administered lands in the western United States. U.S. Department of the Interior, Bureau of Land Management. FES 05-11. 13 pp.
- Bureau of Land Management (BLM). 2005c. Fire Management Plan. Bishop Field Office, Bishop, California.



- Bureau of Land Management (BLM). 2005d. H-1601-1 - Land use planning handbook. U.S. Department of the Interior, Bureau of Land Management. 3 pp.
- Bureau of Land Management (BLM). 2006. Environmental Assessment and Finding of No Significant Impact, on Aurora geothermal leasing. Carson City District Office, Carson City, Nevada.
- Bureau of Land Management (BLM). 2008. 6840 – Special status species management. Bureau Manual Rel 6-125. U.S. Department of the Interior, Bureau of Land Management. 48 pp.
- Bureau of Land Management (BLM). 2010. Notice of intent to prepare a Resource Management Plan for the Battle Mountain District and associated Environmental Impact Statement, Nevada. 75 FR 77652.
- Bureau of Land Management (BLM). 2012a. Response to U.S. Fish and Wildlife Service request for information on greater sage-grouse. Carson City Field Office, Carson City, Nevada. 7 pp.
- Bureau of Land Management (BLM). 2012b. Final programmatic environmental impact statement for solar development in six southwestern states. July 2012. FES 12–24 DOE/EIS–0403.
- Bureau of Land Management (BLM). 2012c. Instruction Memorandum. Bi-State Distinct Population Segment of Greater Sage-Grouse Interim Management Policies and Procedures. December 3, 2012. 16 pp.
- Bureau of Land Management and U.S. Forest Service (BLM and USFS). 2008a. Response to U.S. Fish and Wildlife Service request for information on greater sage-grouse. Map depicting key suitable habitat.
- Bureau of Land Management and U.S. Forest Service (BLM and USFS). 2008b. Record of Decision and final programmatic environmental impact statement for geothermal leasing in the western United States. December 17, 2008, 102 pp.
- Bureau of Land Management and U.S. Department of Energy (BLM and DOE). 2009. Approved Resource Management Plan Amendments/Record of Decision for designation of energy corridors on Bureau of Land Management administered lands in 11 Western States.
- Bureau of Land Management (BLM), U.S. Forest Service (USFS), and Great Basin Unified Air Pollution Control District. 2012. Public Draft Joint Environmental Impact Statement and Environmental Impact Report for the Casa Diablo IV Geothermal Development Project. November 2012. Bishop, California. 27 pp.

- Bush, K.L. 2009. Genetic diversity and paternity of endangered Canadian greater sage-grouse (*Centrocercus urophasianus*). Ph.D. Dissertation, University of Alberta, Edmonton, Alberta. 202 pp.
- Byrne, M.W. 2002. Habitat use by female greater sage grouse in relation to fire at Hart Mountain National Antelope Refuge, Oregon. M.S. Thesis, Oregon State University, Corvallis, Oregon. 62 pp.
- Cadwell, L.L., J.L. Downs, C.M. Phelps, J.J. Nugent, L. Marsh, and L. Fitzner. 1996. Sagebrush restoration in the shrub-steppe of south-central Washington. Pages 143-145 *In* Barrow, J.R., E.D. McArthur, R.E. Sosebee, and R.J. Tausch, comps. Proceedings: Shrubland ecosystem dynamics in a changing environment. General Technical Report INT-GTR-338. U.S. Department of Agriculture, U.S. Forest Service, Intermountain Research Station. Ogden, Utah. 275 pp.
- California Department of Fish and Game (CDFG). 2012. Response to U.S. Fish and Wildlife Service request for information on greater sage-grouse. California Department of Fish and Game, Sacramento, California, unpublished data. 3pp. + attachment.
- California State Parks. 2013. Web accessed on April 16, 2013. <http://www.parks.ca.gov>
- Call, M.W., and C. Maser. 1985. Wildlife habitats in managed rangelands - The Great Basin of southeastern Oregon sage grouse. General Technical Report PNW-187, U.S. Department of Agriculture, Forest Service, La Grande, Oregon. 30 pp.
- Carpenter, F.R. 1981. Establishing management under the Taylor Grazing Act. *Rangelands* 3:105-115.
- Casazza, M.L., P.S. Coates, and C.T. Overton. 2011. Linking habitat selection and brood success in greater sage-grouse. *Studies in Avian Biology* 39:151-167.
- Casazza, M.L., C.T. Overton, M.A. Farinha, A. Torregrosa, J.P. Fleskes, M.R. Miller, J.S. Sedinger, and E. Kolada. 2009. Ecology of Greater Sage-Grouse in the Bi-State Planning Area Final Report, September 2007; U.S. Geological Survey Open-File Report 2009-1113, 50 pp.
- Cayan, D.R., E.P. Maurer, M.D. Dettinger, M. Tyree, and K. Hayhoe. 2008. Climate change scenarios for the California region. *Climate Change (Suppl 1)*:S21-S42.
- Chambers, J.C., and M. Pellant. 2008. Climate change impacts on northwestern and intermountain United States rangelands. *Rangelands* 30:29-33.
- Christiansen, T. 2009. Fence marking to reduce greater sage-grouse (*Centrocercus urophasianus*) collisions and mortality near Farson, Wyoming - summary of interim results. Wyoming Game and Fish Department. Unpublished data. 3 pp.

- Christiansen, T.J., and C.M. Tate. 2011. Parasites and infectious disease of greater sage-grouse. *Studies in Avian Biology*. 38:113–126.
- Clark, L., J. Hall, R. McLean, M. Dunbar, K. Klenk, R. Bowen, and C.A. Smeraski. 2006. Susceptibility of greater sage-grouse to experimental infection with West Nile virus. *Journal of Wildlife Diseases* 42:14–22.
- Coates, P.S. 2007. Greater sage-grouse (*Centrocercus urophasianus*) nest predation and incubation behavior. Ph.D. Thesis, Idaho State University, Boise, Idaho. 191 pp.
- Coates, P.S., and D.J. Delehanty. 2008. Effects of environmental factors on incubation patterns of greater sage-grouse. *Condor* 110:627–638.
- Coates, P.S., and D.J. Delehanty. 2010. Nest predation of greater sage-grouse in relation to microhabitat factors and predators. *Journal of Wildlife Management* 74:240–248.
- Coates, P.S., J.W. Connelly, and D.J. Delehanty. 2008. Predators of greater sage-grouse nests identified by video monitoring. *Journal of Field Ornithology* 79:421–428.
- Coggins, K.A. 1998. Relationship between habitat changes and productivity of sage grouse at Hart Mountain National Antelope Refuge, Oregon. M.S. Thesis, Oregon State University, Corvallis, Oregon. 65 pp.
- Comer, P., P. Crist, M. Reid, J. Hak, H. Hamilton, D. Braun, G. Kittel, I. Varley, B. Unnasch, S. Auer, M. Creutzburg, D. Theobald, and L. Kutner. 2012. Central Basin and Range Rapid Ecoregional Assessment Report. Prepared for the U.S. Department of Interior, Bureau of Land Management. 168 pp. + appendices.
- Commons, M.L., R.K. Baydack, and C.E. Braun. 1999. Sage grouse response to pinyon-juniper management. Pages 238–239 *In* Monsen, S.B. and R.Stevens, eds. *Proceedings: Ecology and management of Pinyon Juniper Communities within the Interior West*. U.S.D.A. U.S. Forest Service Rocky Mountain Research Station RMRS-P9, Fort Collins, Colorado.
- Connelly, J. 2005. Challenging dogma-changing paradigms: Sage grouse harvest management in the United States. *Sage Grouse News* 29:7–11.
- Connelly, J.W., and L.J. Blus. 1991. Effects of pesticides on upland game: a review of herbicides and organophosphate and carbamate insecticides. Pages 92–97 *In* Marsh, M., ed. *Proceedings of the Conference; Pesticides in Natural Systems: How Can Their Effects be Monitored?* U.S. Environmental Protection Agency, Corvallis, Oregon.
- Connelly, J.W., and C.E. Braun. 1997. A review of long-term changes in sage grouse populations in western North America. *Wildlife Biology* 3:229–234.

- Connelly, J.W., W.J. Arthur, and O.D. Markham. 1981. Sage grouse leks on recently disturbed sites. *Journal of Range Management* 34:153–154.
- Connelly, J.W., M.A. Schroeder, A.R. Sands, and C.E. Braun. 2000a. Guidelines to manage sage grouse populations and their habitats. *Wildlife Society Bulletin* 28:967-985.
- Connelly, J.W., A.D. Apa, R.B. Smith, and K.P. Reese. 2000b. Effects of predation and hunting on adult sage grouse *Centrocercus urophasianus* in Idaho. *Wildlife Biology* 6:227–232.
- Connelly, J.W., K.P. Reese, R.A. Fischer, and W.L. Wakkinen. 2000c. Response of a sage grouse breeding population to fire in southeastern Idaho. *Wildlife Society Bulletin* 28:90–96.
- Connelly, J.W., K.P. Reese, E.O. Garton, and M.L. Commons-Kemner. 2003. Response of greater sage-grouse *Centrocercus urophasianus* populations to different levels of exploitation in Idaho, USA. *Wildlife Biology* 9: 255–260.
- Connelly, J.W., S.T. Knick, M.A. Schroeder, and S.J. Stiver. 2004. Conservation assessment of greater sage-grouse and sagebrush habitats. Unpublished Report, Western Association of Fish and Wildlife Agencies. Cheyenne, Wyoming. 610 pp.
- Connelly, J.W., J.H. Gammonley, and J.M. Peek. 2005. Harvest management. Pages 658-690 *In* Braun, C.E., ed. *Techniques for Wildlife Investigations and Management*. The Wildlife Society, Bethesda, Maryland. 658–690 pp.
- Connelly, J.W., C.A. Hagen, and M.A. Schroeder. 2011a. Characteristics and dynamics of greater sage-grouse populations. *Studies in Avian Biology*. 38:53–67.
- Connelly, J.W., E.T. Rinkes, and C.E. Braun. 2011b. Characteristics of greater sage-grouse habitats: a landscape species at micro and macro scales. *Studies in Avian Biology*. 38:69–83.
- Connelly, J.W., S.T. Knick, C.E. Braun, W.L. Baker, E.A. Beever, T. Christiansen, K.E. Doherty, E.O. Garton, C.A. Hagen, S.E. Hanser, D.H. Johnson, M. Leu, R.F. Miller, D.E. Naugle, S.J. Oyler-McCance, D.A. Pyke, K.P. Reese, M.A. Schroeder, S.J. Stiver, B.L. Walker, and M.J. Wisdom. 2011c. Conservation of greater sage-grouse: a synthesis of current trends and future management. *Studies in Avian Biology*. 38:549–563.
- Cook, J.G., T.J. Hershey, and L.L. Irwin. 1994. Vegetative response to burning on Wyoming mountain-shrub big game ranges. *Journal of Range Management* 47:296–302.
- Cooper, S.V., P. Lesica, and G.M. Kudray. 2007. Post-fire recovery of Wyoming big sagebrush shrub-steppe in central and southeast Montana. Report to the U.S. Department of the Interior, Bureau of Land Management, State Office. ESA010009 Task Order #29. Montana Natural Heritage Program, Helena, Montana. 34 pp.

- Cote, I.M., and W.J. Sutherland. 1997. The effectiveness of removing predators to protect bird populations. *Conservation Biology* 11:395–405.
- Crawford, J.A. 1982. History of sage grouse in Oregon. Pages 3–6 *In Oregon Wildlife*. Department of Fisheries & Wildlife, Oregon State University, Portland, Oregon.
- Crawford, J.A. 1999. Response of Wyoming big sagebrush to prescribed fire at Hart Mountain National Antelope Refuge, Oregon. Oregon State University, Corvallis, Oregon. 12 pp.
- Crawford, J.A., and D.M. Davis. 2002. Habitat use by greater sage-grouse on Sheldon National Wildlife Refuge, Nevada. Oregon State University, Corvallis, Oregon. 140 pp.
- Crawford, J.A., and R.S. Lutz. 1985. Sage grouse population trends in Oregon, 1941–1983. *The Murrelet* 66:69–74.
- Crawford, J.A., R.A. Olson, N.E. West, J.C. Mosley, M.A. Schroeder, T.D. Whitson, R.F. Miller, M.A. Gregg, and C.S. Boyd. 2004. Ecology and management of sage-grouse and sage-grouse habitat. *Journal of Range Management* 57:2–19.
- Dahlen, J.H., and A.O. Haugen. 1954. Acute toxicity of certain insecticides to the bobwhite quail and mourning dove. *Journal of Wildlife Management* 18:477–481.
- Dahlgren, D.K., T.A. Messmer, and D.N. Koons. 2010. Achieving better estimates of greater sage-grouse chick survival in Utah. *Journal of Wildlife Management* 74:1286–1294.
- Daubenmire, R.F. 1970. Steppe vegetation of Washington. Washington State University Agricultural Experiment Station Technical Bulletin No. 62. 131 pp.
- Davies, K.W., and T.J. Svejcar. 2008. Comparison of medusahead-invaded and noninvaded Wyoming big sagebrush steppe in southeastern Oregon. *Rangeland Ecology and Management* 61:623–629.
- Deibert, P.A. 1995. The effects of parasites on sage grouse (*Centrocercus urophasianus*) mate selection. Ph.D. thesis, University of Wyoming, Laramie, Wyoming. 139 pp.
- Delong, A.K., J.A. Crawford, and D.C. Delong, Jr. 1995. Relationships between vegetational structure and predation of artificial sage grouse nests. *Journal of Wildlife Management* 59:88–92.
- Dick, A.B. 2008. Survey & monitor the impacts of West Nile virus on the Duck Valley Indian Reservation's greater sage-grouse population. Fourth Quarterly Report. 6 pp.
- Diffenbaugh, N.S., F. Giorgi, and J.S. Pal. 2008. Climate change hotspots in the United States. *Geophysical Research Letters* 35, L16709, doi:10.1029/2008GL035075. 5 pp.

- Diffenbaugh, N.S., J.S. Pal, R.J. Trapp, and F. Giorgi. 2005. Fine-scale processes regulate the response of extreme events to global climate change. *Proceedings of the National Academy of Sciences* 102:15774–15778
- DiTomaso, J.M. 2000. Invasive weeds in rangelands: Species, impacts, and management. *Weed Science* 48:255–265.
- Dobkin, D.S. 1995. Management and conservation of sage grouse, denominative species for the ecological health of shrubsteppe ecosystems. U.S. Department of the Interior, Bureau of Land Management, Oregon State Office, Portland, Oregon. 27 pp.
- Dobkin, D.S., A.C. Rich, and W.H. Pyle. 1998. Habitat and avifaunal recovery from livestock grazing in a riparian meadow system of the northwestern Great Basin. *Conservation Biology* 12:209–221.
- Doherty, K.E., D.E. Naugle, B.L. Walker, and J.M. Graham. 2008. Greater sage-grouse winter habitat selection and energy development. *Journal of Wildlife Management* 72:187–195.
- Donahue, D.L. 1999. The western range revisited: Removing livestock from public lands to conserve native biodiversity. University of Oklahoma Press, Norman, Oklahoma. 388 pp.
- Drut, M.S. 1994. Status of sage grouse with emphasis on populations in Oregon and Washington. Audubon Society of Portland. Portland, Oregon. 42 pp.
- Dunn, P.O., and C.E. Braun. 1986. Late summer-spring movements of juvenile sage grouse. *Wilson Bulletin* 98:83–92.
- Eckert, Jr., R.E., M.K. Wood, W.H. Blackburn, and F.F. Peterson. 1979. Impacts of off-road vehicles on infiltration and sediment production of two desert soils. *Journal of Wildlife Management* 32:394–397.
- Eiswerth, M.E., K. Krauter, S.R. Swanson, M. Zielinski. 2009. Post-fire seeding on Wyoming big sagebrush ecological sites: Regression analyses of seeded nonnative and native species densities. *Journal of Environmental Management* 90:1320–1325.
- Ellis, K.L. 1985. Effects of a new transmission line on distribution and aerial predation of breeding male sage grouse. Final report, Deseret Generation and Transmission Cooperative, Sandy, Utah. 28 pp.
- Eng, R.L. 1952. A two-summer study of the effects on bird populations of chlordane bait and aldrin spray as used for grasshopper control. *Journal of Wildlife Management* 16:326–337.
- Epstein, P.R., and C. Defilippo. 2001. West Nile virus and drought. *Global Change and Human Health* 2:105–107.

- Erickson, W.P., G.D. Johnson, M.D. Strickland, D.P. Young, Jr., K.J. Sernka, and R.E. Good. 2001. Avian collisions with wind turbines: A summary of existing studies and comparisons to other sources of avian collision mortality in the United States. National Wind Coordinating Committee Resource Document. National Wind Coordinating Committee, Washington, D.C. 67 pp.
- Evans, C.C. 1986. The relationship of cattle grazing to sage grouse use of meadow habitat on the Sheldon National Wildlife Refuge. M.S. Thesis, University of Nevada, Reno, Nevada. 92 pp.
- Farinha, M.A. 2011. Habitat selection and association of individual habitat use on survival rates of greater sage-grouse, in Mono County, California. Draft M.S. Thesis, University of Nevada Reno, Reno, Nevada. 80 pp.
- Federal Communications Commission (FCC). 2012. Website accessed on November 9, 2012. <http://www.fcc.gov/>.
- Federal Aviation Administration (FAA). 2008. Final environmental impact statement for the request for operations specifications amendment by Horizon Air to provide scheduled service to Mammoth Yosemite airport. U.S. Department of Transportation. Federal Aviation Administration.
- Fedy, B.C., and K.E. Doherty 2010. Population cycles are highly correlated over long time series and large spatial scales in two unrelated species: greater sage-grouse and cottontail rabbits. *Population Ecology* 165:915–924.
- Fernie, K.J., and S.J. Reynolds. 2005. The effects of electromagnetic fields from power lines on avian reproductive biology and physiology: A review. *Journal of Toxicology and Environmental Health, Part B* 8:127–140.
- Finch, D.M., ed. 2012. Climate change in grasslands, shrublands, and deserts of the interior American West: a review and needs assessment. General technical Report. RMRS-GTR-285. Fort Collins, Colorado. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 139 pp.
- Fischer, R.A., K.P. Reese, and J.W. Connelly. 1996. An investigation on fire effects within xeric sage grouse brood habitat. *Journal of Range Management* 49:194–198.
- Flather, C.H., G.D. Hayward, S.R. Bessinger, and P.A. Stephens. 2011. Minimum viable populations: is there a ‘magic number’ for conservation practitioners? *Trends in Ecology and Evolution* 26:307–316.
- Forman, R.T.T. 2000. Estimate of the area affected ecologically by the road system in the United States. *Conservation Biology* 14:31–35.

- Forman, R.T.T., and L.E. Alexander. 1998. Roads and their major ecological effects. *Annual Review of Ecology and Systematics* 29:207–231 plus C2.
- Frankham, R. 1995. Inbreeding and extinction: A threshold effect. *Conservation Biology* 9:792–799.
- Frankham, R., Ballou, J.D., Briscoe, D.A. 2002. *Introduction to Conservation Genetics*. Cambridge University Press, Cambridge, United Kingdom.
- Franklin, I.R., and R. Frankham. 1998. How large must populations be to retain evolutionary potential? *Animal Conservation* 1:69–70.
- Frankham, R. 2005. Genetics and extinction. *Biological Conservation* 126:131–140.
- Freese, M.T. 2009. Linking greater sage-grouse habitat use and suitability across spatiotemporal scales in central Oregon. M.S. Thesis, Oregon State University, Corvallis, Oregon. 123 pp.
- Friend, M., R.G. McLean, and F.J. Dein. 2001. Disease emergence in birds: Challenges for the twenty-first century. *The Auk* 118:290–303.
- Gardali, T., N.E. Seavy, R.T. DiGaudio, and L.A. Comrack. 2012. A climate change vulnerability assessment of California's At-Risk Birds. *PLoS ONE* 7(3): e29507. Doi:10.1371/journal.pone.0029507.
- Garton, E.O., J.W. Connelly, J.S. Horne, C.A. Hagen, A. Moser, and M. Schroeder. 2011. Greater sage-grouse population dynamics and probability of persistence. *Studies in Avian Biology* 38:293–381.
- Gelbard, J.L., and J. Belnap. 2003. Roads as conduits for exotic plant invasions in a semiarid landscape. *Conservation Biology* 17:420–432.
- Gibson, R. 1998. Effects of hunting on the population dynamics of two sage grouse populations in Mono County, California. *Western Sage and Columbian Sharptailed Grouse Workshop*. 21:15.
- Gibson, R.M. 2001. Status of Mono County sage grouse. September 30, 2001 email to Randy Webb. 5 pp., on file.
- Gibson, R.M., and J.W. Bradbury. 1985. Sexual selection in lekking sage grouse: phenotypic correlates of male mating success. *Behavioral Ecology and Sociobiology* 18:117–123.
- Gibson, R.M., V.C. Bleich, C.W. McCarthy, and T.L. Russi. 2011. Hunting lowers population size in greater sage-grouse. *Studies in Avian Biology* 39:307–315.



- Girard G.L. 1937. Life history, habits, and food of the sage grouse, *Centrocercus urophasianus* Bonaparte. University of Wyoming Publications. University of Wyoming, Laramie, Wyoming. 56 pp.
- Global Climate Change Impacts in the United States. 2009. Report. Web accessed, March 2013. <http://nca2009.globalchange.gov/>.
- Gratson, M.W. 1993. Sexual selection for increased male courtship and acoustic signals and against large male size at sharp-tailed grouse leks. *Evolution* 47:691–696.
- Greater Sage-Grouse Advisory Committee. 2012. Strategic plan for conservation of greater sage-grouse in Nevada. 25 pp. + attachments
- Gregg, M.A. 1991. Use and selection of nesting habitat by sage grouse in Oregon. M.S. Thesis, Oregon State University, Corvallis, Oregon. 56 pp.
- Gregg, M.A., J.A. Crawford, M.S. Drut, and A.K. DeLong. 1994. Vegetational cover and predation of sage grouse nests in Oregon. *Journal of Wildlife Management* 58:162–166.
- Gregg, M.A., M. Pope, and J.A. Crawford. 2003a. Survival of sage grouse chicks in the northern Great Basin - 2002 annual report. Oregon State University, Corvallis, Oregon. 28 pp.
- Gregg, M.A., M. Pope, and J.A. Crawford. 2003b. Survival of sage grouse chicks in the northern Great Basin - 2003 annual report. Oregon State University, Corvallis, Oregon. 28 pp.
- Gregg, M.A., M.R. Dunbar, and J.A. Crawford. 2007. Use of implanted radiotransmitters to estimate survival of greater sage-grouse chicks. *Journal of Wildlife Management* 71: 646–651.
- Gullion, G.W., and G.C. Christensen. 1957. A review of the distribution of gallinaceous game birds in Nevada. *Condor* 59:128–138.
- Hagen, C. 2005. Greater sage-grouse conservation assessment and strategy for Oregon: a plan to maintain and enhance populations and habitat. Oregon Department of Fish and Wildlife, Salem, Oregon. 160 pp.
- Hagen, C.A. 2011. Predation on greater sage-grouse: Facts, process, and effects. *Studies in Avian Biology* 38:95–100.
- Hagen, C.A., J.W. Connelly, and M.A. Schroeder. 2007. A meta-analysis of greater sage-grouse *Centrocercus urophasianus* nesting and brood-rearing habitats. *Wildlife Biology* 13:42–50.

- Hall F.A. 1995. Determining changes in abundance of sage grouse (*Centrocercus urophasianus*) in California. 95 pp.
- Hall, F.A., S.C. Gardner, and D.S. Blankenship. 2008. Greater sage-grouse (*Centrocercus urophasianus*) In Shuford, W.D., and Gardali, T., editors. California Bird Species of Special Concern: A ranked assessment of species, subspecies, and distinct populations of birds of immediate conservation concern in California. Studies of Western Birds 1. Western Field Ornithologists, Camarillo, California, and California Department of Fish and Game, Sacramento. Pages 96–101.
- Hartzler, J.E. 1974. Predation and the daily timing of sage grouse leks. *The Auk* 91:532–536.
- Hemstrom, M.A., M.J. Wisdom, W.J. Hann, M.M. Rowland, B.C. Wales, and R.A. Gravenmier. 2002. Sagebrush-steppe vegetation dynamics and restoration potential in the interior Columbia Basin, U.S.A. *Conservation Biology* 16:1243–1255.
- Hepworth, W.G. 1962. Diagnosis of diseases in mammals and birds. Job Completion Report. Wyoming Game and Fish Laboratory Research. 6 pp.
- Holloran, M.J. 2005. Greater sage-grouse (*Centrocercus urophasianus*) population response to natural gas field development in western Wyoming. Ph.D Thesis, University of Wyoming, Laramie, Wyoming. 215 pp.
- Holloran, M.J., and S.H. Anderson. 2003. Direct identification of northern sage-grouse, *Centrocercus urophasianus*, nest predators using remote sensing cameras. *The Canadian Field Naturalist* 117:308–310.
- Holloran, M.J., and S.H. Anderson. 2005. Spatial distribution of greater sage-grouse nests in relatively contiguous sagebrush habitats. *Condor* 107:742–752
- Holloran, M.J., B.J. Heath, A.G. Lyon, S.J. Slater, J.L. Kuipers, and S.H. Anderson. 2005. Greater sage-grouse nesting habitat selection and success in Wyoming: *The Journal of Wildlife Management* 69:638–649.
- Honess, R.F. 1955. A new flagellate, *Tritrichomonas simoni* from the sage grouse, *Centrocercus urophasianus*. *Wyoming Game and Fish Commission Bulletin* No 8, Article 1:1–3.
- Hornaday, W.T. 1916. Save the sage grouse from extinction: A demand from civilization to the western states. *N.Y. Zoological Park Bulletin* 5:179–219.
- Hull Jr., A.C. 1974. Species for seeding arid rangeland in southern Idaho. *Journal of Range Management* 27:216–218.
- Hupp, J.W., and Braun, C.E. 1989. Topographic distribution of sage grouse foraging in winter. *Journal of Wildlife Management* 53:823–829.

- Integrated Taxonomic Information System. 2010. ITIS report: *Centrocercus urophasianus* phaios Aldirch, 1946. [http://www.itis.gov/servlet/SingleRpt/SingleRpt?search=topic=TSN&search value=175857](http://www.itis.gov/servlet/SingleRpt/SingleRpt?search=topic=TSN&search%20value=175857).
- Intergovernmental Panel on Climate Change (IPCC). 2007. Climate Change 2007: Synthesis Report. adopted section by section at IPCC Plenary XXVII (Valencia, Spain, 12-17 November 2007). 73 pp.
- Johnsgard, P.A. 1983. The grouse of the world. University of Nebraska Press, Lincoln and London. 411 pp.
- Johnsgard, P.A. 2002. Grassland grouse and their conservation. Smithsonian Institution Press, Washington and London. 157 pp.
- Johnson, D.J., M.J. Holloran, J.W. Connelly, S.E. Hanser, C.L. Amundson, and S.T. Knick. 2011. Influences of environmental and anthropogenic features on greater sage-grouse population, 1997–2007. *Studies in Avian Biology* 38:407–450.
- Johnson, G.D., and M.S. Boyce. 1991. Survival, growth, and reproduction of captive-reared sage grouse. *Wildlife Society Bulletin* 19:88–93.
- Johnson, G.D., D.P. Young, Jr., W.P. Erickson, C.E. Derby, M.D. Strickland, and R.E. Good. 2000. Wildlife monitoring studies for seawest windpower project, Carbon County, Wyoming, 1995–1999. Final Report. Bureau of Land Management, Rawlins, Wyoming. 195 pp.
- Johnson, K.H., and C.E. Braun. 1999. Viability and conservation of an exploited sage grouse population. *Conservation Biology* 13:77–84.
- Johnson, M.K. and R.M. Hansen. 1979. Coyote food habits on the Idaho National Engineering Laboratory. *Journal of Wildlife Management* 43:951–956.
- Kaczor, N.W. 2008. Nesting and brood-rearing success and resource selection of greater sage-grouse in northwestern South Dakota. M.S. Thesis, South Dakota State University. 99 pp.
- Kapnick, S., and A. Hall. 2009. Observed changes in the Sierra-Nevada snowpack: potential causes and concerns. California Climate Change Center Report Series: CEC-500-2009-016-F. 26 pp.
- Keller, L.F., and D.M. Waller. 2002. Inbreeding effects in wild populations. *Trends in Ecology and Evolution* 17:230–241.
- Kerlinger, P. 2000. Avian mortality at communication towers: a review of recent literature, research, and methodology. Prepared for: U.S. Fish and Wildlife Service, Office of Migratory Bird Management. 38 pp.

- Kilpatrick, S. 2000. Using prescribed fire to manage sagebrush communities in occupied sage grouse habitats of Wyoming. Twenty-second Western States Sage & Columbian Sharp-tailed Grouse Symposium, Redmond, Oregon. 10 pp.
- Klebenow, D.A. 1969. Sage grouse nesting and brood habitat in Idaho. *Journal of Wildlife Management* 33:649–662.
- Klebenow, D.A. 1970. Sage grouse versus sagebrush control in Idaho. *Journal of Range Management* 23:396–400.
- Klebenow, D.A. 1981. Livestock grazing interactions with sage grouse. *Proceedings of the Wildlife-Livestock Relationship Symposium*. Pages 113–123.
- Klebenow, D.A., and G.M. Gray. 1968. Food habits of juvenile sage grouse. *Journal of Range Management* 21:80–83.
- Knick, S.T. 1999. Requiem for a sagebrush ecosystem? *Northwest Science* 73:53–57.
- Knick, S.T., and S.E. Hanser. 2011. Connecting pattern and process in greater sage-grouse populations and sagebrush landscapes. *Studies in Avian Biology* 38:383–405.
- Knick, S.T., D.S. Dobkin, J.T. Rotenberry, M.A. Schroeder, W.M. Vander Haegen, and C. Van Riper III. 2003. Teetering on the edge or too late? Conservation and research issues for avifauna of sagebrush habitats. *Condor* 105:611–634.
- Knick, S.T., S.E. Hanser, R.F. Miller, D.A. Pyke, M.J. Wisdom, S.P. Finn, E.T. Rinkes, and C.J. Henny. 2011. Ecological influence and pathways of land use in sagebrush. *Studies in Avian Biology* 38:203–251.
- Knight, R.L., H.A.L. Knight, and R.J. Camp. 1993. Raven populations and land-use patterns in the Mojave Desert, California. *Wildlife Society Bulletin* 21:469–471.
- Knight, R.L., and D.N. Cole. 1995. Factors that influence wildlife responses to recreationists. In: R.L. Knight and K.J. Gutzwiller, eds. *Wildlife and recreationists: Coexistence through management and research*. Island Press. Washington, D.C. Pp. 71–79.
- Knight, R.L., and J.Y. Kawashima. 1993. Responses of raven and red-tailed hawk populations to linear right-of-ways. *Journal of Wildlife Management* 57:266–271.
- Kolada, E.J., M.L. Casazza, and J.S. Sedinger. 2009a. Ecological factors influencing nest site selection of greater sage-grouse in Mono County, California. *Journal of Wildlife Management* 73: 1333–1340.
- Kolada, E.J., M.L. Casazza, and J.S. Sedinger. 2009b. Ecological factors influencing nest survival of greater sage-grouse in Mono County, California. *Journal of Wildlife Management* 73: 1341–1347.

- Lande, R. 1988. Genetics and demography in biological conservation. *Science* 241:1455–1460.
- Lande, R. 1995. Mutation and conservation. *Conservation Biology* 9:782–791.
- Larson, D.L., J.B. Grace, and J.L. Larson. 2008. Long-term dynamics of leafy spurge (*Euphorbia esula*) and its biocontrol agent, flea beetles in the genus *Aphthona*. *Biological Control* 47:250–226.
- Laycock, W.A., D. Loper, F.W. Obermiller, L. Smith, S.R. Swanson, P.J. Urness, and M. Vavra. 1996. Grazing on public lands. Council for Agriculture Science and Technology. Task Force Report No. 129. Ames, Iowa. 82 pp.
- Leach, H.R., and A.L. Hensley. 1954. The sage grouse in California, with special reference to food habits. *California Fish and Game* 40:385–394.
- LeBeau, C.W. 2012. Evaluation of greater sage-grouse reproductive habitat and response to wind energy development in south-central, Wyoming. M.S. Thesis, University of Wyoming, Laramie, Wyoming. 120 pp.
- Lenihan, J.M., D. Bachelet, R.P. Neilson, and R. Drapek. 2008. Response of vegetation distribution, ecosystem productivity, and fire to climate change scenarios for California. *Climate Change* 87 (Suppl 1):S215–S230.
- Lenihan, J.M., R. Drapek, D. Bachelet, and R.P. Neilson. 2003. Climate change effects on vegetation distribution, carbon, and fire in California. *Ecological Applications* 13:1667–1681.
- Lesica, P., S.V. Cooper, and G. Kudray. 2007. Recovery of big sagebrush following fire in southwest Montana. *Rangeland Ecology and Management* 60:261–269.
- Leu, M. and S.E. Hanser. 2011. Influences of the human footprint on the sagebrush landscape patterns: implications for sage-grouse conservation. *Studies in Avian Biology* 38:253–271.
- Leu, M., S.E. Hanser, and S.T. Knick. 2008. The human footprint in the west: A large scale analysis of anthropogenic impacts. *Ecological Applications* 18:1119–1139.
- Link, S.O., C.W. Keeler, R.W. Hill, and E. Hagen. 2006. *Bromus tectorum* cover mapping and fire risk. *International Journal of Wildland Fire* 15:113–119.
- Livingston, M.F. 1998. Western sage grouse management plan (1 October 1998 to 30 September 2003), Yakima Training Center. 76 pp.
- Lyford, M.E., S.T. Jackson, J.L. Betancourt, and S.T. Gray. 2003. Influence of landscape structure and climate variability on a Late Holocene plant migration. *Ecological Monographs* 73:567–583.

- Lynch, M., and R. Lande. 1998. The critically effective size for a genetically secure population. *Animal Conservation* 1:70–73.
- Lyon, A.G. 2000. The potential effects of natural gas development on sage grouse (*Centrocercus urophasianus*) near Pinedale, Wyoming. M.S. Thesis, University of Wyoming, Laramie, Wyoming. 129 pp.
- Lyon, A.G., and S.H. Anderson. 2003. Potential gas development impacts on sage grouse nest initiation and movement. *Wildlife Society Bulletin* 31:486–491.
- Mack R.N., and J.N. Thompson. 1982. Evolution in steppe with few large, hooved mammals. *American Naturalist* 119:757–773.
- Maier, A.M., B.L. Perryman, R.A. Olson, and A.L. Hild. 2001. Climatic influences on recruitment of 3 subspecies of *Artemisia tridentata*. *Journal of Range Management* 54:699–703.
- Manville, A.M. 2002. Bird strikes and electrocutions at power lines, communication towers, and wind turbines: State of the art and state of the science – next steps toward
- Marra, P.P., S. Griffing, C. Caffrey, A.M. Kilpatrick, R. McLean, C. Brand, E. Saito, A.P. Dupuis, L. Kramer, and R. Novak. 2004. West Nile virus and wildlife. *BioScience* 54:393–402.
- McArthur, E.D. 1994. Ecology, distribution, and values of sagebrush within the intermountain region. Pages 347–351 *In* Monsen, S.B. and S.G. Kitchen, comps. *Proceedings: Ecology and management of annual rangelands*. General Technical Report INT-GTR-313. U.S. Department of Agriculture, U.S. Forest Service, Intermountain Research Station. 416 pp.
- McEwen, L.C., and R.L. Brown. 1966. Acute toxicity of dieldrin and malathion to wild sharp-tailed grouse. *Journal of Wildlife Management* 30:604–611.
- McLean, R.G. 2006. West Nile virus in North American birds. *Ornithological Monographs* 60:44–64.
- Menard, C., P. Duncan, G. Fleurance, J-Y. Georges, and M. Lila. 2002. Comparative foraging and nutrition of horses and cattle in European wetlands. *Journal of Applied Ecology* 39:120–133.
- Mensing, S., S. Livingston, and P. Barker. 2006. Long-term fire history in Great Basin sagebrush reconstructed from macroscopic charcoal in spring sediments, Newark Valley, Nevada. *Western North American Naturalist* 66:64–77.
- Merritt, S., C. Prosser, K. Sedivec, and D. Bangsund. 2001. Multi-species grazing and leafy spurge. U.S. Department of Agriculture - ARS Team Leafy Spurge Area-Wide IPM Program, Sidney, Montana. 28 pp.

- Mezquida, E.T., S.J. Slater, and C.W. Benkman. 2006. Sage-grouse and indirect interactions: Potential implications of coyote control on sage-grouse populations. *Condor* 108:747-759.
- Miller, R.F., and J.A. Rose. 1999. Fire history and western juniper encroachment in sagebrush steppe. *Journal of Range Management* 52:550–559.
- Miller, R.F., and L.L. Eddleman. 2000. Spatial and temporal changes of sage grouse habitat in the sagebrush biome. Oregon State University Agricultural Experiment Station, Technical Bulletin 151. 37 pp.
- Miller, R.F., S.T. Knick, D.A. Pyke, C.W. Meinke, S.E. Hanser, M.J. Wisdom, and A.L. Hild. 2011. Characteristics of sagebrush habitats and limitations to long-term conservation. *Studies in Avian Biology* 38:145–184.
- Milton, S.J., R.J. Dean, M.A. du Plessis, and W.R. Siegfried. 1994. A conceptual model of arid rangeland degradation. *BioScience* 44:70–76.
- Mooney, H.A., and E.E. Cleland. 2001. The evolutionary impact of invasive species. *Proceedings of the National Academy of Sciences* 98: 5446–5451.
- Moore, R., and T. Mills. 1977. An environmental guide to western surface mining. Part two: Impacts, mitigation and monitoring. FWS/OBS-78/04, U.S. Fish and Wildlife Service, Fort Collins, Colorado. 379 pp.
- Moynahan, B.J., M.S. Lindberg, and J.W. Thomas. 2006. Factors contributing to process variance in annual survival of female greater sage-grouse in Montana. *Ecological Applications* 16:1529–1538.
- Moynahan, B.J., M.S. Lindberg, J.J. Rotella, and J.W. Thomas. 2007. Factors affecting nest survival of greater sage-grouse in northcentral Montana. *Journal of Wildlife Management* 71:1773–1783.
- Nachlinger, J. 2003. Mount Grant Initial Conservation Assessment and Strategies. The Nature Conservancy of Nevada, Reno, Nevada. 69 pp.
- Naugle, D.E., C.L. Aldridge, B.L. Walker, K.E. Doherty, M.R. Matchett, J. McIntosh, T.E. Cornish, and M.S. Boyce. 2005. West Nile virus and sage-grouse: What more have we learned? *Wildlife Society Bulletin* 33:616–623.
- Naugle, D.E., C.L. Aldridge, B.L. Walker, T.E. Cornish, B.J. Moynahan, M.J. Holloran, K. Brown, G.D. Johnson, E.T. Schmidtman, R.T. Mayer, C.Y. Kato, M.R. Matchett, T.J. Christiansen, W.E. Cook, T. Creekmore, R.D. Falise, E.T. Rinkes and M.S. Boyce. 2004. West Nile virus: Pending crisis for greater sage-grouse. *Ecology Letters* 7:704–713.

- Naugle, D.E., K.E. Doherty, B.L. Walker, M.J. Holloran, and H.E. Copeland. 2011. Energy development and greater sage-grouse. *Studies in Avian Biology* 38:489–503.
- Neilson, R.P., J.M. Lenihan, D. Buchelet, and R.J. Drapek. 2005. Climate change implication for sagebrush ecosystems. *Transactions of the 70<sup>th</sup> North American Wildlife and Natural Resources Conference* 70:145–159.
- Nelle, P.J., K.P. Reese, and J.W. Connelly. 2000. Long-term effects of fire on sage grouse nesting. *Journal of Range Management* 53:586–591.
- Nemeth, N.M., D.C. Hahn, D.H. Gould, and R.A. Bowe. 2006. Experimental West Nile virus infection in eastern screech owls (*Megascops asio*). *Avian Diseases* 50:252–258.
- Nevada Department of Wildlife (NDOW). 2009a. Unpublished data. Response to U.S. Fish and Wildlife Service request for information on sage-grouse. Nevada Department of Wildlife, Reno, Nevada. Email exchange, with attachments.
- Nevada Department of Wildlife (NDOW). 2009b. Nevada sage-grouse demographic data 1996–2008 (from annual wing bee analysis). Unpublished data. 1 p.
- Nevada Department of Wildlife (NDOW). 2010. Response to U.S. Fish and Wildlife Service request for information on sage-grouse. Nevada Department of Wildlife, Reno, Nevada. 5 pp. with attachments.
- Nevada Department of Wildlife (NDOW). 2011. The role of private lands within the Nevada portion of the Bi-State (Lyon-Mono) sage-grouse population. 8 pp.
- Nevada Department of Wildlife (NDOW). 2012 *in litt*. Response to U.S. Fish and Wildlife Service request for information on sage-grouse. Nevada Department of Wildlife Reno, Nevada. Letter dated September 28, 2012. 6 pp.
- Nevada Department of Wildlife (NDOW). 2012 unpublished data. Response to U.S. Fish and Wildlife Service request for information on sage-grouse. Nevada Department of Wildlife, Reno, Nevada. Email exchange.
- Nevada Governor's Sage-Grouse Conservation Team. 2010. Nevada energy and infrastructure development standards to conserve greater sage-grouse populations and their habitats. 58 pp.
- Noone, D., E. Blomberg, M.T. Atamian, and J. Sedinger. 2012. Unpublished data. Quantifying observer effects on greater sage-grouse nest survival. Professional paper presentation. 28<sup>th</sup> Western Agencies Sage and Columbian Sharp-tailed Grouse Workshop. Steamboat Springs, Colorado. June 19–22.



- Noone, D., E. Blomberg, G.L. Patricelli, A.H. Krakauer, M.T. Atamian, and J. Sedinger. 2012. Effects of radio collars on male sage-grouse survival and lekking behavior. *Condor*–12–0176. 32 pp.
- Noone, D., E. Blomberg, and J. Sedinger. 2013. Dynamics of greater sage-grouse (*Centrocercus urophasianus*) populations in response to transmission line in central Nevada. Progress report: year 10. 75 pp.
- North Dakota Game and Fish Department (NDGFD). 2008. News release archives – April 2008: Spring sage grouse at record low, NDGF recommends closing season. <http://www.gf.nd.gov/multimedia/news/2008/04/080413.html>
- Oliphant, J.O. 1968. On the cattle ranges of the Oregon country. University of Washington Press, Seattle, Washington. 365 pp.
- Olsen, B.E., and R.T. Wallander. 2001. Sheep grazing spotted knapweed and Idaho fescue. *Journal Range Management* 54:25–30.
- Oregon Department of Fish and Wildlife (ODFW). 2008. Comments submitted to the U.S. Fish and Wildlife Service regarding potential listing of Greater sage-grouse.
- Oyler-McCance, S.J. 2011. Re-examining genetic variation in sage-grouse using genomic methods. Unpublished data. Professional Paper presentation. The Wildlife Society, 18<sup>th</sup> Annual Conference.
- Oyler-McCance, S.J., K.P. Burnham, and C.E. Braun. 2001. Influence of changes in sagebrush on Gunnison sage grouse in southwestern Colorado. *Southwestern Naturalist* 46:323–331.
- Oyler-McCance, S.J., S.E. Taylor, and T.W. Quinn. 2005. A multilocus population genetic survey of greater sage-grouse across their range. *Molecular Ecology* 14:1293–1310
- Oyler-McCance, S.J., and M.L. Casazza. 2011. Evaluation of the genetic distinctiveness of greater sage-grouse in the Bi-State planning area. U.S. Geological Survey Open-File Report 2011–1006, 15 p.
- Oyler-McCance, S.J., and T.W. Quinn. 2011. Molecular insight into the biology of greater sage-grouse. *Studies in Avian Biology* 38:85–94.
- Patterson, R.L. 1952. The sage grouse in Wyoming. Wyoming Game and Fish Commission, Sage Books Inc., Denver, Colorado. 344 pp.
- Payne, G.F., J.W. Foster, and W.C. Leininger. 1983. Vehicle impacts on northern Great Plains range vegetation. *Journal of Range Management* 36:327–331.

- Paysen, T.E., R.J. Ansley, J.K. Brown, G.J. Gottfried, S.M. Haase, M.G. Harrington, M.G. Narog, S.S. Sackett, and R.C. Wilson. 2000. Fire in western shrubland, woodland, and grassland ecosystems – Chapter 6. Pages 121–159 *In* Brown, J.K. and J.K. Smith, eds. *Wildland Fire in Ecosystems: Effects of Fire on Flora*. General Technical Report RMRS-GTR-42 Vol. 2. U.S. Department of Agriculture, U.S. Forest Service, Rocky Mountain Research Station. 257 pp.
- Pedersen, E.K., J.W. Connelly, J.R. Hendrickson and W.E. Grant. 2003. Effect of sheep grazing and fire on sage grouse populations in southeastern Idaho. *Ecological Modeling* 165:23–47.
- Peters, E.F., and S.C. Bunting. 1994. Fire conditions pre- and post-occurrence of annual grasses on the Snake River plain. Pages 31–36 *In* Monsen, S.B. and S.G. Kitchen, comps. *Proceedings: Ecology and Management of Annual Rangelands*. General Technical Report INT–GTR–313. U.S. Department of Agriculture, U.S. Forest Service, Intermountain Research Station. 416 pp.
- Peterson, E.B. 2003. Mapping Percent-Cover of the Invasive Species *Bromus tectorum* (Cheatgrass) over a Large Portion of Nevada from Satellite Imagery. Report for the U.S. Fish and Wildlife Service, Nevada State Office, Reno, by the Nevada Natural Heritage Program, Carson City, Nevada.
- Peterson, J.G. 1970. The food habits and summer distribution of juvenile sage grouse in central Montana. *Journal of Wildlife Management* 34:147–155.
- Peterson, M.J. 2004. Parasites and infectious diseases of prairie grouse: Should managers be concerned? *Wildlife Society Bulletin* 32:35–55.
- Post, G. 1951. Effects of toxaphene and chlordane on certain game birds. *Journal of Wildlife Management* 15:381–386.
- Potts, G.R. 1986. *The partridge: pesticides, predation, and conservation*. Collins, London, United Kingdom.
- Pruett, C.L., M.A. Patten, and D.H. Wolfe. 2009. Avoidance behavior by prairie grouse: implications for development of wind energy. *Conservation Biology* 23:1253–1259.
- Pyke, D.A. 2011. Restoring and rehabilitating sagebrush habitats. *Studies in Avian Biology* 38:531–548.
- Pyle, W.H. 1992. Response of brood-rearing habitat of sage grouse to prescribed burning in Oregon. M.S. Thesis, Oregon State University, Corvallis, Oregon. 56 pp.
- Pyle, W.H., and J.A. Crawford. 1996. Availability of foods of sage grouse chicks following prescribed fire in sagebrush-bitterbrush. *Journal Range Management* 49:320–324.

- Quinney, D.L., M. McHenry, and J. Weaver. 1996. Restoration of native shrubland in a military training area using hand-broadcasting of seed. Pages 156–157 *In* Barrow, J.R., E.D. McArthur, R.E. Sosebee, and R.J. Tausch, comps. *Proceedings: Shrubland Ecosystem Dynamics in a Changing Environment*. General Technical Report INT–GTR–338. U.S. Department of Agriculture, U.S. Forest Service, Intermountain Research Station. Ogden, Utah. 275 pp.
- Rands, M.R.W. 1985. Pesticide use on cereals and the survival of grey partridge chicks: A field experiment. *Journal of Applied Ecology* 22:49–54.
- Rasmussen, D.I., and L.A. Griner. 1938. Life history and management studies of sage grouse in Utah, with special reference to nesting and feeding habits. *Transactions of the Third North American Wildlife Conference* 3:852–864.
- Reed, D.H. 2005. Relationship between population size and fitness. *Conservation Biology* 19:563–568.
- Reese, K.P., and J.W. Connelly. 2011. Harvest management for greater sage-grouse: A changing paradigm for game bird management. *Studies in Avian Biology* 38:101–111.
- Reisen, W., H. Lothrop, R. Chiles, M. Madon, C. Cossen, L. Woods, S. Husted, V. Kramer, and J. Edman. 2004. *Emerging Infectious Diseases* 10:1369–1378.
- Reisner, M. D., J. B. Grace, D. A. Pyke, and P. S. Doescher. 2013. Conditions favoring *Bromus tectorum* dominance of endangered sagebrush steppe ecosystems. *Journal of Applied Ecology*, doi: 10.1111/1365–2664.12097.
- Reisen, W.K., Y. Fang, and V.M. Martinez. 2006. Effects of temperature on the transmission of West Nile virus by *Culex tarsalis* (Diptera: Culicidae). *Journal of Medical Entomology* 43:309–317.
- Remington, T.E., and C.E. Braun. 1991. How surface coal mining affects sage grouse, North Park, Colorado. *Proc. Issues Technol. Manage. Impacted Wildl.* 5:128–132.
- Renewable Energy Transmission Access Advisory Committee (RETAAC). 2007. Governor Jim Gibbons' Nevada Renewable Energy Transmission Access Advisory Committee Phase I Report. 18 pp., 3 maps.
- Restani, M., J.M. Marzluff, and R.E. Yates. 2001. Effects of anthropogenic food sources on movements, survivorship, and sociality of common ravens in the Arctic. *Condor* 103:399–404.
- Richards, R.T., J.C. Chambers, and C. Ross. 1998. Use of native plants on federal lands: Policy and practice. *Journal of Range Management* 51:625–632.

- Riggs, R.A., and P.J. Urness. 1989. Effects of goat browsing on Gambel oak communities in northern Utah. *Journal of Range Management* 42:354–360.
- Ritchie, M.E., M.L. Wolfe, and R. Danvir. 1994. Predation of artificial sage grouse nests in treated and untreated sagebrush. *Great Basin Naturalist* 54:122–129.
- Rowland, M.M. and M.J. Wisdom. 2002. Research problem analysis for greater sage-grouse in Oregon. Final Report. Oregon Department of Fish and Wildlife; U.S. Department of the Interior, Bureau of Land Management, Oregon/Washington State Office; and U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 75 pp.
- Rowland, M.M., L.H. Suring, M.J. Wisdom, L. Schueck, R.J. Tausch, R.F. Miller, C. Wolff Meinke, S.T. Knick, and B.C. Wales. 2003. Summary results for BLM Field Offices in Nevada from a regional assessment of habitats for species of conservation concern. 66 pp. Unpublished report on file at: USDA Forest Service, Pacific Northwest Research Station, 1401 Gekeler Lane, La Grande, Oregon.
- Saether, B-K. and O. Bakke. 2000. Avian life history variation and contribution of demographic traits to the population growth rate. *Ecology* 81:642–653.
- Sage-grouse Conservation Planning Team. 2001. Nevada Sage Grouse Conservation Strategy. 189 pp.
- Schroeder, M.A. 1997. Unusually high reproductive effort by sage grouse in a fragmented habitat in north-central Washington. *Condor* 99:933–941.
- Schroeder, M.A., and R.K. Baydack. 2001. Predation and the management of prairie grouse. *Wildlife Society Bulletin* 29:24–32.
- Schroeder, M.A., C.L. Aldridge, A.D. Apa, J.R. Bohne, C.E. Braun, S.D. Bunnell, J.W. Connelly, P.A. Deibert, S.C. Gardner, M.A. Hilliard, G.D. Kobriger, S.M. McAdam, C.W. McCarthy, J.J. McCarthy, D.L. Mitchell, E.V. Rickerson, and S. J. Stiver. 2004. Distribution of sage-grouse in North America. *Condor* 106:363–376.
- Schroeder, M.A., J.R. Young, and C.E. Braun. 1999. Sage grouse (*Centrocercus urophasianus*). 28 pages *In* Poole, A. and F. Gill, eds. *The Birds of North America*, No. 425. The Birds of North America, Inc., Philadelphia, Pennsylvania.
- Sedinger, J.S., G.C. White, S. Espinosa, E.T. Partee, C.E. Braun. 2010. Assessing compensatory versus additive harvest mortality: An example using greater sage-grouse. *Journal of Wildlife Management* 74:326–332.
- Sedinger, B.S., J.S. Sedinger, S. Espinosa, M.T. Atamian, and E.J. Blomberg. 2011. Spatial-temporal variation in survival of harvested greater sage-grouse. *Studies in Avian Biology* 39:317–328.

- Shafer, S.L., P.J. Bartlein, and R.S. Thompson. 2001. Potential changes in the distribution of western North America tree shrub and taxa under future climate scenarios. *Ecosystems* 4:200–215.
- Shaman, J., J.F. Day, and M. Stieglitz. 2005. Drought-induced amplification and epidemic transmission of West Nile virus in southern Florida. *Journal of Medical Entomology* 42:134–141.
- Shire, G.G., K. Brown, and G. Winegard. 2000. Communication towers: A deadly hazard to birds. American Bird Conservancy, Washington, D.C. 23 pp.
- Slater, S.J. 2003. Sage-grouse (*Centrocercus urophasianus*) use of different-aged burns and the effects of coyote control in southwestern Wyoming. M.S. Thesis, University of Wyoming, Laramie, Wyoming. 187 pp.
- Smith, S.D. 1987. Effects of CO<sub>2</sub> enrichment on four Great Basin grasses. *Functional Ecology* 1:139–143.
- Smith, S.D., T.E. Huxman, S.F. Zitzer, T.N. Charlet, D.C. Housman, J.S. Coleman, L.K. Fenstermaker, J.R. Seeman, and R.S. Nowak. 2000. Elevated CO<sub>2</sub> increases productivity and invasive species success in an arid ecosystem. *Nature* 408:79–82.
- Soule, P.T., P.A. Knapp, and H.D. Grissino-Mayer. 2003. Comparative rates of western juniper afforestation in south-central Oregon and the role of anthropogenic disturbance. *The Professional Geographer* 55:43–55.
- Sovada, M.A., A.B. Sargeant, and J.W. Grier. 1995. Differential effects of coyotes and red foxes on duck nest success. *Journal of Wildlife Management* 59:1–9.
- Spurrier, M.F., M.S. Boyce, and B.F.J. Manly. 1991. Effects of parasites on mate choice by captive sage grouse, *Centrocercus urophasianus*. Pages 389–399 *In* Loyle, J.E. and M. Zuk eds. *Ecology, Behavior, and Evolution of Bird-Parasite Interactions*. Oxford University Press, Oxford, United Kingdom.
- Nevada Executive Order, September 26, 2008. Executive order by the Governor declaring state policy to preserve and protect greater sage-grouse habitat, State of Nevada.
- Nevada Executive Order, March 30, 2012a. Establishing a Greater Sage-Grouse Advisory Committee: State of Nevada, No. 2012–09.
- Nevada Executive Order, November 19, 2012b. Establishing the Sagebrush Ecosystem Council: State of Nevada, No. 2012–19.
- Sage-Grouse Conservation Planning Team. 2001. Nevada sage grouse conservation strategy. 73 pp. + appendices.

- Steenhof, K., M.N. Kochert, and J.A. Roppe. 1993. Nesting by raptors and common ravens on electrical transmission line towers. *Journal of Wildlife Management* 57:271–281.
- Stephens, P.A., W.J. Sutherland, and R.P. Freckleton. 1999. What is the allee effect? *Oikos* 87:185–190.
- Stevens, B.S., Reese, K.P., and J.W. Connelly. 2011. Survival and detectability bias of avian fence collision surveys in sagebrush steppe. *Journal of Wildlife Management* 75:437–449.
- Stevens, B.S., Reese, K.P., J.W. Connelly, and D.D. Musil. 2012. Greater sage-grouse and fences: does marking reduce collision? *Wildlife Society Bulletin* 36:297–303.
- Stiver J.R., A.D. Apa, T.E. Remington, and R.M. Gibson. 2008. Polygyny and female breeding failure reduce effective population size in the lekking Gunnison sage-grouse. *Biological Conservation* 141:472–481.
- Stiver, S.J., A.D. Apa, J. Bohne, S.D. Bunnell, P. Deibert, S. Gardner, M. Hilliard, C. McCarthy, and M.A. Schroeder. 2006. Greater sage-grouse comprehensive conservation strategy. Western Association of Fish and Wildlife Agencies, Cheyenne, Wyoming. 444 pp.
- Strzepek, K., G. Yohe, J. Neumann, and B. Boehlert. 2010. Characterizing changes in drought risk for the United States from climate change. *Environmental Research Letters Online* at: [stacks.iop.org/ERL/5/044012](http://stacks.iop.org/ERL/5/044012).
- Summers, R.W., R.E. Green, R. Proctor, D. Dugan, D. Lambie, R. Moncrieff, R. Moss, and D. Baines. 2004. An experimental study of the effects of predation on the breeding productivity of capercaillie and black grouse. *Journal of Applied Ecology* 41:513–525.
- Suter II, G.W. 1978. Effects of geothermal energy development on fish and wildlife. Topical briefs: Fish and wildlife resources and electrical power generation, No. 6. Biological Services Program Report FWS/OBS-76/20.6, U.S. Fish and Wildlife Service. 26 pp.
- Swenson, J.E., C.A. Simmons, and C.D. Eustace. 1987. Decrease of sage grouse *Centrocercus urophasianus* after ploughing of sagebrush steppe. *Biological Conservation* 41:125–132.
- Taylor, S.E. and J.R. Young. 2006. A comparative behavioral study of three greater sage-grouse populations. *The Wilson Journal of Ornithology* 118:36–41.
- Tebbenkamp, J.M., K.P. Reese, and L.P. Waits. 2012. Landscape effects on genetic structure and vital rates of greater sage-grouse in Mono County, California. Final Report submitted to California Department of Fish and Wildlife. June 2012. 67 pp.
- The Nature Conservancy (TNC). 2009. Bodie Hills conservation action planning. Final report to the Bureau of Land Management, Bishop Field Office. 120 pp. + appendices.

- The Nature Conservancy (TNC). 2012. Web accessed December 15, 2012. <http://www.climatewizard.org/>.
- Thorne, E.T., N. Kingston, W.R. Jolley, and R.C. Bergstrom. 1982. Diseases of wildlife in Wyoming, second edition. Wyoming Game and Fish Department, Cheyenne, Wyoming. 353 pp.
- Town of Mammoth Lakes. 2005. Revised Draft Program Environmental Impact Report- Town of Mammoth Lakes- October, 2005 General Plan Update. Mammoth Lakes, California.
- Town of Mammoth Lakes. 2007a. Final Program Environmental Impact Report. Town of Mammoth lakes 2005 General Plan Update.
- Town of Mammoth Lakes. 2007b. General Plan for the Town of Mammoth Lakes. Mammoth Lakes, California. 280 pp.
- Trall, L.W., B.W. Brook, R.R. Frankham, and C.J.A. Bradshaw. 2010. Pragmatic population viability targets in a rapidly changing world. *Biological Conservation* 143:28–34.
- University of Nebraska. 2008. Lincoln, Nebraska. National Drought Mitigation Center. <http://www.drought.unl.edu/>. Accessed on October 17, 2008.
- U.S. Census Bureau. 2012. Web accessed on December 11, 2012. <http://www.census.gov>.
- U.S. Department of Agriculture, Department of Commerce, Department of Defense, Department of Energy, Environmental Protection Agency, The Council on Environmental Quality, The Federal Energy Regulatory Commission, The Advisory Council on Historic Preservation, and Department of the Interior. 2009. Memorandum of Understanding regarding coordination in federal agency review of electric transmission facilities on federal land. 16pp.
- U.S. Environmental Protection Agency (EPA). July 1996. Registration Eligibility Decision (RED) Fact Sheet, Strychnine, EPA-738-F-96-033.
- U.S. Fish and Wildlife Service (Service). 1996. Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the Endangered Species Act. 61 FR 4722; February 7, 1996.
- U.S. Fish and Wildlife Service (Service). 2005. U.S. Fish and Wildlife Service. Endangered and Threatened Wildlife and Plants; 12-Month Finding for Petitions To List the Greater Sage-grouse as Threatened or Endangered; Proposed Rule.
- U.S. Fish and Wildlife Service (Service). 2006. U.S. Fish and Wildlife Service. Endangered and Threatened Wildlife and Plants; 90-Day Finding for Petitions To List the Mono Basin Area Population of the Greater Sage-grouse as Threatened or Endangered; Proposed Rule. 71 FR 76058; December 19, 2006.

- U.S. Fish and Wildlife Service (Service). 2010. U.S. Fish and Wildlife Service. Endangered and Threatened Wildlife and Plants; 12-Month Finding for Petitions To List the Greater Sage-grouse as Threatened or Endangered; Proposed Rule. 75 FR 13910; March 23, 2010.
- U.S. Fish and Wildlife Service (Service). 2013. Greater Sage-grouse (*Centrocercus urophasianus*) Conservation Objectives: Final Report. U.S. Fish and Wildlife Service, Denver, Colorado. February 2013.
- U.S. Fish and Wildlife Service (Service). 2013. Unpublished data. Geographical Information System analysis. Nevada Fish and Wildlife Office, Reno, Nevada.
- U.S. Forest Service (USFS). 1966. Sage Grouse Habitat Management Plan. USDA Forest Service, Inyo National Forest. 46 pp.
- U.S. Forest Service (USFS). 1986. Record of Decision: Final Environmental Impact Statement and Land and Resource Management Plan. USDA Forest Service, Toiyabe National Forest.
- U.S. Forest Service (USFS). 1988. Final Environmental Impact Statement and Land and Resource Management Plan. USDA Forest Service, Inyo National Forest.
- U.S. Forest Service (USFS). 2007a. Record of Decision: Sierra Nevada Forests Management Indicator Species Amendment. U.S. Department of Agriculture, Forest Service, Pacific Southwest Region. 18 pp.
- U.S. Forest Service (USFS). 2007b. Decision Record and Finding of No Significant Impact on the Carson City Field Office Geothermal Leasing Environmental Assessment (EA–NV–030–06–025). USDA Forest Service, Carson City Field Office, Carson City, Nevada.
- U.S. Forest Service (USFS). 2008. Rangewide data call response to U.S. Fish and Wildlife Service for information pertaining to status review for the greater sage-grouse. 60 pp.
- U.S. Forest Service (USFS). 2009. Final Environmental Impact Statement and Record of Decision for Inyo National Forest Motorized Travel Management. USDA-Forest Service, Inyo National Forest. R5–MB–198a.
- U.S. Forest Service (USFS). 2010. Final Environmental Impact Statement and Record of Decision for the Bridgeport Travel Management Project. USDA-Forest Service, Humboldt-Toiyabe National Forest, Bridgeport Ranger District, Bridgeport, California.
- U.S. Forest Service (USFS). 2012a. Response to U.S. Fish and Wildlife Service request for information pertaining to greater sage-grouse. USDA-Forest Service, Humboldt-Toiyabe National Forest, Bridgeport Ranger District, Bridgeport, California. 10 pp. + attachments.



- U.S. Forest Service (USFS). 2012b. Final Environmental Impact Statement and Record of Decision for geothermal leasing on the Humboldt-Toiyabe National Forest. USDA Forest Service, Humboldt-Toiyabe National Forest.
- U.S. Forest Service (USFS). 2012c. Response to U.S. Fish and Wildlife Service request for information pertaining to greater sage-grouse. USDA-Forest Service, Inyo National Forest. 7 pp. + attachments.
- U.S. Forest Service (USFS). 2012d. Decision Notice and Finding of No Significant Impact on the supplement to the Carson City Field Office Geothermal Leasing Environmental Assessment (EA–NV–030–06–025). USDA Forest Service, Humboldt-Toiyabe National Forest.
- U.S. Geological Survey (USGS). 2012a. July progress update, sage-grouse research (Pine Nut Mountains). Western Ecological Research Center, Dixon Field Station, Dixon, California. 9 pp.
- U.S. Geological Survey (USGS). 2012b. Unpublished data. Geographical Information System analysis predicting woodland expansion in the Bi-State DPS. Western Ecological Research Center, Dixon Field Station, Dixon, California.
- U.S. Geological Survey (USGS). 2012c. Disease Maps 2012. Web accessed December, 14, 2012. <http://diseasemaps.usgs.gov>.
- U.S. Geological Survey (USGS). 2013. April progress update, sage-grouse research (Pine Nut Mountains and Mount Grant PMU). Western Ecological Research Center, Dixon Field Station, Dixon, California. 10 pp.
- U.S. Government Accountability Office (GAO). 2003. Wildland fires. Better information needed on effectiveness of emergency stabilization and rehabilitation treatments. Report to Congressional Requesters. GAO–03–430. 63 pp.
- Vallentine, J.F. 1990. Kind and mix of grazing animals. Pages 217–242 *In* Grazing management, first edition. Academic Press, San Diego, California. 659 pp.
- van den Berg, G.P. 2004. Effects of the wind profile at night on wind turbine sound. *Journal of Sound and Vibration* 277:955–970.
- Vander Haegen, W.M., M.A. Schroeder, and R.M. DeGraaf. 2002. Predation on real and artificial nests in shrubsteppe landscapes fragmented by agriculture. *The Condor* 104:496–506.
- Vitousek, P.M. 1990. Biological invasions and ecosystem processes: Towards an integration of population biology and ecosystem studies. *Oikos* 57:7–13.

- Wagner, F.H. 1983. Status of wild horse and burro management on public rangelands. *In*: Transactions of the Forty-eighth North American Wildlife and Natural Resources Conference. Wildlife Management Institute, Washington, D.C. Pages 116–133.
- Wakkinen, W.L., K.P. Reese, and J.W. Connelly. 1992. Sage grouse nest locations in relation to leks. *Journal of Wildlife Management* 56:381–383.
- Walker, B.L., and D.E. Naugle. 2011. West Nile virus ecology in sagebrush habitat and impacts on greater sage-grouse populations. *Studies in Avian Biology* 38:127–142.
- Walker, B.L., D.E. Naugle, and K.E. Doherty. 2007a. Greater sage-grouse population response to energy development and habitat loss. *Journal of Wildlife Management* 71:2644–2654.
- Walker, B.L., D.E. Naugle, K.E. Doherty, and T.E. Cornish. 2007b. West Nile virus and greater sage-grouse: Estimating infection rate in a wild bird population. *Avian Diseases* 51:691–696.
- Walker, B.L., D.E. Naugle, K.E. Doherty, and T.E. Cornish. 2004. From the field: Outbreak of West Nile virus in greater sage-grouse and guidelines for monitoring, handling, and submitting dead birds. *Wildlife Society Bulletin* 32:1–7.
- Wambolt, C.L., and G.F. Payne. 1986. An 18-year comparison of control methods for Wyoming big sagebrush in southwestern Montana. *Journal of Range Management* 39:314–319.
- Wambolt, C.L., K.S. Walhof, and M.R. Frisina. 2001. Recovery of big sagebrush communities after burning in south-western Montana. *Journal of Environmental Management* 61:243–252.
- Ward, M.R., D.E. Stallknecht, J. Willis, M.J. Conroy, and W.R. Davidson. 2006. Wild bird mortality and West Nile virus surveillance: Biases associated with detection, reporting, and carcass persistence. *Journal of Wildlife Diseases* 42:92–106.
- Webb, W.C., W.I. Boarman, and J.T. Rotenberry. 2004. Common raven juvenile survival in a human-augmented landscape. *Condor* 106:517–528.
- Weisberg, P.J., E. Lingua, and R.B. Pillai. 2007. Spatial patterns of pinyon-juniper woodland expansion in central Nevada. *Rangeland Ecology and Management* 60:115–124.
- West, N.E. 1983. Chapters 11-16, pages 321–421. *In*: West, N.E., ed. *Ecosystems of the World: Temperate Deserts and Semi-Deserts*. Elsevier Scientific Publishing Company, New York, New York. 522 pp.
- West, N.E. and J.A. Young. 2000. Intermountain valleys and lower mountain slopes. Pages 256–284 *In*: Barbour, M.G. and W.D. Billings, eds. *North American Terrestrial*

- Vegetation, 2nd Edition. Cambridge University Press, Cambridge, United Kingdom. 708 pp.
- Westerling, A.L., B.P. Bryant, H.K. Preisler, H.G. HHidalgo, T. Das, and S.R. Shrestha. 2009. Climate change, growth, and California wildfire. California Climate Change Center Report Series: CEC-500-2009-046-D. 43 pp.
- Western Association of Fish and Wildlife Agencies (WAFWA). 2008. Greater sage-grouse population trends: An analysis of lek count databases 1965-2007. Sage and Columbian Sharp-tailed grouse Technical Committee. 126 pp.
- Western Association of Fish and Wildlife Agencies (WAFWA). 2009. Prescribed fire as a management tool in xeric sagebrush ecosystems: is it worth the risk to sage-grouse? A white paper prepared by the sage and Columbian sharp-tailed grouse technical committee for WAFWA. 22 pp.
- Whisenant, S. 1990. Changing fire frequencies on Idaho's Snake River plains: ecological and management implications. Pp. 4-10. *In*: Proceedings from the symposium on cheatgrass invasion, shrub die off and other aspects of shrub biology and management. USFS General Technical Report INT-276.
- Wiechman, L., and K.P. Reese. 2008. Movement patterns and population dynamics of greater sage-grouse in Mono County, California. Quarterly report submitted to California Department of Fish and Game. 12 pp.
- Wiechmann, L. 2013. Movement patterns and population dynamics of greater sage-grouse in Mono County, California. M.S. Thesis. University of Idaho, Moscow, Idaho. 160 pp.
- Wiens, J.A., and J.T. Rotenberry. 1985. Response of breeding passerine birds to rangeland alteration in a North American shrubsteppe locality. *Journal of Applied Ecology* 22:655-668.
- Willis, M.J., G.P. Keister, Jr., D.A. Immell, D.M. Jones, R.M. Powell, and K.R. Durbin. 1993. Sage grouse in Oregon. Wildlife Research Report No. 15. Oregon Department of Fish and Wildlife, Portland, Oregon. 77 pp.
- Wisdom, M.J., L.H. Suring, M.M. Rowland, R.J. Tausch, R.F. Miller, L. Scheuck, C. Wolff Meinke, S.T. Knick, and B.C. Wales. 2003. A prototype regional assessment of habitats for species of conservation concern in the Great Basin Ecoregion and State of Nevada. Version 1.1, September 2003, unpublished report on file at USDA Forest Service, Pacific Northwest Research Station, 1401 Gekeler Lane, La Grande, Oregon.
- Wisdom, M.J., C.W. Meinke, S.T. Knick, and M.A. Schroeder. 2011. Factors associated with extirpation of sage-grouse. *Studies in Avian Biology* 38:451-472.

- Woodward, J.K. 2006. Greater sage-grouse (*Centrocercus urophasianus*) habitat in central Montana. M.S. Thesis. Montana State University, Bozeman, Montana. 106 pp.
- Wroblewski, D.W. 1999. Effects of prescribed fire on Wyoming big sagebrush communities: Implications for ecological restoration of sage grouse habitat. M.S. Thesis. Oregon State University, Corvallis, Oregon. 88 pp.
- Wyoming Game and Fish Department (WGFD). 2004. Greater sage-grouse job completion report. Wyoming Game and Fish Department, Cheyenne, Wyoming. 316 pp.
- Young, D.P., Jr., W.P. Erickson, M.D. Strickland, R.E. Good, and K.J. Sernka. 2003. Comparison of avian responses to UV-light reflective paint on wind turbines. Subcontract Report, July 1999 – December 2000. NREL/SR-500-32840. National Renewable Energy Laboratory, Golden, Colorado. 62 pp.
- Young, J.A. and F.L. Allen. 1997. Cheatgrass and range science: 1930–1950. *Journal of Range Management* 50:530–535.
- Young, J.A., and R.A. Evans. 1978. Populations dynamics after wildfires in sagebrush grasslands. *Journal of Range Management* 31:283–289.
- Young, J.A. and R.A. Evans. 1989. Dispersal and germination of big sagebrush (*Artemisia tridentata*) seeds. *Weed Science* 37:201–206.
- Young, J.A., R.A. Evans, and P.T. Tueller. 1976. Great Basin plant communities - pristine and grazed. Pages 187-215 *In*: Elston, R. and P. Headrick, eds. *Holocene Environmental Change in the Great Basin*. Nevada Archives Survey, Research Paper No. 6, University of Nevada, Reno, Nevada.
- Zablan, M.A., C.E. Braun, and G.C. White. 2003. Estimation of greater sage-grouse survival in North Park, Colorado. *The Journal of Wildlife Management* 67:144–154.
- Ziegenhagen, L.L., and R.F. Miller. 2009. Postfire recovery of two shrubs in the interiors of large burns in the intermountain west, U.S.A. *Western North American Naturalist* 69:195–205.
- Ziska, L.H., J.R. Reeves, III, and B. Blank. 2005. The impact of recent increases in atmospheric CO<sub>2</sub> on biomass production and vegetative retention of cheatgrass (*Bromus tectorum*): implications for fire disturbance. *Global Change Biology* 11:1325–1332.
- Zou, L., S.N. Miller, and E.T. Schmidtman. 2006. Mosquito larval habitat mapping using remote sensing and GIS: Implication of coalbed methane development and West Nile virus. *Journal of Medical Entomology* 43:1034–1041.
- Zou, L., S.N. Miller, and E.T. Schmidtman. 2007. A GIS tool to estimate West Nile virus risk based on a degree-day model. *Environmental Monitoring and Assessment* 129:413–420.

Zouhar, K., J.K. Smith, S. Sutherland, and M.L. Brooks. 2008. Wildland fire in ecosystems: Fire and nonnative invasive plants. General Technical Report RMRS-GTR-42-vol. 6. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, Colorado. 355 pp.

***Personal communications and observations:***

- Abele, Steve. April 26 2012. Wildlife Biologist, Nevada Fish and Wildlife Office, Reno, Nevada. Personal Observation.
- Apa, Ph.D., Anthony. August 28, 2008. Sage-grouse Research Biologist, Colorado Division of Wildlife, Grand Junction, Colorado. Telephone interview with Pat Deibert, Wildlife Biologist Wyoming Fish and Wildlife Office, Cheyenne, Wyoming.
- Axtell, John. August 14, 2008. Biologist, Wild Horse and Bureau Specialist, Bureau of Land Management, Carson City District, Carson City, Nevada. Telephone interview Steve Abele, Nevada Fish and Wildlife Office, Reno, Nevada.
- Banks, R.C., Dr. August 16, 2002. Bird Section, Biological Survey Unit, National Museum of History, Washington, D.C. Email exchange with Pat Deibert, Wildlife Biologist, Wyoming Fish and Wildlife Office, Cheyenne, Wyoming.
- Banks, R.C., Dr. December 13, 2000. Bird Section, Biological Survey Unit, National Museum of History, Washington, D.C. Email exchange with Pat Deibert, Wildlife Biologist, Wyoming Fish and Wildlife Office, Cheyenne, Wyoming.
- Bi-State Local Area Working Group (LAWG). 2012. Meeting discussion, February 23, 2012.
- Blomberg, Eric 2013. Personal communication on March 18, 2013, between Eric Blomberg, Wildlife Biologist, U.S. Geological Survey, Dixon, California, and Steve Abele, Wildlife Biologist, Nevada Fish and Wildlife Office, Reno, Nevada.
- Buckner, George. November 4, 2009. Wildlife Biologist, Bureau of Land Management, Portland, Oregon. Email exchange with Pat Deibert, Wildlife Biologist, Wyoming Fish and Wildlife Office, Cheyenne, Wyoming.
- Burns, Scott. May 7, 2013. Community Development Director, Mono County, California. Telephone interview with Carl Benz, Assistant Field Supervisor, Ventura Fish and Wildlife Office, Ventura, California.
- Carlson, Jay K. September 29, 2008. Roseburg District Manager/Project Manager, Sage-Grouse Conservation Strategy, Bureau of Land Management, Roseburg, Oregon. Email exchange with Pat Deibert, Wildlife Biologist, Wyoming Fish and Wildlife Office, Cheyenne, Wyoming.
- Casazza, Mike. June 25, 2008. Wildlife Research Biologist, USGS, Western Ecological Research Center, Dixon, California. Interview with Steve Abele, Wildlife Biologist, Nevada Fish and Wildlife Office, Reno, Nevada.

- Christiansen, Tom. August 28, 2008. Sage-grouse Program Coordinator, Wyoming Game and Fish Department, Green River, Wyoming. Telephone interview with Pat Deibert, Wildlife Biologist, Wyoming Fish and Wildlife Office, Cheyenne, Wyoming.
- Coates, Pete. June 11, 2012. Wildlife Biologist, USGS, Western Ecological Research Center, Dixon Field Station, Dixon, California. Interview with Steve Abele, Wildlife Biologist, Nevada Fish and Wildlife Office, Reno, Nevada.
- Coates, Pete. June 25, 2008. Wildlife Biologist, USGS, Western Ecological Research Center, Dixon Field Station, Dixon, California. Interview with Steve Abele, Wildlife Biologist, Nevada Fish and Wildlife Office, Reno, Nevada.
- Cornish, Dr. Todd E. August 21, 2009a. Assistant Professor Veterinary Science, Pathobiology, University of Wyoming, Laramie, Wyoming. Email exchange with Pat Deibert, Wildlife Biologist, Wyoming Fish and Wildlife Office, Cheyenne, Wyoming.
- Cornish, Dr. Todd E. August 21, 2009b. Assistant Professor Veterinary Science, Pathobiology, University of Wyoming, Laramie, Wyoming. Email exchange with Pat Deibert, Wildlife Biologist, Wyoming Fish and Wildlife Office, Cheyenne, Wyoming.
- Deibert, Pat. June 29, 2012. Sage-grouse Coordinator, U.S. Fish and Wildlife Service, Cheyenne, Wyoming. Telephone conversation with Steve Abele, Wildlife Biologist, Nevada Fish and Wildlife Office, Reno, Nevada.
- Domenic, Dominic. October 03, 2008. Agent in Charge for Wyoming and Montana, U.S. Fish and Wildlife Service, Casper, Wyoming. Email exchange with Pat Deibert, Wildlife Biologist, Wyoming Fish and Wildlife Office, Cheyenne, Wyoming.
- Dublino, Tony. March 10, 2011. Associate Planner, Mono County, California. Email exchange with Steve Abele, Wildlife Biologist, Nevada Fish and Wildlife Office, Reno, Nevada.
- Espinosa, Shawn. April 19, 2010. Upland Game Biologist, Nevada Department of Wildlife, Reno, Nevada. Meeting with Steve Abele, Wildlife Biologist, Nevada Fish and Wildlife Office, Reno, Nevada.
- Espinosa, Shawn. February 23, 2012. Upland Game Biologist, Nevada Department of Wildlife, in Reno, Nevada. Meeting with Steve Abele, Wildlife Biologist, Nevada Fish and Wildlife Office, Reno, Nevada.
- Espinosa, Shawn. September 13, 2006. Upland Game Biologist, Nevada Department of Wildlife, Reno, Nevada. Email exchange with Kevin Kritz, Wildlife Biologist, Nevada Fish and Wildlife Office, Reno, Nevada.
- Espinosa, Shawn. September 4, 2008. Upland Game Biologist, Nevada Division of Wildlife, Reno, Nevada. Telephone interview with Steve Abele, Wildlife Biologist, Nevada Fish and Wildlife Office, Reno, Nevada.

- Farinha, M. November 13, 2008. Biological Science Technician, U.S. Geological Survey, Western Ecological Research Center, Dixon, California. Telephone interview with Steve Abele, Wildlife Biologist, Nevada Fish and Wildlife Office, Reno, Nevada.
- Gardner, Scott. August 20, 2009. Sage-grouse Program Coordinator, California Department of Fish and Game, Sacramento, California. Telephone interview with Steve Abele, Wildlife Biologist, Nevada Fish and Wildlife Office, Reno, Nevada.
- Gardner, Scott. August 28, 2008. Sage-grouse Program Coordinator, California Department of Fish and Game, Sacramento, California. Telephone interview with Steve Abele, Wildlife Biologist, Nevada Fish and Wildlife Office, Reno, Nevada.
- Gardner, Scott. September 7, 2012. Sage-grouse Program Coordinator, California Department of Fish and Game, Sacramento, California. Telephone interview with Steve Abele, Wildlife Biologist, Nevada Fish and Wildlife Office, Reno, Nevada.
- Garton, Dr. Oz. December 18, 2009. Professor, University of Idaho, Moscow, Idaho. Telephone interview with Pat Deibert, Wildlife Biologist, Wyoming Fish and Wildlife Office, Cheyenne, Wyoming.
- Gentle, Justin. October 07, 2008. Domestic Program Coordinator, USDA APHIS, Cheyenne, Wyoming. Email exchange with Pat Deibert, Wildlife Biologist, Wyoming Fish and Wildlife Office, Cheyenne, Wyoming.
- Gossett, Dan. September 23, 2008. Supervisory Biological Science Technician, National Wildlife Research Center, USDA APHIS Wildlife Service (Former Shoshone-Piute Tribe Sage-grouse Biologist.), Ft. Collins, Colorado. Telephone interview with Pat Deibert, Wildlife Biologist, Wyoming Fish and Wildlife Office, Cheyenne, Wyoming.
- Hagen, Christian. August 29, 2008. Sage-grouse Program Coordinator, Oregon Department of Fish and Wildlife, Bend, Oregon. Telephone interview with Pat Deibert, Wildlife Biologist, Wyoming Fish and Wildlife Office, Cheyenne, Wyoming.
- Johnson, Aaron. June 11, 2012. Lands Director, Eastern Sierra Land Trust, Bishop California. Personal communication with Steve Abele, Wildlife Biologist, Nevada Fish and Wildlife Office, Reno, Nevada.
- Miller, Dr. Scott. August 12, 2009. University of Wyoming, in Laramie, Wyoming. Telephone interview with Pat Deibert, Wildlife Biologist, Wyoming Fish and Wildlife Office, Cheyenne, Wyoming.
- Miller, Dr. Scott. September 5, 2008. University of Wyoming, Laramie, Wyoming. Telephone interview with Pat Deibert, Wildlife Biologist, Wyoming Fish and Wildlife Office, Cheyenne, Wyoming.



- Murphy, Leanne. August 21, 2008. Biologist, Humboldt-Toiyabe National Forest, Bridgeport Ranger District, Bridgeport, California. Telephone interview with Steve Abele, Wildlife Biologist, Nevada Fish and Wildlife Office, Reno, Nevada.
- Nelson, Steve. August 27, 2008. Biologist, Bureau of Land Management, Bishop Field Office, Bishop, California. Telephone interview with Steve Abele, Wildlife Biologist, Nevada Fish and Wildlife Office, Reno, Nevada.
- Nelson, Steve. February 21, 2013. Field Supervisor, Bishop Bureau of Land Management Field Office, Bishop, California. Telephone interview with Steve Abele, Wildlife Biologist, Nevada Fish and Wildlife Office, Reno, Nevada.
- Nelson, Steve. November 15, 2012. Biologist, Bureau of Land Management, Bishop Field Office, Bishop, California. Telephone interview with Steve Abele, Wildlife Biologist, Nevada Fish and Wildlife Office, Reno, Nevada.
- Northrup, Rick. August 29, 2008. Game Bird Coordinator, Montana Department of Fish, Wildlife and Parks, in Helena, Montana. Telephone interview with Pat Deibert, Wildlife Biologist, Wyoming Fish and Wildlife Office, Cheyenne, Wyoming.
- Robin Sell, Robin. January 08, 2010. Conservation Biologist, Bureau of Land Management, Colorado. Email exchange with Pat Deibert, Wildlife Biologist, Wyoming Fish and Wildlife Office, Cheyenne, Wyoming.
- Robinson, Aaron. July 16, 2009. Upland Game Biologist, North Dakota Game and Fish Department, Dickson, North Dakota. Telephone interview with Pat Deibert, Wildlife Biologist, Wyoming Fish and Wildlife Office, Cheyenne, Wyoming.
- Stiver, San. September 25, 2002. Wildlife Staff Biologist, Nevada Department of Wildlife, Reno, Nevada. Telephone interview with Kevin Kritz, Wildlife Biologist, Nevada Fish and Wildlife Office, Reno, Nevada.
- Taylor, Timothy February 23, 2012. Wildlife Biologist, Mono Unit, California Department of Fish and Wildlife, Bridgeport, California. Interview with Steve Abele, Wildlife Biologist, Nevada Fish and Wildlife Office, Reno, Nevada.
- Taylor, Timothy. September 2, 2008. Wildlife Biologist, Mono Unit, California Department of Fish and Game, Bridgeport, California. Telephone interview with Steve Abele, Wildlife Biologist, Nevada Fish and Wildlife Office, Reno, Nevada.
- Warpeha, John. November 2, 2009. Environmental Specialist II, Washoe Tribe of Nevada and California, Environmental Protection Department. Email exchange with Steve Abele, Wildlife Biologist, Nevada Fish and Wildlife Office, Reno, Nevada.

Young, David. 2004. Wildlife Biologist, West, Incorporated, Cheyenne, Wyoming. Interview with Pat Deibert, Wildlife Biologist, Wyoming Fish and Wildlife Office, Cheyenne, Wyoming.

## **APPENDIX A—DEFINITIONS**

Active lek:	A lek with two or more strutting males during at least two years in a five-year period.
AML:	Appropriate Management Levels
AMPs:	Allotment Management Plans
AOU:	American Ornithologists' Union
APHIS:	Animal and Plant Health Inspection Service
BAER:	Burned Area Emergency Response
BIA:	Bureau of Indian Affairs
BLM:	Bureau of Land Management
Breeding complex:	A general aggregation of birds associated with a particular lek or collection of leks in relatively close proximity to one another.
CDFW:	California Department of Fish and Wildlife
CEQA:	California Environmental Quality Act
CFR:	Code of Federal Regulations
COT:	Conservation Objectives Team
CSIRO:	Commonwealth Scientific & Industrial Research Organisation (Australia)
DOD:	Department of Defense
DPS:	Distinct population segment
DMV:	Department of Motor Vehicles
EIS:	Environmental Impact Statement
EPA:	Environmental Protection Agency
ESA:	Endangered Species Act
ESR:	Emergency Stabilization and Rehabilitation
ESLT:	Eastern Sierra Land Trust
FCC:	Federal Communication Commission
FLPMA:	Federal Land Policy and Management Act
FMP:	Fire Management Plan
FR:	Federal Register
GPS:	Global Positioning System
HCP:	Habitat Conservation Plan
HMA:	Herd Management Areas
HTNF:	Humboldt-Toiyabe National Forest
IM:	Instruction Memorandum
Inactive lek:	A lek that has been surveyed three or more times during one breeding season with no birds detected during the visitations and no sign observed on the lek.
INF:	Inyo National Forest
INF LRMP:	Inyo National Forest Land and Resource Management Plan
IPCC:	Intergovernmental Panel on Climate Change
ISAB:	Independent Scientific Advisory Board
IT IS:	Integrated Taxonomic Information System
IUCN:	International Union for Conservation of Nature
LADWP:	Los Angeles Department of Water and Power

LRMPs:	Land and Resource Management Plans
MET:	Meteorological Tower
MIS:	Management Indicator Species
MZII – MZIII:	Management Zone
NDOW:	Nevada Department of Wildlife
NEPA:	National Environmental Policy Act
NF:	National Forest
NFMA:	National Forest Management Act
NRCS:	Natural Resources Conservation Service
NRS:	Nevada Revised Statutes
NSO:	No Surface Occupancy
NV EO:	State of Nevada Executive Order
ODFW:	Oregon Department of Fish and Wildlife
OHVs:	Off Highway Vehicles
PACs:	Priority Areas of Conservation
PLPP:	Public Land Policy Plan
PMUs:	Population Management Units
RETAAC:	Renewable Energy Transmission Access Advisory Committee
RMPs:	Resource Management Plans
RMRS-GTR:	Rocky Mountain Research Station – General Technical Report
ROD:	Record of Decision
ROW:	Rights of Way
RSF:	Resource Selection Function
S&Gs:	Standards and Guidelines
Satellite lek:	A lek that is not active annually but may become active in years of high bird abundance.
Service:	United States Fish and Wildlife Service
SOPs:	Standard Operating Procedures
Subpopulation:	A general aggregation of birds that largely share an annual home range.
TNC:	The Nature Conservancy
TNF LRMP:	Toiyabe National Forest Land and Resource Management Plan
USDA:	United State Department of Agriculture
USFS:	United States Forest Service
USGS:	United States Geological Survey
VHF:	Very High Frequency
WAFWA:	Western Association of Fish and Wildlife Agencies
WGFD:	Wyoming Game and Fish Department
WHT:	Wild Horse Territories
WSA:	Wilderness Study Area

CDFW:	California Department of Fish and Wildlife
HTNF:	Humboldt-Toiyabe National Forest
Inactive lek:	A lek that has been surveyed three or more times during one breeding season with no birds detected during the visitations and no sign observed on the lek.
INF:	Inyo National Forest
LADWP:	Los Angeles Department of Water and Power
NDOW:	Nevada Department of Wildlife
PMU:	Population Management Unit
Satellite lek:	A lek that is not active annually but may become active in years of high bird abundance.
Service:	United States Fish and Wildlife Service
Subpopulation:	A general aggregation of birds that largely share an annual home range.
USFS:	United States Forest Service

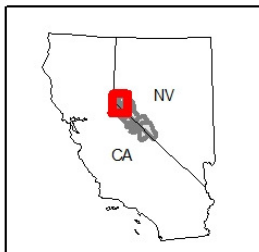
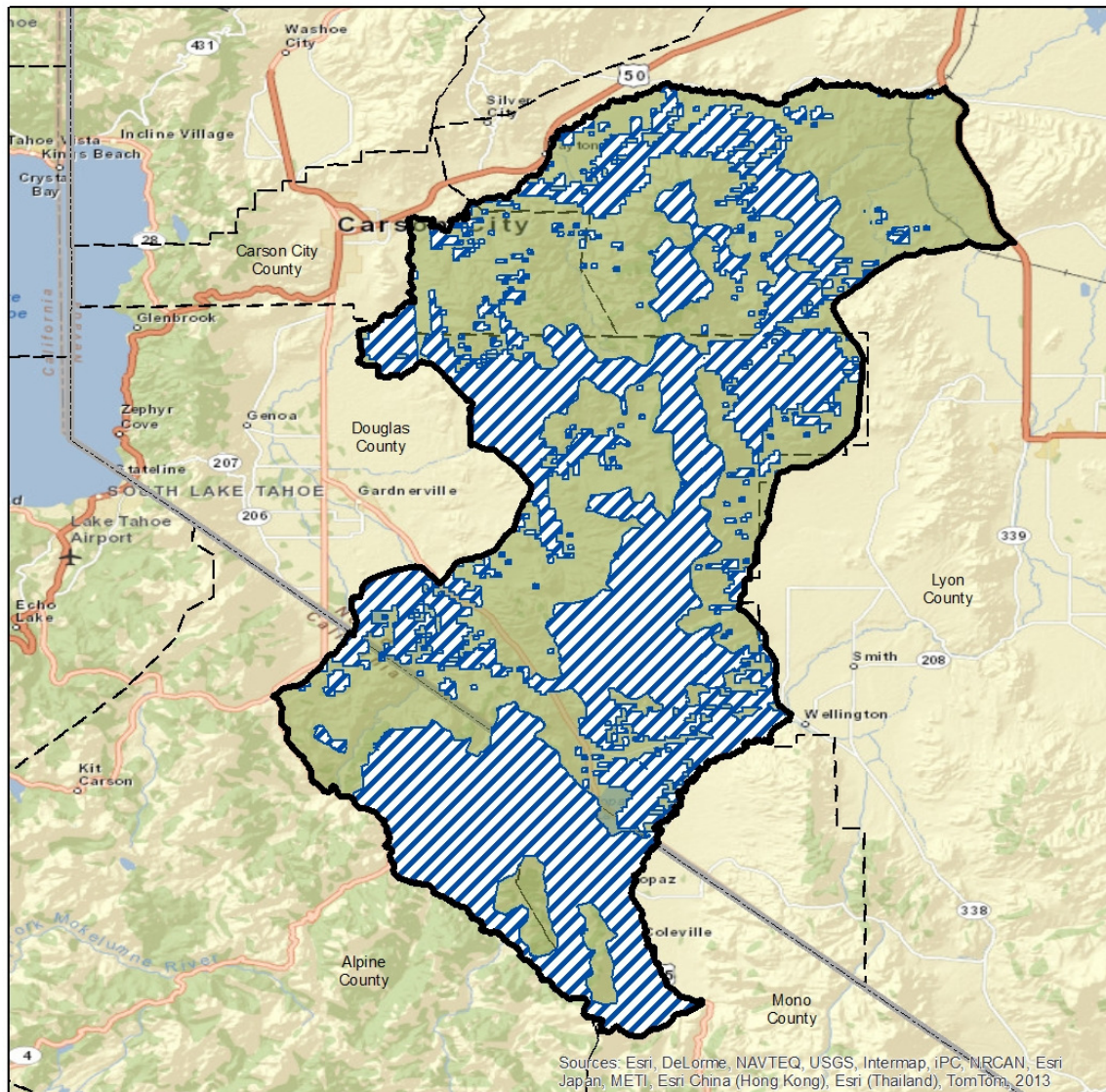
## **APPENDIX B—POPULATION MANAGEMENT UNIT (PMU) MAPS**

**Resource Selection Function (RSF)** models are ranked habitat suitability factors that predict where an animal may occur. RSFs were used to develop habitat suitability indices that rank areas based on a continuum of highly used to strongly avoided. RSFs were developed by modeling the relative probability of occurrence as a function of different environmental factors which consisted of vegetation types, pinyon-juniper cover classes, agricultural areas, elevation, ruggedness, slope, roads, recreation, and urbanization. These factors were measured at multiple spatial scales that reflect movement patterns of sage-grouse. The modeling process contrasted these environmental factors for sites used by sage-grouse (>12,500 sage-grouse telemetry locations) to available sites (randomly generated locations distributed throughout each PMU). Contrasting the environmental factors of used versus available sites provided information about what factors were correlated with Bi-State sage-grouse selection or avoidance (e.g., urbanization, pinyon-juniper). The maps do not necessarily indicate occupied habitat but predict suitable habitat conditions based on model variable used.

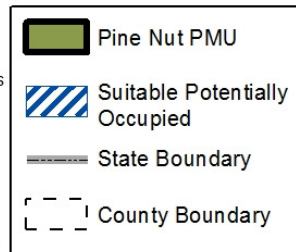
**Bureau of Land Management Key Habitat (2008)** was developed by BLM biologists in conjunction with biologists from the USFS in 2008 to inform the U.S. Fish and Wildlife Service request for information on greater sage-grouse. The map was developed by using remote sensed vegetation data to identify sagebrush vegetation and then augmented by local experts to inform sage-grouse occupancy.



## Pine Nut Population Management Unit



Created By: USFWS  
Map Date: January 31, 2013



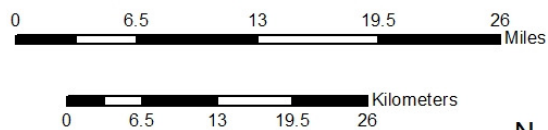
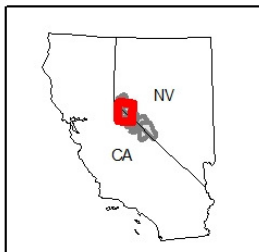
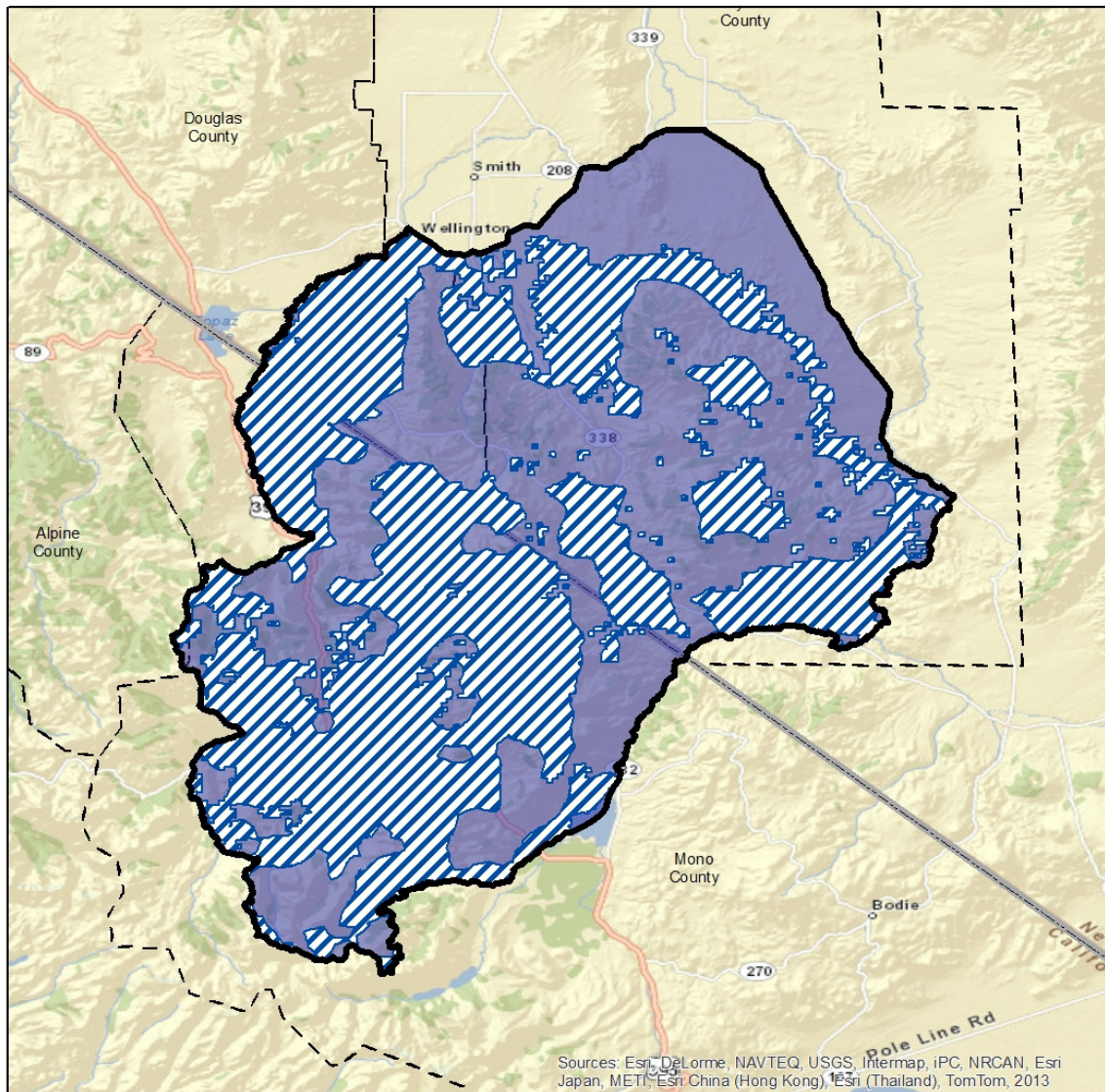




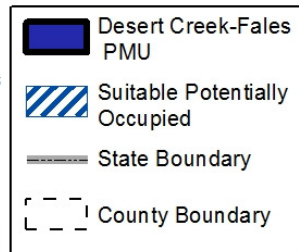
U.S. Fish & Wildlife Service

Nevada Fish and Wildlife Office

## Desert Creek-Fales Population Management Unit (PMU)



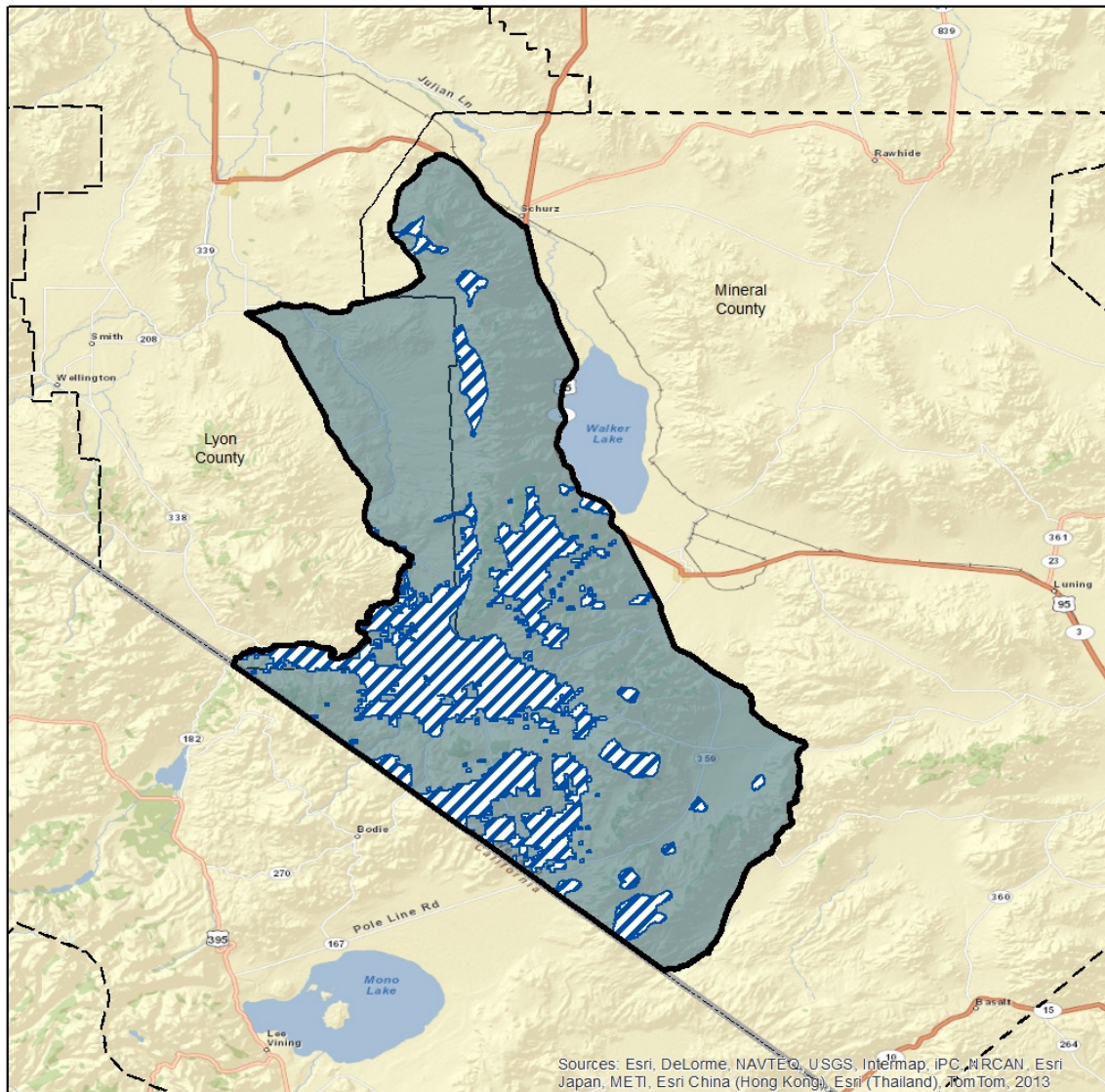
Created By: USFWS  
Map Date: January 31, 2013







# Mount Grant Population Management Unit (PMU)



Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, MRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), Swisstopo, 2013



0 8 16 24 32 Miles

0 8.5 17 25.5 34 Kilometers

Created By: USFWS  
Map Date: January 31, 2013



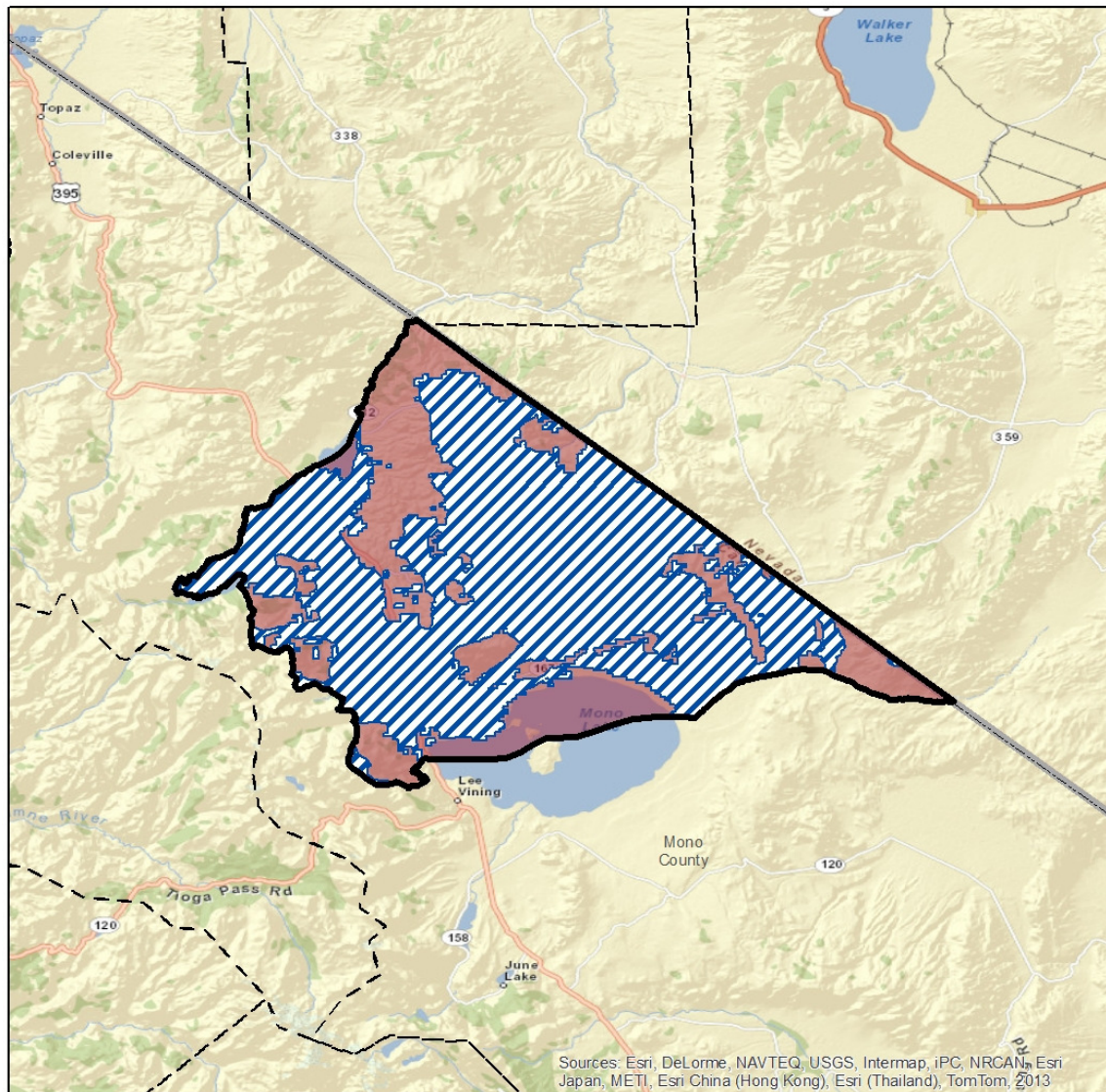
- Mount Grant PMU
- Suitable Potentially Occupied
- State Boundary
- County Boundary



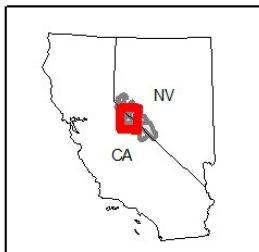
U.S. Fish & Wildlife Service

Nevada Fish and Wildlife Office

## Bodie Population Management Unit (PMU)



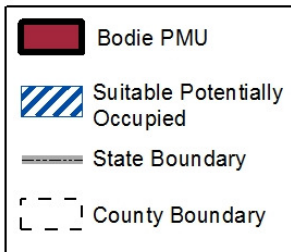
Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013



0 6.5 13 19.5 26 Miles

0 6.5 13 19.5 26 Kilometers

Created By: USFWS  
Map Date: January 31, 2013



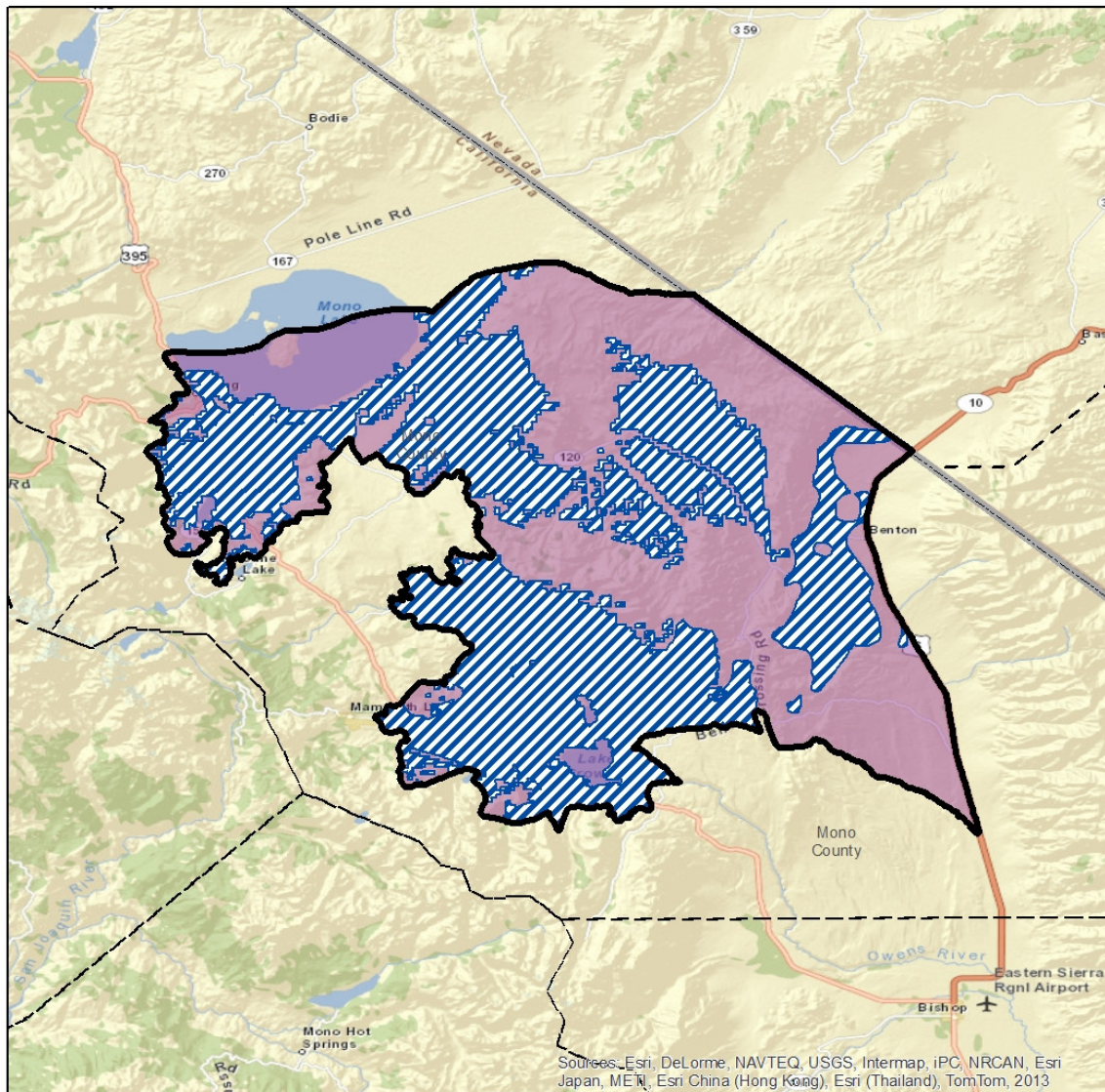




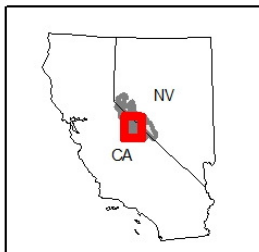
U.S. Fish & Wildlife Service

Nevada Fish and Wildlife Office

## South Mono Population Management Unit (PMU)



Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, MEN, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013







0 6.5 13 19.5 26 Miles

0 6.5 13 19.5 26 Kilometers

Created By: USFWS  
Map Date: January 31, 2013



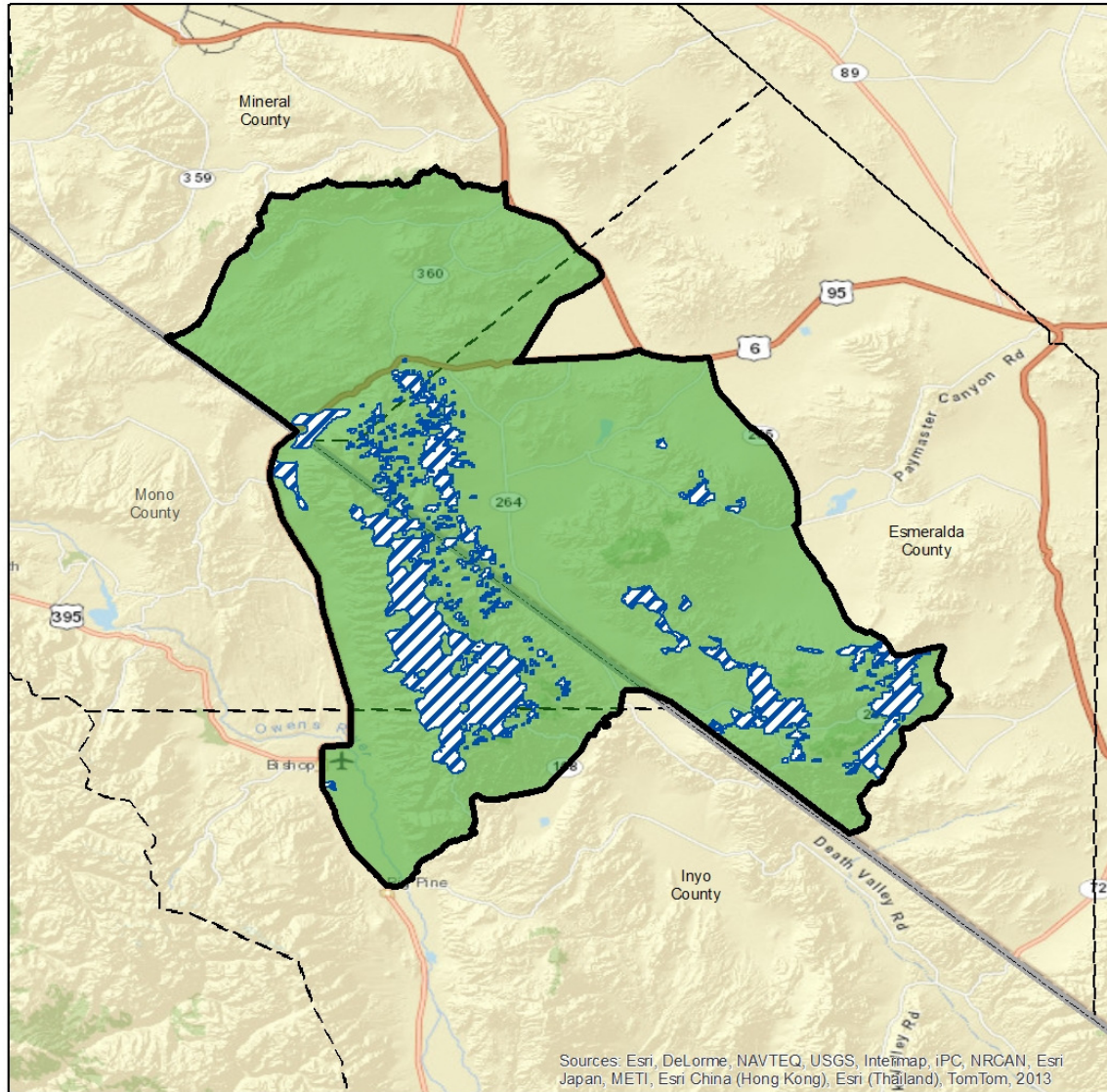
-  South Mono PMU
-  Suitable Potentially Occupied
-  State Boundary
-  County Boundary



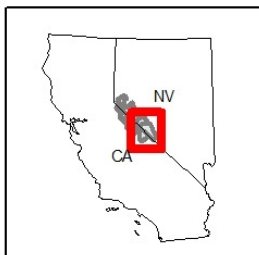
U.S. Fish & Wildlife Service

Nevada Fish and Wildlife Office

## White Mountains Population Management Unit (PMU)



Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013







0 10 20 30 40 Miles

0 10 20 30 40 Kilometers

Created By: USFWS  
Map Date: January 31, 2013



-  White Mountains PMU
-  Suitable Potentially Occupied
-  State Boundary
-  County Boundary



## APPENDIX C—NON-REGULATORY MECHANISMS EVALUATED

### Alpine County, California

The Alpine County General Plan (Alpine County 2009) provides mechanisms to protect sensitive, threatened, rare, and endangered wildlife species through its Conservation Element (i.e., Element I). Element I, Section H provides the following goals and policies for Animal Life:

- *Element I, Section H.* Key to protecting rare or endangered wildlife is in preserving the habitats in which they exist. All available recorded sightings of rare or endangered species are noted in the Data Base Section 5 and Appendix H. Each location is given open space or wilderness designation on the General Plan Land Use Map.
- *General Plan Goal No. 13.* Protect the critical habitat of all Federal or State listed sensitive, threatened, rare, OR endangered wildlife.
  - *Policy No. 13.* The County should provide the California Department of Fish and Game notice of all development that may encroach upon the critical habitat of sensitive, threatened, rare or endangered species with reasonable time for the Department to respond with recommendations for project alternatives and mitigation measures.
- *General Plan Goal No. 14.* Protect important deer habitats and migration routes to the greatest extent feasible.
  - *Policy No. 14a.* The County should provide the California Department of Fish and Game with notice of all development projects located within known or suspected critical summer or winter range or deer migration corridors with reasonable time for the Department to respond with recommendations for project alternatives and mitigation measures.
  - *Policy No. 14b.* The County should encourage cluster development to protect wildlife habitats and migration routes by placing them in permanent open space in conjunction with approved cluster development.

### Mono County, California

The Mono County General Plan (Mono County 2009) includes policies to guide decisions on future growth, development, and conservation of natural resources in the unincorporated area of the County, which includes some specific planning areas.

#### Land Use Element Countywide Policies

- *Policy 7:* Maintain or enhance the integrity of critical wildlife habitat in the county by limiting development in those areas and requiring mitigation in conformance to the California Environmental Quality Act (CEQA) and this General Plan. Examples

of critical wildlife habitat include, but are not limited to: key winter ranges, holding areas, migration routes, and fawning areas for mule deer; habitat for other big game species; leks, and winter and summer range for sage-grouse; fisheries and associated habitat; and riparian and wetland habitat.

### Planning Area Land Use Policies

- ANTELOPE VALLEY: Provide for orderly growth in the Antelope Valley in a manner that retains the rural environment, and protects the area's scenic, recreational, agricultural, and natural resources.
  - *Policy 3 Action 2.4:* Inform owners of critical wildlife habitat areas of the potential for open space easements to protect such areas and of the potential for property tax adjustments.
- BRIDGEPORT AREA WETLANDS POLICIES: Preserve and enhance wetland functions and values, including wildlife and plant habitat, beneficial livestock forage value, water quality benefits, and aesthetic and recreational values, while providing for orderly growth and an efficient, coordinated permitting process.
- TRI-VALLEY: Preserve the rural and agricultural character of the Tri-Valley area.
  - *Policy 3:* Encourage residential development in areas that will minimize the impact on the environment.
  - *Policy 4:* Protect open space and scenic values within and around the community.
  - *Policy 4 Action 2.4:* Encourage private landowners with visual, environmental and agriculturally significant property to grant or sell a conservation easement to a land conservation organization to protect the land as open space and/or agricultural use.
  - *Policy 4 Action 3.2:* Encourage the exchange of environmentally sensitive private lands for public lands.
- BODIE HILLS: Protect and enhance Bodie Hills Planning Area resources that complement the Bodie Experience.
  - *Policy 1:* Grazing on private lands within the Bodie Hills Planning Area is an historic use. Mono County supports the continued agricultural use of private lands within the Bodie Hills.
  - *Policy 1 Action 1.1:* Assign Agricultural land use designations to private property in the Bodie Hills Planning Area.
- LONG VALLEY: Maintain the rural residential character of the Long Valley communities (i.e., Long Valley, McGee Creek, Crowley Lake/Hilton Creek, Aspen

Springs, and Sunny Slopes) in a manner that provides for commercial uses to serve community needs, and that protects the area's visual, recreational, and natural resources.

- *Policy 2:* Discourage the extension of public and private facilities, especially roads, into open space or agricultural land.
- MAMMOTH LAKES: Preserve and enhance natural resources in the Mammoth vicinity.
  - *Policy 1:* Maintain or enhance the integrity of key wildlife habitat in the area by limiting development in the area. Examples of key habitat include, but are not limited to: key winter ranges, holding areas, migration routes, and fawning areas for mule deer; leks, and winter and summer range for sage-grouse; and waterfowl habitat at Crowley Lake, Laurel Pond, and along the Owens River.

#### Conservation/Open Space Element

- *Objective B Policy 1 Action 1.10:* Promote the establishment of local land conservation organizations.
- *Objective B Policy 1 Action 1.11:* Outside community areas, consider land trades involving private lands in Mono County and federal lands elsewhere.
- *Objective B Policy 1 Action 1.12:* Work with the county Assessor to encourage gifts of open space through tax-incentive programs.

#### Biological Resources Goal

- *Policy 6:* Support the acquisition of valuable wildlife habitat by federal or state land management agencies or land conservation organizations.
- *Policy 6 Action 6.1:* Support acquisition of important wildlife areas through outright purchase, land donations, trades, purchase of easements, and related options.
- *Policy 6 Action 6.2:* In coordination with the county Assessor's office, seek reductions of property taxes for areas preserved for wildlife.
- *Policy 6 Action 6.3:* Work with appropriate agencies and organizations to investigate the feasibility of establishing habitat preservation areas to protect and improve significant habitat areas.
- *Policy 6 Action 6.4:* Consider appointing a Fish and Wildlife Technical Advisory Committee to advise the County on fish and wildlife planning and mitigation measures and to seek funding for fish and wildlife protection and habitat acquisition.

- *Policy 7:* Restrict OHV use in valuable habitat areas in order to protect those resources.

### **Carson City, Nevada**

Carson City is organized as an incorporated municipality as opposed to county government formed by the State Legislature. The 2006 Carson City Master Plan (Carson City 2006) does not contain any specific provisions to protect or conserve habitats for the greater sage-grouse. However, Guiding Principal 3 for the stewardship of the natural environment provides the direction that the “City will identify and strive to conserve its natural, scenic, and environmentally sensitive areas including important wildlife habitat.”

One tool used to achieve this direction is represented by adoption of the 1999 Open Space Plan (Carson City 1999). Created in response to voter approval of ballot question #18, the Quality of Life Initiative authorized a 0.25 percent increase in sales tax to raise funds for securing and maintaining open space and recreational opportunities. This funding source generates an approximately \$700,000 per year that is dedicated to support the City’s Open Space Program. To date, 1,860 acres (or nearly 2 percent of the Carson City area) has been secured under this program and is managed as permanent open space (Bollinger, pers. comm. 2012). The protection of wildlife habitat is identified as a priority goal under the City’s Open Space Plan (Carson City 1999), but secured lands currently do not affect Bi-State sage-grouse.

### **Douglas County, Nevada**

The Douglas County Master Plan (Douglas County 2007) established Goal 5.19 “to protect Douglas County’s sensitive wildlife and vegetation in recognition of their importance as components of the county’s quality of life.”

- *Policy 5.19.01.* Specifies that “Douglas County shall protect environmentally sensitive habitat areas that serve valuable ecological functions by limiting their development or by requiring mitigation of adverse impacts resulting from development.”

### **Esmeralda County, Nevada**

The Esmeralda County adopted master plan (Esmeralda County 2011) does not contain specific provisions for sage-grouse or sage-grouse habitat; however, it incorporates a draft Public Land Policy Plan (PLPP) (Esmeralda County 2012, entire). The draft PLPP explains that County residents support a diversity of wildlife and would establish the following policies:

- *Policy 9-1.* A yearly update by Federal and State agencies should be provided to the County Commission to maintain an active and constructive dialogue regarding threatened and endangered species and potential listings of same.



- *Policy 9-2.* Identify habitat needs for wildlife species, such as adequate forage, water, cover, etc., and provide for those needs so as to, in time, attain appropriate population levels compatible with other multiple uses as determined by public involvement.
- *Policy 9-3.* Support habitat restoration to improve wildlife habitat when compatible with other uses.
- *Policy 9-4.* Support hunting and fishing as recreational resources and as a multiple use of public lands. Esmeralda County endorses the State's programs to provide sustained levels of game animals.

### **Lyon County, Nevada**

The Lyon County Comprehensive Master Plan (Lyon County 2010) describes a goal that Lyon County will contain adequate habitat for viable populations of a variety of desirable wildlife species.

- *Policy NR 2.1.* Provides that the county will work to protect critical habitat that is necessary to maintain viable wildlife populations. This policy will be achieved through the following strategies:
  - Recognize species identified through community planning processes, such as wild horses and sage-grouse, as species of community-wide importance, and prioritize habitat protection efforts and resources for these species.
  - Identify the habitat of species of community-wide importance and identify critical habitat areas.
  - Periodically review information and conditions to reveal changes in the range of species and amount of available habitat.
  - Encourage land use patterns on private property that allow for new development while sustaining wildlife populations.
  - Promote programs that educate residents about practices that can promote or endanger wildlife, such as waste disposal, land development, fencing, weed control, and others.
  - Consider acquiring strategic habitat where necessary to protect, sustain, and allow migration of wildlife.

### **Mineral County, Nevada**

Currently, Mineral County has not adopted a general or master plan (Canfield, pers. comm. 2012). However, the County Code of Ordinances, Title 6, Chapter 6.12.010 and 6.12.020 (Mineral County 2011, entire), specifies:

- It is unlawful for any person or persons, firm, company, corporation, or association within the county of Mineral, state of Nevada, to take, kill, catch, trap, net, pound, weir, wound or pursue with attempt to take, catch, capture, injure or destroy any sage hen or sage cock or prairie chicken, at any time except between August 16 and August 31, both dates included, in each and every year (MC-UT Ord. 12 § 1, 1925).
- A person convicted of violating this county ordinance can be punished by a fine of not less than fifty dollars (\$50.00) or more than two hundred fifty dollars (\$250.00), or by imprisonment for a term of not less than twenty five (25) days or more than one hundred twenty five (125) days, or by both such fine and imprisonment (MC-UT Ord. 12 § 2, 1925).

Sage-grouse hunting seasons and regulations in Mineral County and the rest of Nevada are currently managed by NDOW, which supercedes this 1925 County ordinance.

### **Storey County, Nevada**

Zoning and land development in Storey County is controlled by the 1994 Storey County Master Plan (Storey County 1994). This county master plan provides no specific provisions to protect or conserve greater sage-grouse habitat.