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

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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, hereafter sage-grouse or Bi-State DPS, 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 (Act). In October of 2013, we proposed listing the Bi-State DPS as threatened under the Act, with a 4(d) rule and proposed critical habitat (Service 3013b, entire; Service 2013d, entire). In April of 2015, we published a withdrawal of the proposed listing rule and associated critical habitat largely influenced by conservation commitments provided by State, Federal, and local partners in the Bi-State region (Service 2015, entire). Our 2015 withdrawal was challenged in court and in September of 2018, the District Court for the Northern District of California vacated this withdrawal and remanded to us the finding, thereby reinstating the DPS's proposed threatened status. 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 trend for each.

Status:

- There has been a reduction from historical range and habitat of greater than 50 percent; the current trend in range and habitat loss is slowing and potential for gains is apparent.
- There has been a reduction from historical abundance of greater than 50 percent. The current overall population trend across the DPS is generally stable, but variation exists among populations. Likelihood of persistence is considered moderate to high for the two largest (core) populations, comprising approximately 70 percent of strutting males and moderate to low for the four remaining Population Management Units (PMUs).
- Connectivity within and among PMUs is variable. Connectivity is slowly deteriorating, which increases the risk of loss of individual PMUs via stochastic events. Targeted efforts to restore connectivity among populations and thereby improve resiliency are ongoing.
- Leks in the center of the species' range that have remained protected over time have long–term monitoring data suggesting stable population trends.
- The size of the Bi-State population overall is low; individual populations are especially small and increasingly isolated outside the two largest (core) PMUs of South Mono and Bodie.

Impacts:

- Sage-grouse are long–lived, habitat specialists with generally low reproductive rates. They are particularly sensitive to habitat fragmentation.
- No single habitat impact can be identified as the primary cause of habitat loss and modification. Rather, there are multiple impacts to habitat interacting in the Bi-State area.
- *Pinus monophylla* (pinyon pine) and various *Juniperus* (juniper) species encroachment has caused substantial habitat reduction; woodland encroachment continues, but woodland removal projects are on par with encroachment.
- Urbanization has caused substantial habitat reduction; the current trend in urbanization is still increasing, but at a much reduced rate. Voluntary participation by private land owners via conservation easements, land swaps, and fee title sales are ongoing and have substantially increased the percentage of protected sage-grouse habitat on private lands.
- Infrastructure development (e.g., roads) has caused substantial 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 actual or threatened habitat loss from invasive species and fire is increasing.
- Small population size and population isolation increases risk to sage-grouse persistence. Current fluctuations in the four smaller, less secure, less connected PMUs are likely to result in attrition in both range and populations within the Bi-State DPS. Efforts to reverse the negative trend in population connectivity are ongoing.
- Predation may be 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 is unknown but likely increasing.
- There is uncertainty over impacts from climate change and its effects on other factors affecting habitat quality and abundance, such as invasive species. Climate change is anticipated to have an impact on the species and its habitat, but the extent of that change is unknown.
- Recent adoption of new Land Use Plans has substantially improved conservation for the DPS.

Habitat restoration and protection efforts are actively occurring, including removal of encroaching pinyon–juniper trees; securing conservation easements on private land to ensure it continues to be managed to provide habitat for sage-grouse; and improving key wet meadow habitat on public and private lands. Partnerships are strong, long–standing and conservation interest currently high. This area has maintained an active Bi-State Local Working 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. Additionally, in 2016 revised Land Use Plans were adopted by the Humboldt–Toiyabe National Forest and the Carson City District and Tonopah Field Offices of the BLM, substantially improving the regulatory protections afforded this species.

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; BSAP) is a general roadmap toward species conservation. The 2012 Bi-State Action Plan originally lacked specificity in key areas. For example, it identified the importance of pinyon–juniper removal, but did not specify how much and where removal was necessary. It also lacked assurances of funding or implementation. Since our proposed listing in 2013, participating agencies have made significant progress to further refine the conservation actions identified in the 2012 Bi-State Action Plan. Additionally, through the leadership of the Bi-State Executive Oversight Committee (EOC), commitments to implement and the BSAP have been provided, including funding totaling more than 45,000,000 dollars (EOC 2014, p. 2). Substantial on the ground actions have been implemented since funding commitments in 2014.

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 filoplumes (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, pers. comm.). 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." The original petition concerning the Bi-State population of greater sage-grouse, received in January of 2002, requested the population be emergency listed as an endangered DPS of the western subspecies of greater sage-grouse.

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, pers. comm.; 2002, pers. comm.; 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, pers. comm.) 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 concluded that there was not clear and consistent evidence supporting an eastern and western subspecies delineation and therefore did not consider them as unique listable entities under the Act. However, we additionally concluded that the Bi-State population of sage-grouse meets our criteria as a DPS of the greater sage-grouse (entire species) 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; Oyler-McCance *et al*. 2014, p. 5). 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).

Although the Bi-State population may have been isolated for an amount of time similar to the Gunnison sage-grouse population and although it is genetically unique, the Bi-State population does 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 and 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; Kolada *et al*. 2009b, p. 1,343; 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).

<u>Sagebrush Ecosystem</u>

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 13–14 species and 12–13 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 based on their affinities for different soil types: big sagebrush and low sagebrush (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 species 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 has 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 rates 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 150 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).

A variety of invasive plant species (including increasing numbers of existing invasive plant species) can influence sagebrush habitat dynamics. Sagebrush communities vary in their susceptibility to specific disrupters and this susceptibility is influenced by soil properties including temperature and moisture (Chambers *et al*. 2014, p. 9). In general, lower elevation Wyoming big sagebrush communities are more susceptible to *Bromus tectorum* (L.) (cheatgrass) invasion, which is an invasive annual grass that has been a major factor in the loss of this community across the Great Basin (Chambers *et al*. 2007, p. 141; Miller *et al*. 2011, pp. 158–159). In upper elevation sites such as mountain sagebrush communities, *Taeniatherum caput–medusae* (L.) Nevski (medusahead rye) fills a similar niche. In addition, the greatest proportion of pinyon–juniper woodland expansion has occurred in higher elevation mountain big sagebrush plant associations as well as little and black sagebrush plant associations that occur on moderate to deep soils (Miller *et al*. 2011, p. 160).

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. Furthermore, 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, Mount Grant).

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, limiting the species' adaptability to habitat changes (Berry and Eng 1985, pp. 238–240; Fischer *et al.* 1993, p. 1,039; Connelly *et al.* 2004, p. 3–1; Holloran and Anderson 2005, p. 749; Connelly *et al.* 2011b, p. 82). However, recent research has suggested that this high degree of site fidelity may be more flexible than has traditionally been considered, at least with respect to certain restoration actions (e.g., tree removal; Sandford *et al*. 2017, p. 64; Severson *et al*. 2017, p. 55).

Sage-grouse move (migrate) seasonally among various habitat types driven by direct indicators of resource quality as well as individual characteristics such as 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; Pratt *et al*. 2017, p. 635). Research results have parsed the annual life cycle of sage-grouse into several 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). The distances sage-grouse move between seasonal habitats are highly variable across the occupied range (Connelly *et al.* 1988, pp. 119–121). 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). Non–migratory sage-grouse populations have been described as those with seasonal movements of less than 10 km (6.2 mi; Connelly *et al.* 2000a, pp. 968–969), while birds in migratory populations may travel well over 100 km (62 mi) (Tack *et al.* 2012, p. 65). Despite the documentation of extensive seasonal movements in this species (Fedy *et al.* 2012, p. 1066; Tack *et al.* 2012, p. 65; Davis *et al.* 2014, p. 716), the dispersal abilities of sage-grouse are assumed to be low. One study estimated median natal dispersal distances of 8.8 km (5.5 mi) for females and 7.4 km (4.6 mi) for males (Dunn and Braun 1985, p. 622); another study estimated natal dispersal distances of 3.8 km (2.4 mi) for males and 2.7 km (1.7 mi) for females (Thompson 2012, p. 193). 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, if not rare (Dunn and Braun 1986, p. 89; Gibson *et al*. 2014, p. 734; Jahner *et al*. 2016, p. 5). 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 (USGS), using Global Positioning System (GPS) technology is aiding 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 *et al*.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 small, 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 and suggests many of these copulations likely occur off lek. This research, however, was conducted on a small, declining population, which may have influenced the results.

Females may 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 much 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, re–nesting 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).

Across the range of the greater sage-grouse, 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; Doherty *et al*. 2014, p. 322). Sage-grouse may 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 and grass cover provide concealment for sage-grouse nests and young and the vertical and horizontal cover provided by these features 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 vegetation characteristics influence nest concealment and ultimately nest success appears to vary across the species' range (Holloran *et al*. 2005, p. 645; Kolada *et al*. 2009a, pp. 1,336–1,337; Dinkins *et al*. 2016b, pp. 9–12).

Habitat selection during the breeding season suggests 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. There is currently no support for an influence of herbaceous 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; Coates *et al*. 2017a, pp. 53–55). 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 and importance 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; Doherty *et al*. 2014, p. 322).

Nesting propensity or the likelihood of a female sage-grouse nesting in a given year, ranges from approximately 70 to 95 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; Taylor *et al*. 2012, p. 342; Coates *et al*. 2018, p. 248; Coates *et al*. 2020, p. 26). Adult females have higher nest initiation rates than yearling females and are more likely to re–nest following the failure of a first nest (Schroeder *et al*. 1999, p. 13; Connelly *et al.* 2011a, p. 63; Taylor *et al*. 2012, p. 340; Coates *et al*. 2018, p. 248).

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), and nest success appears to be greater for adults than for yearlings (Taylor *et al*. 2012, p. 340) although, at least numerically if not statistically, in the Bi-State area this pattern appears reversed (Coates *et al*. 2020, p. 26). Across the Bi-State DPS, estimated nest survival using maximum likelihood methods ranged from approximately 38 to 49 percent (Kolada *et al*. 2009b, p. 1,344; Coates *et al*. 2020, p. 26). However, nest success varies among subpopulations and years in the Bi-State area, ranging from 21 to 68 percent (Kolada *et al*. 2009b, p. 1,344). Across the species' range, Taylor *et al*. (2012, p. 340) reports mean nest success ranging from a low of 38 percent for first nests of yearlings to a high of 53 percent for re–nests of adults. Furthermore, in the western United States, average nest success for sage-grouse was 51 percent in undisturbed sagebrush habitats 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 cannot differentiate the cause of nest failure; thus, there may be other mechanisms (e.g., 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 43 percent for adults and 18 percent for yearlings (Taylor *et al*. 2012, p. 340). Within the Bi-State data suggest re–nesting rates are less, with median estimates of 23 percent and 13 percent for adults and yearlings, respectively (Coates *et al*. 2020, p. 26). 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 until 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; Coates *et al*. 2020, p. 26) is consistent with this range–wide estimate. Long–term productivity estimates of 1.40–2.96 chicks per hen as estimated by wings collected during the fall hunting harvest across the species' range have been reported (Connelly and Braun 1997, p. 231), with productivity apparently declining slightly after 1985 to 1.21–2.19 chicks per hen (Connelly and Braun 1997, p. 231). Connelly *et al.* (2000a, p. 970 and references therein) suggest that at the minimum 2.25 chicks per hen in the fall are necessary to maintain stable to increasing populations. In the Great Basin, research suggests that recruitment of new individuals necessary for population growth occurs following wet winters when nesting habitat is undisturbed (Blomberg *et al*. 2012, p. 7). Due to low chick survival and limited re–nesting, there is limited evidence that populations of sage-grouse produce large annual surpluses of chicks (Connelly *et al.* 2011a, p. 67).

Hens typically 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. In drier sites, movements can begin shortly after hatch and broods may move more than 5 km (3.1 mi) within the first few weeks after hatch (Connelly *et al.* 2004, p. 4–8). In the Great Basin, nest–site selection has been shown to be more predictive of chick survival than of nest survival, which suggests that females' selection of nesting habitat was primarily influenced on its qualities as brood–rearing habitat (Gibson *et al*. 2016a, p. 696). 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 during this period differs from 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; 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; Atamian *et al*. 2010, p. 1538; Connelly *et al*. 2011b, pp. 76–77 and references therein; Pratt *et al*. 2017, p. 635). 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 pasture and hay fields (Casazza *et al*. 2011, pp. 162–163). Furthermore, brood–rearing foraging habitats with increased perennial forb cover and plant species richness, greater meadow to sagebrush edge (ratio of perimeter to area), and a greater distance from woodlands provide for an increased probability of successful recruitment (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 populations home ranges vary in size from approximately 13,000 to greater than 228,000 hectares (ha) (32,123 to greater than 563,400 acres (ac)) (Casazza *et al.* 2009, p. 8; Mathews *et al*. 2018, p. 31). Variation occurs among individuals and local breeding complexes, presumably due in part to behavior and juxtaposition of seasonal habitats. Recent research in the northern portion of the Bi-State DPS (Pine Nut PMU) has documented typical movements between breeding and brood–rearing/summer habitats of greater than 40 km (24 mi), with at least five individuals moving over 100 km (62 mi) from their site of capture in the Pine Nut PMU to summer and winter habitats in the Desert Creek–Fales, Bodie, and Mount Grant PMUs (USGS 2013, p. 27; USGS 2014, p. 2). 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 potential 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 three and six years after reaching adulthood, but individuals nine 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) reported nearly identical annual survival rates between cocks and hens 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 been suggested to lead toward 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; Hagen *et al*. 2018, p. 4). 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 35 days post hatch to first breeding season) is estimated to average 75 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; Taylor *et al*. 2012, p. 338). For example, Blomberg *et al*. (2014, p. 4496) found that juvenile survival varied across years from approximately 13 percent to 77 percent depending on spring and summer precipitation and mean maximum monthly temperature.

In the Bi-State area, recent research has estimated adult survival of approximately 68 percent annually, with significant variation occurring among local breeding populations (Sedinger *et al*. 2011, p. 321; Coates *et al*. 2014a, p. 14; Coates *et al*. 2020, p. 26). 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). This is similar to seasonal survivorship for sage-grouse across their range. Other survival parameters, namely nest and chick survival, derived across the entire Bi-State area are also consistent with range wide estimates, although we note that there is variation in these vital rates among the PMUs (Taylor *et al*. 2012, p. 338; Coates *et al*. 2020, p. 26).

Historical Range/Distribution and Population Estimates

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, Mineral, and perhaps Storey County in Nevada (Gullion and Christensen 1957, pp. 131–132; Espinosa 2019, pers. comm.). The current range of the DPS in California is presumed to be 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 between 1977 to 1994. However, in a revision to this initial analysis, Hall *et al*. (2008, p. 96) reported that no substantial 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). 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 a historical occurrence represented a location that regularly supported sage-grouse or was a sighting outside the species normal range is not discernible. Therefore, more recent surveys failing to document sage-grouse in these same locations may reflect: (a) Vegetation mapping that inaccurately identified habitat as suitable for sage-grouse, (b) the original sightings representing irregular occurrences or sighting locations were generalized and attributed to nearest significant landmark, (c) a lack of recent survey effort, or (d) 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, pers. comm.). Sage-grouse no longer occur in the Virginia Range, Storey County, Nevada, situated immediately north of the Pine Nut Range (Pine Nut PMU). 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. However, our evaluation suggests range contractions based on past 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). Furthermore, changes in the extent of sagebrush vegetation communities (as described in the “Impact Analysis” section below) also suggest alterations in Bi-State DPS distribution. The principle mechanisms influencing sagebrush extent 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.

Based on our analysis of historical habitat loss, we assumed a 1:1 ratio of bird loss to habitat loss. We also considered the remaining sagebrush habitat in the Bi-State area to be variously compromised by a variety of stressors, thereby reducing the suitability of these habitats for sage-grouse and ultimately the habitats carrying capacity (as described in the “Impact Analysis” section below). Furthermore, there are documented accounts of population extirpation or population reductions in the Bi-State area (USFS 1966, p. 4; Hall et al. 2008, p. 96; Bi-State TAC 2012, p. 24). Therefore, we assumed that population loss exceeded habitat loss and conclude that population loss was greater than 50 percent.

Current Range/Distribution and 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 populations 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 B). Due to improved understanding of population structure, the Bodie and Mount Grant PMUs are often combined and further, populations in the Desert Creek–Fales PMU also share habitat seasonally with populations in Bodie and Mount Grant. 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 in 2014 (Appendix B; Bi-State Technical Advisory Committee (TAC) 2012, unpublished data; BLM 2014a, entire)) across all PMUs is approximately 526,188 ha (1,300,238 ac) (Figure 1; Table 1). This total does not include areas currently unsuitable for the Bi-State DPS that could be restored as suitable habitat.

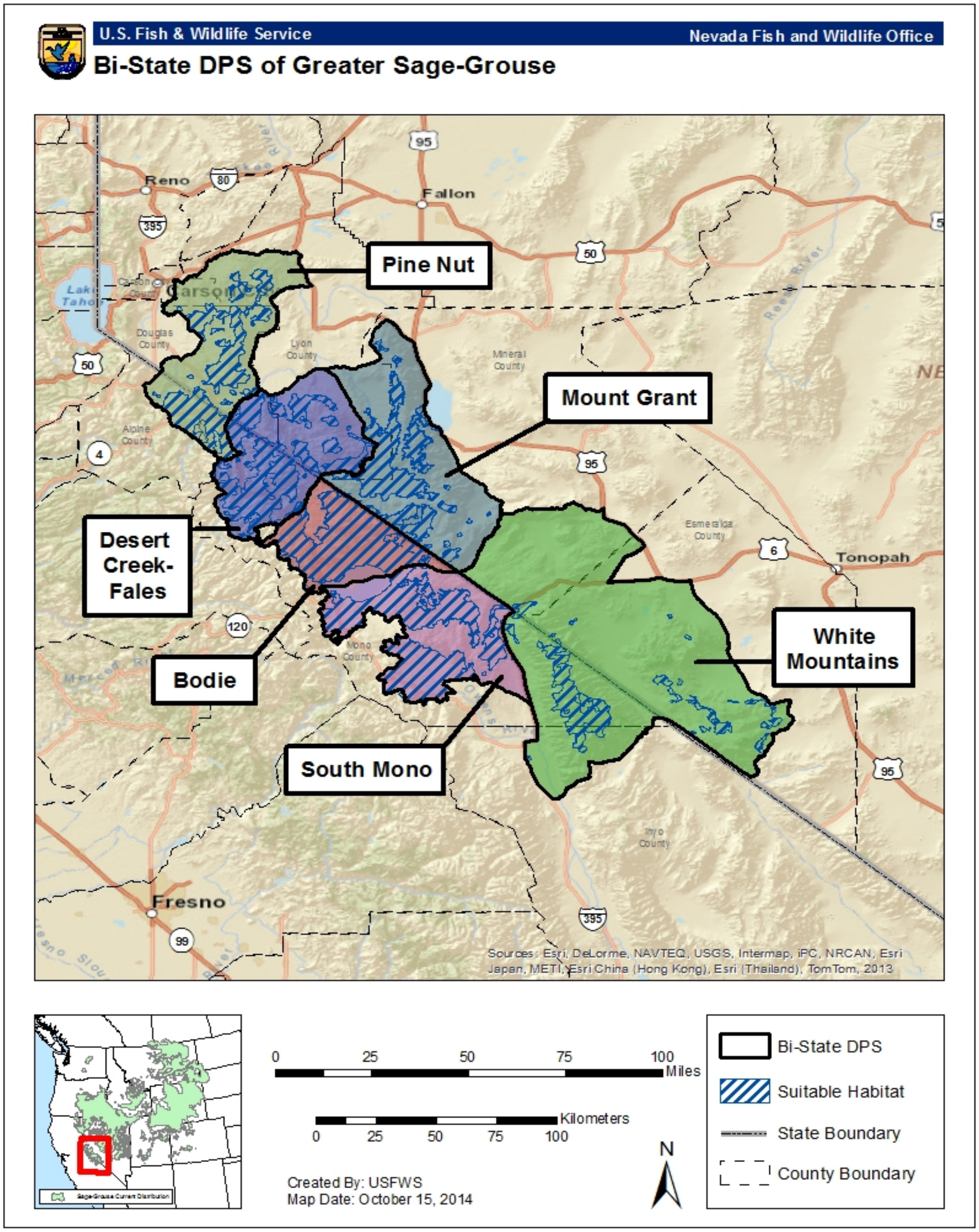

Figure 1. Population Management Units (PMUs) and Resource Selection Function (RSF) model combined with BLM Key habitat map depicting suitable habitat for sage-grouse within the Bi-State DPS, Nevada and California.

Table 1. Bi-State DPS Population Management Units (PMUs), PMU size, estimated suitable sage-grouse habitat, average number of leks, average number of active leks, and range of maximum males on leks within each PMU (2003–2018).

[Number pairs in parentheses are lower and upper limits of the 95 percent credible interval]

PMU	Total size hectares (acres) *	Suitable habitat hectares (acres) **	Average number of leks ***	Average number of active leks ***†	Range in maximum male counts ****
Pine Nut	232,440 (574,372)	77,848 (192,367)	7.3 (2.0, 9.0)	1.8 (0.3, 4.7)	0–67
Desert Creek–Fales	229,858 (567,992)	105,281 (260,155)	12.8 (8.3, 15.0)	6.8 (5.0, 9.7)	61–220
Mount Grant	282,907 (699,079)	45,786 (113,139)	9.6 (5.0, 11.0)	4.4 (1.3, 7.0)	12–220
Bodie	141,490 (349,630)	105,698 (261,187)	17.3 (12.3, 20.0)	13.1 (9.7, 16.7)	137–512
South Mono	234,508 (579,482)	138,123 (341,311)	15.6 (12.3, 19)	13.3 (11.0, 16.7)	172–418
White Mountains	709,768 (1,753,875)	53,452 (132,083)	2+(not available)	2+(not available)	Not available
Total (all PMUs combined)	1,830,972 (4,524,430	526,188 (1,300,238)	64.6 (41.9, 76.0)	41.4 (29.3, 56.8)	427–1,409

* Bi-State Local Planning Group (2004, pp. 11, 32, 63, 102, 127, 153)
** Bi-State TAC (2012, unpublished data); BLM (2014, unpublished data)
*** Derived from Mathews *et al*. 2018, Table 6 and Figure 17.
**** Derived from NDOW and CDFW lek databases. Overall low and high counts occurred in 2008 and 2012, respectively. However, there was variation in annual peak male counts across PMUs, therefore column does not sum to total..
† 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.
NOTE—Research to inform our understanding of the White Mountains PMU was initiated in 2016.

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 (BSAP; 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. Since 2014, annual progress reports have been generated, which describe updates to bird monitoring efforts and project accomplishments. In 2018, a six–year summary, inclusive of all conservation efforts spanning the years from 2012 to 2018 was completed (Bi-State TAC 2018, entire). All of these plans and reports, as well as information from local area biologists and a number of research studies conducted over the past 15 years, 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 exhibit multi–annual fluctuations, indicating that some mechanism or combinations 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 (i.e., change in population size with each unit of time) 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. 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 becoming more consistent since approximately 2002 (Nevada Department of Wildlife (NDOW) 2012, *in litt.*). This lack of consistent survey methodology within and between States in the Bi-State DPS creates uncertainties when comparing annual survey data.

In 2014, the USGS completed an analysis of population trends in the Bi-State area spanning the years 2003 to 2012 (Coates *et al*. 2014a, entire). This analysis, termed an Integrated Population Model (IPM), integrates a variety of data such as lek counts and vital rates (e.g., nest propensity, nest survival, clutch size, chick survival, adult survival) to inform an estimate of population growth within the DPS. This analysis evaluated several populations in the Bi-State area including the Pine Nuts (Pine Nut PMU), Fales (California portion of the Desert Creek–Fales PMU), Desert Creek (Nevada Portion of the Desert Creek–Fales PMU), Bodie Hills (Bodie PMU), Parker Meadows (South Mono PMU), and Long Valley (South Mono PMU). It did not evaluate the populations in the Mount Grant or White Mountains PMUs due to data limitations (i.e., lack of vital rate information). Results at that time suggested a stable trend in population growth across the entire Bi-State area between 2003 and 2012 (Coates *et al.* 2014a, p. 19). However, the trend in population growth was variable among populations (Coates *et al.* 2014a, pp. 14–15). This analysis has since been repeated several additional times. Once using a 13 year dataset spanning the years 2003 through 2015, again using 15 years of data spanning the years 2003 through 2017, and most recently using an approach that segmented the trends into three time intervals (Coates *et al*. 2018, entire; Mathews *et al*. 2018, entire; Coates *et al*. 2020, p. 27). The later approach was adopted to account for cycles in sage-grouse populations. It became apparent after analyzing the 13–year and 15–year datasets that the estimates of growth were being biased low due to an overrepresentation of down cycle years. To alleviate this bias, the latest trend analysis analyzes three time intervals which span one, two, and three cycles, with the start and stop points occurring in the troughs of a cycle. The three time intervals are 1995–2018, 2001–2018, and 2008–2018. However, not all populations had sufficient historic data to evaluate all three time periods and thus analysis was constrained to one or two time periods depending on the population. The most recent analysis includes results from the Mount Grant and White Mountains PMUs. The latest results of the IPM suggest population stability for the entire DPS across all three timeframes, but also showed evidence of population cycling (Coates *et al*. 2020, p. 27). Again, the trends in population growth were variable among populations. Coincidentally, the original analysis spanning the years of 2003–2012 was started and stopped at two peaks in the cycle and therefore remains unbiased. Furthermore, the results from the original analysis and the latest analysis are highly similar. Details pertaining to specific populations and PMUs, as well as the Bi-State in its entirety are provided below.

Two independent genetic evaluations have been conducted in the Bi-State area. Oyler-McCance *et al*. (2014, p. 8) concluded there are between three and four unique genetic clusters within the Bi-State area, while Tebbenkamp (2014, p. 18) concluded there were five unique genetic clusters. In addition, Tebbenkamp (2014, p. 12) did not evaluate the Pine Nut population, which Oyler-McCance *et al*. (2014, p. 8) found to be unique. Thus, presumably Tebbenkamp (2014, entire) would have differentiated six populations had these data been available. Based on this information, in addition to ongoing telemetry monitoring, we presume that there are likely several populations or groups of birds in the Bi-State area that largely operate demographically independent of one another. These potentially include the White Mountains, Long Valley, Parker Meadows, central Bi-State (Bodie, Mount Grant, Desert Creek–Fales PMUs), and the Pine Nut PMUs. However, there are known movements, based on marked individuals, which suggests birds are capable of making movements among these apparently largely demographically isolated populations, albeit frequency is not well delineated.

Historically, there were as many as 122 leks reported in the Bi-State area (Service 2006, p. 76,060), although this number is very likely an overestimate as locations were poorly documented, intermittent (i.e., satellite) lek locations likely appeared during years of high populations, and locations were recorded based on insufficient observations. Currently, the States of California and Nevada recognize 115 known lek locations with approximately 50 considered active leks (i.e., two or more strutting males during at least 2 years in a 5–year period) within the Bi-State DPS Bi-State TAC 2018, p. 11). These currently observed lek data differ slightly from those presented in Table 1 (above) due to averaging across multiple years. 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 (2018, unpublished data.); CDFW (2018, unpublished data); Bi-State Local Planning Group (2004, entire); and Bi-State TAC (2012, unpublished data; 2012, entire; Bi-State TAC 2017, entire; Coates *et al*. 2020, pp. 25–36).

1. Pine Nut PMU

The Pine Nut PMU encompasses the Pine Nut Mountains and Buckskin Range 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 has the fewest sage-grouse and proportionally, appears to have experienced the greatest reduction of sagebrush vegetation over the past 150 years as compared to other PMUs. The extant population in the Pine Nut PMU generally moves annually from breeding locations in the northern extent of the PMU, including the Buckskin Range, 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 decades ago for ranching operations, thus likely influencing distribution of birds in the area and potentially reducing connectivity between populations in this PMU with populations in the Desert Creek–Fales PMU to the south. Sage-grouse are still occasionally documented in Smith Valley, but these are rare occurrences. The western edge of the PMU has been influenced by suburban and exurban development and recreational activity related to that development such as off-highway vehicles. Furthermore, fires in the Pine Nut Mountains have substantially reduced the extent of sagebrush habitat. 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; Bi-State TAC 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. 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 and in turn the Bodie PMU, but probably to a lesser degree than it had historically. 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. The degree of genetic relatedness between birds formerly occurring in the Virginia Range and those occurring in the Pine Nut PMU is not known.

Overall, this PMU appears to have the smallest estimated population size (Median=33; CRI=0–73 individuals in 2018; Coates *et al*. 2020, p. 26) and least number of active leks of the six PMUs within the range of the Bi-State DPS. Historically, a single lek in the northern portion of the Pine Nut Mountains (known as Mill Canyon Dry Lake) was the only known consistently active lek in this PMU. Since 2000, the average male attendance at the Mill Canyon Dry Lake lek has been approximately 14 males (Bi-State TAC 2012, p. 17). However, since 2013 activity on this lek has essentially ceased. An additional lek in the southern extent of the mountain range has periodically been reported but at this point is not considered active. However, aerial surveys over the past few years typically detect birds in this area but actual strutting activity is uncertain.

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. Over the past several years, two newly discovered lek sites in the Buckskin Range appear to be the only reliably active strutting grounds in this PMU (NDOW 2018, unpublished data). Both lek sites are small, with two to five males apiece. The most recent results from the IPM suggests population growth in this PMU has declined on average sixteen percent annually over the past decade (2008–2018; Median $\lambda = 0.835$; CRI = 0..234–1.94) with evidence of likely decrease (Coates *et al*. 2020, p. 27).

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, 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 woodland succession over 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; the loss of brood–rearing/summer habitat has resulted 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 due to exurban housing development and habitat conversion 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. 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, exurban development (particularly near the Fales breeding complex), fire, 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 southern 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.

The Nevada Department of Wildlife uses data from six active leks to evaluate the trend and to tally maximum male attendance in the Desert Creek breeding complex. The long–term average male attendance is approximately 17.7 males per lek (Bi-State TAC 2017, p. 8). This average is influenced by one of these leks becoming inactive, with no males counted within the last 8 years. It is possible that this lek has moved locations but this remains unconfirmed. In 2012, a previously undocumented lek was discovered to the east of Nevada State Route 338 near Dalzell Canyon; 24 males were documented strutting on this lek. Over the last seven years, this lek has remained active but counts have been small (<5). Three additional lek sites have also been discovered over the past five years. One is small (~ 5 males) and apparently intermittently active on the southern end of the Pine Grove Hills. A second, located on the east side of the Pine Grove Hills, has been consistently active over this time period. Males counted at this lek ranged from 5 to 17. The third is located on the northern edge of the Pine Grove Hills; males counted over the past three years has ranged from 15 to 58. The most recent results from the IPM suggests population growth in this PMU has declined in the past decade. Estimated median population abundance in 2018 was 325 (CRI=163–542; Coates *et al*. 2020, p. 26) individuals. Estimated median population growth from 2001–2018 was 0.939 (CRI = 0.348–1.499), and from 2008–2018 was 0.938 (CRI = 0.337–1.535; Coates *et al*. 2020, p. 27).

The Fales breeding complex is located in northern Mono County, California. It is composed of three active and two inactive leks. Two active leks are located near Sonora Junction, in proximity to the intersection of Highway 395 and California Highway 108 and one additional lek is located in the northeast corner of Mono County in the Sweetwater Mountains. Surveys of the Fales breeding complex leks in proximity to Sonora Junction began in the early 1950s and 1960s. The average number of males counted on the then 4 active 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 in the 1970s, and in 1981, lek activity ceased (Bi-State TAC 2012, p. 24). 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, a second lek (Lek #4) in this vicinity of the Fales breeding complex became inactive and subsequently a single family home development occurred within 50 m (165 ft.) of the lek in 2007. In 2012, possible strutting activity was noted on Lek #4; the males observed may have shifted from consistently active Lek #2 nearby. No males have been documented on Lek #4 since possible activity in 2012 (CDFW 2014a, unpublished data; CDFW 2018, unpublished data). In 2018, peak male count on the two remaining leks was at a historic low of 16 males' total. One of the two remaining leks in this area may also potentially be affected by the recent Boot fire (2018) and the construction of a new out–building approximately 200 meters (218 yards) away. The Sweetwater Mountains lek was known but not surveyed prior to 2003; it is surveyed semi–regularly from the air due to limited access. In 2003 and 2004, 10 and 22 males were counted, respectively (CDFW 2014a, unpublished data). In 2012, 18 males were counted (Bi-State Lek Surveillance Program 2012, p. 8). In 2014, 16 males were counted and in 2018, 9 males were documented (CDFW 2018, unpublished data). Over the past four years, male counts on the Sweetwater lek have ranged from 9 to 24. Since 1981, the Fales breeding complex has remained small. The most recent results from the IPM suggest population growth in this population been negative over the past decade but evidence of decline is less robust. Estimated median population abundance in 2018 was 121 (CRI=54–208; Coates *et al*. 2020, p. 26) individuals. Estimated median lambda from 1995–2018 was 0.999 (CRI = 0.59–1.641), from

2001–2018 was 0.984 (CRI = 0.539–1.525), and from 2008–2018 was 0.965 (CRI = 0.544–1.397; Coates *et al*. 2020, p. 27).

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). More recently, recreational Off–Highway–Vehicle use has become more prevalent. Historical sage-grouse 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. Additionally, habitat loss due to woodland expansion 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 are either no longer used or receive little use due to conifer expansion.

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 survey data collection has been influenced by apparent confusion over lek names and potential vagaries in lek locations. These challenges affect the accuracy of inferences drawn from the data.

The largest known lek in the Mount Grant PMU 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 10 in 2013. Over the past five years, peak male counts have ranged between 14 and 41 individuals (NDOW 2018, unpublished data). East of this consistently active 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 2009, 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. Since 2013, activity at one of these lek sites has apparently ceased, as no birds have been documented. A third lek to the south of Ninemile Flat (which historically had been reliably attended) has exhibited significantly diminished activity since 2007 and no activity in the past 3 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). Since it was discovered in 2012, this lek had a high male count of 48 in 2016, with a range of 26 to 48 males (Bi-State Lek Surveillance Program 2012, p. 6; NDOW 2018, unpublished data). 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). This site has not been active in the years following its discovery.

Leks in the Wassuk Range have not been surveyed consistently due to access, which requires aerial survey methods. In 2005 and 2006, a total of 19 and 33 males, respectively, were counted on five active leks in the Wassuk Range (NDOW 2009, unpublished data; Bi-State TAC 2012, p. 35). During 2012, on four leks surrounding Mount Grant, a total of 139 birds (males and females) were counted (Bi-State Lek Surveillance Program 2012, p. 13). In 2013, 38 males were counted on 3 leks; the largest of which contained 30 males and over the past four years, total male counts have ranged between 8 and 35 across 3 to 5 leks, with the largest lek containing 23 males. However, due to access limitations and survey method, these numbers should be considered cautiously. The most recent results from the IPM suggest population growth in this PMU has generally been stable over the past decade, largely mirroring the pattern across the Bi-State DPS overall. Estimated median population abundance in 2018 was 374 (CRI=205–619; Coates *et al*. 2020, p. 26) individuals. Estimated median lambda from 2008–2018 was 0.989 (CRI = 0.551–1.536; Coates *et al*. 2020, p. 27).

4. <u>Bodie PMU</u>

The Bodie PMU primarily encompasses the Bodie Hills located southeast 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 pinyon pine and to a lesser extent 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 (i.e., woodland establishment)—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.

Approximately 8 leks have been regularly surveyed in the Bodie PMU since the late 1980s with some locations being counted as far back as the 1950s. Additional active leks and 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.

Since 1953, the long–term average total male attendance in the Bodie PMU is 192 (Bi-State TAC 2017, p. 11). The minimum count recorded was 64 males on 6 leks in 1998, and the maximum was 524 males on 14 leks in 2014. This PMU represents a significant core population in the Bi-

State DPS because of the number of birds it contains and its apparent long term stability. Best available information also indicates that this PMU harbors the highest number of active leks as compared to other PMUs.

Sage-grouse population growth in the Bodie PMU has no discernible long–term trend (Garton *et al*. 2011, p. 324; referred to as the Mono Lake population). 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). Recent survey years are encouraging because they demonstrate a substantial increase in the peaks associated with the population fluctuations. These increasing peaks, coupled with the general increase in the number of males counted since the early 1990s, suggests the Bodie PMU may be moving toward a cycle that oscillates at generally higher numbers as compared to the other PMUs. The most recent results from the IPM suggest population growth in this population has remained stable, with evidence of increase. Estimated median population abundance in 2018 was 1,521 (CRI=1,181–1,941; Coates *et al*. 2020, p. 26) individuals. Estimated median lambda from 1995–2018 was 1.07 (CRI = 0.76–1.758), from 2001–2018 was 1.029 (CRI = 0.74–1.457), and from 2008–2018 was 1.061 (CRI = 0.783–1.471; Coates *et al*. 2020, p. 27).

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. In addition, loss and fragmentation of habitat due to other causes (infrastructure, wildfire, and water development) has likely altered sage-grouse occurrence in certain locations such as the Mono Basin and Adobe Valley. 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 sage-grouse population size 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, proximity to roads, and recreational activity but the impact these activities have had on habitats in the area and bird use is not well understood. The Granite Mountain and Adobe Valley area (north of Highway 120) contains an expanse of sagebrush habitat and has been known to support birds during severe winters as well as historically (USFS 1966, p. 4; 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 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 an aerial survey suggests that current vegetation is not suitable sage-grouse habitat (Bi-State Lek Surveillance Program 2012, p. 36).

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 10 to 12 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 two active leks located in the Sage Hen Summit area. 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. Both the Granite Mountain and Parker Meadow breeding complexes are small, with generally less than 10 strutting males per complex documented per year.

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, 1986, and 2012 when 408, 405, 406, and 418 male were counted, respectively, on 6–7 leks (Bi-State TAC 2012, p. 44). The long–term average peak male attendance between 1953 and 2018 is approximately 200, counted on an average of 9 leks. The high count during this period was 418 males in 2012, and the low count was 152 males in 2018 (CDFW 2018, unpublished data). 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. The most recent results from the IPM suggest population growth in this population has declined on average approximately four percent annually over the past decade, with more evidence of decrease than increase and is apparently deviating from the remainder of the DPS. Estimated median population abundance in 2018 was 818 (CRI=614–1,053; Coates *et al*. 2020, p. 26) individuals. Estimated median lambda from 1995–2018 was 0.996 (CRI = 0.676–1.427), from 2001–2018 was 0.986 (CRI = 0.655–1.433), and from 2008–2018 was 0.96 (CRI = 0.68–1.361; Coates *et al*. 2020, p. 27).

Four leks are known to exist in the Granite Mountain breeding complex (Adobe, Gaspipe, Big Sand Flat, Sagehen Summit). 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 become 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 this site since 2009. However, sage-grouse are still encountered in the vicinity of the Gaspipe lek suggesting some seasonal use of the area occurs. The Big Sand Flat and Sagehen Summit lek sites remain active with between one to six males counted annually at each site. Estimated median population abundance in 2018 was 20 (CRI=0–75; Coates *et al*. 2020, p. 26) individuals. Estimated median lambda from 1995–2018 was 0.916 (CRI = 0.282–1.964), from 2001–2018 was 0.844 (CRI = 0.18–1.819), and from 2008–2018 was 0.834 (CRI = 0.222–1.658; Coates *et al*. 2020, p. 27).

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 18 males occurred in 2018 and a low count of 3 males occurred in 2010 (Bi-State TAC 2012, p. 45; CDFW 2018, unpublished data). The most recent results from the IPM suggest population growth in this population is generally stable, although this result has likely been influenced by translocation efforts. Estimated median population abundance in 2018 was 48 (CRI=21–86; Coates *et al*. 2020, p. 26) individuals. Estimated median lambda from 2001–2018 was 0.968 (CRI = 0.254–0.7.16), and from 2008–2018 was 1.048 (CRI = 0.361–5.814; Coates *et al*. 2020, p. 27). While growth in this population has little influence on the South Mono PMU as a whole, Parker Meadows likely facilitates connectivity between the Bodie and South Mono PMUs.

In 2017, an experimental translocation program was initiated to bolster low numbers in the Parker Meadows population (Mathews *et al*. 2018, p. 7). Given its infancy, the efficacy of this program has not yet been determined. However, the recent increases in male lek attendance, nest initiation rate, brood success, and number of sage-grouse remaining in the Parker Meadows area offers some optimism.

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 not well 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 suggests 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.

There are currently two active leks in the Nevada portion of the White Mountains PMU. Both were discovered in 2012 and are relatively small with between zero and nine males documented per lek per year (NDOW 2018, unpublished data). Since 2016, no males have been detected at one of these sites. The major extent of sage-grouse distribution in the Nevada portion of the

White Mountains PMU is centered on these lek locations, which 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) and current use may be negatively influenced by housing developments in the Chiatovich Creek area (Bi-State Lek Surveillance Program 2012, p. 38). 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). To inform this lack of understanding, GPS and VHF telemetry efforts were initiated in 2016. While this study is only beginning, it is starting to provide information on bird distribution. To date, the majority of current use centers within Roberts Ridge in the south to Chiatovich Flat in the north and Iron Mountain on the east to Paiute Mountain and Mount Bancroft on the west. A highly concentrated area of use appears to be around the North Fork of Crooked Creek. 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).

Prior to the recent telemetry efforts, several helicopter surveys have been completed over the past decade. In March 2006, 206 sage-grouse (males and females) 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 (Bi-State TAC 2012, p. 40). In April 2008, CDFW documented a total 33 sage-grouse (male and female) in the vicinity of the Mono and Inyo County line, centered near Sagehen Flat and Blanco Mountain (Bi-State TAC 2012, p. 40). 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.

The most recent run of the IPM suggests more evidence of decline than increase, although this estimate is derived from fairly limited data. Estimated median population abundance in 2018 was 45 (CRI=9–86; Coates *et al*. 2020, p. 26) individuals. Estimated median lambda from 2008–2018 was 0.85 (CRI = 0.343–1.957; Coates *et al*. 2020, p. 27).

Bi-State DPS Population Trends

Four separate statistical approaches to assessing the population trend of the Bi-State DPS have been conducted, with two of these approaches being repeated following additional years of data collection: Connelly *et al*. 2004, WAFWA 2008, Garton *et al*. 2011/2015, and USGS 2014/2018/2019 (Coates *et al*. 2014a, Coates *et al*. 2018, Mathews *et al*. 2018; Coates *et al*. 2020).

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 BSAP 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 positive numerical trend, albeit not statistically significant, over this same period (Connelly *et al*. 2004, pp. 6–69 to 6–70).

In 2008, WAFWA (2008, Appendix D) conducted a 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 but using a new approach. 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). In 2015, the researcher updated this analysis by accumulating and analyzing several years of additional of data (Garton *et al*, 2015, entire). The updated estimates of population performance largely remained unchanged, while the outlook for persistence actually improved. For the North Mono Lake population, the estimated minimum number of males increased by 25 percent in 2013 as compared to 2007, while the probability of declining below a, researcher defined, quasi–extinction threshold decreased (Garton *et al*, 2015, pp. 13–14). In the South Mono Lake population, the estimated minimum number of males decreased by six percent in 2013 as compared to 2007, while the probability of declining below a quasi–extinction threshold increased but still remained fairly low (Garton *et al*, 2015, pp. 13–14). Furthermore, for both populations, the predicted population size in 30 and 100 years increased in 2013 as compared to 2007 (Garton *et al*, 2015, p. 45). In sum, this approach suggests both of these populations will remain small, as they have historically, and thus the probability of long–term persistence (100 years) is low, but in the near term (30 years), the probability of persistence is more likely. This, however, is based on the assumption that past conditions remain unchanged in the future.

In 2014, USGS developed and conducted a fourth approach to trend analysis on six populations in the Bi-State area (i.e., Pine Nut (Pine Nut PMU), Desert Creek (Desert Creek–Fales PMU), Fales (Desert Creek–Fales PMU), Bodie Hills (Bodie PMU), Parker Meadows (South Mono

PMU), and Long Valley (South Mono PMU)) over a 10 year period from 2003 to 2012 (Coates *et al*. 2014a, entire). This approach, termed an integrated population model (IPM), affords the use of multiple sources of data (e.g., lek counts, telemetry studies) within a single unified framework to understand population dynamics, providing important advantages over conventional analytic methods that analyze each dataset separately and then try to make an inference about population dynamics (Schaub and Abadi 2011, entire). Over this 10 year timeframe, this assessment estimated trend in population growth had been stable across the Bi-State area over this time period but variation in PMU trends was apparent. Specifically, estimated population growth trend was positive for four of the six populations analyzed (Pine Nut, Desert Creek, Bodie Hills, Long Valley) and negative for the remaining two populations analyzed (Fales, Parker Meadows) over this time period. In 2018, these researches repeated this analysis to include additional years of data, including several years of below average precipitation (Coates *et al*. 2018, entire; Mathews *et al*. 2018, entire), which has been shown to influence sage-grouse population oscillations (Blomberg *et al*. 2012, p. 9). Furthermore, the most recent iteration of the IPM (i.e., *Coates et al*, 2019, p. 46–63) includes analysis of the Mount Grant and White Mountains PMUs.

The results of the most recent iteration of the IPM suggests a general pattern of population cycling within an otherwise stable population across the Bi-State DPS with additional evidence that oscillations were influenced by drought conditions in recent years (Coates *et al*. 2018, pp. 250, 252; Coates *et al*. 2020, p. 27). Furthermore, variation among individual PMU trends was apparent. This analysis estimated that across the Bi-State as a whole, estimated median population growth was 1.018 (CRI = 0.737–1.418) from 1995–2018, 0.989 (CRI = 0.677–1.343) from 2001–2018, and 0.988 (CRI = 0.704–1.304) from 2008–2018 (Coates *et al*. 2020, p. 27). Furthermore, these results suggest that across these three time intervals population performance in the Bi-State DPS outperformed populations occurring in the broader Great Basin by approximately two to four percent. More specifically, over the past decade only the Bodie Hills population demonstrated an average annual positive growth (λ=1.061). The remaining populations including Mount Grant (λ=0.989), Fales, (λ=0.965), Pine Nut (λ=0.835), Desert Creek (λ=0.938), Long Valley (λ=0.96), and the White Mountains (λ=0.85; Coates *et al*. 2020, p. 27) averaged slight negative growth although in each case the 95 percent credibility intervals overlapped 1. Additional analysis suggests that over the past five years performance seven leks occurring in Long Valley, Fales, Bodie, Mount Grant, and to a lesser extent Sagehen have been trending (negatively) in a pattern that deviates from the Bi-State at large (Coates *et al*. 2020, p. 37). This analysis suggests that alternative deterministic factors and not climate or weather may be acting to influence these sites.

In general, these four approaches (with some being run more than once) suggest that the trend in population growth within the Bi-State has fluctuated over the past 40 years. Furthermore, it appears that some populations (Pine Nut, Mount Grant, Bodie and Desert Creek) display greater variation in population growth (both positive and negative) and that trends among populations are variable (WAFWA 2008, Appendix D; Garton *et al*. 2011, p. 324, Coates *et al*. 2020, p. 27). Garton *et al*. (2015, p. 41) used their reconstructed male counts to forecast future probabilities of population persistence assuming that past conditions persist into the future (a potentially unrealistic assumption). They conclude that the probabilities of declining below a quasi–

extinction threshold (as defined by less than 50 breeding adults per population) were approximately 8 and 22 percent over the next 30 and 100 years, respectively, for both the North Mono Lake and South Mono Lake populations. Furthermore, Garton *et al.* (2015, p. 41) indicate that long–term persistence (as defined by more than 500 breeding adults per population) is questionable for both core populations with an estimated 100 percent probability of dropping below this threshold in the next 30 years. However, the researchers note that these populations have already been below this mark in previous years. Therefore, near–term projections (30 years) suggest that the North Mono Lake and South Mono Lake populations have a relative high probability of maintaining between 50 and 500 breeding adults. Thus, in these two core populations, immediate genetic concerns (e.g., inbreeding depression) are not apparent; however, concern over maintaining long–term genetic and demographic viability remains (see *Small Population Size and Population Structure* section below). Coates *et al*. (2019, p. 52) reports that across the Bi-State region, the average rate of population change was stable and that the rate of change varied both by year and population. These researchers suggest that the population trend did not exhibit evidence of decrease or increase but instead showed evidence of cycling within an otherwise stable trajectory (Coates *et al*. 2018, p. 250; Coates *et al*. 2020, p. 27).

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 14 Wilderness and Wilderness Study Areas (WSA) overlap the Bi-State DPS and encompass approximately 5,400 ha (13,400 ac) in the Pine Nut PMU, 19,836 ha (49,018 ac) in the Desert Creek–Fales 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 8,900 ha (22,000 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.
- Nevada State Parks acquired three private ranches along the East Walker River in the Mount Grant PMU in 2016. This acquisition changed ownership status on approximately 4,407 ha (10,891 ac).
- Lands owned by 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)[1]					
		BLM	**USFS**	**Native American**	**Private**	**State/ County/ City**	**DOD**
Pine Nut	232,440 (574,372)	145,408 (359,313)	28,527 (70,492)	24,281 (60,000; approx.)	28,439 (70,276)	5,567 (13,758)	—
Desert Creek–Fales	229,858 (567,992)	2,472 (6,110)	199,757 (493,612)	—	26,594 (65,716)	1,032 (2,552)	—
Mount Grant	282,907 (699,079)	113,277 (279,916)	121,773 (300,910)	11,316 (27,963)	12,567 (31,054)	4,407 (10,891)	19,803 (48,936)
Bodie	141,490 (349,630)	72,852 (180,022)	32,934 (81,382)	16 (40)	23,857 (58,952)	2,460 (6,081)	—
South Mono	234,508 (579,482)	81,250 (200,775)	126,295 (312,084)	178 (441)	7,147 (17,662)	19,636 (48,522)	—
White Mountains	709,768 (1,753,875)	589,107 (1,455,716)	99,367 (245,542)	—	21,292 (52,616) —		
TOTAL	**1,830,972 (4,524,430)**	**1,004,366 (2,481,842)**	**608,656 (1,504,022)**	**35,792 (88,444)**	**98,604 (243,655) plus White Mountains**	**33,102 (81,796) plus White Mountai ns**	**19,803 (48,936)**

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 substantial 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^2 (34,749 mi^2) in 1990 to less than 12,000 km^2 (4,633 mi^2) 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 Invasive and Native Woodland Succession" 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 TAC 2012, pp. 18, 24, 31, 41, 46). Approximately 5 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 further, approximately 11 percent of suitable sage-grouse habitat occurs on private lands. 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 a significant proportion of mesic areas (e.g., 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 or degradation of specific sites (especially brood–rearing habitat) can have negative 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 in California 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).

(4) In the South Mono PMU, sage-grouse use of private lands is relatively minor (<10 percent of the time; Casazza 2009, p. 35).

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 TAC 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 (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, *in litt*.). These developments result in diminished habitat use as well as loss and fragmentation of sagebrush vegetation and sage-grouse distribution (Gillan *et al*. 2013, p. 306); potentially 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. Private land development has occurred on Burcham Flat and, in 2012, a single family residence was constructed within several hundred meters of a 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 is not currently active (Bi-State TAC 2012, p. 24). In the past year or two, a new outbuilding associated with a private residence has been erected within several hundred meters of the single remaining active lek on Burcham Flat (Taylor 2018, pers. comm.).

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 characterized as rangeland; however, the potential for conversion of these private lands for commercial, residential, or recreational development exists, with particular concern for areas that are currently providing connectivity between the Bodie, Mount Grant, and Desert Creek–Fales PMUs.

In the South Mono PMU, habitat loss and fragmentation attributed to land use change and development have been limited to date. However, development in the Mammoth Lakes and Crowley Drive areas exert additional land use pressure on the PMU. The majority of local agency land in the PMU is owned by the City of Los Angeles and managed by the LADWP, and many of these parcels are irrigated pasture, which provide important brood–rearing habitat to nearly 40 percent of the entire Bi-State DPS population. The LADWP is considering altering the extent to which these lands are irrigated and this change, if realized, has the potential to negatively affect brood–rearing success. However, LADWP has provided a commitment to the Service that sufficient water will be allocated to maintain sage-grouse habitat in Long Valley and that determining the amount of water needed to achieve this commitment will be informed by a collaborative, science based approach. Given that the Long Valley population, in the South Mono PMU, has demonstrated negative population growth on average over of the past 10 years, any additional stressors that may affect influential demographic vital rates, will likely exacerbate poor population performance. The largest block of private lands lies adjacent to occupied sage-grouse habitat west of Crowley Lake. The remainder of private lands in the South Mono PMU is rangeland although potential for commercial, residential, or recreational development exists.

The Town of Mammoth Lakes, California, and the surrounding area in the South Mono PMU is a 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 negligible, but increased indirect effects due to associated human growth are expected. An example is the ongoing 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 may increase (Mammoth Yosemite Airport 2012). The airport had regional commercial air service from 1970 until the mid–1990s until cessation (Federal Aviation Administration 2008, p. 1–5). Commercial air traffic was resumed in 2009. While commercial air traffic was anticipated to increase (Town of Mammoth Lakes 2005, p. 4–204), market forces have, in fact, gone the opposite direction and air travel has declined nearly 50 percent from a peak in 2013. 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.

Recently, Mono County revised their General Plan, which further developed 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 (Mono County 2018, entire). 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, as demonstrated by the 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 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 development in this corridor may further limit connectivity within the White Mountains PMU as well as with 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 other habitat degradations such as invasive weed establishment. For example, Rights–of–Way (ROW) granted across public lands for roads, utility lines, and other public purposes (see “Infrastructure” section below) are needed and typically granted to support development activities on adjacent private parcels.

Traditional farming and ranching operations can have both beneficial and detrimental effects on sage-grouse conservation. Continuing farming and ranching operations have limited development of exurban subdivisions in the Bi-State area, but they have also affected sagebrush extent. They have also influenced the current frequent dependence of sage-grouse on irrigated pastures during the brood–rearing season and 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 abandonment of a lek within several hundred meters of this site (Espinosa 2008, pers. comm.).

Current and anticipated future fragmentation caused by subdivision 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 10,415 ha (25,737 ac) of private land, which may provide suitable habitat for sage-grouse in the Bi-State DPS, are currently enrolled in various easement programs. The easements are targeted primarily at development and water rights and vary in length from 30 years to in perpetuity, thus they can ameliorate the threat of development but do not necessarily ensure that habitat remains suitable. The majority of these easement lands are located in the Bodie PMU, with the remainder of easements occurring in the Desert Creek–Fales, South Mono, Pine Nut, and White Mountains PMUs. Of the approximately 60,326 ha (149,071 ac) of private land that may provide suitable habitat for sage-grouse within the Bi-State area, approximately 17 percent are under easements. Furthermore, approximately 9,737 ha (24,060 ac) of previously private land within the Bi-State DPS has been acquired by State and Federal agencies over the past decade. In total, approximately 20,153 ha (49,800 ac) of land, either through conservation easements or acquisitions, has been substantially protected from urbanization challenges. These acres represent approximately 31 percent of total private lands containing suitable sage-grouse habitat across the Bi-State. In addition, approximately 7,280 ha (18,000 ac) of lands identified as important by the 2012 Bi-State Action Plan have funding obligated and are working through the easement development, with many of these efforts anticipated to be completed in a few years. Further, an effort to acquire approximately 5,867 ha (14,500 ac) lands in the Pine Nut PMU by the Carson City BLM has been approved but will likely not finalize until 2020. Combining the realized and reasonably anticipated efforts, approximately 57 percent of high priority private lands in the Bi-State will be protected.

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, suggesting that human development has had long–term impacts on habitat suitability and sage-grouse persistence. Extirpation was more likely in areas having a moderate human population density of at least four people per 1 km^2 (10 people per 1 mi^2). Furthermore, 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). 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 2018) and found five counties in the Bi-State area have documented declines in the estimated number of people present between 2010 and 2017: Alpine, Mono, and Inyo Counties in California, and Mineral and Carson City Counties in Nevada. In addition, all of these counties except Carson City, Nevada support substantially less than four people per 1 km^2 (10 people per 1 mi^2). The remaining counties in the Bi-State area have seen human population increases over the past decade, ranging from 2.8 percent for Douglas County, Nevada, and 4.1 percent for Lyon County, Nevada to 8.4 percent for Esmerelda County, Nevada (U.S. Census Bureau 2018). While Esmerelda County still contains substantially less than 4 people per km^2 (four people per 0.4 mi^2), both Lyon and Douglas Counties, Nevada have from two to six times that population density. 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.

Another indicator of human development pressure on sage-grouse can be inferred from existing sagebrush availability. Aldridge *et al.* (2008, p. 990) and Chamber *et al*. (2014, p. 12) 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. Across the Bi-State, out of the 55 active and pending leks analyzed, no leks contained less than 25 percent sagebrush cover within a 5 km (3.1 mi) buffer centered on the lek. However, 30 out of the 55 leks (55 percent) contained between 25 and 65 percent sagebrush cover suggesting an intermediate probability of persistence (Chamber *et al*. 2014, p. 12). And, the remaining 25 leks (45 percent) contained greater than 65 percent sagebrush cover surrounding a lek site, implying a high probability of persistence.

<u>Summary of Urbanization and Habitat Conversion Impacts</u>

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 potentially influencing 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 11 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 significant percentage of late brood–rearing habitat that occurs on the private lands. Sage-grouse recruitment is highly dependent on late–brood rearing sites such as meadow and spring habitats, and loss or degradation of these relatively small areas may eliminate sage-grouse from much larger areas. Furthermore, 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. Currently, approximately 31 percent of total private lands containing suitable sage-grouse habitat across the Bi-State are enrolled under an easement program or have been acquired by federal and State agencies and this number increase to 57 percent when combining additional efforts that are ongoing but reasonably likely to occur. These easements and acquisitions have generally been targeted at private lands considered most important to sage-grouse conservation or that were considered most at risk of development.

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 apparent in the Bi-State area and have been implicated in impacting sage-grouse: 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).

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). 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 unsuitable (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. Estimating the impact of habitat fragmentation caused by infrastructure on sage-grouse is complicated by the nonrandom placement of these features and 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). A number studies (discussed below) suggest a general negative correlation between infrastructure presence and sage-grouse occurrence or habitat use.

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; Chamber *et al*. 2014, p. 17). 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. 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 includes roads, power lines, fences, landfills, and communication towers.

1. Roads

Roads are a linear feature on the landscape that can contribute to loss and fragmentation of habitat and can cause segregations of populations as a result of behavioral avoidance. Impacts to animals from roads include habitat loss and avoidance, barriers to migration corridors or seasonal habitats, facilitation of predators, and spread of invasive plant species (Forman and Alexander 1998, pp. 207–231, Forman 2000, p. 33; Blickley *et al*. 2012a, p. 467; Knick *et al*. 2013, p. 6). Additionally, direct mortality of sage-grouse 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 increase human access and ultimately lead to disturbance effects in otherwise remote areas (Forman and Alexander 1998, p. 221; Forman 2000, p. 35; Connelly *et al.* 2004, pp. 7–6 to 7–25).

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). As an example, Bui (2009, p. 31) documented ravens following roads in oil and gas fields, which presumably facilitated foraging activity. Furthermore, associated with some roads are rest areas, camp sites, trash bins, and road kills, etc., 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).

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 once established (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; however, the extent of this incursion appears to vary by road type and amount of associated road maintenance.

Lekking sage-grouse appear to avoid roads and related activities (especially traffic). Additional 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. Along Interstate 80 in Wyoming and Utah, Connelly *et al*. (2004, pp. 12–13) reported that no leks were found within 2 km (1.25 mi) of the interstate and fewer birds were documented on leks within 7.5 km (4.7 mi) as compared to leks within 7.5–15 km (4.7–9.3 mi) of the interstate. The number of active leks also increased with increasing distance from the interstate and leks closest (within 7.5 km (4.7 mi)) to the interstate declined at a greater rate (Connelly *et al.* 2004, p. 13–13). Similarly, 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 information suggests a continued impact from highways, possibly due to increased traffic levels, which have been identified as reducing numbers of sage-grouse occupying leks (Holloran 2005, p. 40). However, we note that these earlier studies could not separate the effects of roads themselves from the quality of habitat near roads. Meaning other mechanisms may have been influencing sage-grouse use of these areas but the effect of these other mechanisms could not be teased apart from roads.

The mechanism by which road presence reduces male lek attendance is not entirely clear. However, chronic noise may contribute to these decreases. Male sage-grouse are 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). And while alternative mechanisms may influence attendance (such as increased on–lek mortality due to the masking of predator noise), Blickley *et al*. (2012a, pp. 467–469) documented a 73 percent decrease in lek attendance at leks experimentally treated with road noise relative to paired controls and suggest noise avoidance was the likely causal factor.

Sage-grouse apparently avoid nesting and summering near major roads (i.e., paved secondary highways) in south–central Wyoming and Montana (LeBeau 2012, p. 28; Smith *et al*. 2018, p. 1,510) and traffic disturbance (1 to 12 vehicles/day) within 3 km (1.9 mi) of leks during the breeding season resulted in a 24 percent reduction in nest–initiation rates and a 100 percent increase in distance moved by females to nest (Lyon and Anderson 2003, p. 489). Ultimately, road proximity lowered female fecundity and population recruitment by 10 percent (Lyon 2000, p. 33; Lyon and Anderson 2003, pp. 489–490). In contrast, however, Gillan *et al*. (2013, p. 307) did not find sage-grouse avoiding roads, although they did not attempt to account for traffic volume and the majority of roads in their study site were described as minor and composed of dirt or gravel. Furthermore, Smith *et al*. (2018, p. 1,510) found that distance to two–track roads did not influence nest site selection.

Road density within sage-grouse habitat also appears to influence habitat suitability. Aldridge *et al.* (2008, p. 992) did not find road density to be an important factor affecting sage-grouse persistence or range–wide patterns in sage-grouse extirpation. However, the authors submit that they 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). In contrast, Wisdom *et al.* (2011, p. 18) reported that extirpated range was 60 percent closer to highways (mean = 5 km (3.1 mi)), was generally closer to secondary roads, and had a

25 percent higher road density than occupied range. Furthermore, Knick *et al*. (2013, p. 1,544) found that the most valuable sage-grouse habitats had densities of secondary roads that were below 1.0 km/sq. km, highway densities below 0.05 km/sq. km, and interstate highway densities at or below 0.01 km/sq. km. These range–wide analyses support 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.

Generally, the documented negative effects (described above) of distance to road are positively correlated with increased traffic density and speed (Forman and Alexander 1998, p. 214), as well as timing of traffic events. For example, the upgrade of haul roads associated with coal mining activity in Colorado resulted in increased traffic levels and was correlated with declines in the number of displaying males on leks situated within 2 km (1.25 mi) of the road. Furthermore, rates of declines in sage-grouse male lek attendance increased as traffic volumes on roads near leks increased, and vehicle activity during the early morning strutting period had a greater influence on male lek attendance compared to roads with no vehicle activity during the strutting period in southwestern Wyoming (Holloran 2005, p. 40). Thus, impact of roads on sage-grouse appears to vary by road type, activity level, and timing of traffic events.

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. Traffic volume varies substantially across all roads in the Bi-State area, as does individual populations' exposure. In general, 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. Our analysis of the best available data in the Bi-State area documents that 54 out of 55 known active or pending leks are within 3 km (1.8 mi) or less of an existing minor roads (such as dirt two–track roads). Furthermore, of the 55 known active or pending leks, 20 percent (n=11) are within 1 km (0.6 mi), 35 percent (n=19) are within 2 km (1.2 mi), 49 percent (n=27) are within 3 km (1.8 mi), and 64 percent (n=35) are within 5 km of paved secondary highways (Service 2013c, 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 active or pending leks are in close proximity (< 0.6 mi; <1 km) to dirt two–track roads. Additionally, 6 of 14 leks are less than 1 km (0.62 mi) to well–traveled secondary highways and 12 of 14 are within 2.5 km (1.5 mi) of secondary 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). Still, 6 of 24 active or pending lek sites are within 2 km (1.2 mi) of a paved secondary highway. Furthermore, 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–maintained minor dirt or gravel roads during average spring weather conditions.

- 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 and LADWP, 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 had greatly diminished with intermittent activity since 2009 (although the mechanisms influencing the declines are unknown), and 4 of 11 active leks in the PMU are within 2 km (1.2 mi) of a paved highway (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 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 408 km (254 mi) (USFS 2009, p. 1). The HTNF planning effort adopted approximately 350 km (218 mi) of previously unauthorized routes to the National Forest System, while proposing to close approximately 930 km (578 mi) of unauthorized routes to future vehicle traffic (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. However, past impacts may have caused the population to settle at a lower level. A recent land use plan amendment for the HTNF additionally substantially restricts new road development and further curtails use of existing roads in specific locations and during certain seasons when sage-grouse may be present or vulnerable to disturbance (USFS 2016, p. 14).
- 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).
- The Carson City District Office and Tonopah Field Office also restrict travel off roads. Furthermore, they adopted similar restrictions on new road development and use of existing roads during certain seasons and in specific locations as the HTNF with the specific intent to limit disturbance to sage-grouse (BLM 2016, pp. 1315).

In summary, research suggests that primary roads within 7.5 km (4.7 mi) of leks negatively influence male lek attendance. Increased size of road, traffic levels on roads, and traffic activity during the daily strutting period on roads within 3 km (1.9 mi) of leks negatively affect male lek attendance as well as female behavior, nest–initiation, and nest success. Although minimal traffic volume on these roads (<12 vehicles/day) negatively influence sage-grouse, increased traffic volumes appear to have a greater effect. 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 land use plans amendments, USFS and BLM travel management plans and our current understanding of 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.

2. Power Lines

Power lines are generally classified into two broad categories: Distribution lines, such as those typically carrying power to a single family residence, are generally energized to less than 69 kilovolts (kV) (69,000 volts) and supported by wooden poles; and transmission lines, those carrying greater than 69 kV and more typically are energized to greater than 115kV and supported by various configurations of steel lattice.

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. 1055), resulting in more than 804,500 km (500,000 mi) of transmission lines by 2002 (Manville 2002, p. 1054). 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; Gibson *et al*. 2018, p. 17), increasing predation (Connelly *et al.* 2004, p. 13–12, Gibson *et al*. 2013a, p. 27), facilitating the invasion of nonnative invasive annual plants (Knick *et al.* 2003, p. 612; Connelly *et al.* 2004, p. 7–25), behavioral avoidance (Gillan *et al*. 2013, p. 307), potentially acting as a barrier to movement (Pruett *et al*. 2009, pp. 1,255–1,256), and ultimately negatively affecting population performance (Gibson *et al*. 2018, p 17). Due to the potential spread of invasive species and facilitation of predator occurrence 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, predation, habitat avoidance, individual vital rate suppression, and population level 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, Beck *et al*. (2006, p. 1075), Braun (1998, p. 145), and Connelly *et al.* (2000a, p. 974) report 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.). While collisions occur, the extent of this source of mortality in sage-grouse has not been studied explicitly; however, available research (Messmer *et al*. 2013, p. 283) does not appear to suggest it is substantial.

- 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. 1057; Vander Haegen *et al.* 2002, p. 503; Howe *et al*. 2014, p. 43). For example, 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). These findings and others have led sage-grouse researches (Messmer *et al*. 2013, p. 286) to speculate that increased predators will lead to increased predation mortality in sage-grouse. To date, this direct causal link has not been successfully demonstrated outside of nest depredation (Gibson *et al*. 2018, p. 17). However, recent research has demonstrated that power lines are influencing sage-grouse behavior, demographic vital rates, and population growth rates, of which are being ultimately influenced by raven abundance and predation (Gibson *et al*. 2018, pp. 17). In Utah, the installation of a transmission line within 200 m (650 ft.) of an active lek resulted in a 72 percent decline in mean number of displaying males within two years (Ellis 1985, p. 10). This project also reported the frequency of interactions between raptors and sage grouse increased 65 percent during the lekking season and interactions with golden eagles (*Aquila chrysaetos*) specifically, increased 47 percent between pre– and post–installation (Manier *et al*. 2013, p. 50). In Wyoming, Braun *et al.* (2002, p. 10) reported leks within 0.4 km (0.25 mi) of new power lines had lower growth rates (measured by recruitment of new males onto the lek), and Walker *et al*. (2007a, p. 2649) found the probability lek persistence increased with increasing distance from power lines and decreased with an increasing proportion of power lines within 6.4 km (4 mi) of a lek. In Washington, Shirk *et al*. (2015, p. 1844) found that transmission lines, along with low elevation, could potentially resist gene flow and ultimately, connectivity. This study found that sage-grouse occurrence increased as distance from the transmission line increased and the maximum probability of occurrence was farther than 10 km (6 mi) from the transmission line.

- In likely the most robust approach to date, Gibson *et al*. (2018, pp. 14–17) found proximity to power line in association with raven abundance negatively influenced several vital rates (e.g. pre–fledging chick survival, annual male survival, per capita recruitment and population growth) and behavioral aspects, ultimately influencing population growth and further reports these negative effects can extend out to 12.5 km (7.76 mi). Gibson *et al*. (2018, pp. 1, 17) found that leks located 5 km from the line had a 0.02 to 0.16 higher rates of population growth compared to leks within 1 km of the line in years of average to high raven abundance. In addition, there was also support for downward trends in other vital rates including pre–fledgling chick survival, male survival, *per capita* recruitment, and population growth (Gibson *et al.* 2018, p. 22). Habitat avoidance from any power line was observed within 10 km and demographic suppression from the 345 kV Falcon–Gondor (FG) line was observed up to 12.5 km; these effects combined ultimately resulted in an overall negative association between the FG line and population growth rates to at least 5 km from the line (Gibson *et al.* 2018, p. 17).

Presumably, sage-grouse and other related species are avoiding habitats near power lines due to increased predator populations. 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 yds.) and reported that power lines may limit sage-grouse use within 1 km (0.6 mi). Similarly, Gillan *et al*. (2013, p. 307) reported sage-grouse avoiding power lines by 600 m (656 yards), Hanser *et al*. (2011, p. 130) found there was less probability of sage-grouse pellets occurrence within 500 m (546 yards) of power lines and in Washington State, nesting sage-grouse avoided distribution lines on average by 1.6 km (1 mi; Stonehouse *et al*. 2015, p. 1318). In Nevada, Gibson *et al*. (2018, p. 14) reported transmission line impacts from a newly constructed 345 kV line, as well as from surrounding transmission and distribution lines, affected sage-grouse behavior (e.g., nest site selection) and demographics 2.5 to 12.5 km from the line. These impacts were primarily correlated to increases in common raven abundance. These data suggest that female sage-grouse have high avoidance of areas within 3 km (1.86 mi) of a power line, although several of these studies could not differentiate the effects of the power line itself from those of habitat quality along the power line corridor. In a related genera, lesser and greater prairie–chickens (*Tympanuchus pallidicinctus* and *T. cupido*, respectively) avoided otherwise suitable habitat near power lines (Pruett *et al*. 2009, pp. 1255–1256). In addition, both lesser and greater prairie–chickens crossed power lines less often than nearby roads, which suggests that power lines are a relatively strong barrier to movement (Pruett *et al*. 2009, pp.1255–1256). 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.

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. Alternatively, 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). 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).

Finally, Gibson *et al*. (2018, entire) found that power lines interacting with raven abundance affected several aspects of sage-grouse biology (demographic rates, behavioral voidance) and ultimately negatively influenced population performance and growth.

Power lines can also facilitate the spread of nonnative invasive plant species (such as cheatgrass), 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.

Power lines occur in all Bi-State PMUs but the extent of exposure 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 portion of the 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 PMU continues to experience exurban 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 power line has been reported (Bi-State Local Planning Group 2004, p. 81); however, numbers of birds at this lek have rebounded since 2004. There is a single major transmission line, which parallels Highway 395, in the Bodie PMU but there are no designated transmission corridors in existing land use plans (Bi-State Local Planning Group 2004, p. 82). Furthermore, one decommissioned power line has been removed, and this should prove beneficial (Bi-State TAC 2018, p. 33).

- 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 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 presence (Espinosa 2010, pers. comm.). Shifts in lek locations may partially account for the reported sporadic inactivity at these two known leks in recent years.

- 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.

Data on the total extent (lengths and alignments) of existing power lines (or future transmission projects) within currently occupied sage-grouse habitats are not available for the entire Bi-State area. However, based on the data available (generally restricted to transmission lines) we estimate approximately 210 km (130 mi) of existing power lines are present across suitable habitat in the Bi-State, as indicated in the individual PMU narratives above. Overall, approximately 21 percent of 55 active and pending leks in the Bi-State area are within 2 km (1.2 mi) or less of existing transmission lines and approximately 38 percent of active and pending leks are within 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. Based on the results reported in Gillan *et al*. (2013, p. 307), this suggests a potential loss, due to sage-grouse avoidance, of approximately 25,200 ha (62,270 ac) of otherwise suitable habitat. Furthermore, results from Gibson *et al*. (2018, p. 17) suggest these transmission lines have the potential to be negatively influencing over 250,000 ha (617,700 ac) or approximately 47 percent of suitable habitat. We anticipate that existing power lines will persist on the landscape in the future but new power lines will be limited to smaller distribution lines associated with expansion of urbanization on a portion of the private lands within and around the Bi-State area. Bi-State sage-grouse habitat is currently managed as right–of–way avoidance area by Federal land managers, such that larger lines (>120 kilovolts) and associated facilities will not be authorized (outside of existing corridors; BLM 2016, p. 15; USFS 2016, p. 13).

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. 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. Typically, rights–of–way grants provided by Federal land managers to permit power line construction are issued for 30 years but frequently these grants are extended indefinitely. Of ongoing concern, however, is the loss of suitable habitat in various areas due to the existence of an established power line network as future new developments are anticipated to be limited.

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 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, although Christiansen (2009, p.2) suggests fence construction should be avoided in wintering and riparian areas. 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 in some of the high risk areas 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. Another study by Van Lanen *et al.* (2017, p. 70) came to similar conclusions and found that collisions were reduced by 57 percent using reflective markers; they also found collision probabilities were lower at fences with wood posts and on fences that were farther from leks. While, this relatively inexpensive method does not entirely alleviate the likelihood of mortality caused by fences, it does appear to substantially reduce it. Markers have been installed on a total of approximately 101 km (63 mi) of fence across the Bi-State DPS since 2012.

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 non–habitat due to behavioral avoidance (Cutting *et al.* 2019, p. 626).

Small roads are frequently associated with fences, which may 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 even after the initial 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. Furthermore, recent land use plan amendments encourage evaluation of existing fences with respect to sage-grouse conservation and discourage new installations that may negatively affect sage-grouse and its habitat (BLM 2016, pp. 12, 15; USFS 2016, p. 14).

Data on the total extent (length and distribution) of existing fences and new fence construction projects are not available for the Bi-State area. However, based on data contained within the *Greater Sage-grouse Bi-State Distinct Population Segment Forest Plan Amendment* (USFS and BLM 2014, p . 99), there is likely on the order of 650 km (400 mi) of existing fences across the entire DPS. 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 degradation) 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; BLM 2016, pp. 12, 15; USFS 2016, p. 14). 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 considered 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, 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; Wisdom *et al*. 2011, p. 463).

Within the range of the Bi-State DPS, approximately eight communication towers have been constructed in the past decade (Federal Communications Commission (FCC) 2018, 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 eight sites are likely an underrepresentation 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 2018, unpublished data). We are unable to determine if any sage-grouse mortalities have occurred as a result of collisions with registered or unregistered 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.

Based on existing land use plans as well as existing land designations (i.e., wilderness and wilderness study areas), which significantly restrict new communication site development, we do not expect many new facilities on federally managed land in the Bi-State area (BLM 1993, p. 18;

BLM 2016, p. 13; USFS 2016, pp. 42–43). However, we anticipate that existing communication towers will remain in place and potentially new communication towers will be added at existing tower sites. Typically, rights–of–way grants afforded these facilities are for 30 years, and would likely be renewed indefinitely. It is also probable that new communication towers will be developed on non–federally managed lands along existing Federal Highways and State Routes. Thus, future communication tower placements will most likely affect the Desert Creek–Fales and South Mono PMUs, potentially affecting sage-grouse habitat in those 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 and chick predator that can restrain sage-grouse population growth in some locations (Batterson and Morse 1948, p. 14; Autenrieth 1981, p. 45; Coates 2007, p. 26; Gibson *et al*. 2018, pp. 14–17). Peebles *et al*. (2017, p. 293) captured and GPS–marked ravens at landfills in Wyoming and found that 22 percent of marked ravens foraged at landfills and 68 percent roosted at an anthropogenic site on a given day. Ravens showed increased use of landfills when temperatures decreased (Peebles *et al*. 2017 p. 305); the authors suggest that anthropogenic food subsidies such as landfills can provide resources during winter that are otherwise limiting, which is likely to increase over winter survival of ravens. 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.; USGS 2017, p. 17). 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.; Coates *et al.*. 2018, p. 256). Ongoing research in the Bi-State continues to support these initial findings (USGS 2017, p. 74). 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 closing of the landfill appears probable, as LADWP has stated that they do not intend to renew the lease and Mono County has been funding planning studies for relocation, 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 may degrade 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. 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, 64 percent of active or pending leks are within 5 km (3.1 mi) of highways, and approximately 38 percent are within this distance to existing transmission lines (Service 2013, unpublished data). 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 not occur, other infrastructure features have the potential 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 (see the Recreation section below for more details on the impacts of OHVs).

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) found that cellular towers are highly influential in explaining population extirpation. While additional installations will not likely occur on federally managed lands, new facilities may occur on non–federal lands in the 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 predator numbers are high (Kolada *et al*. 2009b, p. 1,344; USGS 2017, pp. 15, 17). Currently, this core population of sage-grouse in the Bi-State area appears to potentially indicate decline and recovery following any potential future perturbations affecting alternative vital rates (brood survival, adult survival) may be hampered given the apparent limited nesting success.

Overall, impacts from infrastructure occur in various forms throughout the Bi-State DPS's range and are an ongoing threat impacting the species at a population and individual level, and degrading habitat in some areas both currently and into the future. This is based on a variety of range–wide 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 crushing 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). However, whereas theoretical effects are relatively clear and logical, information relating sage-grouse response to mineral developments is not extensive. 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; however, 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 industrial activity, such as mining, has been shown to mask male vocalizations, resulting in reduced lek attendance and ultimately in yearling recruitment in subsequent years (Amstrup and Phillips 1977, pp. 23, 25–27; Gibson and Bradbury 1985, pp. 81–82; Gratson 1993, pp. 693–694; Blickley *et al*. 2012a, p. 467; Blickley and Patricelli 2012, p. 29). Besides masking, noise may also impact birds through direct disturbance (e.g., annoyance, distraction, fear, startle response). Furthermore, evidence of changes in stress response of birds on leks exposed to experimental noise, suggests that noise impacts even those birds that do not avoid leks (Blickley *et al*. 2012b, p. 4).

Varying impacts of mining activities to sage-grouse leks outside the Bi-State area have been documented but the scientific literature is largely lacking. 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). Most recently in Utah, Peterson *et al*. (2016, p. 212) reported that male lek attendance in proximity to a coal mine and processing facility was not affected by the activity of the facility. These latter two studies, however, have limitations associated with their design and based on our understanding from research associated with similar activities such as oil and gas developments, we do not consider these findings persuasive.

Mineral development is classified as leasable (fluid) minerals (in the Bi-State, this is limited to geothermal resource), saleable minerals (sand and gravel pits), and locatable minerals (precious metals). Federal managers have discretion to deny proponents in the case of leasable and saleable mineral and existing land use management plans have provisions that significantly restrict the likelihood of these developments (BLM 2016, pp. 12–13; BLM 1993, p. 18; USFS 2016, pp. 19–21). Locatable minerals are managed under the 1872 Mining Act and as such are considered a nondiscretionary action. Meaning federal land managers have very limited ability to prevent or preclude these activities from occurring.

Mineral extraction has a long history throughout the Bi-State area, and mining continues today to a limited extent in all 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). There are currently several active Plans of Operations that overlap Bi-State sage-grouse habitat and thousands of active mining claims on Federal, State, and private lands.

- In the Bodie PMU, mining impacts were pronounced in the late 1800s and early 1900s 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 an exploratory drilling near the historical Paramount Mine, approximately 8 km (5 mi) north of Bodie, California, within an existing WSA. The exploration was apparently successful (i.e., the gold resource was present), but the WSA designation precludes development, although there were efforts by the mining proponents 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. Significant mineral interest continues in the Bodie PMU. While much of the area is designated WSA, which limits development, other surrounding State and private lands are available. The Bodie Hills (overlapping the Bodie and portions of the Mount Grant PMUs) attracts a fair amount of interest from mineral firms (Risley 2018, pers. comm.)

- In the Mount Grant PMU, numerous open pit mines exist, although no sites have been actively mining in several years. One of these sites, however, is milling ore being trucked into the site. This requires approximately two truck deliveries per week, which is a reduction in activity compared to heavy activity prior to 2013. Mining is largely concentrated around the Aurora Historic District and typically located on private lands. 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 interest remains fairly high, although the price of precious metals has been falling for a number of years and the number of Plan of Operations has significantly decreased since the 1980s. In addition, two active Plans of Operations for exploration efforts are being processed near Spring Peak and Bald Mountain in the Bodie Hills immediately adjacent to the Bodie PMU boundary and California State line. In total, approximately five active leks, one inactive lek, and two historical leks are within approximately 4.8–8 km (3–5 mi) of the operating mill site, exploration actions, or associated infrastructure (roads, power lines). Of greatest concern currently is the exploration action near Bald Mountain, as this area represents significant sage-grouse habitat and lies within 6.4 km (4 mi) of a significant lek sites in the Mount Grant and Bodie PMUs. While the Forest Service has worked with the mining firm to greatly limit impacts during exploration, it remains to be seen how this action would be mitigated if development ensues.

- 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, and since 2012, a limited number of exploration actions have occurred in the southern extent of the mountain range but currently there are no active Plans of Operation on BLM lands. The known mineral potential in the Pine Nuts is generally associated with locatable minerals in the form of copper, zinc, and molybdenum and thus future actions may occur. Limited saleable mineral sites also occur.

- 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 the Desert–Creek–Fales PMU there are three gold resource targets located mostly on private land on the east side of the Pine Grove Hills. Two of these actions are for exploration and one action is for development. Generally these locations are outside of currently recognized suitable habitat but approximately 16 ha (40 ac) of overlap with habitat occurs at one site and one lek is within 6.4 km (4 mi). In addition, a saleable mineral site is located within approximately 2.4 km (1.5 mi) of the largest, most reliable lek on the Nevada side of this PMU. Noise from this mine site can be heard from the lek but mining activity is sporadic.

- In the White Mountains PMU a porphyry copper exploration drilling project is being undertaken in the northwest region of the PMU. The project is located primarily on BLM managed lands but extends onto lands managed by the USFS. Additionally, an exploration project in the same general vicinity is nearing completion, but future drilling exploration is anticipated. None of the current projects overlap with sage-grouse habitat.

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 and activity in the Bodie and Mount Grant and Pine Nut PMUs (BLM 2012a, *in litt.*; USFS and BLM 2014, pp. 110–113). 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. While interest in the Bodie PMU is high, until such time the WSA designation is resolved activity will likely be relatively restricted as activity will be limited to State and private lands. Currently operational mines are not within the core population areas of the Bi-State DPS, although existing inactive mining sites, exploration actions, and potential future developments could impact important lek complexes and population connectivity.

Renewable Energy Development

Renewable energy development and associated infrastructure were identified risks for sage-grouse in the Bi-State area in 2012 (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.* 2009, pp. 1,255–1,256; see discussions regarding power lines and roads in the "Infrastructure" section above). Further indirect and direct impacts to sage-grouse and its habitat were also anticipated through direct habitat degradation, but also indirectly due to increased noise, increased human presence, and altered predator community among others (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. To date, there has been minimal direct habitat loss in the South Mono PMU based on the currently operating geothermal facility in Long Valley. However, as late as 2015, we anticipated additional loss in the Mount Grant and potentially the Desert Creek–Fales PMUs due to the locations of active leases at that time (BLM 2006, entire).

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 facilities, 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 direct habitat loss is not apparent. However, they do sit adjacent to nesting habitat, so displacement from or functional loss of suitable habitat may have occurred.

Since 2015, significant changes have occurred. All active leases, those which raised substantial concerns over the past decade, expired in 2017. Currently there are no geothermal leased lands in the Bi-State, aside from the operating facility in Long Valley described above. Furthermore, while there had been previous concern over wind development in the Pine Nut PMU, this lease was not renewed due to concerns over sage-grouse (BLM 2012a, *in litt.*). Finally, the BLM had previously 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).

There are currently two parcels of geothermal leased land, outside but adjacent to Bi-State sage-grouse habitat; one on the northern edge of the Pine Grove Hills (Desert Creek–Fales PMU) and one on the eastern edge of the Mount Grant PMU. While adjacent to habitat, based on telemetry neither parcel is in proximity to bird use areas. Although geothermal energy production may indirectly influence the quality of adjacent habitat through human activity, noise, and alteration to the predator community, if developed neither of these locations would appear to be an impediment to conservation.

The potential for future renewable energy actions appears unlikely in Bi-State sage-grouse habitat. In 2016, the Carson City and Tonopah BLM offices along with the Bridgeport District of the HTNF amended their land use plans and the new amendments greatly restrict future renewable energy developments (BLM 2016, pp. 12–13; USFS 2016, pp. 15, 19). These plans govern the northern half of the Bi-State, preclude the development of commercial solar and wind facilities, and stipulate a “No Surface Occupancy” requirement on any new geothermal leases sold. With these amendments and associated restrictions, geothermal facility development could not occur on public lands in sage-grouse habitat. However, facilities could be sited adjacent to habitat given directional drilling to access the geothermal resource is feasible (i.e., plant and drill sites are located outside of habitat but access geothermal resource located underneath habitat by drilling wells diagonally). These largely restrictive land use allocations along with direction provided by the Bishop BLM and Inyo National Forest’s existing land use plans, which also largely preclude these development, suggests the challenge to sage-grouse conservation posed by renewable energy has largely been abated.

In summary, very minimal direct habitat loss has occurred in the DPS due to renewable energy development. Furthermore, future development is unlikely. While there is strong political and public support for energy diversification in Nevada and California, and the energy industry considered the available resources in the Bi-State area to warrant investment (RETAAC 2007, p. 8), no substantial investment has occurred over the past decade. There remains limited potential that negative indirect effects may occur but, at this time, concern is low. Based on our assessment of existing facilities and the probability of new or expanding development, it does not appear renewable energy actions will significantly affect the Bi-State DPS.

Grazing and Rangeland Management

Livestock grazing has a long history in sagebrush ecosystems. Initially, native vegetation communities within the western sagebrush–steppe ecosystem largely evolved in the absence of significant grazing (Mack and Thompson 1982, p. 768). With European settlement of western States (1860–early 1900s), unregulated numbers of cattle, sheep, and horses rapidly increased, peaking at the turn of the twentieth 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 during this period along with severe drought significantly impacted sagebrush ecosystems (Knick *et al.* 2003, p. 616). In 1934, the Taylor Grazing Act was established and provided a mechanism for managing grazing on public lands. Permitted 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 livestock have declined on all Federal land since the early 1900s (Laycock *et al.* 1996, p. 3), although long–term effects from overgrazing can 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 still not well defined (Braun 1987, p. 137; Connelly and Braun 1997, p. 231) and the reported effects of grass–related variables on nest site selection and nest survival have been inconsistent in the literature. Depending on timing and intensity, grazing can have both positive and negative impacts to greater sage-grouse populations. Monroe *et al*. (2017, p. 1102) found that populations responded favorably to higher grazing levels after peak vegetative productivity, but declined when grazed earlier. While some studies have reported grass height as important for sage-grouse nesting habitat (Greg *et al*. 1994, p. 164; Herman–Brunson *et al*. 2009, p. 400; Doherty *et al*. 2014, p. 322) others have reported weak or no effects (Kolada *et al*. 2009b, pp. 1,343–1,344; Lockyer *et al*. 2015, p. 792; Coates *et al*. 2017a, pp. 53, 55; Smith *et al*. 2018, pp. 1,510–1,511). Additionally, other studies concluded no influential effects of grass–related variables on nesting success (Coates and Delehanty 2010, p. 245–246: Gibson *et al*, 2016b, p. 3627; Coates *et al*. 2017a, pp. 53, 55; Smith *et al*. 2018, pp. 1,510–1,511). Recently, Gibson *et al*. (2016b, p. 3,627) demonstrated the reported positive effect of grass height on nesting success may be an artifact of sampling procedures. Specifically, the collection of grass height data at the time of nest failure and not the predicted hatch date, which can result in bias towards greater grass height relative to the true effect.

Suitability of sage-grouse nesting habitat and nesting success can be impacted by livestock grazing activities. Sage-grouse need significant cover for protection from predators during the nesting season, and females will preferentially choose nest sites based on this quality (Hagen *et al.* 2007, p. 46; Coates *et al*. 2017a, pp. 53, 56). In a microhabitat synthesis conducted over 16 study sites in the Great Basin by Coates *et al*. (2017a, pp. 53, 55) (including 9 mesic and 6 xeric sites), results suggested that perennial grass height was selected for by female nesting grouse and positively influenced nest success at statistically significant levels within xeric habitats; however, within mesic habitats, even though this feature was selected for, it did not influence survival. Bi-State DPS study sites were classified as mesic sites in this study; however, there are areas within this region that could be classified as xeric (e.g. portions of Mount Grant and Pine Nut PMUs). 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. This study suggests that grazing, or more importantly maintenance of 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; Coates *et al*. 2017a, p. 55). Presumably, this is 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 can reduce food availability for sage-grouse and may act in direct competition (Vallentine 1990, p. 226). 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 (Pedersen *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). Jankowski *et al*. (2014, p. 241) found that pre–nesting female sage-grouse captured in grazed sites had higher immunoreactive corticosterone metabolite (ICM) levels than those at ungrazed sites and total plasma protein levels were negatively correlated with elevated ICM levels. Limited findings suggests that ICM concentrations and fitness are negatively correlated because, although elevations of this hormone enable an animal to confront immediate challenges in the environment, resources for reproduction and long–term survival are sacrificed (Bonier *et al*. 2009, entire). While this negative correlation remains uncertain, Blickley *et al*. (2012b, p. 4) found an increase in fecal ICMs with noise playback, which was also associated with avoidance and altered display behavior on leks, suggesting that in sage-grouse, higher ICMs are associated with negative impacts. However, while Jankowski *et al* (2014, entire) findings are interesting, the researchers caution that this correlation does not imply causation and the direct link to sage-grouse demographic parameters is not established. Furthermore, 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, Klebenow (1981, p. 121) noted that sage-grouse used openings in meadows created by cattle. These studies suggest that a threshold may exist whereby grazing can occur without detriment to sage-grouse resources. We note, however, the specifics of this threshold remain uncertain.

Aside from direct competition over forage resources, livestock grazing can also influence the sagebrush ecosystem and thereby indirectly affect sage-grouse. Livestock grazing can reduce water infiltration rates, reduce cover of herbaceous plants and litter, compact soils, and increase 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). As far back as the mid–1900s, livestock grazing has been implicated in facilitating the spread of cheatgrass (Leopold 1949, p. 165; Billings 1951, p. 112). Additional research continues to support this finding, suggesting livestock grazing reduces invasion resistance by imposing a competitive disadvantage on native herbaceous understory species and altering soil properties (Reisner et al. 2013, p. 10). While livestock grazing has been used strategically in sage-grouse habitat to control some 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), there is limited evidence that controlling cheatgrass, once established, through grazing is feasible and rest from grazing may, in fact, be a more effective strategy of building resistance to invasion into a site (Reisner *et al*. 2013, p. 10). Collectively, these studies suggest managed livestock grazing at moderate intensities 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 (Boyd *et al*. 2014, p. 60).

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 *et al*. 2008, p. 426), 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 may 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 relatively widespread in the Pine Nut PMU and occurs at lower densities throughout the remaining PMUs.

Historically, 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 1970s, 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 1940s and intensified in the 1960s and early 1970s (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 1970s 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. Recently, Smith and Beck (2018, p. 497) found chemical treatments had a minor positive effect on sage-grouse populations and sagebrush protein content but conclude that treatment benefits do not outweigh the risks and costs to be justified in areas with Wyoming sagebrush.

- 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, railing, raking, and plowing) (Connelly *et al.* 2004, p. l7–47). These treatments began in the 1930s and continued at relatively low levels into the late 1990s (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^2 (78 mi^2) 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 grasses, degrade sage-grouse habitat by altering the structure and composition of the vegetative community. Recently, Smith and Beck (2018, p. 497) found mechanical treatments had a negative impact on sage-grouse populations and suggest alternative management actions should be prioritized.

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 more substantial influence on 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 (2012a, *in litt.*) and USFS (2012a,c, *in litt.*) have stated that with rare exceptions, they no longer convert sagebrush to other habitat types, and that future treatments shall maintain, improve, or restore Bi-State sage-grouse habitat (BLM 2016, p. 11 ; USFS 2016, p. 16). Federal land managers 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.

Infrastructure related to livestock management such as water developments (e.g., springs, tanks, guzzlers) and fences in 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. 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. 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. Fences to manage livestock can also contribute to collision related mortality, particularly in close proximity to leks (Stevens *et al*. 2012, p. 301). Additionally, Coates *et al*. (2016a, p. 10) found the odds of common raven occurrence, a pervasive sage-grouse nest predator, increased by approximately 46 percent in areas where livestock were present. The researchers suggested that the increased raven presence may be attributable to the presence of water developments and associated perching structures (windmills and fences).

In the Bi-State area, there are 149 grazing allotments identified across all PMUs. Of these, 122 are considered active allotments encompassing approximately 73 percent of suitable sage-grouse habitat. 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). Rangeland Health Assessments (RHA) or its equivalent (i.e., the standard used by federal agencies to assess habitat condition) have been completed on 120 allotments (104 that are active) and have not been conducted on the remaining 29 allotments (18 that are active). In general, this affords us understanding of habitat condition across approximately 81 percent of suitable sage-grouse habitat in the Bi-State area. Of the allotments with RHAs completed, 81 percent (n=97) are meeting upland vegetation standards suggesting that approximately 352,249 ha (870,427 ac) out of approximately 563,941 ha (1,393,529 ac) of suitable sage-grouse habitat are known to be in a condition compatible with sagebrush community maintenance. Furthermore, of the allotments with RHA completed (n=120), 45 percent are meeting riparian standards and 27 percent are not, with the remainder being unknown or the allotment does not contain riparian habitat. Of those not meeting riparian standards, livestock were a significant or partially significant cause for the allotment failing to meet identified standards within 15 percent of those allotments, while the remainders were attributed to other causes such as past mining activity or road presence. In each instance (upland or riparian) of an allotment not meeting standards due to livestock, remedial actions have been taken by the representative land managing agency such as changes in intensity, duration, or season of use by livestock. Therefore, while there are public allotments or portions of allotments exhibiting adverse impacts from current or historical livestock grazing (e.g., vegetation condition or composition is generally less than desired), our understanding is the majority of allotments in the Bi-State area are in good condition (Axtell 2008, pers. comm.; Murphy 2008, pers. comm.; Nelson 2008, pers. comm. BLM 2014b, *in litt*.; Bi-State TAC 2017, pp. 31–33), 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 and the majority of allotments have or will have, pending renewals, associated terms and conditions that consider sage-grouse habitat, including the establishment or placement of infrastructure (Nelson 2008, pers. comm.; BLM 2016, pp. 11–12; USFS 2016, pp. 16–18).

In addition to domestic livestock, feral horses can negatively impact meadows and brood–rearing habitats used by sage-grouse and these impacts can be more severe given horses cannot be managed on a seasonal basis (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 as well as management considerations (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). Finally, horses unlike cattle are not managed on a seasonal basis and as such our ability to control their use of vegetation is limited to controlling their numbers.

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 substantial 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 775 horses (March 1 2018 survey). (BLM 2018, *in litt*.). In February of 2019, 340 horses were removed from this HMA with the intention to remove an additional 235 animals in the near future.
- 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 174 horses (BLM 2012a, *in litt*.). The Powell Mountain WHT had an estimated 36 horses in 2015. The appropriate management level (AML) for the Powell Mountain WHT is 29 horses (USFS 2012a, *in litt.*).
- Bodie and South Mono PMUs: The Bodie PMU has 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 largely in the White Mountains PMU have shifted their distribution to the northern portion of the South Mono PMU (which has some limited overlap with the WHT), south of Mono Lake near Sagehen Summit. Aerial surveys conducted in 2015 of the Montgomery Pass WHT documented 537: 518 within the HMA and 19 within the WHT. The established AML for the Montgomery Pass WHT is 138–230 animals.
- 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 2012b, *in litt*.). The most current number of horses in the Montgomery Pass WHT is 537, but use has shifted to lands managed by the BLM and private lands located in Adobe Valley (South Mono PMU (*see* Bodie and South Mono PMUs above). Herd size of the White Mountains Wild Horse Unit was established at 70 animals in 1976 (USFS 2012b, *in litt*.), and 79 animals were documented during 2010 (USFS 2012b, *in litt*.) and 72 horses in 2015. 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 2012b, *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; numbers in the Fish Lake HMA were 116 in 2015, 6 in the Piper Mountain HMA, and 39 horses and 217 burros in the Marietta Burro Range.

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 and often controversial. Based on this understanding, we anticipate future impacts caused by wild horses to increase. However, we recognize that changes in management direction, if realized, could influence the degree of impact caused by horses.

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 (McArthur *et al*. 1988, p. 115). 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.

<u>Summary of Potential Grazing and Rangeland Management Impacts</u>

Grazing and domestic livestock management has 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 can also compact soils, decrease herbaceous vegetation abundance, increase soil erosion, increase the probability of invasion of nonnative invasive plant species, and degrade the hydrologic function of meadow systems. 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 documented negative impacts, some research suggests that under specific conditions, grazing domestic livestock can benefit sage-grouse (Klebenow 1981, p. 121). Domestic livestock and 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, although their impacts and management potential can differ. 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 a single species.

Overall, impacts from historic grazing and current 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). The effect of this action may, at times, have impacted sage-grouse habitat in the Bi-State area, resulting in less–than–optimal conditions (i.e., lack of understory plants). However, positive effects of grazing may have also occurred (e.g., fire prevention). 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 as these restricted habitat sites control population dynamics at a much larger scale given they are essential for recruitment of young. However, across the entire Bi-State it is apparent that livestock are at least partially the cause of approximately 8 percent of allotments not meeting upland vegetation standards and approximately 15 percent of allotments not meeting riparian standards. Furthermore, in all of these instances, remedial actions have been taken by the representative land managing agency to address documented impacts. 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). While we recognize that livestock, feral horses, and native ungulates may negatively impact sage-grouse habitat, it does not appear that this is a significant concern in the Bi-State area today.

Nonnative Invasive and Native Woodland Succession

<u>Nonnative Invasive Plants</u>

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 therefore is not 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 upon. 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). Furthermore, research has suggested that the presence of cheatgrass influences lek persistence (Knick *et al*. 2013, p. 1544), nest site selection (Lockyer *et al*. 2015, p. 791), and ultimately population performance (Blomberg *et al*. 2012, p. 7; Coates *et al*. 2016b, p. 12747). Nonnative plants typically replace vegetation essential to sage-grouse and degrade existing sage-grouse habitat (Miller *et al.* 2011, pp. 160–164). Because nonnative invasive plants are present in the Bi-State area, sage-grouse habitat and population demographics are potentially impacted both short–term (e.g., nest site selection, loss of forbs and associated insects) and long–term (e.g., population growth, 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. Cheatgrass is considered a low level threat across four PMUs (i.e., White Mountains, South Mono, Bodie, and Desert Creek–Fales), a moderate threat in the Mount Grant PMU and a high threat in the Pine Nut PMU (Bi-State TAC 2012, pp. 19, 26, 32, 37, 41, 49). Furthermore, within the Desert Creek–Fales PMU, cheatgrass is more abundant and therefore more of a concern on the Nevada portion of this PMU as compared to the California portion. 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) suggested 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, a decade 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 (Provencher 2013, pers. comm.). Areas of greatest immediate concern are in the Pine Nut PMU because cheatgrass abundance is greatest and post–fire restoration challenges are becoming apparent. This PMU has experienced some relatively substantial fires within the Bi-State DPS such as the 9,712 ha (24,000 ac) Bison Fire (2013), 5.666 ha (14,000 ac) Adrian Fire (2007), 2,833 ha (7,000 ac) Topaz Ranch Estates Fire (2012) and several other smaller fires on the periphery of sage-grouse habitat.

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). More recently, this barrier appears less certain and in the Bi-State area cheatgrass occurs at elevations previously thought to be relatively immune based on the grass's ecology. This suggests that few locations in the Bi-State area are immune to 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 the invasive species 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) reseeding 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; Monaco *et al*. 2016, pp. 353–355). These researchers suggest that use of herbicides to control cheatgrass is promising, although the long–term effectiveness of these treatments are not well known as recent studies have been of limited (1–2 years) durations. 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 is 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 challenging scenario into the future. Chambers *et al*. (2014, pp. 16–17) mapped sagebrush habitats across the range of greater sage-grouse and categorized these habitats based on their resistance and resilience to disturbance. These results suggest that in the warm and dry sagebrush habitats contained within the Nevada portion of the Bi-State (i.e., Pine Nut, Mount Grant and Desert Creek portion of the Desert Creek–Fales PMUs) and most of the South Mono PMU, both resistance and resilience is low. That is, these areas have lower productivity, higher susceptibility to cheatgrass or other invasive annual grass incursion, and will therefore face greater restoration challenges should fire occur. In the wetter and cooler sagebrush habitats found in the White Mountains, Bodie, Fales portion of the Desert Creek–Fales PMUs, and high elevation sites of the Mount Grant PMU, resilience and resistance were ranked as moderately high to high, inferring these locations have greater productivity and are generally less suitable to invasive annual grass establishment.

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 (which is currently present in the Bi-State area) and *Bromus rubens*, (red brome; 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 Woodland Succession

In addition to nonnative plant invasions within sagebrush habitat, some native tree species are increasing in 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, past disturbance, 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 but in some instances responsive to treatment actions 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 five percent juniper cover more often in the breeding and summer seasons.
(4) Baruch-Mordo *et al*. (2013, p. 237) found sage-grouse incur population impacts at low levels of encroachment; no leks remained active when conifer canopy cover exceeded four percent.
(5) Prochazka *et al*. (2017, p. 46) found that sage-grouse encountering pinyon–juniper communities coupled with the rate of movement through these communities negatively affected bird survival.
(6) Severson *et al*. (2017, p. 53) found that sage-grouse readily nest in conifer treatment sites after trees had been removed.

(7) Sandford *et al*. (2017, p. 63) found woodland treatments increased suitable available breeding habitat and enhanced nest and brood success.

(8) Coates *et al*. (2017b, pp. 31–33) found sage-grouse avoided pinyon–juniper communities across varying degrees of community dominance and that this avoidance increased survival.

(9) Olsen (2019, pp, 21–22) found that removal of pinyon–juniper trees encroaching into sagebrush vegetation communities can increase sage-grouse population growth through improving juvenile, yearling, and adult survival as well as improving nest survival. This research found population growth was 11.2 percent higher in treatment vs control sites within five years of conifer removal.

Therefore, forest or woodland encroachment into occupied sage-grouse habitat reduces, and likely eventually eliminates, sage-grouse occupancy. However, treatment action to remove trees increases sagebrush habitat, and these habitats are used successfully by sage-grouse.

Land managers in the Bi-State area consider pinyon–juniper encroachment a substantial 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 more 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. 2*007, 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. Based on recent drought conditions, these rates of expansion may be slowing.

A variety of techniques (e.g., mechanical, herbicide, cutting, burning) are being implemented to remove conifers in sage-grouse habitat. Furthermore, recent research supports previous assertions that these treatments would expand sage-grouse habitat and ultimately be used successfully by birds (Sandford *et al*. 2017, p. 63; Severson *et al*. 2017, p. 53; Olsen 2019, pp. 21–22). Prior to the development of the BSAP in 2012, approximately 18 woodland thinning or removal projects had been undertaken, removing approximately 5,454 ha (13,479 ac) of woodland (Bi-State TAC 2012, p. 5). Since this time, an additional 81 projects have been initiated, treating approximately 18,798 ha (46,450 ac). While it is premature to measure a population–level response of sage-grouse to these treatments in the Bi-State region, increases in occupied habitat and increases in nest and brood success as well as survival parameters are anticipated based on recent research finding a positive overall outcome for population performance and connectivity (Coates *et al*. 2017b, pp. 31–33; Sandford *et al*. 2017, p. 63; Severson *et al*. 2017, p. 53; Olsen 2019, pp. 21–22). Furthermore, preliminary analysis of marked birds in the Bi-State demonstrates bird use of these treatments and offer support for these research findings (Mathews *et al*. 2018, pp. 33–34). Implementation and planning of additional woodland treatment projects are also underway over the next several years covering tens of thousands of acres.

Using the best available data, we estimate that the rate of treatment efforts falls within the range of estimated woodland expansion and further, that these efforts will continue based on ongoing commitments provided by land managers to implement the Bi-State Action Plan (see Conservation Efforts section below). Climate projections (see “Climate Change” section below) suggest warming temperatures in the future, which will facilitate upslope movement of woodlands but also depending on timing and amount of precipitation, drying conditions may slow the rate of expansion. Therefore, we consider woodland succession to be a substantial impediment to sage-grouse conservation in the Bi-State but consider it to be a manageable risk, while recognizing restoring historical connectivity and preventing further loss of suitable habitat will require continued focused effort.

<u>Summary of Nonnative Invasive and Native Woodland Succession</u>

Both nonnative and native 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 limited 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 continues to occur 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. Currently treatment actions are on par with expansion rate and we foresee future woodland encroachment will be a manageable risk.

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 if not managed. 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

<u>Wildfire History in Sagebrush Ecosystems</u>

Wildfire is the principal disturbance mechanism affecting sagebrush communities. The nature of historical fire patterns, particularly in big sagebrush, is not well understood; however, it 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; Bukowski and Baker 2013, pp. 556–558) 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; Bukowski and Baker 2013, p. 558).

<u>Wildfire Frequency within Sage-grouse Range</u>

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). Bukowski and Baker (2013, entire) used General

Land Office surveys conducted from about 1860–1900 to reconstruct historical fire regimes and sagebrush landscapes. 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; Bukowski and Baker 2013, pp. 556–558). Mean fire return intervals in low lying, xeric (dry areas with little moisture) 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 cause impacts 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 that 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) (Miller *et al*. 2008, p. 10; Baker 2011, p. 200; Miller *et al*. 2011, pp. 167–169; Bukowski and Baker 2013, p. 560). Each of these factors have likely influenced the current pattern of vegetation in the Bi-State area today and have led to an estimated 40 percent decline in sagebrush extent due to woodland succession and isolation of sage-grouse populations across the DPS (see "Native Woodland Succession" above). Active wildfire suppression is occurring throughout the Bi-State DPS, as land managers implement a full suppression policy.

Conversely, the invasion and establishment of nonnative invasive annual grasses, such as cheatgrass and medusahead rye can increase wildfire frequency within sagebrush ecosystems and negatively influencing the likelihood of recovery (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).

<u>Potential Impacts of Fire on Sage-grouse and its Habitat</u>

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, 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 and Desert Creek–Fales PMUs where burned habitat may be influencing already small and disjunct populations. 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 (Knick and Hanser 2011, pp. 401–404).

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; Coates *et al*. 2016b, pp. 12,746–12,747). 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 relatively small increases in burned habitat surrounding a lek can have a large influence on lek extirpation and population growth (Knick and Hanser 2011, p. 401; Blomberg et al. 2012, p. 7; Coates *et al*. 2016b, p. 12,747). 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) appear to strongly influence the probability of local population persistence (Beck *et al*. 2012, p. 452; Coates *et al*. 2016b, p.12,748).

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; Wrobleski 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. Still, there is likely some benefit to sage-grouse, over an undetermined time frame, from small fires intermixed with sagebrush habitat as this likely affords an attractive mosaic for early brood rearing habitat.

Insects are an important food source for sage-grouse chicks. 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. In the Bi-State area, telemetry data appear to lend support to this finding, as sage-grouse have been documented using burned sites, specifically smaller, heterogeneous sites (Taylor 2013, pers. comm.). 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. Suggesting, 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 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).

<u>Potential Recovery of Sagebrush Habitat Following Wildfire</u>

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 mountain sagebrush communities ranges between 25 and 100 years, and in 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). Successes in restoration appear to be correlated with the post–treatment climate in treated locations rather than with the methods of restoration used (Arkle *et al.* 2014, p. 15).

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 relatively 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). An assessment by Arkle *et al*. (2014, p. 16), found these programs were largely ineffective at providing suitable sage-grouse habitat, at least over the short–term (20 years). Assuming complete success of restoration efforts on targeted areas, however likely, 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).

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 by reducing the likelihood of large, expansive wildfires. 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; however, considerations of impacts to sage-grouse habitat will greatly influence management decisions. Future use will likely be limited to situations that minimize potential loss of residential developments.

<u>Impact of Wildfires and an Altered Fire Regime within the Bi-State Area</u>

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 numerous wildfires have occurred in the Pine Nut, and South Mono PMUs (fewer in the other PMUs) over the past 18 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 exception of the Pine Nut PMU where fire occurrence is more frequent (Service 2018, 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 Great Basin.

Table 3. Wildfires across the Bi-State area (2000–2018), California and Nevada.

PMU	Estimated Habitat Burned ha (ac)	Estimated Number of Fire Events (2000–2018)
Pine Nut	46,418 (114,703)	54
Desert Creek–Fales	13,215 (32,655)	12
Mount Grant	4,087 (10,101)	3
Bodie	2,634 (6,509)	8
South Mono	16,574 (40,956)	30
White Mountains	931 (2,303)	10
TOTAL	**83,859 (207,220)**	**117**

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 Invasive and Native Woodland Succession" section above). 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 loss 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 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). Furthermore, many climate scientists suggest that in addition to the predicted change in climate toward a warmer and generally drier Great Basin, variability of annual and decadal 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, Ault *et al*. 2014, p. 7538). 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 (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; Coates *et al*. 2016b, pp. 12,746–12,747). 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, approximately 117 wildfire events have affected approximately 83,859 ha (207,220 ac) of sagebrush habitat across Bi-State area since 2000 but conversion of sagebrush habitat to a nonnative invasive vegetation community has been largely 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 substantial 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. Research in the Great Basin, based on plot–level vegetation characteristics, found that sage-grouse habitat features are unlikely to occur in many burned areas even 20 years post–restoration (Arkle *et al.* 2014, p. 15).

Within the Bi-State area, participants in the BSAP (Bi-State TAC 2012, entire) have treated areas to reduce the threat of wildfire by using broadcast burns and mechanical treatment (e.g., fuel breaks and conifer removal projects). To lower the risk of wildfire, approximately 1,806 ha (4,462 ac) of fuels reduction treatments have been conducted to remove conifers (Bi-State TAC 2019, unpublished data). Additionally, the reseeding of 7,699 ha (19,025 ac) from past fires has been completed. The efficacy of these treatments to achieve desired results is generally unknown.

Overall, the threat of wildfire and the existing altered fire regime occurs throughout the Bi-State DPS's range. Fire is considered a significant threat to the species both currently and into the future. Within the Bi-State DPS, the continued reduced fire frequency exacerbates pinyon–juniper encroachment into sagebrush habitat in some locations, however an increased fire frequency in other locations promotes the spread of cheatgrass and other invasive species that in turn can hamper recovery of sagebrush habitats in other locations. 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, human footprint, and the projected effects of climate change.

Climate

<u>Drought</u>

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 and predation exposure (Gibson *et al*. 2017, p. 177; Prochazka *et al*. 2017, p. 47; Coates *et al*. 2018, p. 255). 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^2 (982 mi^2) of sagebrush shrublands died in Utah in 2003 as a result of drought and infestations with the aroga moth (*Aroga* sp.; Connelly *et al.* 2004, p. 5–11). Occurrence of this moth in the Bi-State area is not known. These habitat component losses can result in declining sage-grouse populations due to increased nest predation and early brood mortality associated with decreased nest and brood cover and food availability (Braun 1998, p. 149; Moynahan 2007, p. 1,781).

Sage-grouse populations declined during the 1930s period of drought (Patterson 1952, p. 68; Braun 1998, p. 148). Drought conditions in the late 1980s and early 1990s 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 occur periodically in the Bi-State region. Recent events include substantial precipitation declines during 2007 and 2008 and between 2011 and 2015.

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). More recent analyses suggest a much stronger pattern of influence between sage-grouse population performance and precipitation. 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). More broadly within the Great Basin, population growth derived from lek count data was also shown to be influenced by climatic conditions (Coates *et al*. 2016b, p. 12,749). These results support the importance of water balance in sagebrush systems to sage-grouse population dynamics. Furthermore, the Blomberg *et al*. (2012, p. 10) study along with the Coates *et al*. (2016b, p. 12,749) study demonstrated a strong interaction between climate variables and the presence of invasive annual grasses (cheatgrass) and fire burned habitat. Documented recruitment pulses during years of favorable weather conditions were tempered or nonexistent when the habitat surrounding a lek site was impacted by fire or conversion to nonnative invasive grasses following wildfire.

Climate change projections in the Great Basin and Eastern Sierra suggest hotter air temperatures and a generally stable level of precipitation, with a shift in precipitation events away from winter snow and towards summer rain; 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; Garfin *et al*. 2014, pp. 463–486; Georgakakos *et al*. 2014, 75; Reich *et al*. 2018, pp. 3, 17). Furthermore, drought frequency and persistence are anticipated to increase and currently climate change has been demonstrated to exacerbate the impacts of low precipitation years (Ault *et al*. 2014, p. 7545; Reich *et al*. 2018, p. 31; Gonzalez *et al*. 2018, entire). 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 e*t 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. Recent research suggests, similar to findings in other locations across the Great Basin, sage-grouse population performance in the Bi-State region responds to alterations in annual precipitation (Coates *et al*. 2018, p. 252). While there is variation among subpopulations, on average across the Bi-State findings suggest a 50 percent increase in precipitation corresponds to a 15.5 percent increase in population growth the following year. Moreover, these results indicate that precipitation needs to be approximately 20 percent greater than average for population recovery following drought, consistent with results from the Great Basin in the absence of wildfire (Coates *et al*. 2016b, p. 12,747; Coates *et al*. 2018, p. 255). Furthermore, there are known occasions where reduced brood rearing habitat condition due to weather 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 drought conditions were to increase in frequency or persist longer than the typical adult life span, drought could have significant ramifications on population persistence. Furthermore, drought impacts on sage-grouse may be exacerbated when combined with other habitat impacts that reduce cover and food (Braun 1998, p. 148). Within the Bi-State area, several projects have been undertaken to improve meadows and riparian areas for sage-grouse. These projects include grazing exclosures, changes to grazing management plans, prescribed fires, invasive plant control, mechanical stream treatments, and conservation easements (Bi-State TAC 2019, unpublished data).

Climate Change

The Intergovernmental Panel on Climate Change (IPCC) has concluded that warming of the climate is unequivocal, human influence on the climate is clear, and recent anthropogenic emissions of greenhouse gases is the highest in history (IPCC 2014, p. 2). Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850 and further, the period from 1983 to 2012 was likely the warmest 30–year period of the last 1400 years in the Northern Hemisphere (Global Climate Change Impacts in the United States 2009, p. 17; IPCC 2014, p. 2). Climate–change scenarios estimate that the mean air temperature could increase from approximately 0.3 °C to 2.1 °C (.5 °F to 4 °F) in the next few decades and 1.5 to over 5 °C (2.7 °F to 9 °F) by 2100 (Finch 2012, p.1; Melillo *et al*. 2014, p. 8; IPCC 2014, pp. 58, 60; He *et al*. 2018, p. 11). Modeling scenarios also project that there will likely be regional increases in drought risk, frequency of hot extremes, heat waves, increased precipitation, and more precipitation falling as rain instead of snow, as well as increases in atmospheric carbon dioxide (Strzepek *et al*. 2010, p. 5; IPCC 2014, p. 60; Ault *et al*. 2014, p. 7545; Garfin *et al*. 2014, p. 463; He e*t al*. 2018, pp. 1617; Reich *et al*. 2018, p. 21).

In our analysis, we rely primarily on synthesis documents (e.g., Global Climate Change Impacts in the United States 2009, entire; IPCC 2014, entire; Climate Change Impacts in the United States 2014, entire, Gonzalez *et al*. 2018, entire) that present the consensus view of a large number of experts on climate change from around the world. We have concluded 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 (i.e., Greater sage-grouse).

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; Halofsky *et al*. 2018, pp. 211, 265). In arid regions such as the Great Basin, weather patterns are likely to become hotter and drier (due to changes in rate of evapotranspiration), 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; Climate Change Impacts in the United States 2014, pp. 463–486; Halofsky *et al*. 2018, pp. 174–177; Snyder *et al*. 2019, pp. 4, 8).

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; Halofsky *et al*. 2018, pp. 204–293). Under projected future temperature and precipitation conditions, the amount of sagebrush habitat across the west is anticipated to decline (Shafer *et al*. 2001, p. 209; Neilson *et al*. 2005, p. 154; Chambers and Pellant 2008, p. 30; Bradley 2010, p. 205; Still and Richardson 2015, p. 33). 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; Halofsky *et al*. 2018, pp. 276–277). 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 (Nielson *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, research forecasts 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 vegetation communities (Comer *et al.* 2012, pp. 142–143; Still and Richardson 2015, p. 33). 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 2001, 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 40 percent since 1750, with about half of this cumulative anthropogenic carbon dioxide emissions occurring in the last 40 years (IPCC 2014, pp. 44–45). 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). 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 predicted climate change, depending on the current (average climate conditions from 1970–2000) and projected future (average climate conditions from 2090–2100) 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; Still and Richardson 2018, p. 34). 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 range–wide 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. More recently, Still and Richardson (2018, p. 34) came to a similar conclusion. Predicting a general northward expansion of sagebrush toward Canada , with a general contraction or loss in the southern Great Basin by 2050. In the Bi-State, these data suggest potential refugium for sagebrush at higher elevations but loss sagebrush at lower elevations.

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, 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; He *et al*. 2018, pp.

15–17; Gonzalez *et al*. 2018, CH 25, p. not defined). 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; He *et al*. 2018, pp. 9, 12, 16; Gonzalez *et al*. 2018, CH 25, p. not defined). 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. In general, model predictions tend to agree on an increasing temperature regime (Cayan *et al.* 2008, pp. S38–S40; He *et al*. 2018, p. 11; Gonzalez *et al*. 2018, CH 25, p. not defined). Of greater uncertainty is the influence of climate change on local precipitation (Diffenbaugh *et al.* 2005, p. 15776; Cayan *et al.* 2008, p. S28; He *et al*. 2018, p. 14: Reich *et al*. 2018, p. 21). 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 and ultimately population performance (Blomberg *et al*. 2012, p. 7; Coates *et al*. 2018, p. 252). Across the west, as well as across the Bi-State, models predict a general stability in precipitation but suggest a relatively drier environment due to elevated temperature, increased rates of evapotranspiration, more precipitation falling as rain instead of snow, and more frequent and prolonged drought (Neilson *et al*. 2005, p. 150; He *et al.* 2018, p. 9, 11, 16). Given the known negative association between drought and sage-grouse population performance, if the impacts climate change has on the frequency and extent of drought as well as the annual water cycle remains unmitigated, persistence of this DPS will likely be challenged.

A warming trend in the mountains of the western U.S. is decreasing snowpack, accelerating spring runoff, reducing summer stream flows, and exacerbating the impact of drought (Mote *et al*. 2018, p. 2; Reich *et al*. 2018, pp. 31, 33). These events will likely impact sagebrush and meadow habitat qualities, affect fire frequency and intensity, and potentially alter WNv outbreaks in the Bi-State area. In the Sierra Nevada, March temperatures have warmed over the last 50 years, resulting in more rain than snow precipitation, and snowpack has declined, which translates into earlier snowmelt (Chambers and Pellant 2008, p. 30; Mote et al. 2018, p. 2). 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, although climate change has been shown to influence the impact of drought and the annual water cycle and these in turn have been shown to influence grouse population performance in the Bi-State area (Coates *et al*. 2018, p. 251; Reich *et al*. 2018, pp. 31, 33). 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. An 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 bird species to climate change in comparison to other at–risk California bird species. Comer *et al*. (2012, pp. 142, 145), suggest the Bi-State area will become generally less suitable to invasion by cheatgrass. However, these same models suggest 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 we 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 with some low elevation sites or populations currently exposed to greater cheatgrass abundance significantly so (i.e., Pine Nut, Desert Creek–Fales, South Mono and portions of the Mount Grant PMUs. 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 to high. Synthesis documents of climate change typically predict changes based on mid– and end of the century timeframes. However, models tend to diverge with longer timeframes (over 50 years). Additionally, changes in regulations that may mitigate these challenges could alter these projections.

Overutilization Impacts

Commercial Hunting

Sage-grouse were heavily exploited by commercial hunting in the late 1800s and early 1900s (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 1950s (Patterson 1952, p. 242; Autenrieth 1981, p. 11). The compensatory mortality hypothesis contends that populations compensate for harvest mortality through reduced rates of natural mortality (e.g., starvation, predation, or disease) produced by a density–dependent feedback on the subsequent survival of the population, such that losses are compensated by increased survival of individuals that remain following harvest. Therefore, overall mortality in the population remains unchanged (Anderson and Burnham 1976, pp. 5–10). Furthermore, research suggests that compensation operates, at least in part, through individual heterogeneity in mortality risk (Lindberg *et al*. 2013, p. 4051). Meaning individuals with a higher probability of dying anyway tend to be more likely to be shot by hunters. Additive mortality results in an increase in total mortality with increasing harvest mortality, as no such density–dependent response exists.

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 mortality is relatively low (approximately 2 percent) compared to other grouse species (Connelly *et al.* 2000b, p. 229). This suggested that populations of sage-grouse may be 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). More recent research, however, has shown that sage-grouse mortality peaks in the fall, after hunting season but before winter (Blomberg *et al*. 2013, 352). Suggesting that harvest mortality is more likely compensatory than additive.

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. However, Sedinger and Rotella (2005, pp. 374–375) suggested that the apparent growth rate variation suggested by Connelly *et al.* (2003, entire) could be explained by variation in sage-grouse density; harvest was more liberal where sage-grouse were more dense. Finally, Sedinger *et al*. (2010, p. 329) analyzed process correlation between harvest rate and survival and failed to find the negative correlation necessary to indicate an additive harvest mortality.

Given the uncertainty described above, 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 a conservative harvest level is compatible with conservation (Reese and Connelly 2011, entire; Conover and Roberts 2016, pp. 217–218; Caudill *et al*. 2017, p. 762).

In the Nevada portion of the Bi-State area, NDOW regulates hunting of sage-grouse. 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 (Warpeha 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 (South Mono PMU) well below the apparent carrying capacity but had no measurable impact on the Bodie Hills population (Bodie PMU), which is contiguous with populations in Nevada. As a result of the documented population declines and Gibson's (1998) work, CDFW substantially 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 0 to 35 single–bird hunting permits for the North and South Mono Hunt Units each (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. Since 2013, zero permits have been issued for the South Mono Unit and over the last four years 30 permits were issued for the North Mono Unit in 2015 and 2016 but zero permits were offered in 2017 and 2018.

Comparing estimated harvest levels to the estimated fall population in California over the past decade, harvest has been on the order of 0 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 estimated harvest rate, controlled by the permit system employed by CDFW, is below the currently accepted harvest rate of 5 to 10 percent of the fall population. Given our understanding of additive mortality, it is highly unlikely that harvest could be additive under the California permit system.

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 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 improving 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 generally 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 altered their approach to harvest in this location and today employs a conservative permit system 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 recreational hunting in the Bi-State area for over 20 years. 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 or non–existent currently.

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 decreasing diversity of 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 (including snowmobile) 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 at a local scale. The authors also determined that sage-grouse were extirpated in virtually all counties reaching a human population density of 25 people/km^2 (65 people/mi^2) by 1950. However, their analyses did not separate recreational activities from other human activities and infrastructure. Leu *et al.* (2008, p. 1,133) 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 may 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; Blickley *et al*. 2012a, p. 467). 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 recreational use of OHVs is one of the fastest growing outdoor activities, and 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 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). A 2012 assessment reported recreation and human disturbance to be low level threats in the Bodie and Mount Grant PMUs but relatively high threats in the Pine Nut and South Mono PMUs (Bi-State TAC 2012, pp. 19, 32, 37, 49). To address these apparent challenges, across the Bi-State, vehicular travel is limited to designated roads and trails and development of new roads is largely restricted (limited to improve public safety, administrative, and access of valid existing rights). In addition, organized OHV events are prohibited during specific dates and in specific habitats (i.e., breeding and winter) limiting the exposure of birds (BLM 2016, pp. 13–14; USFS 2016, p. 43). [Note – The HTNF is currently in litigation pertaining to their Land Use decision limiting OHV events].

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 2018, pers. comm.). A moderate 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 recreational activity will continue to increase.

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, pers. Comm.). 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 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 be 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 25 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.). Recently, an illegal road development has occurred near this lek and it appears to be developed for the sole purpose of getting a closer view of strutting males (Abele 2019, pers. obs.). Still, aside from this potential behavioral disruption, the lek remains active and the local population appears generally stable (NDOW 2012, *in litt*.; Coates *et al*. 2018, p. 252).

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. For example, in the South Mono PMU, data indicates that seasonal road closures have reduced the human disturbance at three leks and have protected an estimated 475 ha (1,175 ac) of breeding habitat (Bi-State TAC 2012, p. 49).

There are very likely impacts caused by recreation but currently there are few 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. For example, people will often visit hot springs or fish, frequently with dogs, in the morning and evening hours near leks during the breeding season. 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 designated as wilderness or wilderness study areas, curtailing vehicular traffic in these locations today and potentially more so in the future.

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. 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. Given the lack of data associated with the suite of recreational activities occurring across the Bi-State area, we are uncertain as to the potential current or future impacts that may result from these activities.

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 across multiple PMUs has reported limited and similar mortality rates 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. 13,965). 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, an 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 (Gibson *et al*. 2013b, p. 773). 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. Data investigating the later concept suggest that collared male vocalization is apparently altered (Gibson *et al*. 2013b, p. 773; Fremgen *et al*. 2017, p. 4). 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 substantial 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 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 from nests. In Nevada, Gibson *et al*. (2015, p. 401–402) modeled the impact of visitation on nest survival and determined that visitation did not increase the probability of nest failure of an individual nest.

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). Recent results from ongoing studies in Nevada and California suggest annual survival rates of birds marked by rump–mounted equipment may is nearly half that of birds collared by traditional necklace style transmitters (Severson *et al.* 2019, p. 8). In addition, research in the Bi-State area, where 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, additional research effort on sage-grouse within the Bi-State DPS is scheduled to occur. This will entail the capture and marking of approximately 60 to 200 individuals annually across the six PMUs (approximately 30 birds per population is necessary to assume a representative sample but not all PMUs are scheduled for monitoring annually). Assuming the rate of mortality from handling birds remains the same, 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 (approximately 1–4 percent of average population size). While there are very likely impacts to nesting success caused by these activities, we have little information to inform the significance of this impact. Over the past five years, the number of GPS transmitters deployed remains relatively low (~78). In the coming years, it is anticipated that approximately 10 to 25 GPS transmitters will be deployed annually. 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 addition to monitoring efforts, an experimental translocation effort to augment the Parker Meadows population in the South Mono PMU was initiated in 2016. The initial approach included artificial insemination of translocated females and has since been refined to include the translocations of hens with broods, thus eliminating the need to capture males and extract semen. Overall, a total of 55 sage-grouse were handled as part of the translocation effort. This number includes sage-grouse that were translocated and released at Parker Meadows, males that were de–seminated and released back at capture sites, and broods that were captured (or attempted capture) but not translocated for various reasons. Six mortalities (11 percent) were associated with complications from capture or transport. Given the level of mortality, changes in field protocols were initiated. As most of mortalities occurred in semen donor males, future de–seminating of males, if needed, will occur at the capture sites instead of transporting them to a central location. Also redesign of transport boxes was initiated as several birds appeared to die from jumping or attempting to flush while in transport. Perhaps most importantly, placing a greater emphasis on brood–only translocation offers promise in both reducing the number of individuals required to be handled and improving success of the translocation overall. Prior to initiating this effort, members of the Bi-State TAC evaluated habitat condition at the site. Tree encroachment was identified as an issue at this time and a treatment to remove trees was initiated prior to sage-grouse capture and release. In addition, the Bi-State TAC evaluated the potential impact the source population may incur, due to the removal of birds, via the IPM. Essentially, altering adult female and brood survival in the IPM for the source population and calculating the resulting impacts to population performance. The source population was the Bodie PMU and the results suggested the removal of birds from this location would not affect overall population growth within this PMU.

In summary, much remains unknown about the impacts of research on sage-grouse population dynamics. The available information indicates limited 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 minor 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

<u>Disease</u>

The best available data indicate that parasites and disease in general are not major 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 simony*), blood parasites (including avian malaria (*Plasmodium* spp.), *Leucocytozoon* spp., *Haemoproteus* spp., and *Trypanosoma avium*), tapeworms (*Raillietina centrocerci* and *R. cesticillus*), gizzard worms (*Habronema* spp. and *Acuaria* spp.), cecal worms (*Heterakis gallinarum*), and filarid nematodes (*Ornithofilaria tuvensis*) (Honess 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 dependent 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 the disease was first identified as a cause of mortality 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 has also been documented 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 Jordan Valley, Oregon and 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 mosquitos; 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 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 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 atypical. However, there is beginning to be additional indications that resistance to WNv in sage-grouse has increased (Conover and Roberts 2016, p. 219). 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 populations 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. At that time, 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 also 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 populations 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. Since 2012, the number of cases reported is no longer tallied. Instead, a simple presence or absence by County is documented. From 2013 through 2018, Lyon County reported occurrence in five years, Douglas County reported occurrence in four years, and Carson City County and Mineral County reported occurrence in 2 years (CDC 2018). Mono County has not reported any occurrences since 2010. While WNv appears annually present in proximity to the Bi-State area, it does not appear to occur consistently across the entire Bi-State area. The extent to which 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 populations. And the impact on individual populations 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. To partially ameliorate this concern, Federal land managers require livestock water troughs to be emptied when not in use (BLM 2016, p. 11; USFS 2016, p. 17). 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 (Paz 2015, p.3).

<u>Predation</u>

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). 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 several 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; Dinkins *et al*. 2013, p. 305). 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 more 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 sexes. Adult male sage-grouse are most 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). 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). Predation of adult sage-grouse generally occurs during the lekking, nesting, brood–rearing and fall seasons (Connelly *et al.* 2000b, p. 230; Naugle *et al.* 2004, p. 711; Moynahan *et al.* 2006, p. 1536; Hagen 2011, p. 97; Blomberg *et al*. 2013, p. 351). 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 have been several 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 2015 across the entire Bi-State (excluding the White Mountains PMU), survival varied by age, year, and population, with most variation explained by year (Coates *et al*. 2018, p. 249; Mathews *et al*. 2018, p. 53). In other words, survival varied among populations but not as much as survival varied among years. The researchers reported that subadults (1–year old) had similar survival rates to adults and that survival was greatest during the winter. Both of these results are generally consistent with the other findings from across the range of the species (Connelly *et al*. 2011a, p. 65; Taylor *et al*. 2012, p. 338). Across seven populations in the Bi-State (i.e., Pine Nuts Mountains, Desert Creek, Mount Grant, Fales, Bodie Hills, Parker Meadows, Long Valley), excluding the White Mountains PMU and analyzing independently Parker Meadows from Long Valley as well as Fales from Desert Creek, overall estimated mean annual survival ranged between 66 and 70 percent (Mathews *et al*. 2018, pp. 56-59). The estimated 95 percent credibility intervals surrounding these means ranged from 41 to 86 percent. The estimates are generally aligned with and are slightly higher than annual survival estimates reported across the range of the species (Connelly et al. 2011a, p. 65; Taylor *et al.* 2012, p. 338). An additional study in the Nevada portion of the Desert Creek–Fales PMU reported a significantly reduced annual survival rate of just 16 percent, although this latter study had a restricted sample size (n=6) (Sedinger *et al*. 2011, p. 324). The results of the Mathews *et al*. (2018) study suggest annual survival is appropriate for these locations relative to other populations of sage grouse, although in the case of the Sedinger *et al*. (2011) study, Desert Creek–Fales PMU would not be consistent with a stable population. An additional study conducted between 2010 and 2011 across many of the same California populations as Mathews, *et al*. (2018), reported annual survival rates for females of 86 percent in the Bodie Hills (Bodie PMU), 47 percent in Long Valley (South Mono PMU), and 100 percent in Parker Meadows (South Mono PMU) (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.

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. 1,777) 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). As with survival, a number of studies in the Bi-State have quantified nesting success. Across all populations, except the White Mountains, mean estimated nest success was 40 percent for adults and 44 percent for yearlings, which generally aligns with range wide estimates of 44 and 38 percent for adults and yearlings, respectively (Taylor *et al.* 2012, p. 338; Mathews *et al*. 2018, p. 54). Kolada *et al.* (2009b, p. 1,344) estimated nest success as ranging from 21 to 68 percent among several California populations. 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 population (Bodie PMU) and a 45 percent nest success rate for the Long Valley population (South Mono PMU). Again, apparent nest success can vary widely from modeled estimates and thus comparisons are generally inappropriate. While predation appeared to account for the majority of nest loss, researches generally do not explicitly assess the cause of nest failure. The difference in nest success among some populations 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 (slated for closure in 2023) readily supports large numbers of common ravens and California gulls (Abele 2012, pers. obs.). Recent raven surveys conducted across the Bi-State found nearly two to three times greater number of raven detections in Long Valley as compared to other populations (Mathews *et al*. 2018, p. 53). 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). In Nevada, Gibson *et al*. (2017, p. 172) found weekly chick survival varied within years, ranging from an estimated 58 percent immediately after hatch to 97 percent at brood breakup. Furthermore, annual chick survival varied among years, ranging from 9 percent to 48 percent. 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. In a review and analysis of 50 sage-grouse research findings, Taylor *et al*. (2012, p. 338) reported that for adult females, mean chick survival to 35 days was 41 percent. Across the Bi-State, estimated mean chick survival to 50 days was 38 percent (Mathews *et al*. 2018, p. 54). These posterior distributions were derived, however, with input from informative priors based on Taylor *et al*. (2012). Thus alignment would be anticipated unless data collected in the Bi-State were sufficient to overwhelm the priors derived from the 50 studies used in the Taylor *et al*. (2012) analysis during estimation. Chick survival in the Bi-State differed among populations and ranged from a low of 31 percent in Long Valley to a high of 45 percent in Fales (Mathews *et al*. 2018, pp. 58).

Nesting success of sage-grouse is dependent on habitat quality. Nesting success is positively correlated with the presence of greater amounts of cover (Gibson *et al*. 2016a, p. 694; Coates *et al*. 2017a, p. 18) 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 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). A number of factors have been reported to influence the density and diversity of predators including agricultural development, landscape fragmentation, livestock presence, habitat alterations, and human populations, among others (Ritchie *et al.* 1994, p. 125; Schroeder and Baydack 2001, p. 25; Connelly *et al.* 2004, p. 7–23; Summers *et al.* 2004, p. 523; Coates *et al*. 2016a, p. 10). These factors 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 and increasing travel time through habitats where they are vulnerable to predation.

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; Howe *et al*. 2014, p. 41). The presence of ravens is negatively associated with grouse nest and brood fate (Bui 2009, p. 27; Gibson *et al*. 2018, pp. 14–15). 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 1960s (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 and nesting substrate (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; Howe *et al*. 2014, p. 41). Holloran (2005, p. 58) and Gibson *et al*. (2018, pp. 14–15) 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 and power line development in Nevada, respectively. 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. In the Virginia Mountains (just north of the Bi-State DPS), Lockyer *et al*. (2013, p. 246) found that ravens were the most common nest predator, accounting for almost 47 percent of nest depredations. 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 sage-grouse habitat is lost to industrial conversion, woodlands, agriculture, and other exurban development, sage-grouse nesting and brood–rearing habitats 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 limited support of these efforts influencing sustainable population growth (Cote and Sutherland 1997, p. 402; Hagen 2011, p. 9; Leu and Hanser 2011, p. 27; Dinkins *et al*. 2016, pp. 5455; Peebles *et al*. 2017, p. 475). For example, raven removal has been shown to have a positive effect on nest success (Dinkins *et al*. 2016, p. 54); however, ultimate results on population growth rates are negligible or not as well understood. 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; Dinkins *et al*. 2016, p. 57). 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). Raven removal in one Wyoming study resulted in a 50 percent reduction in raven populations during 2008–2014, and non–removal sites saw a 42 percent increase in raven densities (Peebles *et al.* 2017, p. 476). The authors reported increases in lek counts following a one year lag during raven removal, however other factors were also associated with increased lek counts in this study that included minimum temperatures and precipitation during the brood–rearing period. Badger predation also appeared to partially compensate for decreases in ravens (Coates 2007, p. 152). 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 and composition, infrastructure (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, we are unsure if predation is currently a significant impact to the DPS, but we recognize it 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 (South Mono PMU), which is one of the two largest (core) populations in the Bi-State DPS as well to the Desert Creek population (Desert Creek–Fales PMU) and the Pine Nut PMU.

As specified in the BSAP and associated project spreadsheet (Bi-State TAC 2012, entire), the participants have worked to reduce threats to sage-grouse in the Bi-State DPS from predators. In the Bodie PMU, perching and nesting sites have been eliminated by infrastructure removal (e.g., windmill, transmission line). In the Desert Creek/Fales PMU, 3 km (1.85 mi) of fence in the Sweetwater Summit area was fitted with perch deterrents. Additionally, nearly 24,281 ha (60,000 ac) of conifer–encroached sagebrush have been treated in the Bodie, Desert Creek/Fales, Pine Nut, Mount Grant and South Mono PMUs to remove conifers and reduce perch sites for predators.

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 unlikely 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 and ultimately influencing population performance (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; nest loss is a key determinant in sage-grouse population dynamics (Schroeder *et al.* 1999, p. 15; Taylor *et al*. 2012, p. 342). 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; Mathews *et al*. 2018, p. 54). 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; Mathews *et al*. 2018, p. 53). Although more birds were present in the past, the Long Valley population (South Mono PMU) appears generally stable, albeit cyclic. The negative impact from reduced nesting success in this location is presumably being offset by other demographic statistics such as chick or adult survival. Preliminary results from the Pine Nuts PMU and the Desert Creek population (Desert Creek–Fales PMU) suggest that average nest survival is also low (24 and 21 percent, respectively; USGS 2015, p. 10; USGS 2017, p. 15). In the Mount Grant PMU, the estimated average nest survival is 47 percent.

Limited data are available to 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, as was demonstrated by Gibson *et al*. (2018) research investigating raven occurrence in association with power lines. 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 populations 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 typical of other upland 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 were 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, depends on relatively stable adult survival rates, 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 general, we do not consider small population size, in itself, a threat but recognize small population size and isolated populations can exacerbate the effects of genetic issues, stochastic events, and other threats to the DPS.

Based on radio–telemetry and genetic data, sage-grouse populations 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; Oyler-McCance *et al*. 2014, p. 8; Tebbenkamp 2014, p. 18). Birds in the White Mountains PMU as well as those in the South Mono PMU are largely isolated from sage-grouse populations 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 appears less substantial. 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). Mathews *et al*. (2018, pp. 24,26,28,30) demonstrates overlapping utilization distributions for spring, summer and winter habitats within the Bodie Hills, Mount Grant and Desert Creek/Fales PMUs based on VHF and GPS–marked sage-grouse. Traditionally the Pine Nut PMU was presumed isolated; however, recent GPS telemetry data show birds 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 but it does not appear that these movements are common. Further, it is not apparent that birds leaving the Pine Nuts are returning. While adults are unlikely to switch breeding populations, 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. However, Jahner *et al*. (2016, pp. 8–9) found fine–scale genetic differentiation among sage-grouse populations at relatively small scales (approximately 10 km (6 mi)). Suggesting dispersal among populations is highly restricted. 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). Two independent genetic evaluations have concluded there are between three and four (Oyler-McCance *et al*. (2014, p. 8) or five (Tebbenkamp 2014, p. 18) unique genetic clusters in the Bi-State area. In addition, Tebbenkamp (2014, p. 12) did not evaluate the Pine Nut population (Pine Nut PMU), which Oyler-McCance *et al*. (2014, p. 8) found to be unique. Thus, presumably Tebbenkamp (2014, entire) would have differentiated six populations had these data been available. Based on this information, we presume that there are likely three to six populations or groups of birds in the Bi-State area that largely operate demographically independent of one another.

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 (Franklin 1980, entire; Soule 1980, entire). However, some estimates of effective population size necessary retain evolutionary potential are as high as 5,000 individuals, although these estimates are thought to be highly species specific and influenced by many extrinsic factors (Lande 1995, p. 789).

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 more recent genetic evidence suggests that the percentage of the male population successfully breeding may be closer to 50 percent (Bush 2009, p. 108). However, the population that Bush (2009) studied was very small and declining and this likely inflated male breeding propensity. 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.

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.

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). Based on data from 2018, the median abundance estimate of the Bi-State DPS spring breeding population is approximately 3,305 individuals (95 percent CRI=2,247–4,683; Coates *et al*. 2020, p. 26). This estimate (as well as PMU specific estimates) was derived using the integrated population model outputs of male abundance based on lek count and demographic (telemetry) data, as well as by multiple post–hoc adjustments, given results of ancillary research. Adjustments included reported distributions for detection probability (Coates *et al*. in press, entire), lek attendance probability (Wann *et al*. 2019, p. 7), and sex ratio (Hagen *et al*. 2018, p. 4). Also included was an adjustment to account for 'unknown' leks, based on a 95 percent assumed known lek value. This value was derived from expert knowledge by members of the Bi-State Technical Advisory Committee. Using this estimate and the studies identified above describing effective population size being on the order of 10 to 20 percent of the actual population size, in the Bi-State area, the estimated average effective population size (for the entire Bi-State area in 2018) is approximately 330 to 661 sage-grouse. Genetic and radio–telemetry studies, however, indicate 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 calculate the effective population size for four generally discrete populations in the Bi-State (as described in Oyler-McCance *et al*. 2014, Figure 4) to provide context surrounding long–term genetic viability of these units (Table 4).

Table 4. 2018 estimated population size and range of estimated effective population size by genetic cluster for the Bi-State area, Nevada and California.

PMU	Estimated median population size 2018	Estimated effective population size range 2018
Pine Nut	33	3–6
Desert Creek–Fales, Mount Grant, Bodie	2,342	234–468
Long Valley	818	81.–163
White Mountains	45	4.5–9
Bi-State **DPS**	3,305	330–661

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 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-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 populations in the Bi-State area have unique detectable qualities that allow differentiation from one another (Oyler-McCance *et al*. 2014, entire; Tebbenkamp 2014, p. entire). 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 (Oyler-McCance *et al*. 2014, p. 1,304). To address this, a translocation project was developed in conjunction with the USGS and implementation began in 2017. Twenty–eight birds (20 females; 8 males) were translocated from the Bodie Hills to Parker Meadows. Translocated grouse had an annual survival probability of 0.19 (95 percent CRI = 0.05–0.46) and the probability of nest initiation for translocated females was 0.21 (95 percent CRI = 0.10–0.32). Three broods from translocated females were monitored in 2017 along with three females with broods that were moved from the Bodie Hills to Parker Meadows. The sample size is insufficient to accurately model differences in brood survival between the method of translocation; however, two of the three translocated broods survived to 50 days post hatch, after which monitoring ceased (Mathews *et al*. 2018, p. 37). In 2018, 20 additional birds (13 females; 7 males) were moved from Bodie Hills to Parker Meadows. Annual survival improved in 2018 to 50 percent, nest initiation increased to 46 percent, and brood success improved, suggesting initial optimism in the efforts effectiveness. The effort continued 2019 but results are not currently available. Further, in the Pine Nut PMU in 2014 a similar event occurred, where a number of nests were documented with unhatched eggs (USGS 2014, p. 3). While concerns over genetic diversity may or may not be apparent today, the overall population size for the Bi-State DPS is small. 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, isolated populations such as those found in the Bi-State area are more challenged by 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 50 active leks representing several relatively discrete populations (see the “Species Information” and the “Current Range/Distribution and Population Estimates/Annual Lek Counts” sections above. Research has shown fitness and population size across a variety of taxa are strongly correlated and smaller populations are more challenged by environmental and demographic stochasticity (Keller and Waller 2002, pp. 239–240; Reed 2005, p. 566). These small populations 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) can be challenging (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 as observed from data collected between 2003 and 2017, representing approximately 5 percent of the DPS). However, each population in the Bi-State DPS is relatively small, as is the entire DPS on average (estimated approximately 3,280 individuals).

Overall, the challenge presented by population size is likely exacerbating threats throughout the Bi-State DPS’s range. 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 suggests 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 substantially 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 1980s (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., carbaryl, 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 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. Furthermore, 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.

<u>Local Regulatory Mechanisms</u>

Approximately nine percent of the land contained within Bi-State PMUs is privately owned or owned by a Native American Tribe, State or County (Table 2). 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 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 prevent habitat loss.

<u>State Regulatory Mechanisms</u>

State agencies directly manage approximately two 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 and 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.

<u>California Fish and Game Codes (CFGC)</u>

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 8,498 ha (21,000 ac) have been completed in the Bi-State area. For example, CDFW 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 considered a hunt–able species on the California side of the Bi-State DPS, although no permits for harvest have been made available for the past several years. 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 2014b, *in litt*.). Actual harvest over the past decade 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.

<u>California Environmental Quality Act (CEQA)</u>

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.

<u>Nevada Revised Statutes (NRS)</u>

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.

In 2017, the Nevada Division of State Parks acquired approximately 4,400 ha (10,872 ac).of previously privately owned lands in the Mount Grant PMU. Under NRS 407.013, it is the intention of the Nevada Legislature that the Division shall acquire, protect, develop and interpret a well–balanced system of areas of outstanding scenic, recreational, scientific and historical importance for the inspiration, use and enjoyment of the people of the State of Nevada and that such areas shall be held in trust as irreplaceable portions of Nevada's natural and historical heritage. The Administrator of the Division has some discretion when implementing the intention of the Legislature but maintaining natural resources is significant responsibility.

Nevada 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). One of the main recommendations of the 2012 State Plan was the creation of the Sagebrush Ecosystem Program (SEP), which would consist of the Sagebrush Ecosystem Council (SEC) and the Sagebrush Ecosystem Technical Team (SETT). The SEC was originally established under Executive Order 2012–19 (Nevada Executive Order 2012b, entire), on November 19, 2012, and later codified under state statute NRS Chapter 232.162.

The SETT began work in February, 2013. In April, 2013, the SEC directed the SETT to further develop the recommendation in the 2012 State Plan into a more comprehensive and detailed strategy. The result of those efforts culminated in the 2014 Nevada Greater Sage-grouse Conservation Plan (2014 State Plan). An additional component of these planning efforts was the establishment of the Nevada Conservation Credit System (CCS). The CCS is essentially a conservation banking system where individuals or entities can buy and sell credits to offset impacts to the sagebrush ecosystem. To date, however, these efforts remain voluntary in nature. Therefore, the protection afforded 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. Furthermore, 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.

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.). Furthermore, 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. The nature of these measures and direction vary, 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.

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, prevent, 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 2005b, 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 reports that the issuance of waivers and modifications is rare.

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 the greater sage-grouse was designated specifically as a California BLM Sensitive Species. 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 District Land Use Plan Amendment for the Nevada and California Greater Sage-grouse Bi-State Distinct population Segment (BLM 2016).

In 2016, the Carson City District Office adopted a land use plan amendment specifically targeted at conserving the Bi-State DPS of greater sage-grouse. The amendment more fully addresses conservation of the Bi-State area by providing specific direction to management of the of the DPS and its habitat, including (but not limited to): Recreation management; grazing management; weed management; wild horse and burro management; minerals management; renewable energy management; fire management; and rights–of–way management (BLM 2016, entire). Numerous land use allocations restrict or substantially limit new habitat and bird disturbances and identify Best Management Practices to further minimize allowable actions. Additionally, the Carson City land use plan 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).

<u>Tonopah Land Use Plan Amendment for the Nevada and California Greater Sage-grouse Bi-State Distinct population Segment (BLM 2016).</u>

In concert with the Carson City District Office, the Tonopah Field Office adopted the same land use plan amendment as described for Carson City District (above) in 2016. This amendment affords significant protection from discretionary activities by restricting land use allocations that may harm the DPS and its habitat. Furthermore, Sage-grouse are recognized as BLM Sensitive Species in the State of Nevada and as such are afforded additional protection guided by the BLMs Manual on Special Status Species management (BLM 2008, entire).

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.

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)). Furthermore, new and renewed grazing permits are required to contain term and conditions to move an allotment toward or maintain sage-grouse habitat desired conditions.

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 and Record of Decision (ROD) for vegetation treatments on BLM lands in the western United States (BLM 2007, entire). 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.

<u>National Forest Management Act (NFMA)</u>

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 greater sage-grouse is designated as a USFS Sensitive Species in the Intermountain (R4) and Pacific Southwest (R5) Regions, which includes the Humboldt–Toiyabe National Forest (HTNF) (Bridgeport and Carson Ranger Districts) and the Inyo National Forest (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 a Management Indicator Species (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.

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 efforts may offer conservation value by limiting disturbance to sage-grouse and their habitat in the Bi-State area. Travel management efforts on the INF annually hires seasonal staff to monitor, implement restoration and educate users of cross country travel and permanent law enforcement patrol enforce off highway vehicles and over–snow vehicles accordingly. 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.

<u>Humboldt–Toiyabe National Forest Greater Sage-grouse Bi-State Distinct Population Segment Forest Plan Amendment (2016).</u>

The HTNF completed a Forest Plan Amendment to their LRMP in conjunction with the BLM Carson City District Office and the Tonopah Field Office in 2016 (USFS 2016). This amendment was targeted at conservation of the DPS in light of the findings by the Service in our 2013 listing evaluation (Service 2013, pp. 64358–64384). The amendment more fully addresses conservation of the Bi-State area by providing specific direction to management of the of the DPS and its habitat, including (but not limited to): Recreation management; grazing management; weed management; wild horse and burro management; minerals management; renewable energy management; fire management; and rights–of–way management (USFS 2016, entire). Numerous land use allocations restrict or substantially limit new habitat and bird disturbances and identifies Best Management Practices to further minimize allowable actions.

Inyo National Forest Land Management Plan (USFS 2019).

The INF LRMP identifies several standards and guidelines for managing sage-grouse habitats (USFS 2019, 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 2012b, *in litt*.), specifically within livestock grazing and vegetation treatment environmental analyses.

The Inyo National Forest revised their LRMP in the fall of 2019. The record of decision explains alternative B–modified and includes revisions and additional plan components for sage-grouse. In addition, the best available scientific information was used to develop a much more comprehensive affects analysis and persistence analysis (see chapter 3 of the final environmental impact statement, Revision Topic 2, terrestrial ecosystem, sagebrush section; and terrestrial at–risk animals, Bi-State Sage-grouse sections; and Rationales for Plant Species Considered for Species of Conservation Concern, Inyo National Forest; Persistence Analysis, appendix F). The analyses in the final environmental impact statement evaluated the sagebrush site potential in an area of Nevada and how that relates to the management direction in the Humboldt–Toiyabe National Forest Greater Sage-grouse Bi-State Distinct Population Segment Forest Plan Amendment was used to review and revise the plan components specific to the Inyo plan area (see final plan chapter 2, "Animal and Plant Species" section). We anticipate the revised LRMP will more fully address concerns to conservation of the DPS due to discretionary actions but until such time the revised LRMP is finalized, we remain uncertain as to the specifics (e.g., land use allocations).

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 current INRMP that they are implementing (HAD 2018). This INRMP, largely restricts or prevents all activities occurring in sage-grouse habitat on Mount Grant as well as identifies conservations actions designed to improve habitat. 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 still proceeded with and completed an INRMP in 2018 (MWTC 2018, entire). While lands owned by the MWTC are limited and outside of identified sage-grouse habitat, they conduct exercises on lands managed by the HTNF that do contain identified habitat under the auspices of a long–term special use permit. Stipulations of the permit attempts to minimize impacts to habitat and the species by restricting, among other things, the timing, type, and footprint of activities such as limiting access to existing roads and restricting the number of personnel engaged in training.

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 direction and practices designed to minimize negative impacts 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 some protection to sage-grouse habitat necessary to protect the species but typically cannot prevent an action from occurring. 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. Recent adoption of new land use plan amendments by the BLM, HTNF, and INYO directed at conserving the Bi-State DPS and its habitat have substantially curtailed the likelihood of new discretionary actions negatively affecting the area (BLM 2016, entire; USFS 2016, entire; USFS 2019, entire). Furthermore, existing land use plans (Bishop BLM, Inyo National Forest), as they pertain to sage-grouse, are largely robust although the approaches used are less prescriptive and more holistic in nature. For example, the Bishop BLM affords "yearlong protection" to sage-grouse habitat. While the interpretation of this clause may afford latitude to decision makers, it has proven highly effective based on the track record of conservation apparent over the past 25 years. Therefore, we consider currently existing Federal mechanisms as effective in reducing the magnitude of many ongoing threats, while recognizing that the perfect solution may not yet be realized.

CONSERVATION EFFORTS

A variety of management efforts directed at conservation of the Bi-State DPS have been implemented since approximately 2000, such as habitat restoration, remediation, and protection efforts. Many additional conservation efforts are ongoing and under development, including many associated with the 2012 BSAP (Bi-State TAC 2012, entire). In 2013, the 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 2013a, 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 BSAP and the 2013 Greater Sage-grouse COT Report.

It is important to note that sagebrush habitat is challenging 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 Euro–American 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). Arkle *et al*. (2014, p. entire) evaluated 101 post fire seeding projects over a 14 year period and found that, of 313 plots seeded after fire, none met all sagebrush guidelines for breeding habitats, but almost half met guidelines for herbaceous components, particularly perennial grasses. 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 Euro–American 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) represented 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.

Conservation measures outlined in the Bi-State Plan (Bi-State Local Planning Group 2004, entire) have been implemented by members and partners of the Bi-State Local Area Working Group (Bi-State LAWG; Bi-State TAC 2012, pp. i–iii). In December 2011, the Bi-State Executive Oversight Committee (EOC) was formed to leverage collective resources and assemble the best technical talent to direct and prioritize future conservation actions to ensure consistent regulatory oversight and achieve long–term conservation of the Bi-State DPS. The EOC includes resource agency directors from the Service, BLM, USFS, NRCS, USGS, NDOW, and CDFW (Bi-State TAC 2012, pp. i).

The Bi-State Plan was revised by the Bi-State TAC and Bi-State LAWG in 2012 to include updated information on the status of, threats to, and actions needed for conservation of the species at the direction of the EOC (Bi-State TAC 2012, entire). This updated information includes a summary of the conservation actions completed since 2004 to mitigate threats to the Bi-State DPS. Additionally, the updated plan includes a comprehensive set of strategies, objectives, and actions to accomplish specific goals and objectives for effective long–term conservation of the Bi-State DPS and its habitats. Prioritized projects were ones that protected contiguous blocks of unfragmented habitat, restored historic habitat impacted by pinyon–juniper encroachment and wildfire, reestablished habitat connectivity, and secured permanent habitat conservation of important private lands (Bi-State TAC 2012, p. ii). The overall intent of the 2012 BSAP was for it to be a living document, a road map. While it contains many specific actions to accomplish, it was also understood by the signatories to the plan that we would learn as we go and adjust as necessary driven by new science.

To reduce uncertainty and assist with project prioritization, USGS developed a Conservation Planning Tool (CPT), which is continually refined as new information is available (e.g., new spatial data). The CPT incorporates predictive models to evaluate the effectiveness of completed conservation actions, validate population and habitat risk assumptions, and provide managers (the EOC and others) with quantitative science–based information for making risk–based decisions (Bi-State TAC 2012, p. ii). In conjunction with CPT, the USGS developed an Integrated Population Model (IPM) and a region–wide habitat suitability map (Coates *et al.* 2014a, entire; Coates *et al.* 2014b, entire). The Technical Advisory Committee and the Bi-State LAWG typically meet several times a year to discuss annual work plans, prioritize projects based on updated risk assessments, and evaluate completed actions (Bi-State TAC 2012, pp. i–iii).

The 2012 BSAP is non–regulatory; however, it provides a strategic path forward toward conservation of the Bi-State DPS and its habitat, affords a degree of confidence in implementation among stakeholders, and has buy–in from a diverse group of partners. Furthermore in 2014, signatories to the BSAP committed funding totaling more than 45 million dollars to achieve implementation of the plan (EOC 2014, p. 2). This total exceeds the amount projected to implement all actions identified to date in the Bi-State Action Plan. Furthermore, reaffirmation of these commitments, in the form of Memorandum of Understanding, Service

First Agreement, and additional letters of commitment, are periodically updated by the partnership, most recently in 2018.

Examples of conservation actions implemented to date, including those identified in the 2004 and 2012 Bi-State Action Plans (Bi-State Local Planning Group 2004, entire; Bi-State TAC 2012, entire), are targeted at identified threats and include (but are not limited to):

1. Urbanization

Prior to the implementation of the 2012 BSAP, approximately 4,935 ha (12,200 ac) of sage-grouse habitat had been protected from development through conservation easements between 2002 and 2011 across the Bi-State DPS (Desert Creek–Fales, Bodie, South Mono, and White Mountains PMUs). Additionally, approximately 3,075 ha (7,600 ac) were acquired in land purchases or exchanges between 2004 and 2011 in the same PMUs. Thus prior to 2012 approximately 8,012 ha (19,800 ac) were protected from the threat of urbanization through conservation easements or acquisitions.

The 2012 BSAP identified sixteen private land conservation easements that would benefit the Bi-State DPS by preserving important habitats. Of these original sixteen, six easements have been secured, totaling approximately 3,626 ha (8,968 ac). In addition, 840 ha (2,076 ac) have been acquired through land exchanges. Thus, approximately 4,469 ha (11,044 ac) of land identified in the 2012 BSAP as important to minimize potential impacts caused by urbanization have been acquired through land exchanges, purchase, or conservation easement, representing approximately 67 percent of all land identified in the in the Action Plan for protection against development and urbanization. Four additional projects not specifically identified in the 2012 BSAP but considered important by the TAC have additionally been completed including 1,851 ha (4,574 ac) conserved through easements and 5,922 ha (14,636 ac) conserved through land exchanges. In total, 12,243 ha (30,254 ac) have been entered into conservation easements or acquired through land purchase or exchange since 2012.

Furthermore, several policy changes have occurred to benefit the Bi-State DPS. Mono County has implemented new policies in County plans and programs to reduce development and human disturbance impacts. The BLM has implemented measures to prioritize irrigation to important wet meadows during drought years. Finally, NRCS has designated the Bi-State region as "Grasslands of Special Environmental Significance." This designation raises the amount of funds NRCS can contribute to the acquisition of an easement from 50 to 75 percent. All of these conservation easements, land ownership changes, management actions, and policies have contributed to reducing urbanization impacts in the Bi-State area (see "Urbanization and Habitat Conversion" section above).

Conservation efforts on private lands in the Bi-State area have benefited from active participation by numerous private citizens, local landowners, non–governmental organizations, local governments, State agencies, and Federal partners including Wilderness Land Trust, Eastern Sierra Land Trust, American Land Conservancy, TNC, Boy Scout of America, LADWP, CDFW, NDOW, Nevada Department of Forestry, and the NRCS. Including efforts completed prior to the 2012 BSAP, approximately 19,460 ha (48,089 ac) of land, either through conservation easements or acquisitions, has been substantially protected from urbanization challenges across the Bi-State. These acres represent approximately 31 percent of total private lands containing mapped sage-grouse habitat across the Bi-State. In addition, approximately 7,280 ha (18,000 ac) of lands identified as important for conservation by the TAC have funding obligated and are in various stages of easement development, with many of these efforts anticipated to be completed in a few years. Further, an effort to acquire approximately 5,867 ha (14,500 ac) lands in the Pine Nut PMU by the Carson City BLM has been approved and is anticipated to finalize in spring of 2020.

2. Infrastructure—Fences

Prior to 2012, several projects within the Bodie and South Mono PMUs removed approximately 5.4 km (3.4 mi) of fence and modified additional fence, affecting approximately 36 ha (90 ac) of sage-grouse habitat. Modifications included conversions of hog–wire style livestock exclosures to two–strand barbed wire fence and conversions of 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. Additionally, approximately 1.6 km (1 mi) of fence was marked with flight diverters. From 2012 through 2018, an additional 21 km (13 mi) of fence has been removed in the Bodie, Pine Nut and South Mono PMUs and an additional 0.6 km (0.4 mi) has been converted to let–down fence design. Furthermore, nearly 101 km (63 mi) of fence were marked with flight diverters.

3. Infrastructure—Road

Prior to 2012, approximately 928 km (577 mi) of road were permanently closed. Additionally, seasonal road closures near leks in the South Mono PMU afforded protection to approximately 971 ha (2,400 ac) of breeding habitat. From 2012 through 2018, an additional 393 km (244 mi) of road have been permanently closed. Additional seasonal road closures have also been implemented by the LADWP during peak lekking period to reduce the potential for human disturbance. Furthermore, recent adoption of land use plan amendments by the BLM and HTNF limit the establishment of new roads and seasonally restricts activities on existing roads. All areas within PMUs are closed to off–road travel (see the "Roads" discussion under the "Infrastructure" section above).

4. Infrastructure—Other

Prior to 2012, two windmills were removed – one within the Bodie PMU and one within the South Mono PMU. In 2012, the Poleline Pit restoration project was completed to restore 40 acres of disturbance within the Bodie PMU. Also within the Bodie PMU, a power line identified in the BSAP was removed and an additional windmill was removed from the South Mono PMU. Additionally, progress was made to close the Benton Crossing landfill in the South Mono PMU through planning and funding acquisition. Closure of this facility is on track to be completed in 2023.

5. Grazing—Livestock

Prior to 2012, 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 2012b, *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). From 2012 through 2018, 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. Furthermore, recent land use plan amendments established additional requirements to minimize impacts to habitat and will be phased in as allotment renewals are processed (BLM 2016, p. 12; USFS 2016, pp. 16–17).

Within the Bi-State DPS area, compliance monitoring has occurred on 86 percent of the allotments within the past 3 years. Additionally, rangeland health assessments or equivalent analyses have occurred on 81 percent of allotments (Bi-State TAC 2016, unpublished data). Of these allotments, over three quarters meet these standards. This exceeds the average percentage of allotments meeting standards across the west (PEER 2014, *in litt.*). Where these standards are not being met, actions have been implemented to address the issues. For example: fencing off or repairing fences around riparian areas, herding and hauling water to livestock to improve livestock distribution, changing the season of use and/or rest rotation schedule, and increasing monitoring.

Other steps to improve grazing allotment health prior to 2012 included fencing approximately 12 meadows representing roughly 149 ha (370 ac) in the Bodie and South Mono PMUs to exclude livestock. Since 2012, an additional 257 acres have been protected through exclosure fencing in the Pine Nut, Desert Creek–Fales, and Mount Grant PMUs. Escape ramps have been installed in the Pine Nut, Desert Creek–Fales, and Bodie PMUs on approximately 22 livestock water troughs to minimize drowning risk to sage-grouse. Additionally, the grazing permits on LADWP land have been updated and additional monitoring is ongoing on 7,950 ha (19,644 ac).

6. 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. As of 2014, wild horse and/or burro use occurs on 31 percent of the allotments within the Bi-State DPS (BLM 2014b, *in litt.*). In 2019, 340 head were removed from the Pine Nut PMU, with an additional 235 head anticipated to be removed in the near future, bringing the population in line with approved AML.

7. Invasive Species—Noxious Weeds

Prior to 2012, approximately 78 ha (193 ac) of weed treatment to eradicate and limit the spread of noxious weeds has occurred in the Pine Nut, 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. Inyo National Forest has reduced populations of *Tamarix ramosissima* (salt cedar) and *Melilotus alba* (sweet clover) in the White Mountains PMU. From 2012 through 2018, mechanical treatment of invasive and noxious weeds has occurred on nearly 526 ha (1,300 ac) in the Pine Nut, Desert Creek–Fales, and Bodie PMUs. The Smith Valley conservation district has completed weed monitoring on approximately 858 ha (2,121 ac) across multiple PMUs.

8. Pinyon and Juniper Encroachment

Prior to 2012, approximately 5,454 ha (13,479 ac) of rangeland affected by conifer woodland encroachment were treated at 18 project sites to remove trees and improve sagebrush habitat within the Pine Nut, Desert Creek–Fales, Mount Grant, South Mono, and Bodie PMUs. From 2012 through 2018, an additional 18,798 ha (46,450 ac) have been treated at 81 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. Additionally, approximately 3,017 ha (7,455 ac) of previous conifer treatment underwent maintenance actions to remove trees previously missed or new tree development, which often occurs due to existing seed bank. Of the completed conifer treatments, 49 percent were ranked as high priority, 13 percent were ranked as moderate priority and 0 percent was considered low priority by the Bi-State TAC. Additionally 38 percent were not ranked during the development of the BSAP but were incorporated following subsequent reevaluation by the Bi-State TAC. In 2018, National Environmental Policy Act (NEPA) documents were completed on an additional 2,174 ha (5,373 ac) of conifer treatments in the Mount Grant and South Mono PMUs and in 2019 approximately 6,070 ha (15,000 ac) of conifer treatments have occurred or are planned to occur in early winter.

9. Wildfire Fuel Reduction and Rehabilitation

Fuels reduction treatments in the wildland/urban interface (WUI) reduce the threat of catastrophic wildfires spreading from or into urban areas (see "Wildfires and Altered Fire Regime" section below). Prior to 2012, eight fuel reduction projects were completed on approximately 887 ha (2,191 ac) in the Pine Nut PMU to reduce ignition risks on the treated areas and also reduce the risk of wildfire in adjacent habitats. Additionally, 102 ha (252 ac) were mechanically treated across multiple PMUs and 18 ha (45 ac) were preventively burned in the Bodie PMU. Post fire restoration occurred on 1,368 ha (3,381 ac). Between 2004 and 2009, LADWP instituted a fire prevention closure on their lands in the South Mono during the July 4th holiday to limit ignition potential.

From 2012 through 2018, BLM and USFS fire management plans have been updated to incorporate suppression direction to minimize loss of suitable sage-grouse habitat and inter–

agency fire agreements have been put in place. Resource advisor kits are updated annually, and dispatch personnel receive training on fire protocols in sage-grouse habitat. LADWP has closed their lands to all camping and adopted a no campfire policy which greatly reduces the threat of ignition on LADWP managed lands.

Furthermore, 213 ha (527 ac) of conifer have been removed and 7 fuels reduction projects, representing 585 ha (1,447 ac), have been completed in the Pine Nut, Desert Creek–Fales and Bodie PMUs. Additionally, 2,284 ha (12,175 ac) have been rehabilitated post fire through grass seeding, shrub planting conifer, removal and erosion control.

10. Meadow and Sagebrush Habitat Condition

Prior to 2012, 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, fencing, and prescribed fire. From 2012 through 2018, 451 ha (1,114 ac) of meadow and sagebrush restoration and enhancement occurred through the completion of 20 projects in the Desert Creek–Fales, Mt. Grant, Bodie and South Mono PMU. This work was completed through, mechanical treatment, prescribed burning and irrigation projects. One of these projects, specifically detailed in the Action Plan was the restoration of Wheeler Creek in the Desert Creek–Fales PMU to restore hydrologic function and increase forb cover and diversity in adjacent brood meadows. NEPA was completed for this project in 2014, and in 2015, that restoration project was complete. In 2017, NEPA was completed for an additional hydrologic restoration project in Aurora Canyon in the Bodie PMU, and an interagency meadow assessment across multiple PMUs was completed to better understand the health of Bi-State meadows and to direct future conservation efforts.

In 2018, the Nevada State Parks initiated three meadow monitoring projects in the Walker River State Recreation Area.

11. Disease or Predation

Regarding disease in the Bi-State area, two programs have been implemented to assist in our understanding of West Nile virus (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. 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 below). In addition, NDOW currently holds a Federal Migratory Bird Depredation Permit that allows take of up to 2,500 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. Additionally, Mono County has developed a raven mitigation plan to install perch deterrents and reduce attraction to the landfill.

Across the Bi-State, infrastructure is evaluated and removed when deemed necessary. Perch deterrents on fence posts, signs and additional structures have been installed and USGS developed and has implemented protocols for monitoring raptors and ravens in conjunction with sage-grouse monitoring across the Bi-State since 2015.

12. Monitoring/Research and Public Outreach

Since 2004, applied research studies (such as University and USGS led research efforts) have been conducted in all PMUs. Examples include the following:

- USGS 2015. Monitoring and research on the Bi-State Distinct Population Segment of Greater sage-grouse in the Pine Nut Mountains, California and Nevada—Study Progress Report, 2011–2015;
- Coates *et al*. 2016b. Wildfire, climate, and invasive grass interactions negatively impact an indicator species by reshaping sagebrush ecosystems;
- Coates *et al*. 2016a. Landscape characteristics and livestock presence influence common ravens: relevance to greater sage-grouse conservation;
- Doherty *et al*. 2016. Importance of regional variation in conservation planning: a range–wide example of the Greater sage-grouse;
- Coates *et al*. 2017b. Pinyon and juniper encroachment into sagebrush ecosystems impacts distribution and survival of greater sage-grouse;
- Prochazka *et al*. 2017. Encounters with pinyon–juniper influence riskier movements in greater sage-grouse across the Great Basin;
- Duvall *et al*. 2016. Conserving the Greater Sage-grouse: A social–ecological systems case study from the California–Nevada region;

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 encourage 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. Furthermore, seasonal closures have been implemented at two lek sites in the South Mono PMU.

Since 2012, the Nevada Partners for Conservation and Development (NPCD) program, an NDOW program, has been monitoring vegetation treatment projects effectiveness. The NPCD currently has approximately 466 treatment and control monitoring locations across the Bi-State region. While it takes time for monitoring results to be informative, due to the substantial annual variation in vegetation condition and expression – driven by precipitation in the sagebrush ecosystem, the programs efforts will eventually be highly informative to our efforts to effectively restore these lands.

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 2013a, 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 2013a, pp. 13–14). The concept revolves around effective conservation strategies in key areas across the landscapes that are necessary to maintain redundant, representative, and resilient populations (Service 2013a, 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 2013a, p. 36). The COT report identified all occupied habitat in the Bi-State area as PAC, delineating four separate populations: 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 2013a, 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 2013a, 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 2013a, pp. 37–52)). Additional information on the threats specific to the Bi-State area is provided in the "Impact Analysis" section above.

<u>PACs</u>

(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.

<u>Threat Reduction</u>

(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.

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 relatively long lived, reliant on sagebrush, highly traditional in areas of seasonal habitat use, and particularly susceptible to 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 generally low recruitment rates, and they exhibit natural cyclical variability in abundance.

The Bi-State DPS has 6 PMUs representing several demographically independent populations with a combined total of approximately 50 active leks. Each population is relatively small as is the entire DPS in general (estimated 3,305 (CRI=2,247–4,683 individuals in 2018). Populations outside the two largest (i.e., Bodie Hills in the Bodie PMU and Long Valley in the South Mono PMU) are small. Historical sage-grouse abundance and sagebrush habitat reductions within the Bi-State area are both estimated at approximately 50 percent since 1850, 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. Connectivity of populations and habitats within and among the PMUs is challenged but management actions are targeted at improving this.

The Bodie and Long Valley populations 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 appear relatively stable at present but population performance varies through time and recent data indicates Long Valley may be experiencing general decline. Although the scope and severity of known impacts are comparatively less than for other populations or 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. Both core PMUs are projected by species experts to have moderately high to high probabilities of persistence into the future, with projected population size ranging between 50 and 500 breeding adults for each PMU (Aldridge *et al*. 2008, entire; Garton *et al*. 2015, p. 38; Wisdom *et al*. 2011, entire).

Declining population trends are generally apparent for the Pine Nut population (Pine Nut PMU), and Desert Creek–Fales PMU. These trends are of concern at the DPS level because fluctuations in these small, less secure populations are likely to result in extirpations and loss of population redundancy across 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 more 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 more similar to extant sites (Aldridge *et al*. 2008, entire; Wisdom *et al*. 2011, entire).

(1) The Pine Nut PMU has the smallest known number of sage-grouse of all Bi-State DPS PMUs (one population with an estimated 33 individuals (CRI=0–73) in 2018, representing less than 1 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 based on genetics and observed movements of radio–collared birds. Urbanization, historic grazing management, wildfire, invasive and increasing 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. In the past several years, actions to address woodland encroachment and urbanization have been conducted in earnest and have the potential to mitigate some of these concerns.

(2) The Desert Creek–Fales PMU contains two populations totaling approximately 447 individuals (CRI=218–750) in 2018. The populations in the Desert Creek–Fales PMU have some level of connectivity with the Bodie and Mount Grant PMUs and potentially more weakly with the Pine Nut PMU. The most substantial impacts in this PMU are wildfire, woodland encroachment, predation, infrastructure, and urbanization. Private land acquisitions and easements along with conifer removal efforts have likely mitigated some of the impacts locally within this PMU. While some of these impacts are more easily mediated than others (i.e., conifer encroachment), the existing condition is not ideal. Recent wildfire activity in proximity to Sonora Junction has likely exacerbated habitat concerns. This PMU has seen episodic sage-grouse population declines in the past, and the indicators of these declines remain. Long–term conservation of the sage-grouse populations in the Desert Creek–Fales PMU will likely be challenged and dependent on successful implementation of additional conservation measures.

(3) The Mount Grant PMU contains one population, and population estimate for this PMU in 2018 was 374 individuals (CRI=205–619). The population in the Mount Grant PMU has connectivity with the Bodie PMU and also some level of connectivity with the Desert Creek–Fales PMU. Impacts in this PMU include woodland encroachment, mineral development, infrastructure, meadow degradation, 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. A recent land exchange near Nine–mile Flat may improve long–term conservation but may have unintended consequences stemming from increased recreational activity. Long–term conservation of the sage-grouse population in the Mount Grant PMU is uncertain but high elevation habitat in the Wassuk Range are largely pristine and protected from impacts due to DOD ownership.

(4) The Bodie PMU contains one population (Bodie Hills), which is one of the two core populations for the Bi-State DPS. Population estimate for this PMU in 2018 was 1,521 individuals (CRI=1,181–1,941) and population performance has been positive over the past 20 years. This PMU typically has the highest number of active leks (i.e., 13 on average) of all the PMUs. The population in the Bodie PMU has 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. Management actions to address this concern are ongoing. 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 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.

(5) The South Mono PMU contains three populations (Long Valley, Parker Meadows, and Granite Mountains). The Long Valley population is one of the two core populations for the Bi-State DPS and comprises over 90 percent of the PMUs abundance. Population estimate for this PMU in 2018 was 885 individuals (CRI=634–1,214). This PMU is considered demographically isolated from the other PMUs. The most substantial 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 to cycle around general stability. The Parker Meadows population currently has 1 active lek and is quite small; from 2004 to 2018, male sage-grouse counts have ranged between 3 and 18. This population is declining, 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. Recent efforts to augment this population via translocation efforts appears positive but long–term success will not be known for several years.

The Granite Mountains population is also small. Strutting activity has been intermittent in the recent past and persistence appears challenged.

(6) The White Mountains PMU contains one population. Population estimate in 2018 was 45 (CRI=9–86) individuals. The area is remote and difficult to access and most historical 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, feral horses, recreation, and invasive species may be influencing portions of the population and may increase in the future, but impacts largely remain unquantified and are considered minimal due to the remote location and the fact that much of the area is designated Wilderness. 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. In 2016, initial efforts to study this population began in earnest. It will take several years of data collection before we are afforded a more informed understanding on population performance.

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, although they currently affect populations across the DPS to varying degrees. The populations and habitat in the northern extent of the Bi-State area including the Pine Nut and Desert Creek–Fales PMUs are now and will likely continue to be most at risk. We anticipate loss of some populations and contractions in the range of others in these two PMUs, which will leave them susceptible to extirpation from stochastic events such as wildfire, drought, and disease (each of which is currently acting upon certain populations within the Bi-State DPS). We expect the two largely isolated core populations in the Bodie and South Mono PMUs (i.e., the Bodie Hills and Long Valley populations, respectively) will remain in 30 years. The impacts that are of high current or potential scope and severity within the Bi-State DPS (i.e., substantial impacts) include: Nonnative invasive and native woodland species (e.g., pinyon–juniper encroachment, cheatgrass), meadow degradation, wildfire and altered fire regime, infrastructure (e.g., fences, power lines, and roads), urbanization, climate, and predation. Each of which may be exacerbated by small population size and population structure. Other impacts within the Bi-State DPS, which are considered to either have lesser and/or more localized current or future effects include: Grazing, recreation, and mining 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 population loss.

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 habitat degradation, fragmentation and loss, and isolation of small populations, presents challenges to the entire Bi-State DPS.

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 11 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 substantial 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, irrigated pasture, 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 areas of impacts have been realized and additional future impacts are anticipated but at a reduced rate. Currently, approximately 31 percent of total private lands containing suitable sage-grouse habitat across the Bi-State are enrolled under an easement program or have been acquired by federal and State agencies and this number increases to 57 percent based on reasonably likely outcomes from ongoing efforts. These easements and acquisitions have generally been targeted at private lands considered most important to sage-grouse conservation or that were considered most at risk of development.

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 potentially 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). Furthermore, given current and future development (based on existing designated energy corridors), 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, 64 percent of annually occupied leks are within 5 km (3.1 mi) of paved secondary highways, and 38 percent are within this distance to existing transmission lines (Service 2013c, unpublished data). 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 are likely negatively influenced by these anthropogenic features (Gibson *et al*. 2018, entire).

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 of increasing (unimproved 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 may occur in the 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 relatively stable, recovery following any potential future perturbations affecting alternative vital rates (brood survival, adult survival) will be limited by nesting success.

<u>Mining</u>

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 inquires 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.

<u>Renewable Energy Development</u>

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. The likelihood of additional renewable energy facility development is low given recent land use plan amendments adopted by the Carson City and Tonopah BLM and the Humboldt–Toiyabe National Forest. While renewable energy development in the Bi-State area has previously been a concern it does not appear currently that these concerns will be realized.

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 and shrub cover used for concealment from predators. Grazing can also compact soils, decrease herbaceous abundance and plant diversity, alter soil characteristics and increase soil erosion, and increase 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). Despite documented negative impacts, some research suggests that under well managed conditions grazing domestic livestock can be negligible or even beneficial to sage-grouse (Klebenow 1981, p. 121). Management, or the lack thereof, of feral horses has the potential to negatively affect sage-grouse habitats. Horse use is year–round, affording limited recovery of native vegetation communities, and population growth is substantial and difficult to manage. 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 PMU 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. Currently, livestock management in the Bi-State area is generally meeting desired Rangeland Health Standards. 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 Invasive and Native Woodland Succession

Both nonnative invasive and native woodland species 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. 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. Currently, woodland restoration treatments are on par with encroachment but the success of these efforts to restore sage-grouse habitat in the long–term remains somewhat uncertain. Recent research, however, has demonstrated that sage-grouse do use these treatments sites and population performance can be improved.

<u>Wildfires and Altered Fire Regime</u>

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 exception of the Pine Nut PMU where fire occurrence is relatively frequent (Service 2013c, 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 Invasive and Native Woodland Succession” 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 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 substantial 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 and sage-grouse populations (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 substantial 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). However, in the South Mono PMU birds have been documented using the edges of burned and unburned habitat, suggesting the mosaic produced by fire and fire suppression can be potentially beneficial under certain circumstances. 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 may have a substantial 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 habitat will decrease. Furthermore, 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. We do know of occasions in the past, however, where reduced brood rearing habitat condition due to drought have resulted in little to no recruitment within certain PMUs, ultimately affecting overall population performance (Gardner 2009, pers. comm.; Coates 2012, pers. comm.; Coates *et al*. 2018, pp. 251–252). 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 substantial ramifications on population persistence. Furthermore, 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, although climate change has been shown to influence drought and the annual water cycle and these in turn have been shown to influence grouse population performance in the Bi-State area (Coates *et al*. 2018, p. 251; Reich *et al*. 2018, pp. 31, 33). 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. An 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 current extent of shrub habitat will decrease, and 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) known nest predators associated with a county landfill may be the cause of the reportedly low nesting success. In addition, low adult survival and low nesting success estimates from the Desert Creek–Fales and Pine Nut PMUs, respectively, suggest predators may be influencing population growth there. However, we generally consider habitat alteration as the root cause of these results but recognize there is an interaction between predation and habitat condition. Thus, we do not know the current extent that predation independently has on population growth and stability but consider it important.

Small Population Size and Population Structure

The Bi-State DPS is comprised of approximately 50 active leks representing several relatively discrete populations. Research has shown fitness and population size are strongly correlated and smaller populations are more challenged by stochastic environmental and demographic events (Keller and Waller 2002, pp. 239–240; Reed 2005, p. 566). When coupled with mortality, stressors related to human activity and significant fluctuations in annual population size, long–term persistence of small populations is uncertain. The Pine Nut PMU has the smallest known number of sage-grouse of all Bi-State area PMUs (representing less than 1 percent of the DPS).

However, each population in the Bi-State DPS is relatively small, as is the entire DPS on average (estimated 3,280 individuals in 2018).

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

The Bi-State area is largely comprised of federally–managed lands. Until recently, most existing land use plans, as they pertain to sage-grouse, were typically general in nature and afforded 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. Therefore, we had considered most existing Federal mechanisms sufficiently vague as to offer limited certainty as to managerial direction pertaining to sage-grouse conservation. However, in addition to our continued support of the existing Bishop BLM RMP, the Humboldt–Toiyabe National Forest and the Carson City and Tonopah BLM Offices recently amended their Land Use Plans to more fully consider the conservation needs of the Bi-State DPS. Upon consideration of current regulatory mechanisms, including the BLM and Forest Service Land Use Plan amendments (USFS and BLM 2016, entire), we have found considerable improvement in the ability of such mechanisms to conserve the Bi-State DPS and its habitat. 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. However, given that federal land encompasses the vast majority of sage-grouse habitat in the Bi-State area and current land use plans afford substantial conservation to the species, we do not consider existing regulatory mechanisms to be inadequate at this time.

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 small portion of the Bi-State DPS, but when combined with invasive species, drought, and wildfire, it could 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 have resulted in a fragmented habitat for a relatively long–lived habitat specialist. Woodland encroachment has caused substantial, measurable habitat loss throughout the range of the Bi-State DPS. While techniques to address this habitat impact are available and being implemented, our knowledge of the efficacy of these actions is not complete, although recent research suggests sage-grouse populations respond positively to these actions. 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, while woodland treatments have been implemented on approximately 24,181 ha (59,753 ac). Placing treatments on par with estimated expansion rates. Meanwhile, the existing and potential impacts of cheatgrass and wildfire are steadily increasing and will likely escalate further with climate change, providing conditions that may result in rapid but episodic loss of substantial 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 current trends in habitat–based impacts in all PMUs would likely act to fragment and further isolate populations within the Bi-State DPS. Current or future impacts caused by wildfire, invasive species, urbanization, infrastructure, recreation, woodland succession, mineral development, grazing, 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 generally more stable with 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, at the highest elevation (>11,000 ft.,), extremely remote, likely relatively small and is currently in the initial data collection phase of a multiyear research project. While the South Mono, White Mountains, and Pine Nut PMUs appear to be largely isolated entities, the Bodie PMU interacts with the Mount Grant PMU but additionally with the Desert Creek–Fales 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 may prove difficult without substantial management attention. Given the Bi-State DPS's relatively low current rate of growth and strong site fidelity, recovery and repopulation of extirpated areas may 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. The current translocation effort in Parker Meadows should inform our knowledge of these challenges and preliminary results from this effort afford promise. Within the next several decades, it is possible that sage-grouse in the Bi-State area will likely persist in the two larger populations located in the South Mono PMU (Long Valley) and the Bodie PMU (Bodie Hills). These two populations currently appear largely demographically isolated from one another. The remaining four PMUs appear less resistant and resilient to future impacts and we anticipate contraction of both habitat and populations.

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APPENDIX A—DEFINITIONS

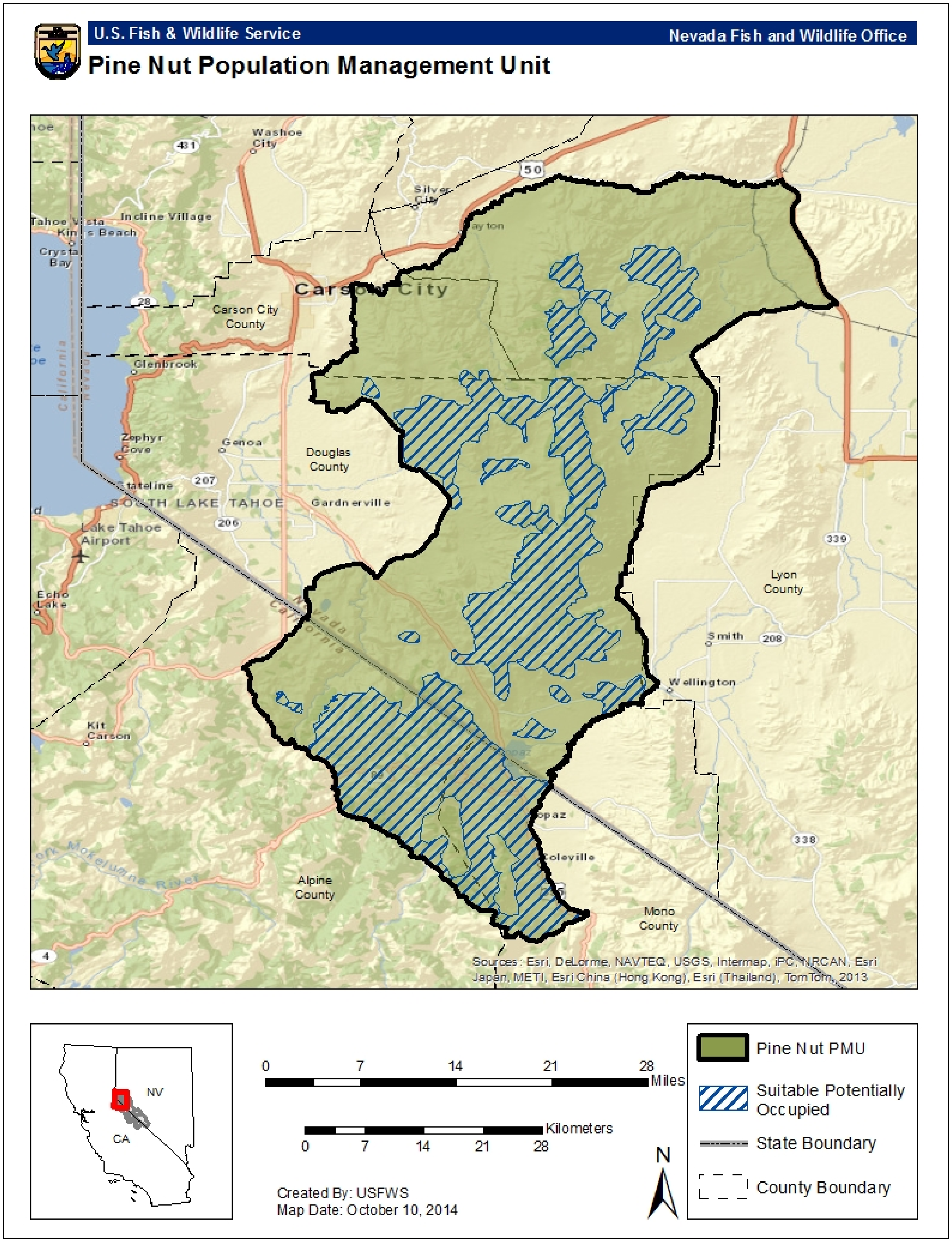
Active lek:	A lek with two or more strutting males during at least two years in a five–year period.
AML:	Appropriate Management Levels
AMPs:	Allotment Management Plans
AOU:	American Ornithologists' Union
APHIS:	Animal and Plant Health Inspection Service
BAER:	Burned Area Emergency Response
BIA:	Bureau 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
ITIS:	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
PMU:	Population Management Unit
RETAAC:	Renewable Energy Transmission Access Advisory Committee
RMP:	Resource Management Plan
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 States 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

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 (2014) was developed by BLM Bishop Field Office biologists. 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.


U.S. Fish & Wildlife Service
Nevada Fish and Wildlife Office
Pine Nut Population Management Unit
Washoe City
Silver City
Incline Village
Tahoe Vista
Crystal Bay
Carson City
Carson City County
Glenbrook
Zephyr Cove
Genoa
Douglas County
Stateline
SOUTH LAKE TAHOE
Gardnerville
Lake Tahoe Airport
Echo Lake
Kit Carson
Lyon County
Smith
Wellington
Coleville
Alpine County
Mono County
Nevada
California
Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
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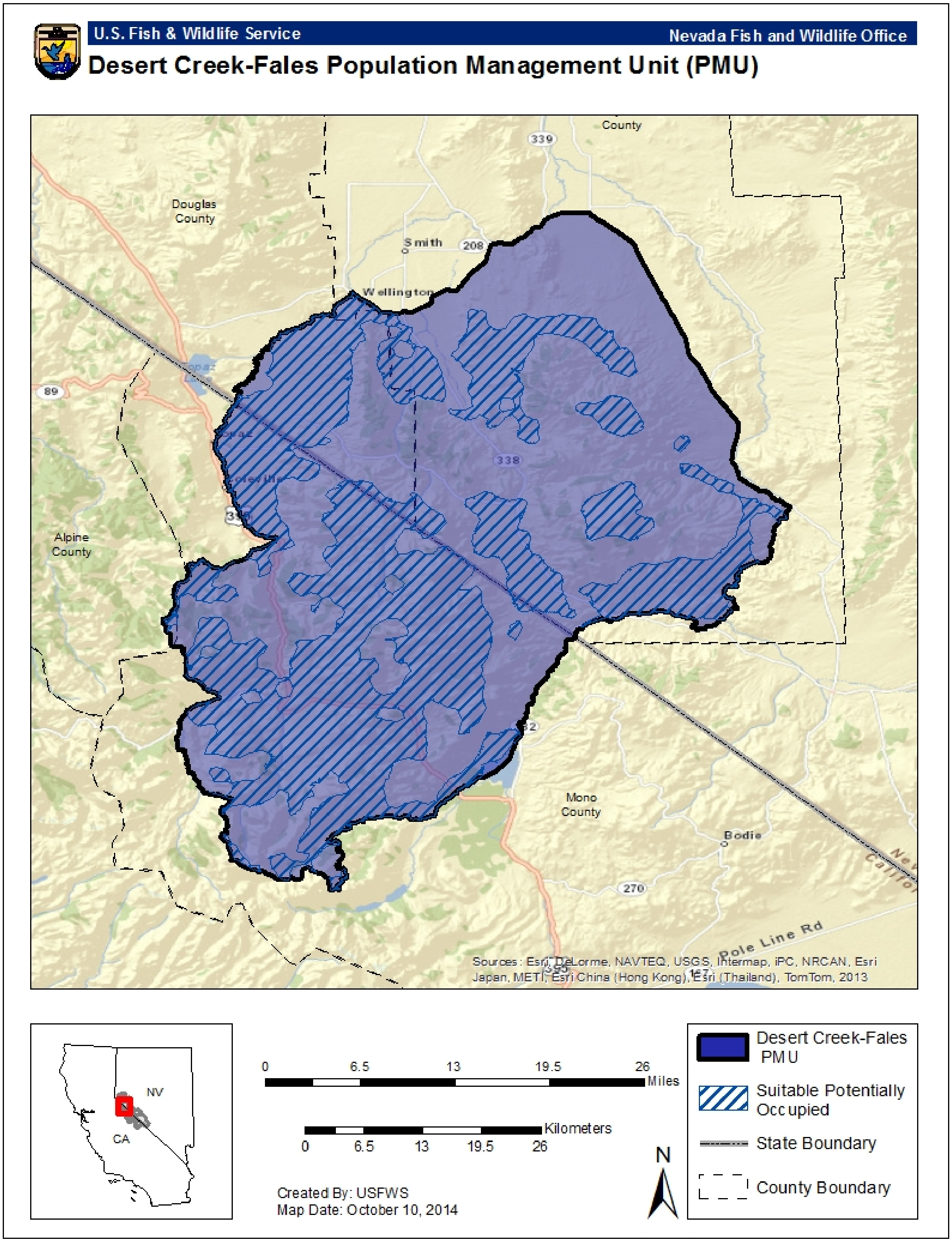
0 7 14 21 28 Kilometers
N
Created By: USFWS
Map Date: October 10, 2014
Pine Nut PMU
Suitable Potentially Occupied
State Boundary
County Boundary


U.S. Fish & Wildlife Service
Nevada Fish and Wildlife Office
Desert Creek-Fales Population Management Unit (PMU)
County
339
Douglas County
Smith
208
Wellington
89
338
Alpine County
Mono County
Bodie
270
Pole Line Rd
Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
NV
CA
0 6.5 13 19.5 26 Miles
0 6.5 13 19.5 26 Kilometers
Created By: USFWS
Map Date: October 10, 2014
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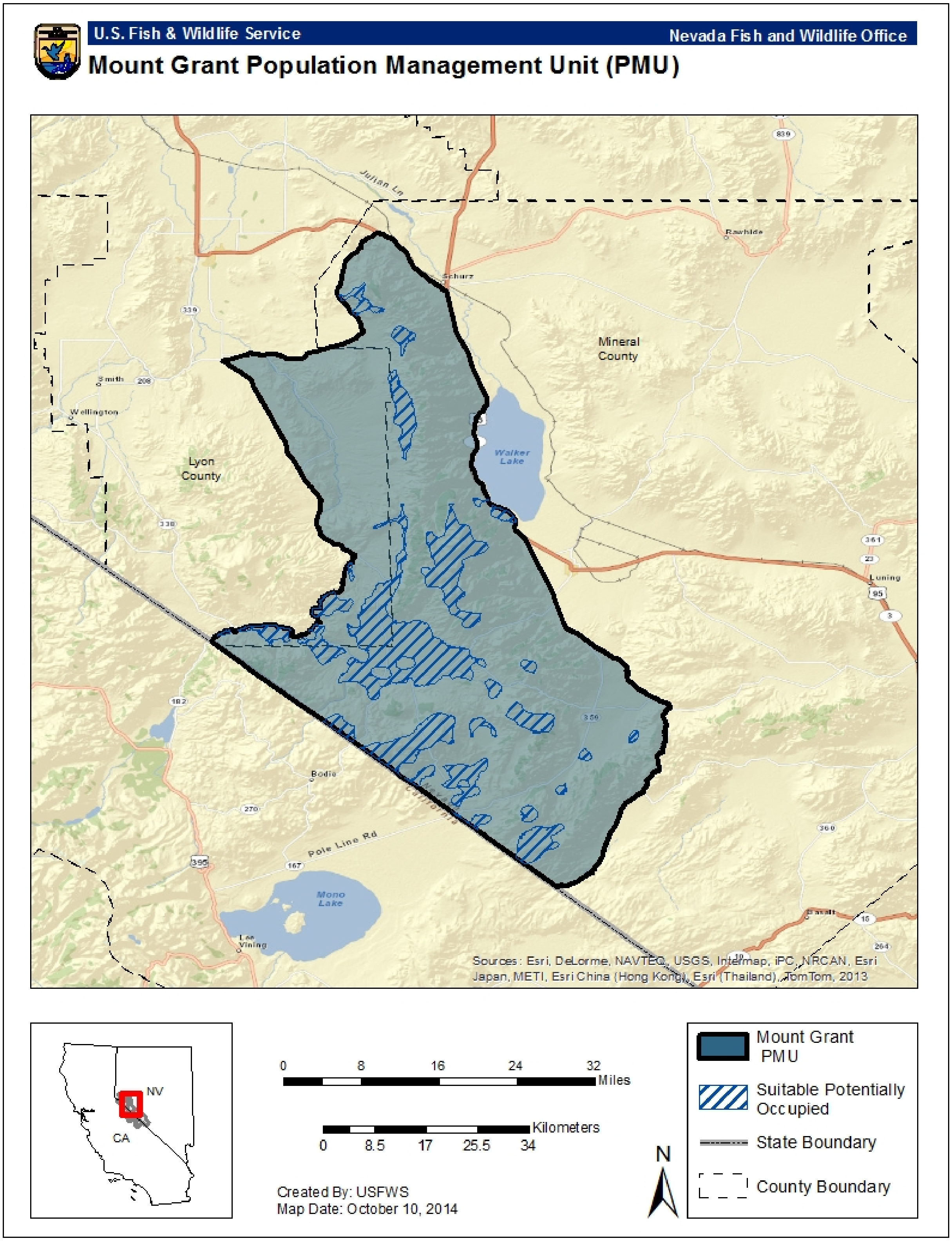
Desert Creek-Fales PMU
Suitable Potentially Occupied
State Boundary
County Boundary


U.S. Fish & Wildlife Service
Nevada Fish and Wildlife Office
Mount Grant Population Management Unit (PMU)
Julian Ln
Rawhide
Schurz
Mineral County
Smith
Wellington
Lyon County
Walker Lake
Luning
Bodie
Pole Line Rd
Mono Lake
Lee Vining
Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
NV
CA
0 8 16 24 32 Miles
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Created By: USFWS
Map Date: October 10, 2014
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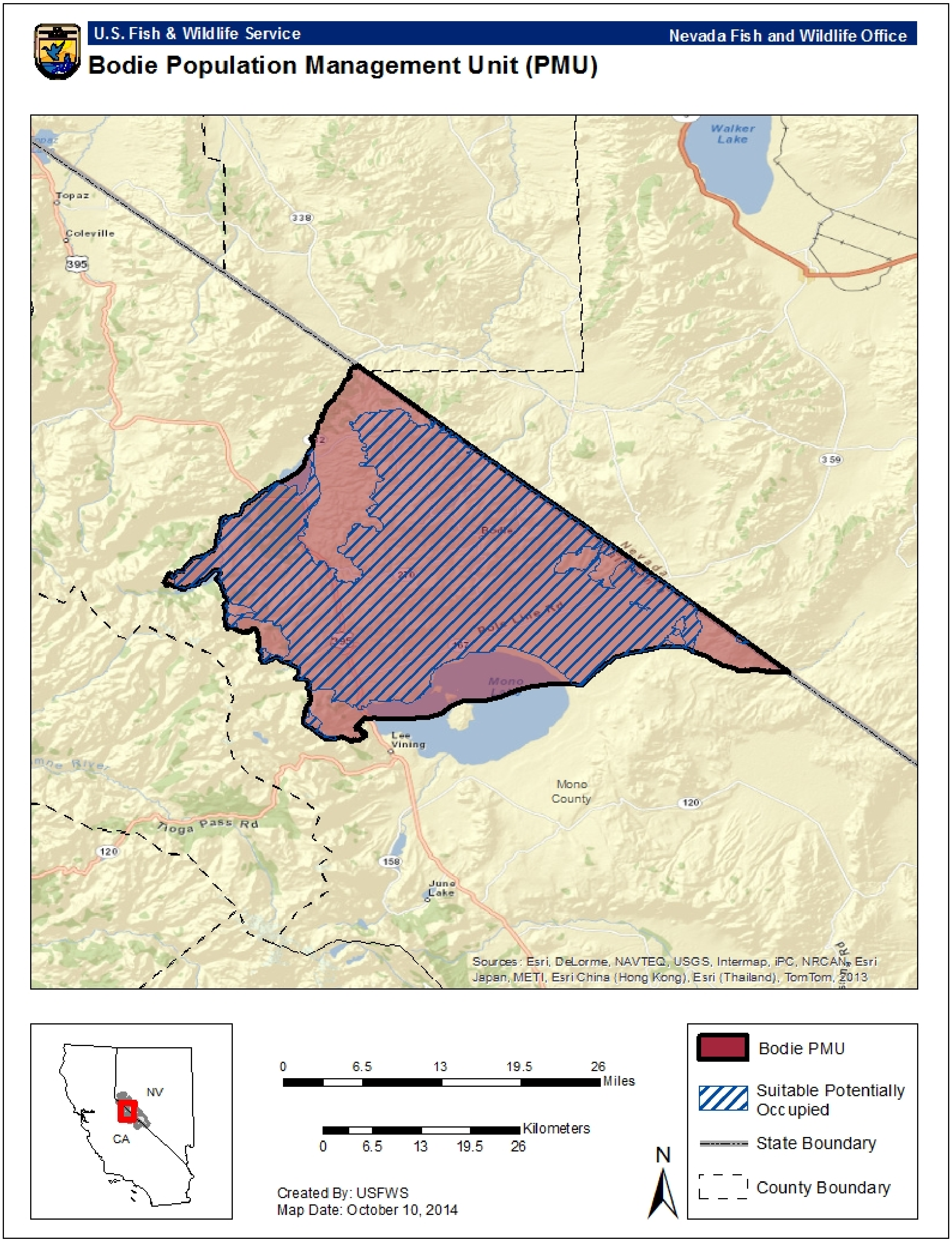
Mount Grant PMU
Suitable Potentially Occupied
State Boundary
County Boundary


U.S. Fish & Wildlife Service
Nevada Fish and Wildlife Office
Bodie Population Management Unit (PMU)
Walker Lake
Topaz
Coleville
395
338
359
Bodie
270
Bodie Lake Rd
167
Nevada
Mono Lake
Lee Vining
Mono County
120
Tioga Pass Rd
158
June Lake
Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
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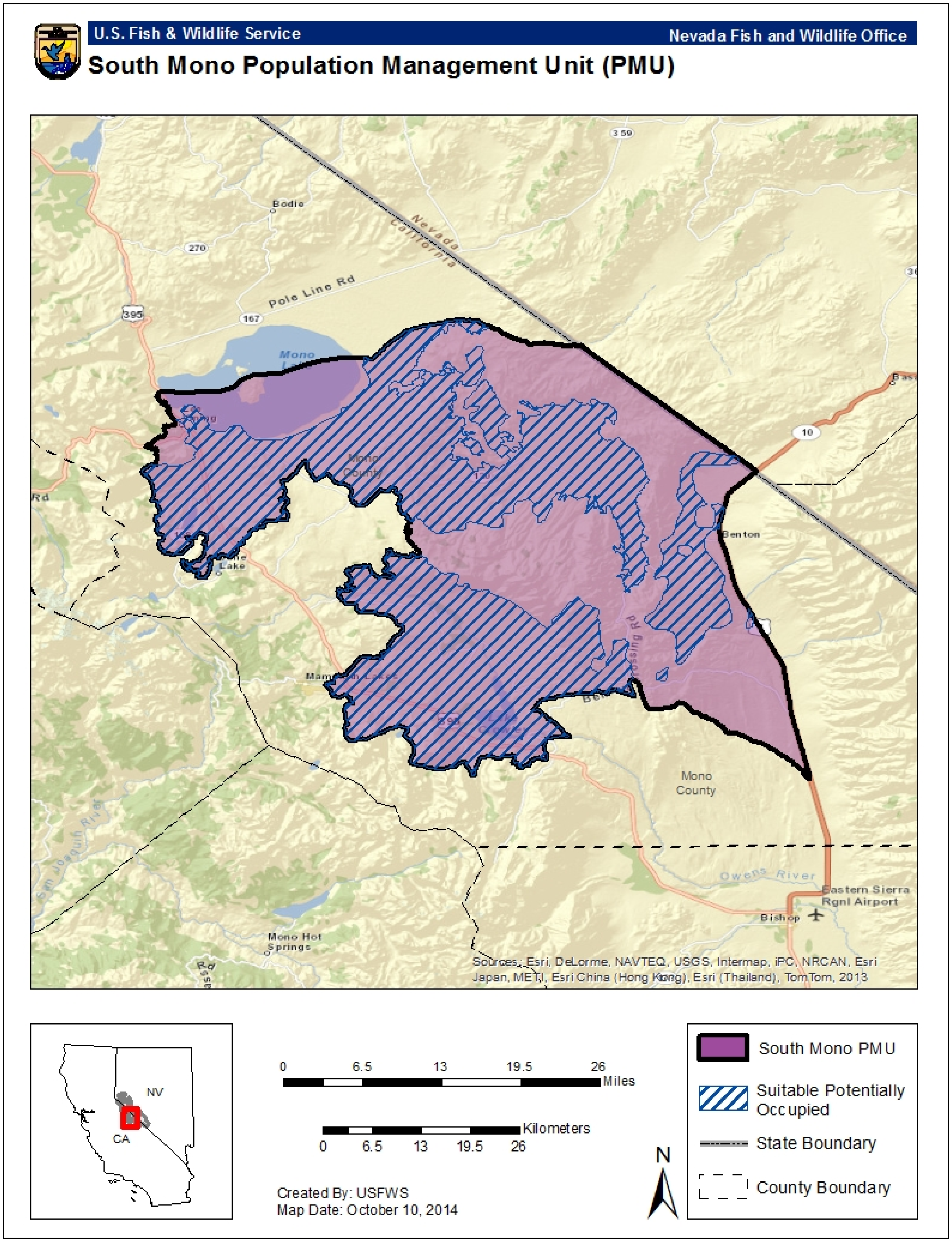
Bodie PMU
Suitable Potentially Occupied
State Boundary
County Boundary


U.S. Fish & Wildlife Service
Nevada Fish and Wildlife Office
South Mono Population Management Unit (PMU)
Bodie
Pole Line Rd
Mono Lake
Nevada
California
Benton
Mono County
Owens River
Eastern Sierra Rgnl Airport
Bishop
Mono Hot Springs
Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
NV
CA
0 6.5 13 19.5 26 Miles
Kilometers 0 6.5 13 19.5 26
Created By: USFWS
Map Date: October 10, 2014
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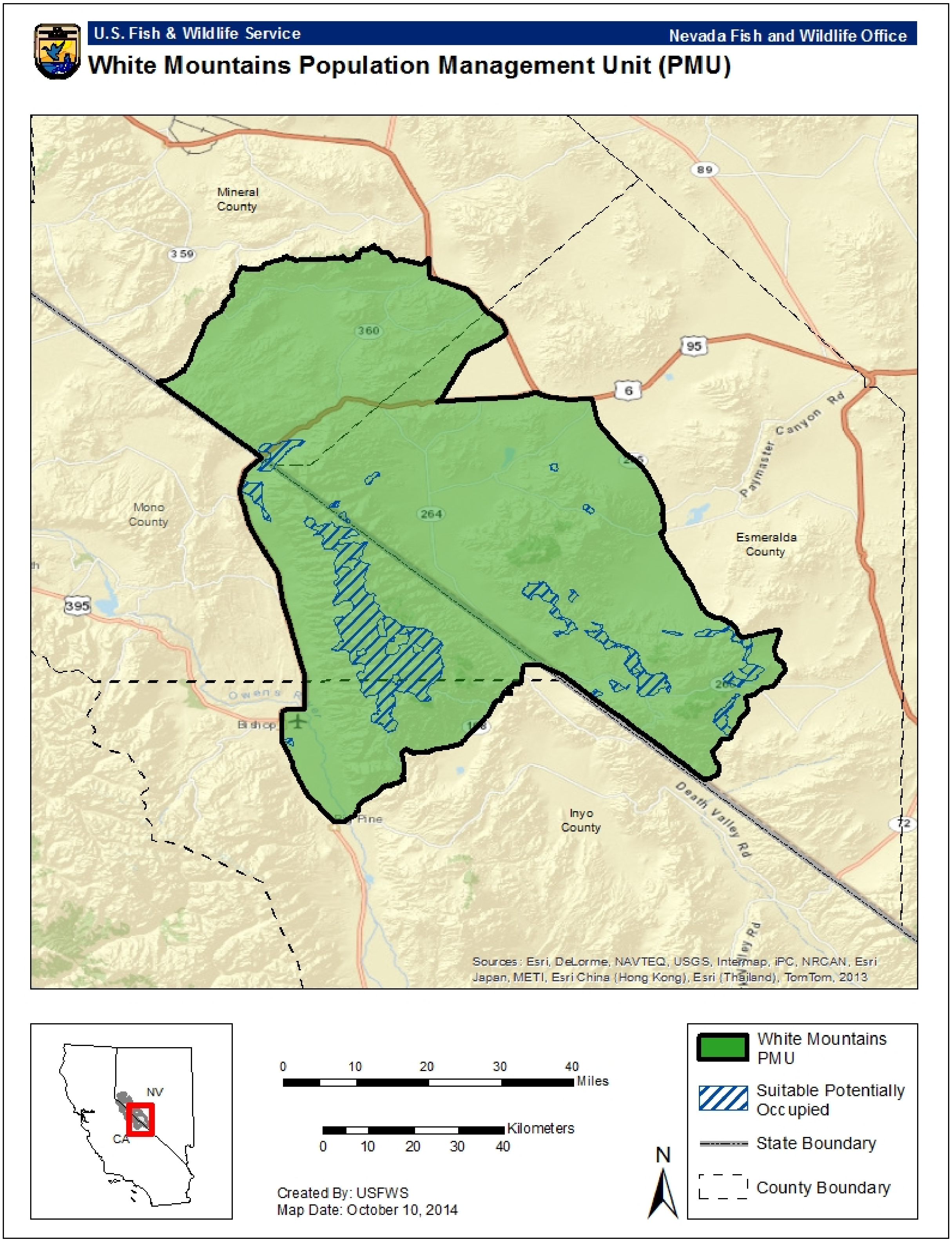
South Mono PMU
Suitable Potentially Occupied
State Boundary
County Boundary


U.S. Fish & Wildlife Service
Nevada Fish and Wildlife Office
White Mountains Population Management Unit (PMU)
Mineral County
Mono County
Esmeralda County
Inyo County
Paymaster Canyon Rd
Death Valley Rd
Owens R
Bishop
Big Pine
89
95
6
360
359
264
395
72
Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
NV
CA
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0 10 20 30 40 Kilometers
Created By: USFWS
Map Date: October 10, 2014
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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 2018) 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

Objective 1.A. Accommodate future growth in a manner that preserves and protects the area's scenic, agricultural, natural, cultural and recreational resources and that is consistent with the capacities of public facilities and services.

Policy 1.A.1. Contain growth in and adjacent to existing community areas.

Policy 1.A.8. Maintain or enhance the integrity of critical wildlife habitat in the county by limiting development in those areas and requiring mitigation in conformance to 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, nesting areas and winter and summer range for sage grouse; fisheries and associated habitat; and riparian and wetland habitat.

Action 1.A.8.a. Implement policies contained in the Conservation/Open Space Element and appropriate Area Plans.

Policy 1.A.9. Regulate resource development projects in a manner that maintains environmental quality.

Objective 1.G. Protect open space and agricultural lands from conversion to and encroachment of developed community uses.

Policy 1.G.2. Preserve and protect open space in order to protect natural and cultural resources and to provide for a variety of recreational opportunities.

Action 1.G.2.c. Designate California Department of Fish and Wildlife and Wildlife Conservation Board lands as "Open Space."

Planning Area Land Use Policies

Sonora Junction

Objective 5.C. Safeguard against potential impacts to sage grouse in all development activities.

Policy 5.C.1. Consider the location of sage grouse habitat and leks when processing development applications.

Action 5.C.1.a. Ensure project consistency with sage-grouse conservation and mitigation measures in the Conservation/Open Space Element.

Action 5.C.1.b. Work with landowners and recreational users to mitigate potential impacts to sage grouse and improve pursuant to policies in the Conservation/Open Space element.

Swauger Creek

Policy 6.A.5. Encourage fence design to facilitate the migration and movement of wildlife, with particular attention given to sage grouse, deer migration routes, and protection of wildlife from highway traffic.

Bodie Hills

Policy 9.G.3. Grazing on public lands within the Bodie Hills shall be guided by the BLM Bishop RMP and the Coordinated Resource Management Plans (CRMPs).

BLM RMP Decisions:

- Use the existing Coordinated Resource Management Planning (CRMP) process to identify and implement vehicle route closures to protect sensitive plants or deer or sage grouse habitats; to manage grazing; and to attain DPC and stream improvement goals.

Policy 9.G.4. Wildlife habitat management on public lands shall be guided by the BLM's Bishop RMP and the CRMPs.

<u>Mammoth Vicinity</u>

Objective 21.C. Preserve and enhance natural resources in the Mammoth vicinity.

Policy 21.C.1. Maintain or enhance the integrity of key wildlife habitat 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.

Action 21.C.1.a. Implement policies in the Conservation/Open Space Element.

Policy 21.C.3. Preserve, maintain and enhance surface and groundwater resources in the planning area.

Action 21.C.3.a. Require projects that could adversely impact water resources, including down–gradient water resources, to avoid or mitigate effects to a point where clearly no significant effects would occur.

Action 21.C.3.b. Work with the appropriate agencies to develop and implement a comprehensive management plan for Crowley Lake and the downstream areas of the aqueduct system. The management plan should ensure that the aqueduct system is managed in a manner that protects the ecological values of the Long Valley and the downstream areas of the aqueduct system.

Policy 21.C.5. Plan for the timely closure of Benton Crossing landfill and the mitigation of wildlife impacts during operation and after closure.

Action 21.C.5.a. Work with the appropriate agencies to develop and implement a raven mitigation plan for the landfill to protect sage-grouse populations.

<u>Antelope Valley</u>

GOAL 4. 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.

Objective 4.B. Maintain the scenic, historic, agricultural, and natural resource values in the Valley.

Policy 4.B.2. Preserve the agricultural lands and natural resource lands in the Antelope Valley.

Action 4.B.2.c. 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.

Policy 4.B.3. Work with appropriate agencies to manage water resources in a manner that protects natural, agricultural, and recreational resources in the Antelope Valley.

Policy 4.B.5. Work with appropriate agencies to manage fish and wildlife resources within the Antelope Valley.

Swauger Creek

GOAL 6. Distribute and regulate residential land uses in a manner that minimizes impacts to natural resources, supports low–impact recreational uses on wildlands, and preserves and enhances agricultural resources and wildland recreational and research values in areas adjacent to rural residential uses.

Policy 6.A.1. Future subdivisions in the planning area should recognize the inherent limitations of the land and the environment when determining appropriate parcel size and uses.

Bridgeport Valley

GOAL 7. Provide for orderly growth in the Bridgeport Valley in a manner that retains the small town character, and protects the area's scenic, recreational, agricultural, and natural resources.

Objective 7.B. Maintain the scenic, agricultural, and natural resource values in the Bridgeport Valley.

Policy 7.B.1. Preserve agricultural lands and wetlands.

Action 7.B.1.a. Work with appropriate agencies to manage water resources in the Valley in a manner that will protect the natural and recreational values of the water resource and associated resources (wildlife, riparian, etc.)

Policy 7.B.3. Ensure that any transfer (by sale or lease) of surface water rights will not impact the natural resource values of the Bridgeport Valley.

Bridgeport Area Wetlands Policies

GOAL 8. 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.

Bodie Hills

GOAL 9. Protect and enhance Bodie Hills Planning Area resources that complement the Bodie Experience.

Objective 9.H. Allow for agriculture, resource management activities, and rural resort uses on private lands in the Bodie Hills Planning Area that do not detract from the Bodie Experience.

Policy 9.H.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.

Action 9.H.1.a. Assign Agricultural land use designations to private property in the Bodie Hills Planning Area.

Action 9.H.1.b. Continue to implement the Development Credits program as described in Chapter 12 of this Element.

Policy 9.H.2. Wildlife management on private land shall be guided by the provisions of the Mono County Land Use Designation, the Mono County Land Development Regulations, and the policies of the Mono County General Plan.

<u>Mono Basin</u>

GOAL 10. Maintain the spectacular natural values of the Mono Basin and rural, small–town character of communities by managing growth, ensuring high–quality aesthetics, and providing for community development needs to enhance the quality of life for residents.

Objective 10.D. Maintain, protect and enhance the natural, historical and recreational attributes of the Mono Basin.

Policy 10.D.1. Coordinate with public agencies and other land–management organizations, such as the BLM, USFS, LADWP, CDFW, and US Fish and Wildlife Service, to understand local policies and engage locals in the management of their lands.

Policy 10.E.4. Support agricultural and grazing uses, such as sheep and cows, in historic locations, locations compatible with resource sensitivity and availability, and where consistent with scenic and natural resources.

Action 10.E.4.b. Support guidelines for sound grazing management practices on public lands to maintain environmental resource values while supporting agricultural uses.

<u>June Lake</u>

GOAL 18. Conserve and enhance the quality of the June Lake Loop's natural, scenic and cultural resources.

Objective 18.A. Protect the Loop's natural environment by guiding development in environmentally sensitive areas and by mitigating the impacts of development to the greatest extent practical.

Policy 18.A.1. Mitigate impacts or limit development to an appropriate level in environmentally and visually sensitive areas. Environmentally sensitive areas include: riparian areas, potential high groundwater table zones, wetlands, and steep hill slopes.

Action 18.A.1.a. Ensure projects on lands designated for natural habitat protection or located in environmentally sensitive zones adequately consider and protect areas of high natural resource value.

Action 18.A.1.b. Discourage, where feasible, the filling or dredging of wetlands, related springs or highwater table areas, and waterways, and direct applicants to applicable regulatory agencies such as the Lahontan Regional Water Quality Control Board.

Action *18.A.1.c.* Ensure projects protect the ecosystem functions of vegetation within natural habitat protection districts and in environmentally sensitive areas.

Action 18.A.1.d. Reduce, to the extent possible, the impacts of cutting, filling, grading or excavation on the natural water regimen, vegetation stability, land form or stream morphology.

Action 18.A.1.e. Work with local, state and federal agencies to identify environmentally sensitive areas and to develop measures for their protection. Should conflicts occur over the designation of sensitive areas, expert studies, provided by the project proponent, will be required to prove that the area in question does not qualify as an environmentally sensitive area.

Action 18.A.1.f. Work with state and federal lead agencies in resolving conflicts over the delineation of environmentally sensitive areas.

Policy 18.A.2. Promote USFS land exchanges and/or purchases by land conservation groups of sensitive areas. Where such exchange or purchase is infeasible, guide development to protect environmentally sensitive areas.

Action 18.A.2.c. Work with the USFS to facilitate land exchanges within the June Lake Loop involving federal lands not possessing high habitat or visual resource values. Federal lands traded into private ownership should be located near established, developing or Area Plan–designated community areas. Reverse land exchanges, or trading highly sensitive private lands for less–sensitive National Forest lands, should also receive priority consideration. Due to the limited private land available within the Loop, lands exchanged into federal ownership should be traded for developable lands in the June Lake Loop, if feasible.

Objective 18.B. Protect lands identified in the natural habitat protection district (LUD map reference) and potential high groundwater table areas (MEA reference).

Policy 18.B.1. Preserve natural habitat areas by limiting development and curtailing harmful uses on identified wetland areas. Assign top priority to these lands for land exchanges.

Policy 18.C.3. Use comprehensive water management plans to guide water use, the construction of new water supply facilities, and the protection of natural resources.

Action 18.C.3.a. Promote the development of a comprehensive water management plan by local entities that plan for the present and expected water needs in the Loop. This plan should consider the effects of upstream water diversions on Mono Lake, the visual effects of fluctuating water levels in lakes and streams, and the potential effects of future water diversions on spawning fish or other wildlife.

Policy 18.C.5. Recognize in–stream flows as a beneficial use of water.

Action 18.C.5.a. Work with water and wildlife management agencies to ensure that stream diversions will not harm existing wildlife.

Action 18.C.5.b. Promote studies that establish minimum in–stream flows and lake levels. These levels must protect existing aquatic communities and associated vegetation. Coordinate efforts with local water districts and land and wildlife management agencies.

Action 18.C.5.c. Use the California Environmental Quality Act (CEQA) review process to identify mitigation measures and alternatives to water–diversion projects that may have significant environmental impacts.

Mammoth Vicinity

Policy 21.C.2. Maintain or enhance the integrity of fisheries in the planning area.

Action 21.C.2.a. Support the trout enhancement by the CDFW for the Mammoth area.

Action 21.C.2.b. Manage riparian areas to maintain high–quality habitat for fish, especially in threatened and endangered species waters, wild trout waters, and the meadow reaches of streams.

Upper Owens River

GOAL 22. Retain the existing rural character and environmental resources of the Upper Owens Area.

Objective 22.A. Protect the unique natural setting, ecology, riparian corridor and fishery, wildlife, recreational and agricultural resources of the Upper Owens by limiting the types and intensity of development in the area.

Policy 22.A.3. Restrict development in a manner that preserves the environmental quality of the area.

Action 22.A.3.a. Based upon existing resource information, estimate thresholds for maintaining the area's environmental quality; thresholds should address air quality, viewsheds, water quality, noise environment, traffic, and wildlife habitats. The type and intensity of permitted development should not exceed the estimated thresholds. Development projects proposed prior to the establishment of these thresholds should address these issues in project environmental assessments.

Action 22.A.3.b. Development projects that may have significant environmental impacts shall assess potential impact(s), determine if they exceed estimated environmental thresholds, and recommend project alternatives and/or mitigation measures prior to project approval, in the manner required by General Plan policies and CEQA.

Action 22.A.3.c. Development projects shall avoid potential significant environmental impacts or mitigate impacts to a level of non–significance, unless the benefits of the proposed project outweigh the unavoidable adverse environmental effects, and an appropriate statement of overriding considerations is made through the EIR process.

Objective 22.B. Protect the water resources of the Upper Owens Area.

Policy 22.B.1. Ensure that direct and indirect impacts of development projects on the water resources of the Upper Owens Area are avoided or mitigated to a point where clearly no significant effects would occur.

Action 22.B.1.b. Oppose water transfer projects that could affect the Upper Owens Watershed – such as the development of the Dry Creek Wellfield – unless it is demonstrated that there will clearly be no significant adverse effects on the area's water resources.

Action 22.B.1.c. Require development projects subject to the California Environmental Quality Act (CEQA) to set back 50 feet from the top of the bank of natural waterways, and to comply with other stream, riparian and wetland area setback requirements of federal and state agencies

Action 22.B.1.d. Request that potential impacts from development projects subject to CEQA to the Upper Owens River be thoroughly considered in applicable environmental studies.

Action 22.B.1.e. Require development projects subject to CEQA with the potential to impact the water resources of the Upper Owens area to conduct long–term water monitoring programs in order to ensure the maintenance of the area's water quality and quantity.

Policy 22.B.2. Preserve the Upper Owens River water resources and riparian corridor.

Action 22.B.2.a. Work with local landowners to develop coordinated strategies for preserving the Upper Owens River corridor, including the riparian corridor, downstream to Crowley Lake. All reasonable stream preservation options and techniques – such as conservation easements, transfer of development rights, fencing, enhancement of water quality, and the sale of sensitive land to conservation organizations – may be considered.

Action 22.B.2.b. Promote sound grazing management in accordance with the Conservation/Open Space Element, Agriculture/Grazing/Timber policies, Goal I, Objective C.

Objective 22.C. Promote the continuation of agricultural uses that are compatible with the rural recreational and open–space values of the area.

Policy 22.C.1. Allow for the continuation and reasonable expansion of agricultural uses, including grazing in a manner consistent with the environmental and recreational values of the area.

Action 22.C.1.a. Designate lands used for agricultural purposes as "Agriculture" to ensure consistency with the General Plan.

Action 22.C.1.b. Require new construction to be sited in a manner that avoids interference with existing ranching operations and livestock and wildlife movement.

<u>Long Valley</u>

GOAL 23. 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.

Objective 23.E. Provide for recreational and open–space uses in and around the Long Valley planning area.

Policy 23.E.1. Ensure the preservation of open space in the planning area.

Action 23.E.1.a. Require in–filling of areas designated for residential, commercial, and industrial uses prior to allowing conversion of agricultural land or public open space.

Action 23.E.1.b. Designate lands owned by the LADWP for open space or public facilities use (e.g., fire station).

Policy 23.E.2. Discourage the extension of public and private facilities, especially roads, into open space or agricultural land.

<u>Wheeler Crest</u>

Objective 24.B. Preserve the value of land dedicated or deeded for community services, natural resources or recreation use as development occurs in the planning area (parks, community centers, equestrian trails, ski trails, hiking trails, tennis courts, deer migration corridors, etc.).

Policy 24.B.3. Guarantee that improvements for community use will increase the attractiveness of the use, and that the use will be compatible with residential uses and surrounding resource values.

Action 24.B.3.a. Buffer all community use from residential uses with a combination of open space, plantings, and physical barriers.

Action 24.B.3.c. Buffer new developments from deer corridors or other key wildlife habitats using a combination of open space, plantings and physical barriers.

Objective 24.C. Provide for recreational and open–space uses in and around the Wheeler Crest area.

Policy 24.C.1. Preserve adequate open–space rangeland to protect movement of wildlife, cattle and pack stock.

Action 24.C.1.a. Monitor and discourage the conversion of viable agricultural land.

Policy 24.C.2. Prevent the intrusion of development into rangelands, with special attention to protecting range vegetation and water supply.

Action 24.C.2.a. Discourage extensions of public and private facilities, especially roads, into open space rangeland as defined by California Department of Fish and Wildlife, BLM, and USFS.

Policy 24.C.5. That existing National Forest and BLM lands surrounding the community be retained in public ownership or be utilized for community purposes.

Action 24.C.5.a. Coordinate all planning and development activities adjacent to public lands with the affected public entity.

Action 24.C.5.b. Assist in the preservation of valuable deer habitat by establishing a land bank, or other mechanisms, to retain migration corridors.

Action 24.C.5.c. Coordinate with public agencies to preserve and enhance natural stream courses.

Objective 24.F. Protect and enhance the environmental resources in the area that contribute to the quality of life and form the basis for the recreation–oriented local economy; i.e., open space, air and water quality, scenic resources, streams, and wildlife.

Policy 24.F.3. Protect wildlife and native plants, especially rare and endangered species.

Action 24.F.3.b. Require an environmental analysis for any proposed land use located in areas that are known habitats for rare and endangered wildlife or flora. The analysis would study the effects of the proposed development upon this resource and how adverse impacts would be mitigated.

Action 24.F.3.c. The entire planning area is either within or in close proximity to valuable deer migration routes. Thus all projects, other than homes on subdivided lots, shall assess and mitigate to the greatest degree possible the impacts of development on this resource. Mitigation measures may include but not be limited to: clustering; reduction of density; large minimum lot sizes; prohibiting construction in certain locations; relocation; contribution to a land bank for alternate routes; fencing of gardens/landscaping; protection of special habitat types such as wet meadows; and building setbacks.

Action 24.F.3.d. Restrict off–road vehicle use in areas of environmental sensitivity (i.e., deer migration and habitat areas).

Action 24.F.3.e. Support the CDFW's continuing program to reintroduce native game species (bighorn sheep).

Action 24.F.3.f. Consult/engage with the California Department of Fish and Wildlife as the responsible agency for the protection and recovery of Sierra

Nevada Bighorn Sheep prior to approving any new or renewed grazing use or a or altering any existing grazing use for domestic sheep.

Policy 24.F.4. Protect open space and scenic values within and around the community.

<u>Tri–Valley</u>

GOAL 26. Preserve the rural and agricultural character of the Tri–Valley area.

Policy 26.A.2. Prevent the intrusion of development into agricultural areas in order to protect agricultural resources.

Action 26.A.2.a. Monitor and discourage the conversion of viable agricultural land to non–agricultural uses.

Action 26.A.2.b. Agricultural activities shall have precedence over incompatible uses/activities in the Tri–Valley area.

Action 26.A.2.c. Carefully evaluate subdivisions outside existing community areas. Consideration should be given to assigning large minimum parcel sizes.

Policy 26.A.3. Encourage residential development in areas that will minimize the impact on the environment.

Policy 26.B.3. Prevent the intrusion of development into agricultural areas in order to protect agricultural resources.

Action 26.B.3.a. Monitor and discourage the conversion of viable agricultural land to non–agricultural uses.

Action 26.B.3.b. Agricultural activities shall have precedence over incompatible uses/activities in the Tri–Valley area.

Action 26.B.3.c. 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.

Objective 26.F. Protect Natural Resources, and provide for recreational and open–space uses in the Tri–Valley area.

Policy 26.F.1. Utilize the open space provided by federal lands to ensure that the open–space needs of the community are met and to provide buffer space between communities.

<u>Oasis</u>

GOAL 28. Protect agricultural and natural resource values in the area.

Objective 28.A. Preserve the agricultural lands and natural resource lands in the Oasis area.

Policy 28.A.1. Designate existing agricultural lands for agricultural use in the Land Use Element.

Action 28.A.1.a. In accordance with the California Environmental Quality Act (CEQA), require the preparation of an Environmental Impact Report (EIR) for projects that may convert agricultural lands to other uses.

Action 28.A.1.b. Pending restoration of funding by the State of California, encourage agricultural land owners to utilize the property–tax incentives for agricultural land provided for in the county Williamson Act program.

Action 28.A.1.c. 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.

KEY POLICIES: CONSERVATION/OPEN SPACE ELEMENT POLICIES

Issues/Opportunities/Constraints

3. The protection and enhancement of natural habitats is a critical element in preserving and restoring the long–term existence of local wildlife. Riparian woodlands, wetlands, migration corridors, sagebrush steppe, and wintering and summering grounds are recognized as critical, highly localized wildlife habitat. Increased recreational use in the county and increased development, particularly in areas outside existing community areas, creates potential impacts to the long–term sustainability of fish and wildlife populations and plant communities through degradation of resources and increased conflicts between wildlife and humans.

5. Resource management agencies have given special status to a number of plant and animal species that are known or expected to occur in the county. In addition, a number of locally significant species have been identified. The protection of these species is a concern.

6. Endangered and threatened species, and their associated listings under the Endangered Species Act (ESA), are becoming a greater concern in Mono County. These species are valuable to Mono County, directly contributing to the local economy and recreational aspects, and representing healthy natural resources and landscape that is critical to quality of life.

7. ESA listings often cause an immediate fear of overregulation and a sense that community needs are incompatible with species conservation. However, Mono County has recently been successful cooperating with conservation partners to preclude a listing because of adequate species protection, demonstrating human activity can be compatible with species conservation. Even when the County does not directly participate in conservation efforts, utilizing best–available science to meet both conservation and community needs is in the County's best interest.

Biological Resources Policies:

Objective 2.A. Maintain and restore botanical, aquatic and wildlife habitats in Mono County.

Policy 2.A.1. Future development projects shall avoid potential significant impacts to animal or plant habitats or mitigate impacts to a level of non–significance, unless a statement of overriding considerations is made through the EIR process.

Action 2.A.1.a. Future development projects with the potential to significantly impact animal or plant habitats shall assess site–specific resource values and potential impacts prior to project approval. Examples of potential significant impacts include:

a. substantially affecting a candidate, sensitive, rare or endangered species of animal or plant or the habitat of the species; and/or

b. interfering substantially with the movement of any resident or migratory fish or wildlife species; and/or

c. substantially diminishing habitat for fish, wildlife, or plants, including wetlands and riparian areas.

The analysis shall:

a. be funded by the applicant;

b. be prepared by a qualified person under the direction of Mono County and in consultation with the California Department of Fish and Wildlife (CDFW);

c. assess existing conditions in the general project vicinity, including the identification of any listed or candidate threatened or endangered species or habitats of special concern, and annual and daily wildlife movement patterns and corridors;

d. describe the impacts of the proposed development upon animal and plant habitat extent, quality and connectivity within the project site and on surrounding areas; and

e. recommend project alternatives or measures and monitoring to avoid or mitigate impacts to animal and plant habitat.

Mitigation measures and associated monitoring programs shall be included in the project plans and specifications, and shall be made a condition of approval for the project. The project sponsor shall fund the monitoring and shall be responsible for remedying deficiencies.

Action 2.A.1.g. Projects outside community areas within identified deer and sage grouse habitat areas, (see the Biological Resources Section of the Master Environmental Assessment), which may have a significant effect on deer or sage grouse resources shall submit a site–specific study performed by a recognized and experienced biologist in accordance with Action 1.1.

Policy 2.A.3. Protect and restore sensitive plants, wildlife and their habitat, and those species of exceptional scientific, ecological, or scenic value.

Action 2.A.3.a. Enforce maximum site disturbance standards in appropriate land use designations in the Mono County General Plan.

Action 2.A.3.b. Require landscape plans to incorporate the use of native vegetation when feasible. The transplanting of existing vegetation and use of locally collected seed may be required in the landscape plan.

Action 2.A.3.c. When applicable, revegetation and landscape plans should include provisions to retain and re–establish upland vegetation, especially bitterbrush and sagebrush, as important mule deer and sage grouse habitat.

Action 2.A.3.d. In order to protect their special value to plant diversity and wildlife habitat, limit development in edge zones, riparian areas, and wetlands.

Action 2.A.3.e. Projects within key sage grouse habitat shall not be permitted unless a finding is made that potential impacts have been avoided or mitigated to a level of non–significance or a statement of overriding considerations is approved. Potential mitigation measures may include:

- Minimizing site disturbance and limiting it to the poorest quality habitat on the parcel (e.g., near trees, away from leks and water, etc.);
- Siting structures taller than 6 feet or above the sagebrush average height outside the line of sight of a lek;
- Minimizing the installation of fencing and all fencing shall be of a wildlife friendly design, which may include the following specifications: not taller than 42”, three strands, bottom strand a minimum of 16” from the ground, top wire marked for visibility, lay down and let–down fencing, and avoidance of posts serving as avian predator perches. Other designs may be warranted depending on the wildlife concerns of the areas, and the BLM, USFWS and/or CDFW should be consulted;
- Installing perch deterrents on structures taller than 6 feet or above the sagebrush average height;
- Controlling domestic animals on the property;
- Designating seasonal use restrictions;
- Restoring native vegetation or otherwise improving vegetative habitat, including removal of invasive trees and annual grasses, and reducing fire risk on nearby public lands;
- Contributing financially to an established program undertaking habitat restoration within Mono County; and
- Including other measures developed in consultation with key Bi-State sage grouse partners (e.g., USFWS, CDFW, BLM, USFS), including considerations to mitigate impacts to reduced connectivity and fragmentation.
- To protect nesting and brood–rearing habitat, agricultural cultivation shall not disturb or remove sagebrush habitat within three miles of an active lek, or as determined through an informal consultation process with applicable Bi-State Conservation partners.

Action 2.A.3.f. Review ministerial permits in sage grouse habitat for impacts and make every effort to work with the applicant to include mitigation measures, including those in Action 2.A.3.e.

Action 2.A.3.g. Participating in collaborative conservation efforts to minimize adverse impacts to sensitive species.

Policy 2.A.4. Participate in the Bi-State Local Area Working Group on sage grouse conservation and assist with the implementation of the Bi-State Action Plan.

Action 2.A.4.a. Assist with coordination, communication and administration of the working group and associated conservation efforts, including reporting, education events, and outreach.

Action 2.A.4.b. Partner on sage grouse conservation projects and monitoring, including habitat management and improvement, signage, drainage improvements, fence removal and modification, and annual lek counts.

Action 2.A.4.c. Work with partners to implement the Bi-State Action Plan over the next 10 years, including responsibilities specific to Mono County such as the development of General Plan policies (included in this Element) and planning for the closure of Benton Crossing Landfill.

Policy 2.A.7. Support the acquisition of valuable wildlife habitat by federal or state land management agencies or land conservation organizations.

Action 2.A.7.a. Support acquisition of important wildlife areas through outright purchase, land donations, trades, purchase of easements, and related options.

Action 2.A.7.b. Provide information to property owners on incentives for protecting key wildlife habitat, including conservation easements, purchase at fair market value, land trades, etc.

Action 2.A.7.c. Work with appropriate agencies and organizations to investigate the feasibility of establishing habitat preservation areas to protect and improve significant habitat areas.

Action 2.A.7.d. The Economic Development Department should work with the Fisheries Commission to advise the County on fish and related wildlife issues.

<u>Water Resources and Water Quality Policies:</u>

Policy 4.B.3. Degradation of water quality from livestock shall be minimized.

Action 4.B.3.a. As necessary, investigate the use of fencing, alternate grazing patterns, and/or reduction in the number of animals grazed, or other measures to protect stream water quality and habitat for sensitive species such as the Yosemite Toad and sage grouse (see Biological Resources policies for sage grouse fence design recommendations).

<u>Energy Resources & Resource Efficiency</u>

GOAL 14. Minimize the visual, environmental, and public health and safety impacts of electrical transmission lines and fluid conveyance pipelines.

Objective 15.B. Transmission and distribution lines shall not adversely impact wildlife, fisheries, or public health and safety.

Policy 15.B.1. New transmission or distribution lines shall avoid open expanses of water, wetland, and sagebrush steppe, particularly those heavily used by birds. They shall also avoid nesting and rearing areas.

Policy 15.B.2. Avoid the placement of transmission or distribution lines through crucial wildlife habitats such as deer fawning and migration areas, and sage grouse lekking and brood–rearing habitat.

Policy 15.B.3. Design transmission lines to minimize hazards to raptors and other large birds, and require the installation of anti–perching devices when overhead placement in sensitive habitat is unavoidable.

CONSERVATION/OPEN SPACE ELEMENT POLICIES:

<u>Issues/Opportunities/Constraints</u>

4. The cumulative impacts of increased development and recreational usage on natural habitats and local wildlife are a major concern. In particular, the cumulative impacts of development on deer herds and sage grouse are a concern throughout the county.

8. A number of agencies are involved in wildlife resource management in the county, including the USFS, BLM, CDFW, and the US Fish and Wildlife Service. Each of these agencies has jurisdiction over certain aspects of the protection and enhancement of wildlife habitat and local wildlife populations. The County must work with these agencies and other agencies that are responsible for other areas of resource management, such as the Natural Resource Conservation Service (NRCS), Lahontan Regional Water Quality Control Board, and the US Army Corps of Engineers.

<u>Open Space Policies</u>

GOAL 1. Preserve natural open–space resources which contribute to the general welfare and quality of life for residents and visitors in Mono County and to the maintenance of the county's tourism economy.

Objective 1.A. Preserve existing open space.

Policy 1.A.7. Implement policies in other sections of the General Plan relating to preservation of open space.

Policy 1.A.8. Work with appropriate agencies, organizations, and individuals to preserve open space permanently for wildlife habitat, viewshed values, recreational uses, or other resource protection purposes.

Action 1.A.8.a. Keep current on land acquisition and disposal plans and activities of federal and state land management agencies and the LADWP in order to achieve a coordinated effort to preserve and maintain open space for purposes such as natural resource protection, scenic views and recreation.

Action 1.A.8.b. During the Specific Plan and subdivision processes, consider conditions of approval such as the use of open space, conservation, and scenic easements; the dedication of open space by project sponsors; the use of deed restrictions that require setbacks and the preservation of natural vegetation and wildlife habitat, cultural resources and recreational values; or other provisions that preserve the open–space values of an area.

Action 1.A.8.d. Evaluate available methods to encourage the acquisition of key open–space areas for resource values, including the use of taxes, tax–incentives, state and federal funding, grants, and other programs.

Policy 1.A.4. Continue to designate undeveloped lands owned by out of county agencies such as the Los Angeles Department of Water and Power (LADWP), and the Walker River Irrigation District (WRID), or by utility entities such as Liberty Utilities, and Southern California Edison (SCE) as "Open Space" ("OS") in the Land Use Element. Exceptions to this policy may include lands adjacent to community areas needed for community uses, or lands outside community areas needed for public purposes.

Policy 1.A.6. Coordinate policies in the county General Plan with policies in the USFS's Land and Resource Management Plans for the Inyo and Humboldt–Toiyabe national forests and the BLM's Resource Management Plan in order to coordinate open–space programs.

Policy 1.A.7. Implement policies in other sections of the General Plan relating to preservation of open space.

Policy 1.A.8. Work with appropriate agencies, organizations, and individuals to preserve open space permanently for wildlife habitat, viewshed values, recreational uses, or other resource protection purposes.

<u>Biological Resources Policies:</u>

GOAL 2. Maintain an abundance and variety of vegetation, aquatic and wildlife types in Mono County for recreational use, natural diversity, scenic value, and economic benefits.

Policy 2.A.2. Protect and restore threatened and endangered plant and animal species and their habitats.

Action 2.A.2.a. If a project is likely to have significant impacts on any state or federally listed threatened or endangered species, the County will consult fully with appropriate agencies and organizations, such as the CDFW, the USFWS, and the CNPS, concerning project alternatives and mitigation measures.

Action 2.A.2.b. Support the acquisition of areas with threatened or endangered species by federal or state land management agencies or land conservation organizations.

Action 2.A.2.c. Work with appropriate agencies and organizations to investigate the feasibility of establishing preservation areas to protect and restore threatened and endangered species.

Action 2.A.2.d. Work with the USFWS and other appropriate agencies to protect and restore listed species and their habitats while also minimizing impacts to county residents and visitors.

Action 2.A.3.h. Maintenance agreements and procedures for roads and other infrastructure shall consider impacts to special–status species including consultation with appropriate state and federal agencies.

Policy 2.A.8. Restrict or seasonally limit OHV and other recreational uses in valuable habitat areas in order to protect those resources.

Policy 2.A.9. Maintain water quality for fishery habitat by enforcing the policies contained in the Water Quality and Agriculture / Grazing/ Timber sections of the Conservation/Open Space Element.

Policy 2.A.10. Support efforts to regulate in–stream flows and lake levels to maintain fishery and other wildlife values, including riparian habitat.

Water Resources and Water Quality Policies:

GOAL 3. Ensure the availability of adequate surface and groundwater resources to meet existing and future domestic, agricultural, recreational, and natural resource needs in Mono County.

Objective 3.B. Identify and secure adequate water for future local domestic needs while maintaining natural resources.

Policy 3.B.2. Encourage the preparation of water management plans by local water providers.

Action 3.B.2.a. Assist special districts in securing available grant moneys for water management planning.

Policy 3.B.3. Encourage the USFS and the BLM to assist local communities in securing the water resources necessary to accommodate community demands, particularly those demands that directly and indirectly result from increased activities on adjacent federal lands.

Objective 3.F. Promote the restoration and maintenance of Mono Lake, tributary streams, and downstream areas of the aqueduct system in Mono County, including Grant Lake, the Upper Owens River, Crowley Lake, and the Owens River Gorge.

Policy 3.F.1. Work with the appropriate agencies to develop and implement a comprehensive water management plan for Mono Basin and the downstream areas of the aqueduct system. The water management plan should ensure that Mono Lake and the local aqueduct system are managed in a manner that protects the ecological and fisheries values of the Mono Basin and downstream areas of the aqueduct system.

Action 3.F.1.a. Support the State Water Resources Control Board Decision 1631 requiring minimum flows to Mono Lake to maintain the lake level over 6,391 feet above mean sea level.

Action 3.F.1.b. Support management of the aqueduct system that avoids drastic fluctuations in stream flows.

Action 3.F.1.c. Ensure that any comprehensive water management plan developed as per Policy 1, above, is consistent with the USFS's existing Comprehensive Management Plan for the Mono Basin National Forest Scenic Area.

Action 3.F.1.d. Manage Crowley Reservoir to protect its fishery and recreational opportunities.

Action 3.F.1.e. Manage the Upper Owens River to protect the quality of the fishery.

Objective 3.G. Reestablish streams impacted by diversions in the Mono Basin and Long Valley hydrologic units with flows adequate to support fish populations, riparian habitat, and associated recreational and scenic values.

Policy 3.G.1. Support minimum flows in all streams impacted by water diversions.

Action 3.G.1.a. Review technical documents prepared for the Mono Basin, Upper Owens, and Crowley Lake areas in order to provide input to the LADWP's water management plan on a periodic basis.

Policy 3.G.2. Provide land use controls that facilitate the restoration of impacted stream channels and adjacent areas.

GOAL 4. Protect the quality of surface and groundwater resources to meet existing and future domestic, agricultural, recreational, and natural resource needs in Mono County.

Agriculture, Grazing, and Timber

GOAL 5. Preserve and protect agricultural and grazing lands in order to promote both the economic and open–space values of those lands.

Objective 5.A. Encourage the retention of agricultural and grazing lands.

Policy 5.A.1. Discourage the conversion of agricultural lands to non–agricultural uses.

Objective 5.C. Promote sound management practices to preserve and enhance the economic and open–space values of the land, as well as natural resources, water resources and other public trust values, and sequester carbon.

Energy Resources & Resource Efficiency

Policy 15.B.4. Where burial is not possible, overhead transmission lines shall provide a maintenance and fire safety plan.

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 supersedes 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.